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“We have always stressed the importance of science and knowledge and keeping pace with their developments with all possible means, with active brain, on the bases of thinking and experience.”

December 18th 2010, His Majesty Sultan Qaboos bin Said,
May Allah rest him in the abodes of the pious and righteous in Paradise.

“On top of our national priorities is the education sector, with all its types and levels. It will receive full attention, and it will be provided with the supporting environment which motivates research and innovation.

February 23rd 2020, His Majesty Sultan Haitham bin Tarik Al Said

Acknowledgment

I am grateful to all of those with whom I have had the pleasure to work and who contributed immensely to drive our teamwork to success. In this regard, I would like to thank our highly dedicated team who made our center a great success. I am indebted to the chancellor of the University for his encouragements and unlimited support as well as personal and professional guidance in all aspects. Moreover, I thank the Vice Chancellor for Academic Affairs and VC for Finance and Administrative Affairs for their invaluable support. The achievements and activities presented in this book wouldn't have been possible without the generous support from the University of Nizwa which is reflected in recruitment of researchers, support of PhD students, building and furnishing the research laboratories and acquiring capital equipment. The support of the External Relations office with regard to MOUs and students exchange program is highly acknowledged.

I highly value the remarkable contribution of the Oman Research Council TRC for funding several projects through Open Grants and FURAP projects. I also thank Industrial Innovation center for its efforts to link some of our innovative projects with industry which was a great success. I am grateful to OAPGRC for the generous support and to PDO for funding NGS. I also thank Oman LNG and Al Mouj for funding some equipment and events. The gene bank of Oman is a major addition to the Sultanate to protect our genetic resources which is a joint initiative with OAPGRC, I therefore thank them for choosing our center to be a partner.

I am indebted to our local and regional collaborators who participated in several projects. In this regard I thank SQU, Qatar University, Qatar Foundation and Kuwait University for the joint projects through bilateral agreements with these universities. I am also thankful to our international partners and collaborators for the successful joint projects that have resulted in high impact publications.

Finally our team and I were working hard not only during the working days but outside the working hours and in weekends, I therefore thank our families for their understanding and patience.

Ahmed Al-Harrasi

March 2020

Contents

I Introduction

The University of Nizwa (UoN), as an entrepreneurial, civic, and outreach University, has set its objectives, mission and vision to become a global hub for research, and contribute effectively in Oman's economy. The University Charter "recognizes research as a major constituent of the University towards the establishment of a rich culture of innovation and creativity". Core values governing the mission of the University provide scientific research full support for knowledge acquisition and enhancement of the interactive role of the University. The University has developed a comprehensive research strategy that is aligned with the University's strategic mission and the national research strategy of The Research Council (TRC). The University has quantified three major research components: research infrastructure, funding, and human resources to produce effective research development. In addition to the research strategy, the UoN has a research operational plan in place, to effectively manage research activities and resources across the campus.

The University has created the Natural and Medical Sciences Research Center (NMSRC) as one of the means to deliver its research objectives. This successful project is a consortium of distinguished scholars with multidisciplinary scientific backgrounds including marine chemistry and biology, medicinal phytochemistry, analytical chemistry, organic synthesis, catalysis, polymer chemistry, computational chemistry, fragrance chemistry, spectroscopy, X-ray crystallography, mass spectrometry, NMR spectroscopy, microbiology, plant physiology, structural and molecular biology, biotechnology, tissue culture, genomics, proteomics, enzymology, cancer biology, stem cells, regenerative medicine and tissue engineering. The NMSRC possess state-of-the-art laboratories in the aforementioned areas.

The NMSRC is pioneered and sustained by skillful young Omani scientists who obtained the required qualification to become future leaders in the above areas. Funding is sustained through different internal and external programs. Moreover, the NMSRC has liaised with local government organizations and industries whereby new innovative projects have been funded jointly. The NMSRC has also capitalized effectively on its international collaboration network that is evidenced by more than fifty active international collaborations worldwide. The research outcomes are evidenced by more than 500 publications in reputable journals including patents, original papers, reviews, book chapters, books and conference proceedings.

II Foreword

Foreword by His Highness Sayyed Asaad bin Tariq Al Said, University of Nizwa, Chairman of the Board of Trustees

The University of Nizwa is highly committed in realizing its vision to be a beacon of Knowledge and Enlightenment. Such commitment indeed can be attained only through emphasis on research and research-led learning. To that end the UoN has geared up its effort to be a conducive research environment, hence the Natural and Medical Sciences Research Centre (NMSRC) was established. This research centre along with other specialized chairs and centres provide needed platforms that support a wide spectrum of vital areas which shall secure Oman's economic growth and further development. The NMSRC is a case in point that reflects UoN research strategy which is a direct response to the research strategy of the Sultanate of Oman that aims at creating an innovation culture where innovation outcomes are transformed toward social economic growth which is in alignment with the Sultanate's strategy to diversify its economic resources.

The NMSRC with its ten years of research excellence in natural and medical sciences embodies all those objectives. The NMSRC at the University of Nizwa has emerged to be a leading research centre in the Sultanate given its research infrastructure, state-of-the-art facilities, large network of local and international collaborators, skilful and creative professionals, multidisciplinary nature of its projects and high impact publications. It has played and continues to play a significant role to provide expert opinions to some challenges facing the Sultanate by providing solutions and services to the government and industrial stakeholders. Given the size of the research topics and infrastructure, the NMSRC is expected to be a leader in promoting the growth of science and technology and shall nucleate a robust foundation for a research-led learning.

This comprehensive book introduces the reader to the research projects and activities being conducted by the NMSRC and shall serve as a reference to both academia and industries. I congratulate the centre for their outstanding achievements and breakthroughs and look forward to their future achievements.

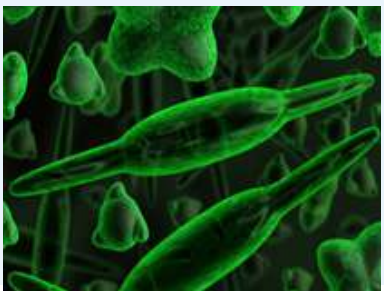
The University of Nizwa is highly committed in realizing its vision to be a beacon of Knowledge and Enlightenment. Such commitment indeed can be attained only through emphasis on research and research-led learning.

III Highlights

III.1. Center's Highlights

A library of compounds has been generated comprising more than 600 natural and synthetic compounds with their NMR and MS data

A gene bank is being established by OAPGRC in collaboration with NMS, UoN and CAMS, SQU comprising more than 2000 strains



More than 200 medicinal plants, marine species and microorganisms have been and are being evaluated for the medicinal value in a well-defined drug-discovery approach

More than 500 published papers in various disciplines were published in high impact journals as well as one patent, 10 book chapters and two books were published

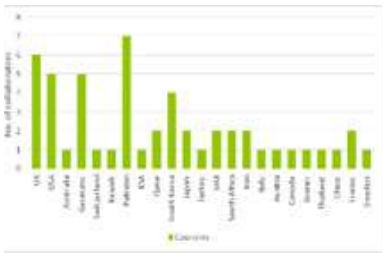
Skillful full-time researchers have been recruited among which are 15 Omani

Full-fledged, state-of-the-art laboratories have been constructed and furnished. Massive capital equipment of more than 5 million Omani riyals have been acquired

More than 200 graduates from different higher education institutions in Oman and abroad spent a training period of two months and above in our laboratories

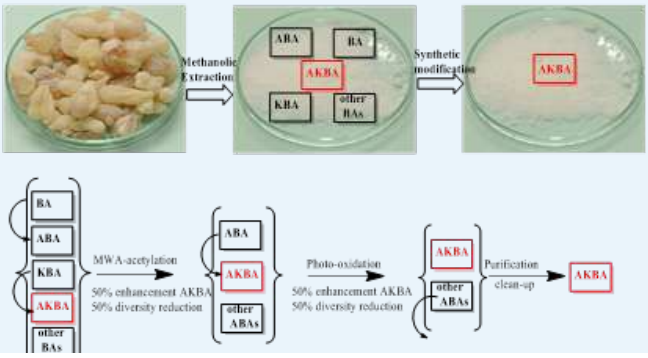
Several workshops and colloquia were conducted by our staff in different organizations in the Sultanate. In addition, we launched for the first time “Future Scientists Program” to talented high school students.

A network of active collaboration is established with international prominent universities and research institutions



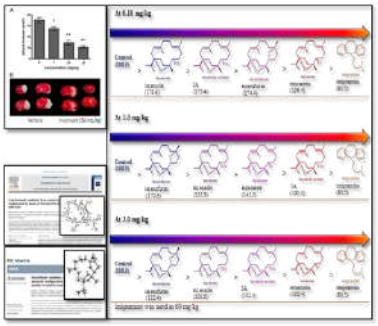
Weekly scientific seminars are offered by the staff in the center in our “Science Café”

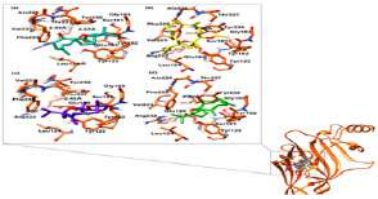
III.2. Research Highlights

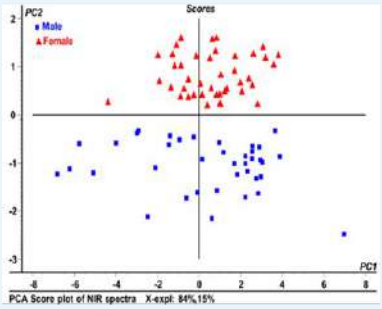


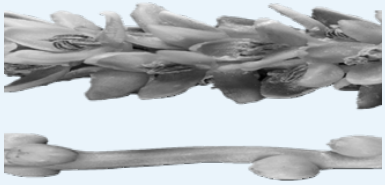
Patented method for the gram-scale isolation, quantification and purification of AKBA.
WO 2015166462 A1, Ahmed Al-Harrasi , Javid Hussain, Liaqat Ali, Ahmed Al-Rawahi, Method of Purifying 3-O-acetyl-11-keto-ß-boswellic acid (AKBA).

Evidence for the Involvement of GABAergic Mechanism in the Effectiveness of Natural and Synthetically-Modified Incensole Derivatives in Neuropharmacological Disorders.



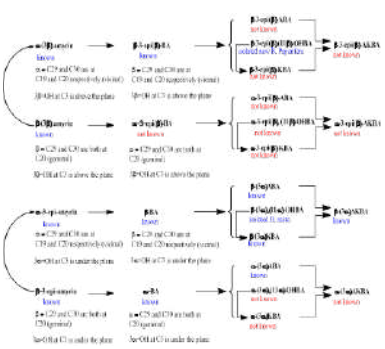


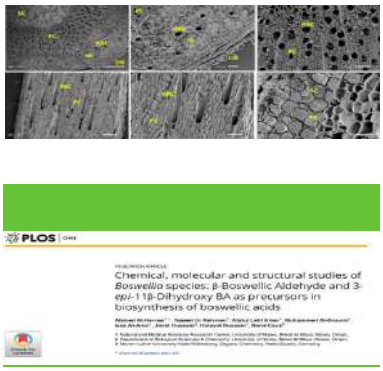


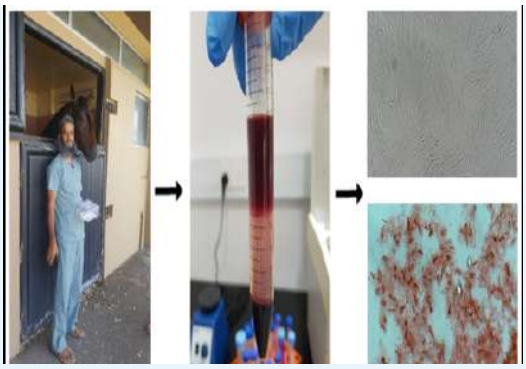


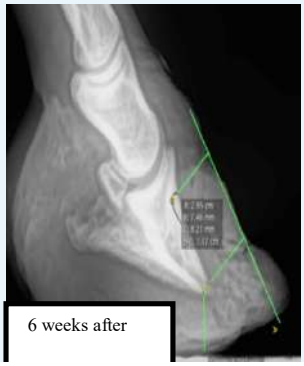
Development of a new and robust IR & NMR spectroscopic methods coupled with chemometrics supported by molecular analysis that can differentiate gender in immature date palm trees

Chemical, molecular and structural evidences supported the biosynthesis of boswellic acids.



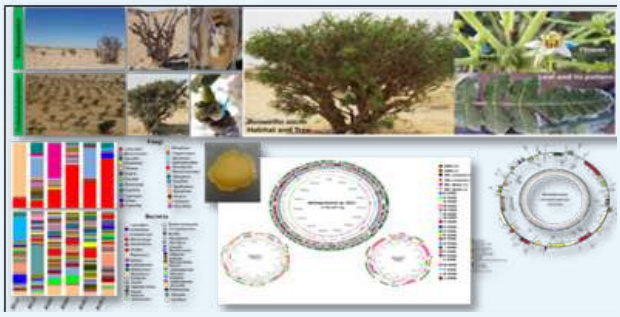




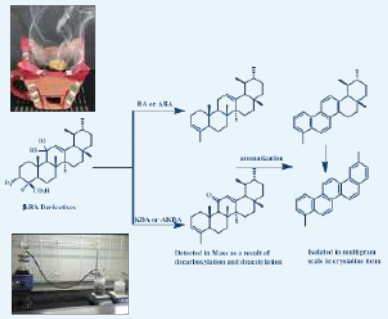


Mesenchymal stem cells (MSCs) were used to treat tendon, bone and cartilage in equine. After mesenchymal stem cell isolation from bone marrow, large quantity of stem cells were expanded and injected to the defected area. The results support current encouraging outcome from clinical use in horses treated with bone-marrow-derived stem cells. Recent studies have also demonstrated that some soluble factors as small vesicles released from stem cells, named microvesicles are responsible for better tissue regeneration. These extracellular vehicles play major role in cell-to-cell communication. Both stem cells and microvesicles were applied to achieve bone regeneration in vivo.

First Chloroplast genomics of Phoenix dactylifera (var. Naghal and Khanezi) are established

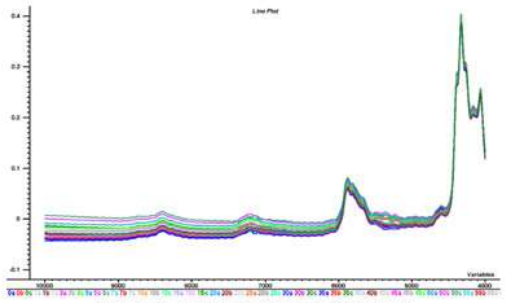


The chloroplast genome of Boswellia sacra is established and the work is on progress for WGS



Two pyrolysate products from Omani frankincense smoke: First evidence of thermal aromatization of boswellic acids.

Detection and estimation of Super premium 95 gasoline adulteration with Premium 91 gasoline using new NIR spectroscopy combined with multivariate methods.



1. Message from the Chancellor

Prof. Ahmed Al-Rawahi

Chancellor, University of Nizwa

Recently, the world-leading economies have been transformed into knowledge-based economies. In such systems, "knowledge and talent" workers are becoming a major component of their workforce; and the knowledge-production/institutions are becoming critical drivers of the wealth transfer and prosperity making of those evolving societies. Indeed, the future economies will witness greater changes in the role of the different components of the wealth making process. For all these reasons, research institutions will be the key for economic development of the future societies. Accordingly, the Research Strategy of the Sultanate envisions mobilizing Oman's economy to become among those that are knowledge-based and knowledge-driven.

The University of Nizwa, as an entrepreneurial, civic, and outreach university, has set its objectives, mission and vision to become a major player, locally and regionally, in knowledge production, knowledge transfer and knowledge dissemination. With such a role, UoN will contribute effectively in Oman's economy along with other institutions. To achieve its full potential requires greater attention to human capacity building especially of faculty and staff who are entrusted with such responsibility. In addition, financial resources must be developed to ensure effective attainment of such potential.

Research chairs and centers have been recognized as an effective vehicle for the delivery of multidisciplinary research. Hence, the creation of the Natural and Medical Sciences Research Center (NMSRC) comes as the first step by UoN to realize its research strategy. NMSRC with its dedicated researchers, large collaboration network, and state-of-the-art laboratories is continuing to produce a comprehensive set of new areas of knowledge by focusing on Chemistry, Biology and Medical Sciences. This book intends to introduce the reader tithe current activities, researchers, active collaboration, funds, discoveries, capital equipment and publications. Thus, it would serve as a useful reference for scholars and for future developments.

Prof. Ahmed Al-Rawahi

2. Message from the Chairman

Prof. Ahmed Al-Harrasi

Vice Chancellor for Research, Graduate Studies and External Relatins

Chairman of NMSRC

The University of Nizwa (UoN) has implemented plans that emphasize dynamic sequential initiatives for both internal as well as external funding. As a result, the UoN has built and furnished required research facilities and labs, recruited highly qualified researchers, and has capitalized effectively on its international networks. The University of Nizwa has created the Natural and Medical Sciences Research Center (NMSRC) as a crucial vehicle in delivering its research strategy's objectives among other means including research Chairs and research groups. NMSRC focuses on research development pertaining to Natural and Medical Sciences to build upon Omani excellence in chemistry, biology and medicine. Indeed, young Omani scientists' development stands out among the major achievements of the Center. Drugs discovery from Omani natural resources including medicinal plants, marine sources and microorganisms has received and will continue to receive great emphasis due to their immense economic potential and importance.

It is my intent to accelerate the knowledge transfer, enhance Omani human resources development, and promote scientific exchange and cooperation between Oman and other countries, the fact that is evidenced by the large network of local and international active collaborators the center has signed several agreements with. I shall continue to cater to the various needs of the country related to the aforementioned mentioned specialized areas.

NMSRC has managed to create an innovation culture where capacities were developed, collaboration and networking among researchers were fostered, scholarship and academic institutions were cultivated, and where innovation outcomes are geared toward social economic growth. More than 600 publications, patents, book chapters and books demonstrate the research outcomes of the Center.

This book intends to highlight the discoveries and research activities of the Natural and Medical Sciences Research Center.

Prof. Ahmed Al-Harrasi

3. Preamble

The University of Nizwa has created the Natural and Medical Science Research Center as a vital vehicle in delivering its research strategy's objectives among other means including research teams and research centers. This Center focuses on medicinal plants and marine natural products.

Indeed, it comes as a direct response to the research strategy of the Sultanate of Oman that aims at creating an innovation culture where capacities are being built, collaboration and networking among researchers, scholars and institutions are being forged, and where innovation outcomes are transformed toward social economic growth. This new Center embodies all those noble objectives.

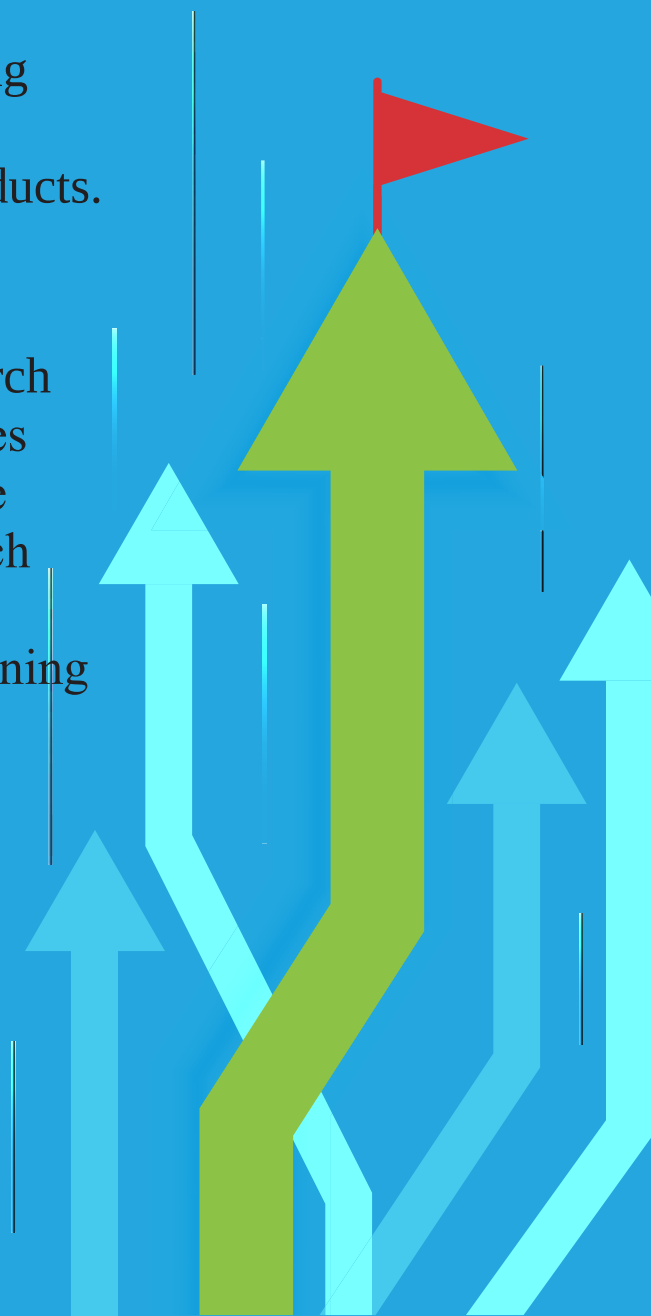
This five-year program is set to further build on Omani excellence in the chemistry, pharmacognosy, pharmacology, spectroscopy, molecular biology, microbiology and plant physiology and taxonomy. All of which are of immense economic potentials. No doubt, this Center will boost knowledge transfer, enhance Omani human resources building and strengthen scientific bridging between Oman and other countries. The Center shall cater to various needs of the country in basic as well as applied and specialized areas of natural products research and education related to the Center scope of activities.

The University of Nizwa (UoN) envisioned this Center and drew necessary implementation plans that emphasized dynamic sequential implementations and both internal as well as external funding. As a consequence, the UoN built and furnished required research facilities and labs, recruited highly qualified researchers and capitalized effectively on its international networks.

4. Vision and Mission

Vision: To be recognized nationally, regionally and internationally as a leading center for drugs discovery from Omani medicinal plants and marine natural products.

Mission: To perform cutting-edge research utilizing state-of-the-art research facilities and skillful human resources, to promote academic education by offering a research environment for undergraduate and postgraduate students and to provide training for Omani graduates.



5. Background & Rationale

Oman is endowed with rich biodiversity both marine and terrestrial that has acclimated to the arid climate. Its agro systems both traditional and conventional encompass a wide range of crops including herbs, vegetables, fruits, grains and forges. Its mountains, villages, valleys and coastline are rich with indigenous plants, animals and species.

The indigenous knowledge transferred over generations about various medicinal plants need to be documented and researched. Likewise, marine natural products are also of immense importance due to diversity and quantities available in Omani waters. Biotechnological research of these bio-resources is vital to Oman's economic growth and sustainability. This Center offers a unique opportunity for interdisciplinary research into medicinal plants and marine natural products with a view to discovering and developing novel therapeutic agents. The Center will develop a Center of Research Excellence for interdisciplinary research in the chemistry, pharmacognosy, pharmacology, spectroscopy, molecular biology and microbiology of medicinal plants and marine natural products and will apply the advances in knowledge that emanate from this to develop products for health improvement and disease management.

The Center's duties include the following:

- **Develop a body of research in the fields of chemistry, pharmacognosy and pharmacology of medicinal plants and marine natural products of Oman**
- **Attract funds through research proposals locally, regionally and internationally**
- **Build network with other researchers and research bodies in Oman and abroad, including industry and non-governmental organizations**
- **Contribute to public understanding and policy development in the areas of chemistry, biology, pharmacognosy and pharmacology of medicinal plants and marine natural products**
- **Contribute to the training of highly qualified personnel**
- **Enhance financial resources through innovations and products directed to the market**

The Center is led by a professor to undertake work at an ultra-precompetitive level and has the freedom to develop an area of natural products which will ultimately grow so that industry could take forward. The Center is subjected to an annual review of achievement with a major review every three years. From the outset, the Chair-holder has made industrial connections, thereby stimulating interest and dialogue of mutual benefits.

6. Themes & Scopes

The main theme of research activities under the Center involves the study of biologically active natural compounds from medicinal plants and marine natural products, which ranges from collection to purification and structural elucidation of the compounds. Biological activities, utilization, synthesis, and structure-activity relationships of isolated compounds are being carries out in collaborations with scientists in related fields such as microbiology, pharmacology, agricultural chemistry, and medicine. The 2020 onward focus will be towards drugs discoveries.

7. Impact to Oman

Oman has a wide variety of medicinal plants and fascinating unexplored marine natural products. The country is home to about 1,200 native plant species, which includes trees, shrubs and herbs. Oman also bestows brilliant underwater gardens which favors greater species diversity for rare varieties of marine natural products.

This Center is pioneered by devoted researchers with outstanding research profiles. Located at the University of Nizwa in Birkat Al-Mauz, our scientists enjoy tremendous opportunities of investigating numerous species growing in Jabel Al-Akhdar as well as other parts of Oman.

With the firm belief that intensive research in pharmaceutical sciences can bring about great benefits to the public in terms of improving quality of life and national development, the Natural and Medical Science Research Center is investing efforts and money in creating various specialized research laboratories within its premises.

7.1. Scientific Impact

The work under this Center is producing a comprehensive set of data by focusing on Medicinal Plants and Marine Natural Products and related natural resources of Oman. The project is motivating and stimulating research cooperation between biologists, taxonomists, natural products chemists, synthetic chemists, analytical chemists, pharmacologists, microbiologists and molecular biologists. International collaboration has been initiated with several prominent research institutions. Likewise, local collaboration with concerned government and private industries and institutions has been set.

Despite considerable research and development efforts for the discovery of synthetic drugs, there is paucity for the discovery of natural drugs and therefore there is a massive scope for finding alternative natural and safe drugs from natural products. In this regard, this Center brings cutting-edge research to the Sultanate of Oman.

7.2. Academic Impact

This Center constitutes an excellent research hub leading to awards of 6 Ph.Ds. via co-supervision, more than 40 B.Scs. degrees and hosted more than 300 graduate students for their internship and training. Chemistry, Biology and pharmacy graduates are enjoying the opportunity of getting state-of-the art training in the Center through courses, senior research projects, postgraduate projects, workshops and seminars. The graduates are carrying this knowledge to the Omani industries, which in turn benefits the economy.

7.3. Industrial, Technological & Economic Impact

Oman industries are the second beneficiary of this Center. The results obtained in these studies are being directly used to promote Omani industries. The Center is currently liaising with several industrial companies. In addition, the Center serves as a consultant for the industry whenever they face specific related problems. This is in agreement with the Sultanate of Oman's goals of attracting and establishing new industries, with the aim of diversifying its economic foundations, increasing its knowledge pool and creating new employment. A particular attraction lies in industries that are linked to the country's wealth of medicinal plants and marine life and have the potential to provide significant added value to the economy. The present Center fulfils these requirements. The raw materials employed are plants and marine organisms, and the isolation of lead compounds from them will lead to products of considerable economic value. Moreover, the main application of the intended products is in the drug-discovery market, which is an area of rapid growth when it comes to the chiral pool and will initiate the creation of a skilled and specialised workforce. Overall, the successful outcome of the project will enhance the Sultanate's visibility in a modern and growing research field and may, in the longer term, contribute towards the establishment and growth of new and attractive pharmaceutical industries within the country.

In addition, the Sultanate of Oman is in possession of enormous medicinal plants and marine organisms resources, and it is highly desirable that these resources be processed within the country so that value adding occurs in the country. Overall, the Sultanate of Oman's rich wealth of natural products makes it an ideal location for establishing new pharmaceutical industries based on natural products, and so it would be a unique opportunity for the country to be at the forefront of the envisaged development. This is valuable from a technology transfer point of view, as it allows the broadening of the technical expertise base in Oman, the training of staff to work in the emerging industries and, long-term, the creation of new employment.

The combination of the expertise of the active international collaborators and University of Nizwa team hence offers the unique opportunity to advance the research field of natural products in Oman and thus enhance Oman's visibility in medicinal plants research. The successful outcome of the Center will lead to patentable and marketable results, with the possibility of launching industrial ventures through the formation of new companies or the collaboration with existing organizations. Overall, the current projects would move Oman into the small circle of countries that are actively discovering drugs from natural products for the future, a case in point of what the Oman Research Strategy aims for.

8. General Objectives

1. To introduce a high-quality research and development program through the support of active international collaborators.
2. To develop research capacities, build up and produce highly qualified personnel.
3. To create and manage intellectual property that shall lead into the development of new products and spin-off businesses.
4. To establish contacts and networking with national and international academic and industrial organizations
5. To develop and implement new teaching curricula, degree programs at the undergraduate and graduate levels.
6. To assist and advise for the development of needed processing and manufacturing plants in the field of natural products, thereby creating more jobs for Omani graduates and enhancing the economic growth.
7. To provide relevant expertise to government agencies of the Sultanate of Oman.
8. To conduct scientific research and studies concerned with the progress of national industry and which facilitates the correct use of medicinal plants.
9. To encourage the practice of scientific research and nourish the spirit of research in the younger generation.
10. To explore and study medicinal plants and marine natural products for maximizing their economic, social and ecological returns to Oman.

9. Ethical Permissions

- Plant collection permits from Ministry of Environment and Climate Affairs.
- Animal collection permits from Ministry of Environment and Climate Affairs.
- All preclinical experiments are in accordance to ethical legislations from the University of Nizwa Ethical Committee for animal research and according to the National Committee for Bioethics.

10. Intellectual Property

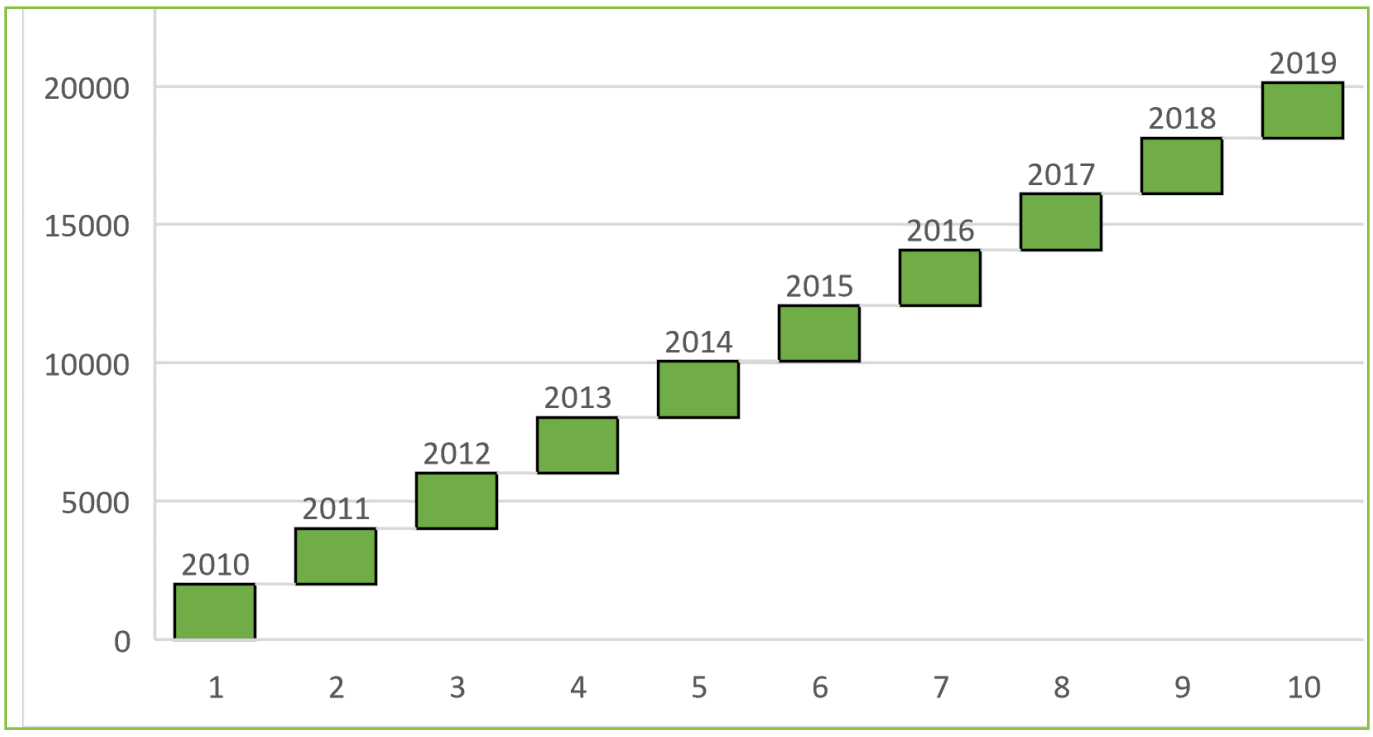
Consequent of the applied character of our current research and development work, commercially sensitive ideas and results are being generated. These require rigorous patent protection, while they are submitted to patents. Inventorship will lie with the creators of the ideas and results, while it is proposed that the ownership will be assigned to the University of Nizwa. In order to facilitate patenting, it is imperative that sufficient funds are available under the Center to afford the filing procedure as well as early-stage maintenance. Costs involved in patent protection can be very considerable indeed; economies in patent protection often negate the protection itself.

11. Funding

There is a remarkable and steady research progress during the last seven years. UoN has allocated a percentage of its revenues for research in different forms including: research funds, students research support, exchange students support, postgraduate students support, full-time researchers, establishment of research laboratories and acquisition of research equipment.

The Center has succeeded so far in attracting over 2,000,000 OMR through internal as well as external research grants. Externally funding sources include, but are not limited to, Oman Research Council, Industrial Innovation Center, GCC co-funding program and SQU-UoN co-funding program.

In order to sustain the productivity of the Center, a minimum of 300,000 OMR should be secured through open grants per annum.




Elix
Technology
Inside

11.1 Funded Projects (Internal and External)

No	Investigators	Title	Code (ID)	Year	Source	Amount
1	Ahmed Al-Harrasi, Raeid Abed, Ahmed Al-Rawahi	Utilization of produced water as a growth medium for algae cultivation and biofuel production	EJAAD/ SQU/ NMSRC	2019	National	90,000 OMR (230,000 USD)
2	AbdulLatif Khan, Ahmed Al-Harrasi, Sajjad Asaf, Tapan Mohanta	Genomics and transcriptomics for exploring putative genes involved in incensole, its precursors and derivatives in Boswellia and streptomyces for cemrenoids biosynthesis	BFP/RGP/ CBS/19/221	2019	National	25,000 OMR 65,000 US$
3	AbdulLatif Khan, Prof. Ahmed Al-Harrasi, Ali Al-Lawathi, Nadiya Al-Saadi, Daniel Schachtman, Jean-Jack Reithoven, Sajjad Asaf, Jason Eslamieh	Understanding the genomics, evolution and taxonomy of Frankincense producing genus Boswellia	TRC/ OAPGRC/ NMSRC	2019	National	19,000 OMR 50,000 US$
4	AbdulLatif Khan, Ali Al-Lawathi, Saif Al-Hosni	Sub-Culturing of Fungal strains from Gene Bank of Oman	TRC/ OAPGRC/ NMSRC	2019	National	3,800 OMR 10,000 US$
5	Yaseen Al-Mulla, Mohammed Faizuddin, Ahmed Al-Harrasi, Abdullatif Khan	Mapping tree cover and morphological changes in the Frankincense (Boswellia sacra) populations in Huluf, Wadi Sahnut and Wadi Dawkah, in Dhofar, Oman	HMF/SQU/ NMSRC	2018	National	37,000 OMR 96,000 US$
6	Fatemah Jamshidi, Sulaiman Al-Hashmi, saeid Vakilian	In vivo study of the effect of Acridocarpus Orientalis on breast cancer	BFP/RGP/ HSS/18/024	2018	National	5,000 OMR 13,000 US$

7	Najeeb Rehman, Ahmed Al-Harrasi	Exploring the Lead Compounds from the Seaweeds of three Omani species; Dictyopteris hoytii, Codium dwarkense and Padina boergesenii for the Development of Drugs Discovery Process	BFP/RGP/ CBS/18/011	2018	National	5,000 OMR 13,000 US$
8	Ali Rostami, Ahmed Al-Harrasi	Carbon Dioxide and Isocyanate Organocatalysis: A Sustainable Approach in Turning Greenhouse Gas and Toxic Compounds into Chemical Feed stock	BFP/RGP/ EI/18/021	2018	National	5,000 OMR 13,000 US$
9	Majid Al-Salmani, Sulaiman Al-Hashmi	Cellular and molecular investigations of selected channelopathies in Omani patients: towards the advancement of population-specific personalised therapies	BFP/RGP/ HSS/18/030	2018	National	9,600 OMR 25,000 US$
10	Ajmal Khan, Sobia Ahsan	Anti-diabetics Potential of Boswellic acids and Improvement of their Efficacy by Nanoparticle Formulation and Glycosylation: A Novel Approach for Diabetics	BFP/RGP/ HSS/18/018	2018	National	3,000 OMR 8,000 US$
11	Abdulatif Khan, Ahmed Al-Harrasi, Sajjad Asaf	Genomic and Physiological Strategies for Ommatissus lybicus de Bergevin (Dubas Bug) on Date Palm (Phoenix dactylifera) in Oman	BFP/RGP/ EBR/18/005	2018	National	9,000.OMR 24,000 US$

12	Sulaiman Al-Hashmi, Ahmed Al-Harrasi, Issa Al-Amri Hany Elsayed Marei Mady, Asma Ali Althani	Use of patient-specific induced pluripotent stem cells (iPSCs) to study stroke in Qatar and GCC countries	GCC-2017-004	2017	International	1,709,340 OMR (3,886,101 USD)
13	Ahmed Al-Harrasi, Raeid Abed, Fahad Al-Senaf, Huda Mahmoud	Biotechnological applications of marine biofilms developing on solid surfaces in the Arabian Gulf	GCC-2017-004	2017	International	92640 OMR (240,000 USD)
14	Ahmed Al-Harrasi, Liaqat Ali	Antimicrobial, Antioxidant, Anticancer, and Enzyme Inhibitory Activities of Saponins and other Polar Secondary Metabolites from the Polar/Aqueous Extract of the Endemic Omani Medicinal Plant Aloe Dhufarensis for the Development of Lead Compounds	A/16-17-UoN/01/ Chair MPMNP/IF	2016-2017	Internal	9000 OMR (23,313 USD)
15	Ahmed Al-Harrasi, Abdulatif Khan, Genomic	Transcriptomicand proteomic involved in Resin Production from endemic Boswellia sacra Tree in response to wounding and fungal elicitation: Physiological and genomic perspectives	ORG/ EBR/15/007	2015	National	191,600 OMR (497,921 USD)
16	Sulaiman Al-Hashmi, Ahmed Al-Harrasi, Fahad Al-Zadjali	Use of fatal membrane stromal cells for the prevention of graft versus host disease after stem cell transplantation	ORG/ HSS/15/006	2015	National	245,000 OMR (636,694 USD)

17	Ahmed Al-Harrasi, Fahad Al-Zadjali, Gilles Guillemen, Noaki Matsuda, Sulaiman Al-Hashmi, Husain Yar Khan, Javid Hussain	Exploration of new Acetyl 11-Keto-β Boswellic acid (AKBA) Derivatives as Tumor sensitizing agents	ORG/ HSS/14/004	2014	National	312,000 OMR (810,810 USD)
18	Ahmed Al-Harrasi, Liaqat Ali, Lubna Al-Kharousi, Javid Hussain	Exploration of Padina boergesnii from Marine Resources of Sultanate of Oman as a source of Potential Lead Compounds for the development of New Drugs	A/13-14-UoN/09/ Chair MPMNP/IF	2013-2014	Internal	28000 OMR (72,765 USD)
19	Ahmed Al-Harrasi, Hidayat Hussain, Ghulam Abbas, Sulaiman Al-Hashmi	Identification of new glucagon agents from natural and synthetic products	A/14-15-UoN/11/ Chair/IF	2014-2015	Internal	28000 OMR (72,765 USD)
20	Ahmed Al-Harrasi, Gilles Guillemen, Faruck Hakkim, Javid Hussain	Exploration of new Acetyl 11-Keto-β Boswellic acid (AKBA)Derivatives as Tumor sensitizing agents	A/13-14-UoN/02/ Chair MPMNP/IF	2013-2014	Internal	27000 OMR (70,166 USD)
21	Fazal Mabood, Ahmed Al-Harrasi, Javid Hussain, Najeen ur Rehman, Abdulatif Khan	Spectroscopic and chemometric Studies of date Palm fruits Grwoing in Sultanate of Oman	A/13-14-UoN/05/ DBSC CAS/ IF	2013-2014	Internal	18550 OMR (48,206 USD)
22	Zakira Naureen, Ahmed Al-Harrasi, Faik Kantar, Javid Hussain, Abdulatif Khan	Bio-priming with Silicate Solubilizing bacteria for Plant Growth Promotion and Biological Control of Phytopathogens in Selected Omani Crops	A/13-14-UoN/08/ DBSC-CAS/ IF	2013-2014	Internal	15900 OMR (41,320 USD)

23	Ghulam Abbas, Ahmed Al-Harrasi, Javid Hussain, Hidayat Hussain, Iqbal Choudhary	Discovery of New Antagonists of Glucagon Receptor and New Inhibitors of Protein Clycation, alpha-Glucosidase, Dipeptidyl Peptidase from Natural and Synthetic Products for the management of Diabetes Mellitus and late Diabetic Complications	A/13-14-UoN/11/ DBSC MPMNP/IF	2013-2014	Internal	9800 OMR (25,467 USD)
24	Abdul Latif Khan, Ahmed Al-Harrasi, Javid Hussain, Jae-Ho Shin, In-Jung Lee	Exploration Of Heavey Metal remediating Endophytic Bacteria from Extremophylic Ecosystems in Oman	A/13-14-UoN/01/ Chair MPMNP/IF	2013-2014	Internal	17800 OMR (46,257 USD)
25	Javid Hussain, Ahmed Al-Harrasi, Simon Gibbons, Gilles J. Guillemin	Phytochemical Investigations, Proximate Analysis and Biological Investigation of Some Selected Omani Medicinal Plants	ORG/ CBS/12/004	2012-2014	National	528,000 OMR (1,495,582.17) USD)
26	Ahmed Al-Harrasi, Ahmed Al-Rawahi, Jamal Al-Sabahi, Javid Hussain	Comparative, Physicochemical and Microbiological Investigations of Omani Luban (Boswellia sacra) and Related Frankincense Species	ORG/ CBS/10/002	2011-2014	National	177,540 OMR (460,879.51 USD)
27	Ahmed Al-Harrasi, Ahmed Al-Rawahi	Comparative and Phytochemical Study of Omani Luban (Boswellia sacra) and Related Frankincense Species	A/09-10-UoN/28/ A&S/IF	2009-2010	Internal	14,000 OMR (36358 USD)

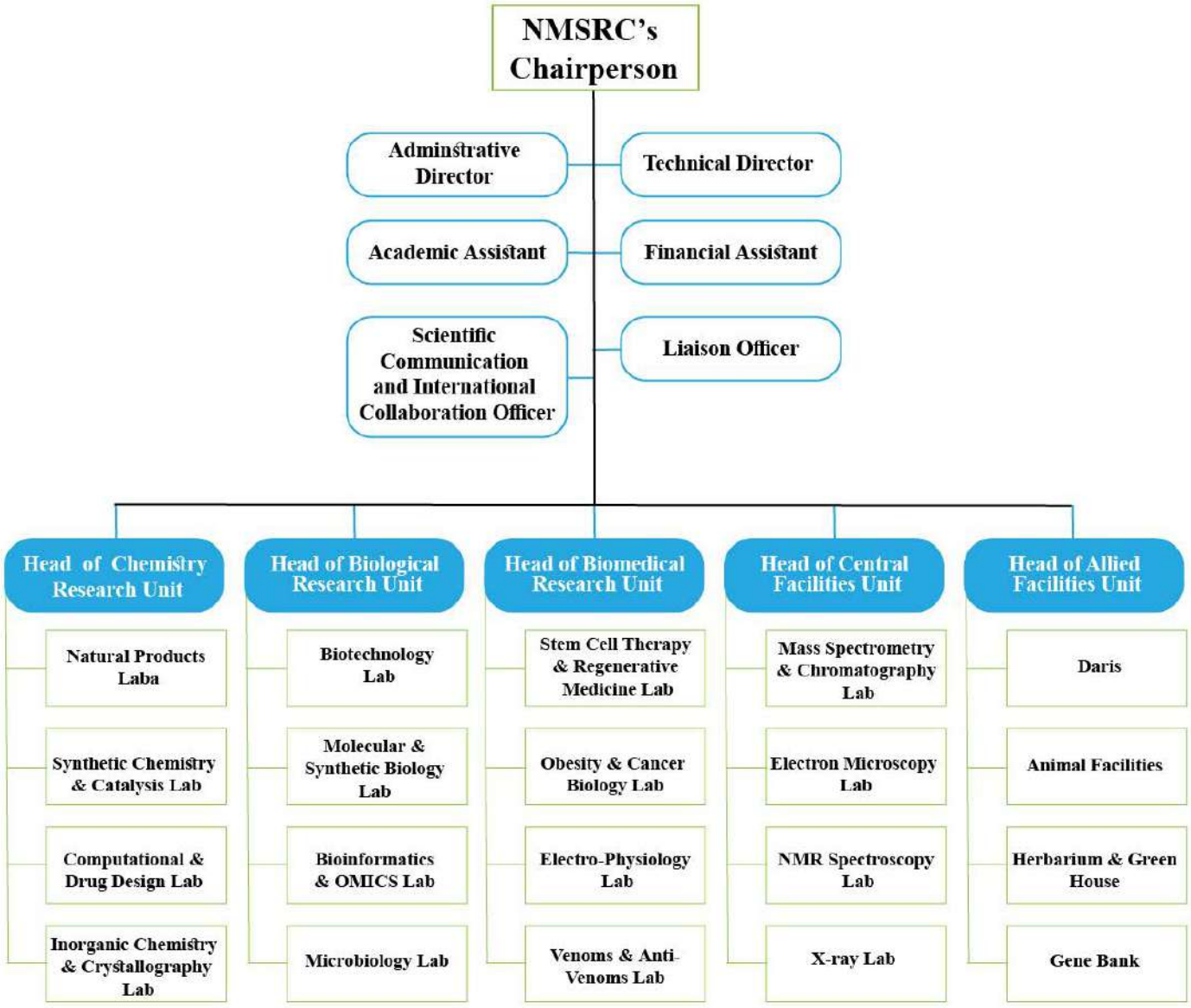
28	Javid Hussain, Ahmed Al-Harrasi	Phytochemical Investigations, Proximate Analysis and Biological Investigation of Some Selected Omani Medicinal Plants	A/ URC/2011-12/CA and S/03/ November, 2011	2011-2012	Internal	19,700 OMR (51,036 USD)
29	Yahya Ismail, Ahmed Al-Harrasi	Fabrication of Conducting Polymer based Artificial Muscles and Evaluation of their Actuation and Sensing Characteristics	P-09-10/ UoN/29/ CA&S/IF	2010-2012	Internal	8500 OMR (22,074.77 USD)
30	Ann Mothershaw, Ahmed Al-Harrasi, Basil Nzeako	Physicochemical Properties and Antimicrobial Activity of Omani Frankincense	IG SQU / CAMS 2010	2010-2012	National	4500 OMR (11,686.64 USD)
31	Salma Al-Kindy, Ahmed Al-Harrasi	Synthesis and Luminescence Properties of a Novel Label Based on Coumarin Nucleus	IG SQU / SC 2007	2007-2010	National	4500 OMR (11,686.64 USD)
32	Issa Al-Amri, Ibraheem Mahmood, Abdulaziz Al-Kindy, Ahmed Al-Harrasi	The Effect of incubation temperature on sex determination in relation to reproductive steroid levels, progesterone receptors and gonadal ultra-structural steroid genic features in embryos and post hatchings of the green turtle, Chelona mydas, Oman	NA	2013	National	15,300 OMR (39,802USD)
33	Ahmed Al-Harrasi	Characterization to determine purity and health benefits and confirm Omani origin. The development of a new fragrance using endemic flowers and fruits of Oman.	P-2012-001	2012	National / Idustrial	31,880 OMR (82590 USD)

11.2 Funded FURAP Projects from TRC

No	Project title	Faculty Mentor
1	Phytochemical Investigations on Omani Seaweed species Codium dwarkense Borgesen in search for Potential Lead Compounds for the Drug Discovery Process	Dr. Liaqat Ali
2	Investigating the Role of Marine Bacteria Oil in UV Resistance	Dr. Thomas Dzeha
3	Condensation and Analysis of the Frankincense Resin Incense	Prof. Dr Ahmed Al- Harrasi
4	Synthesis, Characterization, and Biological Screening of Organotin Complexes	Dr. Liaqat Ali
5	Synthesis of Anthraquinone antibiotics as α-Glucosidiase Inhibitors	Prof. Dr Ahmed Al- Harrasi
6	Implementation of Halogen Bonding in Chromones Analogues and other Bioactive Natural Products towards Lead Development	Dr. Zahid Hassan
7	Synthetic Studies of Halogenated Naphthalenes via Chemoselective Palladium(0)-catalyzed Coupling reactions and Their Biological Properties	Dr. Zahid Hassan
8	Design, Synthesis, Characterization and Application of Palladium Catalyzed Regio-, Chemo-, and Stereoselective Coupling Reactions: An approach in Material Sciences	Dr. Zahid Hassan
9	Isolation, Identification and bioactivities of gibberellins producing Endophytic fungi associated with medicinal plants of Jabal Al- Akdar	Dr. Abdul Latif Khan
10	Assessment of oxidative stress mitigation by selected medicinal plants of Jabal Al AKhdar Oman	Dr. Abdul Latif Khan
11	Identification of Symbiotic Endophytes from Boswellia sacra (Frankincense) and assessment of their role in secretion of essential secondary metabolites	Dr. Abdul Latif Khan
12	Genome Sequencing of Endophytic microbes isolated from the bark of Boswellia sacra (Frankincense)	Dr. Abdul Latif Khan
13	Denaturing gradient gel electrophoresis coupled with PCR based assessment of Fungal Diversity in the leaves and bark samples of Frankincense tree	Dr. Abdul Latif Khan
14	Enzyme Inhibitory Secondary Metabolites Characterization from Endophytic Fungus of Boswellia sacra (Frankincense)	Dr. Abdul Latif Khan
15	Role of Signal Tranducer and Activator of Transcription 3 (STAT3) Accompanied with Epithelial to Mesenchymal Transition in Microenvironment of Omani Breast Cancer Patient : Halmark of Metastasis	Dr. Husain Yar Khan
16	Synergistic cytotoxic effect of current clinical drugs and boswellic acid on cispatin resistant ovarian cancer cells (A2780cis): chronomodulation approach	Dr. Husain Yar Khan
17	Effect of Omani Frankincense Derived Essential oil on Breast Cancer Heterogeneity	Dr. Husain Yar Khan

12. Structure of the Center

In order for the Center to have sufficient time and resources to fulfill its duties, it is mandatory to establish a robust and broad structure. The University of Nizwa has employed a director technical who will be responsible for purchases of equipment and consumables. He will be a focal point between the Center, the finance department and the companies. The University will also appoint an academic assistant to the Center with the main task of delivering the teaching curriculum to be developed and liaised with various stakeholders.



13. Research Relevance & Disciplines

The research being conducted under this Center should help explaining the interactions between plants and humans and is leading to advancements in the prevention and treatment of common diseases in Oman and the region including cancer, cardiovascular diseases and diabetes. Our very promising results in this field have been disseminated to international community through publications and to the local community via media. The research areas associated with the Center demonstrate the multidisciplinary nature of research thereby providing an excellent research environment for training of Omani graduates in the field of chemistry, biology, pharmacy and medicine. The following figure illustrates this interaction.

- **Venoms & Anti-Venoms**
- **Electro-Physiology**
- **Histology & Immunology**
- **Cancer Biology**
- **Stem cells Therapy & Regenerative Medicine**

- **Pharmacognosy & Pharmacology**
- **Drug Design & Discovery**
- **Spectroscopy**
- **Natural Products Chemistry**
- **Phytochemistry**
- **Organic Synthesis & Catalysis**
- **Inorganic & Crystallography**
- **Analytical Chemistry**

NMSRC

- **Biotechnology**
- **Microbiology**
- **Molecular Biology**
- **OMICS & Bioinformatics**
- **Taxonomy**

14. Human Resources

The current projects under the Center have executed adequately a very broad range of activities in terms of supervising, reporting and liaising with academic and industrial partners. The University of Nizwa has invested in this by recruiting highly qualified researchers.

15. Capacity Building, Training and Knowledge dissemination to Public

Workshops and colloquia are being held for the training of manpower and to create awareness about the potentials of medicinal plants and marine natural products application. At least 5 such moots will be held each year in different areas so that the relevant information is disseminated widely.

National and international forums will be organized to discuss scientific and technological developments leading to new ideas. Sharing of knowledge and project results will help in planning economic development of medicinal plants and marine natural products. The potential cooperative organizations would be Diwan of Royal Court, Oman Botanic Garden, Ministry of Tourism, Public Authority for Craft Industries, Ministry of Health, Ministry of Agriculture and Fisheries as well as Academic institutions. Regular meetings or conferences are held to review critical evaluation of the Center results and plan for future. The Center is establishing a herbarium for medicinal plants in addition to a museum for the genetic of natural resources.

16. Research alignment with National & International strategic plans

The Natural and Medical Sciences Research Center (NMSRC) aligns its research projects with the 3 major development guidelines used by the Omani government:

The United Nations' 17 Sustainable Development Goals 2030

The 12 Strategic Directions of the Oman Vision 2040

Developing the necessary skills for the 4th Industrial Revolution

NMSRC Education and community outreach	Oman Vision 2040	UN's Sustainable Development Goals 2030
• Graduate students training at the center • School Outreach • Community Outreach • Seminars on the environment, reptiles, water conservation, renewable energies, etc. • Partnership with internal i.e. UoN and external i.e ESO, MOE	1. Inclusive education, sustainable learning, and scientific research that leads to a knowledgeable society and competitive national capabilities 3. A society proud of its identity and culture and committed to its citizenship 10. Effective, balanced, and flexible ecosystems in order to protect the environment and ensure the sustainability of its resources in support of the national economy	
• Caves, Wadis, and others local environment exploration • Fauna and flora data collection • Partnerships with Ministry of Environment, Ministry of Tourism, Ministry of Agricultre and Fisheries, OBG, OAPGRC, SQU	1. Inclusive education, sustainable learning, and scientific research that leads to a knowledgeable society and competitive national capabilities 3. A society proud of its identity and culture and committed to its citizenship 10. Effective, balanced, and flexible ecosystems in order to protect the environment and ensure the sustainability of its resources in support of the national economy	
• International Research Cooperation, international students' internships, Omani students' research abroad, Scientific workshops, Conferences, Open lectures	1. Inclusive education, sustainable learning, and scientific research that leads to a knowledgeable society and competitive national capabilities	

NMSRC Industry Consulting	4th Industrial Revolution	Oman Vision 2040	UN's Sustainable Development Goals 2030
• Sustainability • Environmental Protection and Remediation • Oil &Gas, Hospitality Industries • Industry Research and Applications • Natural product based on knowledge • National economy diversification • Oil &Gas Industries, Agriculture, Pharmacology, Perfumery, cosmetics • SME entrepreneur support	Innovation	1. Inclusive education, sustainable learning, and scientific research that leads to a knowledgeable society and competitive national capabilities 3. A society proud of its identity and culture and committed to its citizenship 10. Effective, balanced, and flexible ecosystems in order to protect the environment and ensure the sustainability of its resources in support of the national economy	

NMSRC Research Topics	4th Industrial Revolution	Oman Vision 2040	UN's Sustainable Development Goals 2030
• Plant genomes, Natural products of Oman medicinal plants, Chemical & biological properties of Natural pure compounds, Essential Oil Research and olafactrometry • Microbes diversity, Biotransformation, Biotechnological applications • Natural Products and bioactive compounds from Marine species, Marine-Microbes isolation and identification • Stem cells and regenerative Medicine, Bone healing, Wound Healing, Venom Research, Diabetic and Cancer Research, In-vitro & In-vivo experiments • Next Generation Sequencing (NGS), 3D Computational Biology, Bio-informatics	Innovation Nanotechnology Synthetic Biology 3D Bio Printing	1. Inclusive education, sustainable learning, and scientific research that leads to a knowledgeable society and competitive national capabilities 2. A pioneering healthcare system with international standards 3. A society proud of its identity and culture and committed to its citizenship 6. A diversified and sustainable economy that embraces knowledge and innovation, operates within integrated frameworks, attains an accomplished competitiveness, keeps abreast of industrial revolutions, and achieves fiscal sustainability 10. Effective, balanced, and flexible ecosystems in order to protect the environment and ensure the sustainability of its resources in support of the national economy	

1st ICFMP 2018
First International Conference on
Frankincense and Medicinal Plants:
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OMAN BOTANIC GARDEN
حديقة النباتات والأشجار الطبية

Conference Overview

Oman's diverse climate offers a variety of habitats for wildlife including mountains, valleys, deserts, coastal plains and sea coasts. Over one thousand four hundred species of plants have been recorded in Oman. The most famous is the Boswellia sacra, the frankincense tree. Indeed, frankincense is one of the most evocative expressions of Oman's vibrant heritage and culture. Given the increasing interest in discovering new drugs from medicinal plants in general and from frankincense in particular, coupled with the need to better link academia with industry, it is important to highlight recent advances in this area. This inaugural conference aims to promote an exchange of knowledge and information about medicinal plants and frankincense to establish linkages between producers and consumers of natural products worldwide. It also offers an opportunity to introduce delegates to new developments and breakthroughs in many disciplines related to these areas. The conference further aims to contribute to increased production, underline the in-dustrial and environmental value of Omani's natural products, and highlight recent medical and scientific discoveries.


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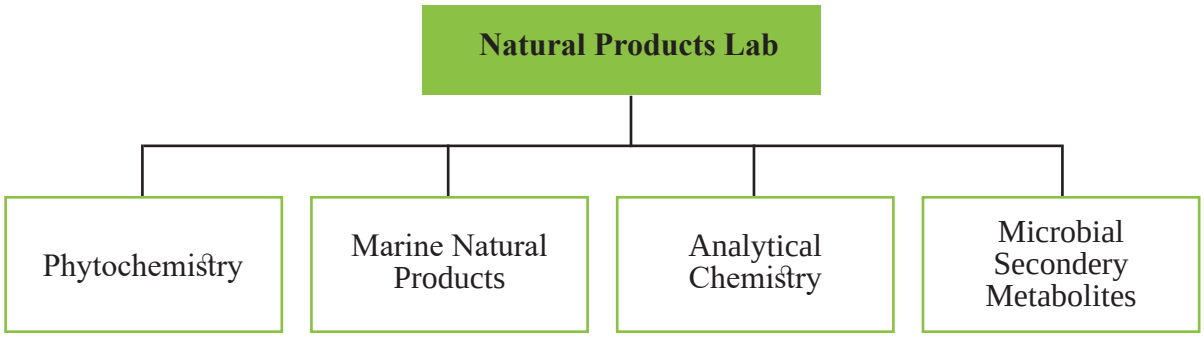
17. Current Activities under the Center

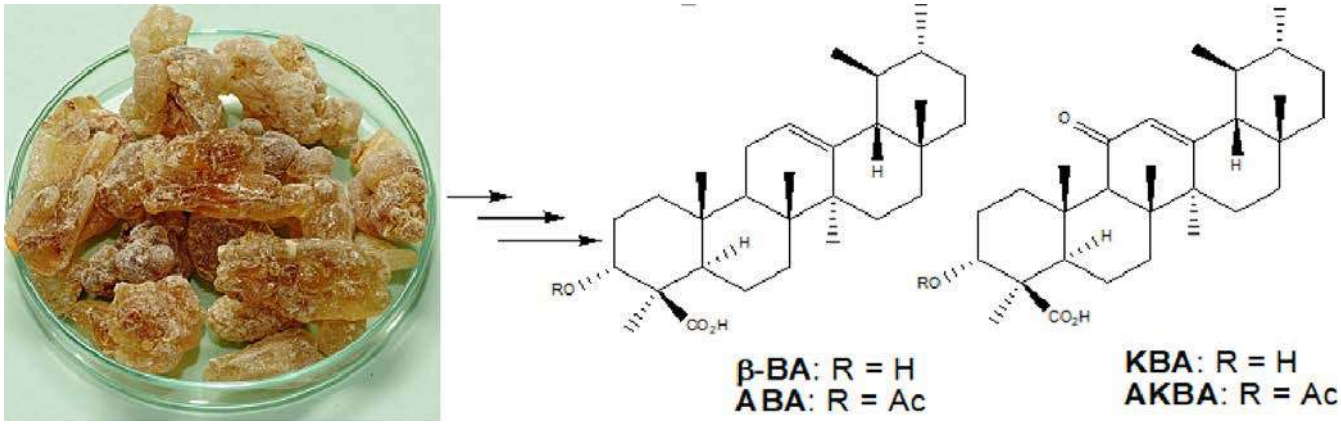
17.1. Natural Products Lab



17.1.1. Discovery of Lead Compounds from Oman Frankincense

Natural products, the secondary or non-primary metabolites produced by living organisms, have been exploited by people for a variety of purposes including use as food, fragrances, pigments, insecticides, and medicines. Historically, plants have served as the major source of medicinally useful natural products, developed from a legacy of folk medicine based on herbal remedies. Today, more than one fourth of all pharmaceutical sales are drugs derived from plant natural products. Our mission is to develop an interdisciplinary research in the Chemistry/Pharmacology of medicinal plants and to apply the advances in knowledge that emanate from these to develop novel plant based bio-actives for health and disease.

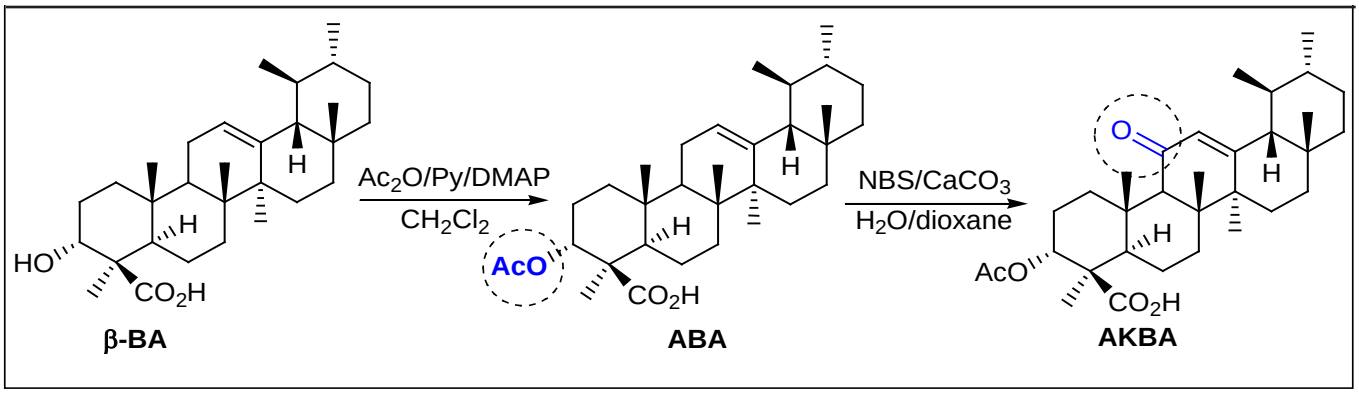
Frankincense is one of the most evocative expressions of Oman's vibrant heritage and culture. Dhofar region, which is situated in the southern part of Oman, is the world's leading source of frankincense. Since most of the Omani people are using frankincense for fumes generation, exploring the nature and composition of these fumes would provide a significant contribution to completing our knowledge of this traditional precious plant resin. We have discovered lead compounds viz., β-boswellic acid (BA), acetyl-β-boswellic acid (ABA), keto-β-boswellic acid (KBA), and acetyl-keto-β-boswellic acid (AKBA)from Omani frankincense resins (Figure 1) and test their biological activities both in vitro and in vivo.



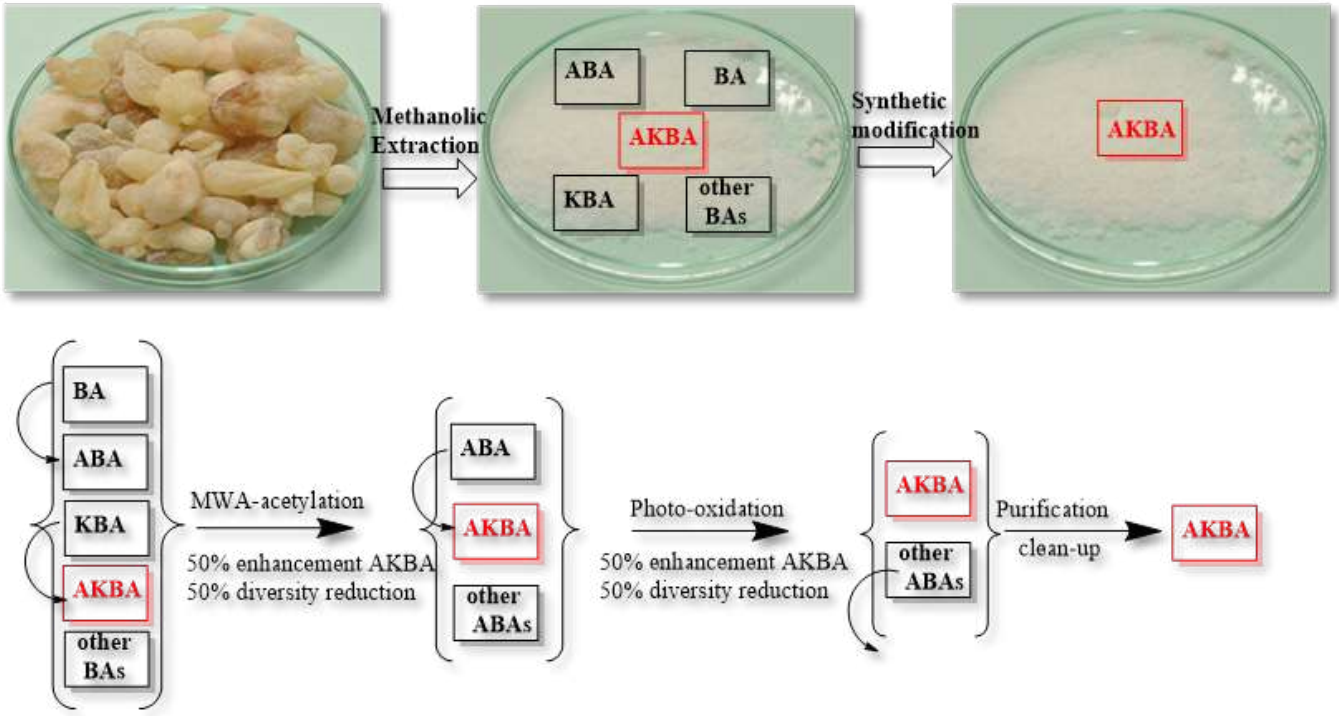
We are also interested in the microbiology and pharmacology as well as the molecular biology research. In this regard we are testing the activities of frankincense and other medicinal plants in various forms including as a crude extracts, as the distilled essential oils as well as the isolated pure compounds.

17.1.2. Enhancement of the Most Active Anti-Cancer Boswellic Acid (AKBA) in Boswellia sacra Extract

Boswellic acids are very fascinating compounds and there is an increasing demand for these substances for pharmaceutical and medicinal studies. Our laboratory has been very busy in isolating these compounds from the Omani frankincense (Boswellia sacra). Unfortunately, the concentration of the most active boswellic acid, 3-*O*-acetyl-11-oxo-β-boswellic acid AKBA (Figure 1), in extracts from Boswellia resins is in the range of 0.1-3% and it is therefore very difficult and time consuming to isolate large amounts of this compound. Here, we wish to follow a chemical modification strategy for the large-scale synthesis of AKBA (3) and the other boswellic acids. The big-scale synthesis of AKBA will allow further modifications thereby increasing the possibilities of better activities. Via two-steps approach, large-scale synthesis of AKBA and the other boswellic acids is achieved.



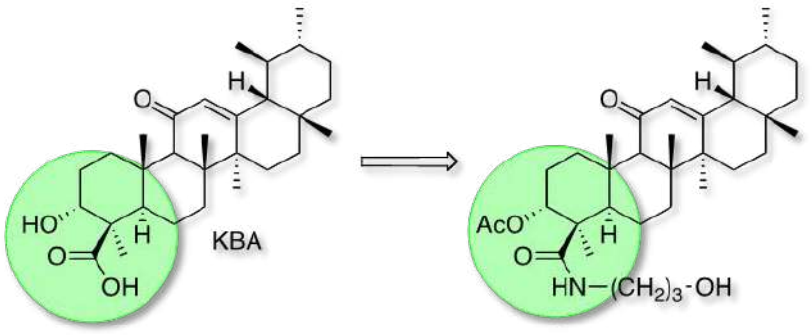
Using the above scheme, the percentage of AKBA will be raised from 3% to about 35%. The following focus approach illustrates this enhancement process.



Likewise, the β-boswellic acid (BA) can be enhanced applying similar policy, first by deacetylation followed by Wolf-Kishner reaction to convert the ketone moiety into methylene.

17.1.3. 11-Keto-boswellic acid derived amides and monodesmosidic saponins induce apoptosis in breast and cervical cancers cells

Beta-boswellic acids are considered the main bioactive components of frankincense. Their potential to act as cytotoxic agents, as well as that of their derivatives remained unexploited so far. In this study we were able to prepare derivatives of 11-keto-β-boswellic acid (KBA) that showed lower IC50 values as determined by a sulphorhodamine B (SRB) assay using several different human tumor cell lines. Monodesmosidic saponins of KBA are as cytotoxic as 3-acetyl-KBA. The presence of a free hydroxyl group at position C-3 seems to lower cytotoxicity while the presence of an amide function at C-24 improves cytotoxicity. The most active compound of this series gave IC_{50} values as low as 4.5 µM. Cell death proceeded mainly via apoptosis.



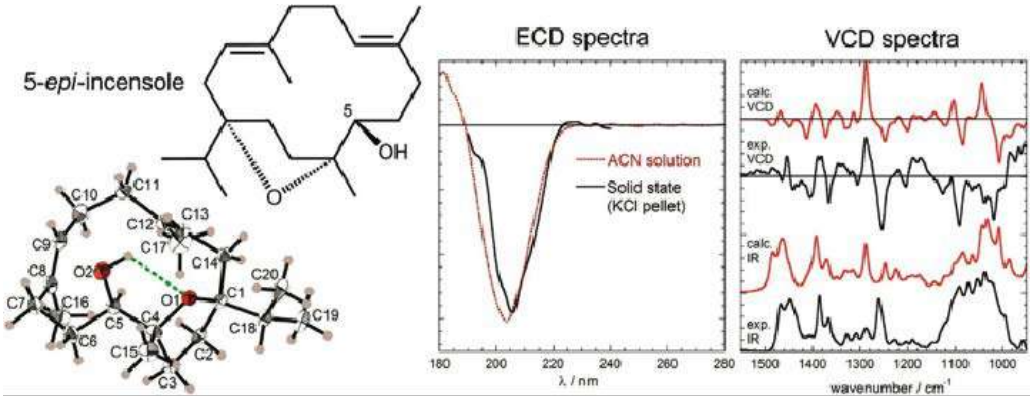
IC_{50} = 35.8 µM MCF-7
IC_{50} = 37.9 µM A2780

IC_{50} = 4.5 µM MCF-7
IC_{50} = 5.9 µM A2780

11-Keto-boswellic acid derived amide

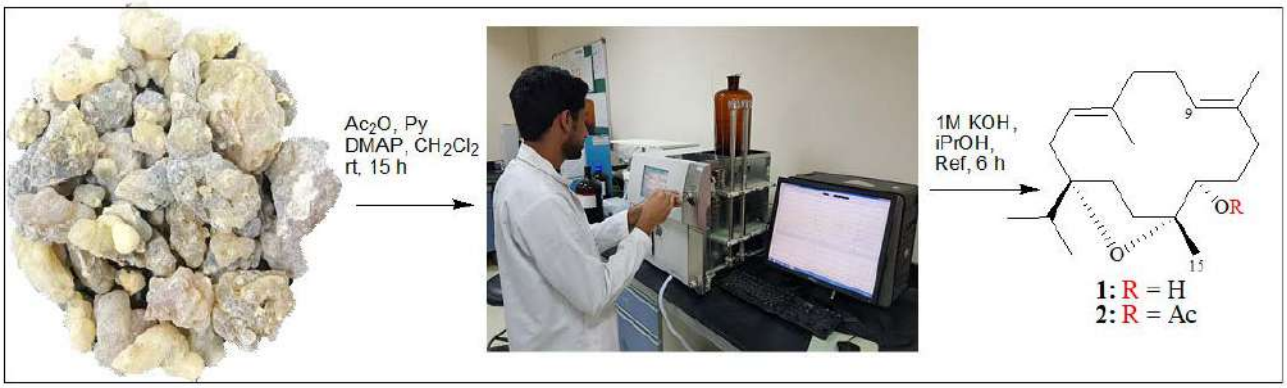
MCF-7... human breast adenocarcinoma
A2780... cis-platin resistant ovarian cancer

17.1.4. 5-epi-Incensole: synthesis, X-ray crystal structure and absolute configuration by means of ECD and VCD studies in solution and solid state:



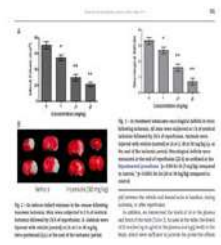
Incensole 1 and its acetate 2, found in incense, demonstrate interesting biological activities. Incensole acetate 2 was prepared on a large scale by employing the Paul and Jauch protocol from the crude extracts of *Boswellia papyrifera Hochst. 5-epi*-Incensole 3, obtained as colourless crystals, was prepared from Incensole acetate via three steps; deacetylation, oxidation and reduction. The structure of 5-epi-incensole 3 was elucidated by means of spectroscopic data analysis, and the absolute configuration was established by single crystal X-ray analysis in combination with electronic and vibrational circular dichroism. In particular, the applicability of the solid-state ECD/TDDFT protocol to a compound with only two non-conjugated alkene chromophores was verified.

17.1.5.Enhancement of the Most Active Antidepressant Compounds (incensole and incensole acetate) in Boswellia papyrifera Extract

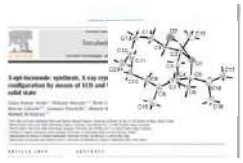


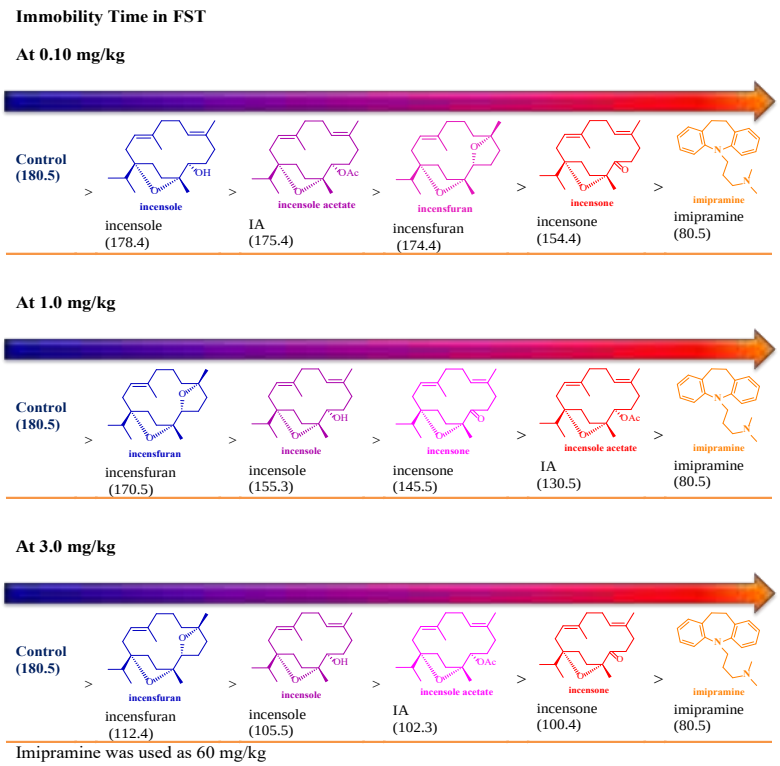
The crude MeOHextract of *B. papyrifera* (50 g) was dissolved in CH_2Cl_2 (100 mL) in a 500 mL three-necked flask followed by the addition of pyridine (36 mL), Ac_2O (40.8 mL) and DMAP (3 g). The reaction mixture was refluxed for 6 h, then allowed to cool and quenched with 1 M HCl (500 mL). The organic and aqueous phases were separated and the aqueous phase was extracted with Et_2O (100 mL). The combined organic phases were dried over Na_2SO_4, filtered, and the filtrate was evaporated under reduced pressure to yield yellowish oil that was subjected to column chromatography using EtOAc–*n*-hexane (2:98) as eluent; six sub-fractions F1–6 were obtained. Investigation demonstrated that F2 contained incensole acetate 2 in large quantities. Re-chromatography of this fraction using EtOAc–*n*-hexane (2:98) afforded the pure incensole acetate 2. A pure incensole acetate (2, 250 mg, 0.718 mmol), and 1M KOH (12 mL) in iPrOH (20 mL) was refluxed for 4 h. After cooling, the iPrOH was removed in vacuo, and the residue was acidified with 1 M HCl and extracted with EtOAc. The combined organic extracts were dried with Na_2SO_4, and the solvent was evaporated in vacuo to give a colorless oil of incensole (1).

Four compounds including incensole (1), incensole acetate (2) and their derivatives namely incensfuran (3) and incensone (4) showed significant antidepressant-like effects in forced swimming test (FST) and in tail suspension test (TST) (*P<0.05, **P<0.01). Furthermore, compounds 1-4 were evaluated for their anxiolytic potential using classical mouse model of anxiety involving elevated plus maze (EPM) and anticonvulsant effects in PTZ-induced seizure tests. These compounds also exhibited significant anticonvulsant effects in PTZ-induced seizures (*P<0.05, **P<0.01) at the dose level of 1 and 3 mg/kg. All four compounds have significantly elevated the brain GABA level indicating the involvement of GABAergic mechanism.



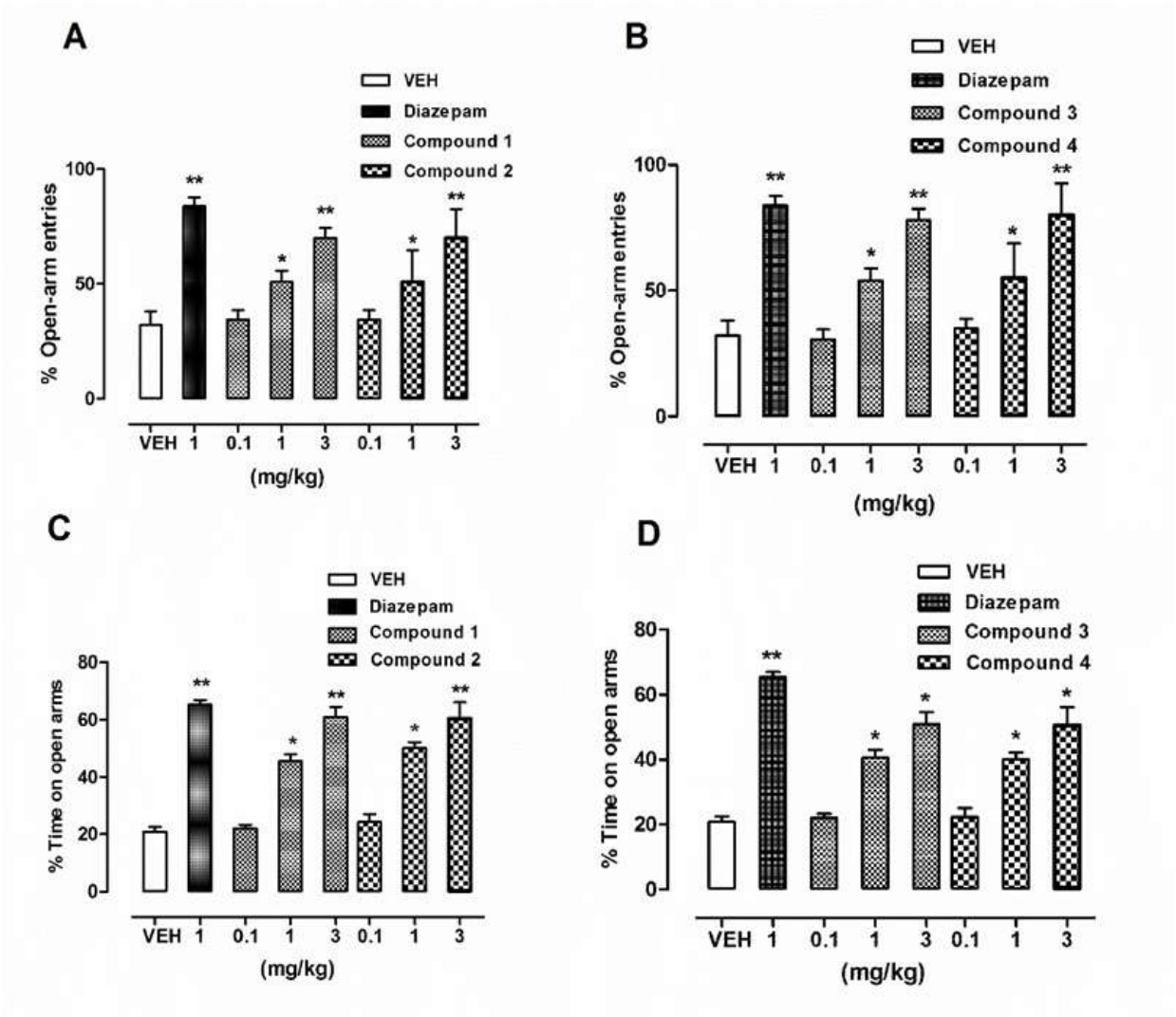
IA reduces infarct volumes in the mouse



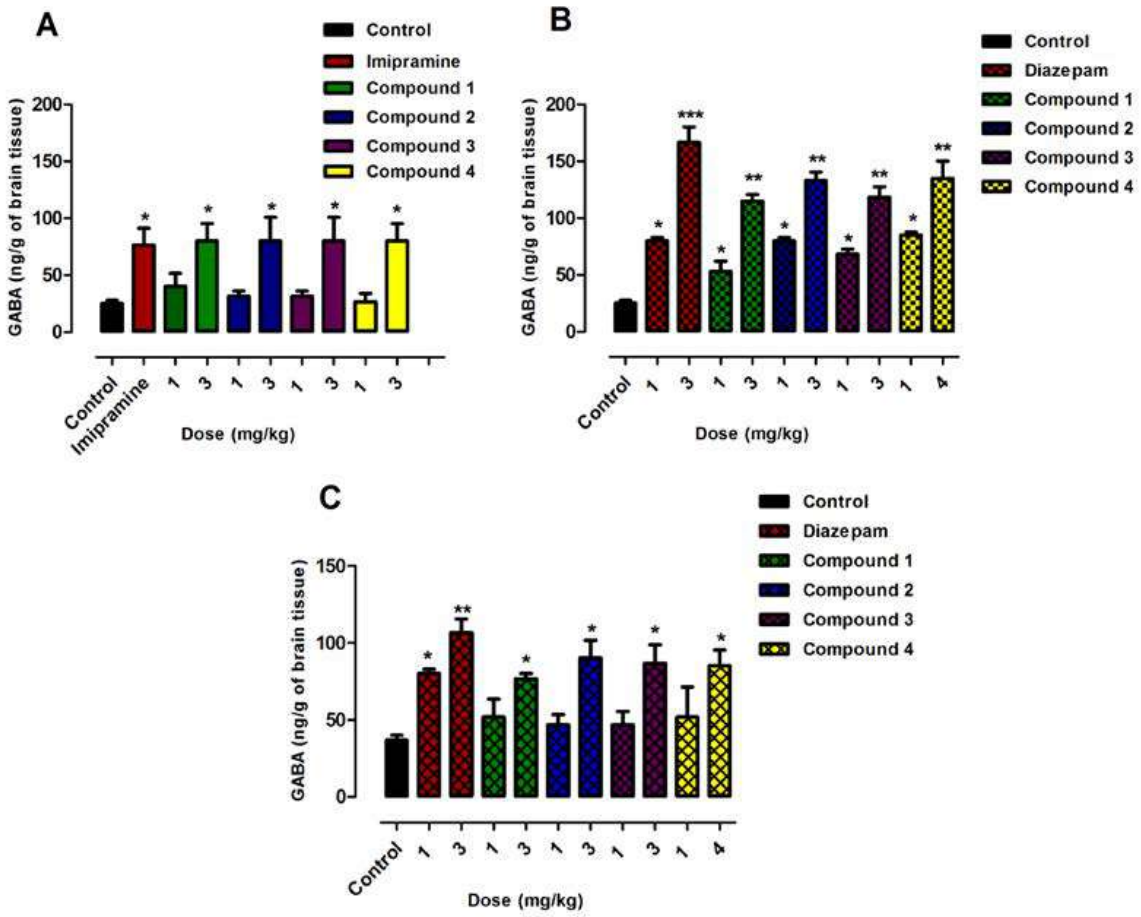


Imipramine was used as 60 mg/kg

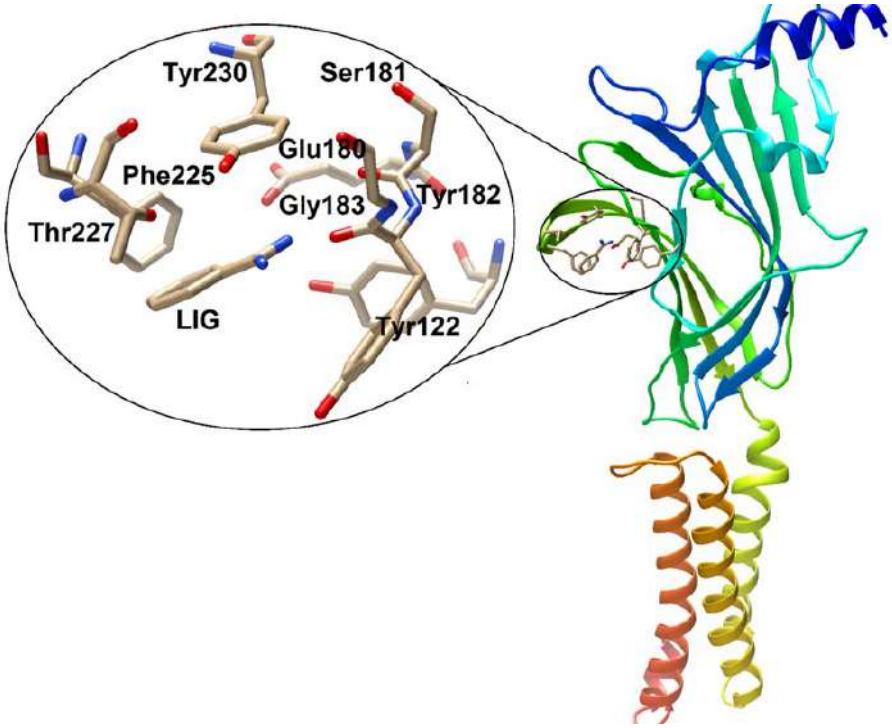
Imipramine (standard) was used as 60 mg/kg (Dose) for both tests. All values are expressed in mean ± SEM (n=6). *P < 0.05, **P < 0.01, ***P< 0.001 compared to the vehicle group. Difference between groups was analyzed using one- way analysis of variance (One- way ANOVA) followed by Dunnett's test.



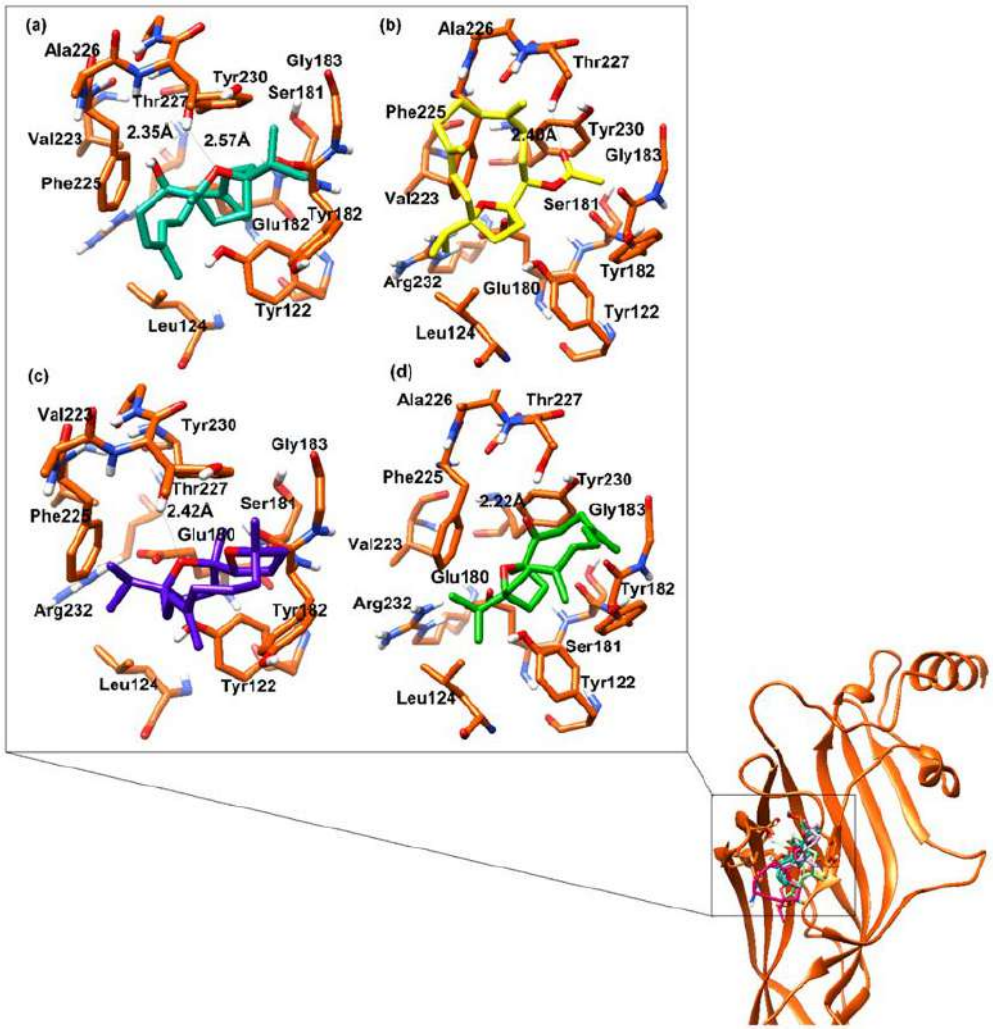
Effect of incensole derivatives and diazepam on the behavior of mice in the EPM (A) % open-arm entries (C) % time spent in open-arms registered over a session of 5 min, after 20 min of an i.p injection of 1 and 2 (0.1, 1 and 3mg/kg), diazepam (1 mg/kg) or vehicle (B) % open-arm entries (D) % time spent in open-arms registered over a session of 5 min, after 20 min of an i.p injection of 3 and 4 (0.1, 1 and 3mg/kg), diazepam (1 mg/kg) or vehicle. Column represent mean ± SEM (n=6/group). *: P<0.05, **: P<0.01, compared with vehicle group using One-way ANOVA followed by Dunnett's test.



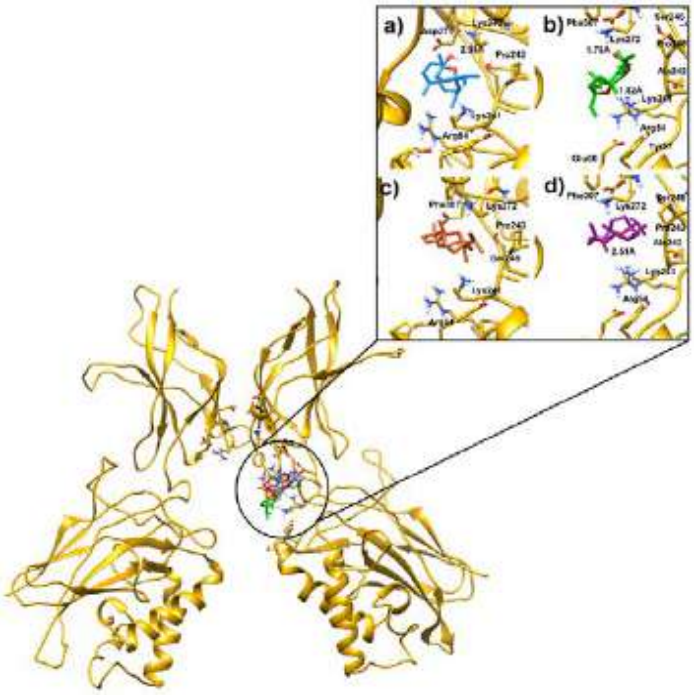
Estimation of brain GABA (ng/g of brain tissue) (A) after FST (B) after EPM (C) after PTZ-induced seizure test. * $p<0.05$, ** $p<0.01$, *** $p<0.001$. All data compared with control using one way ANOVA followed by Dennett's post hoc test.



The three dimensional structure of the model is shown here. The conformation of the bound agonist (LIG) shows the interacting residues (stick model) in circle.



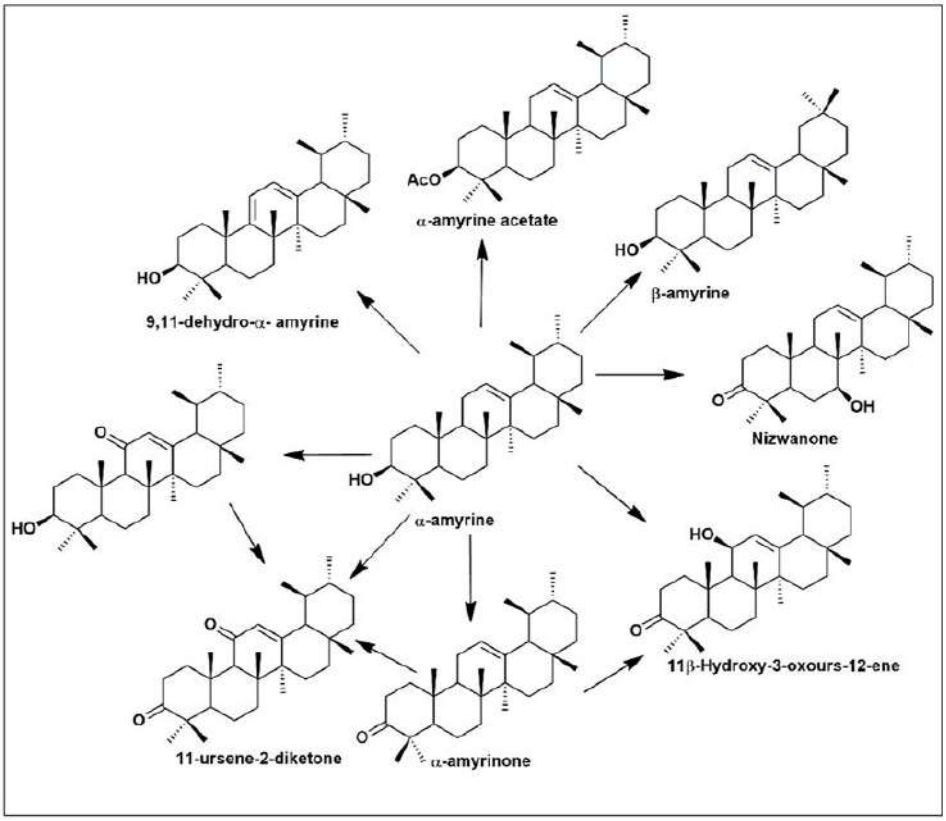
The docked view of compounds 1 (a), 2(b), 3(c) and 4(d) are shown at the ligand binding site of mouse $GABA_A$ receptor. The interacting residues are shown in orange sticks while H-bonds are shown in green line, with labeled distances.

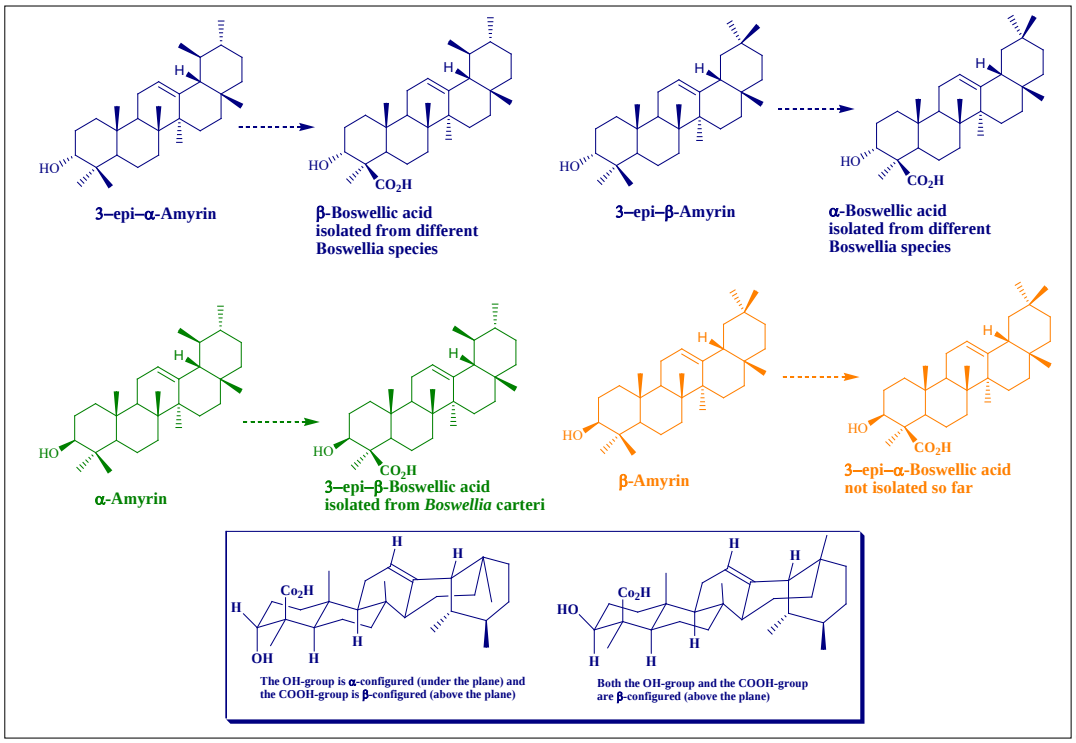


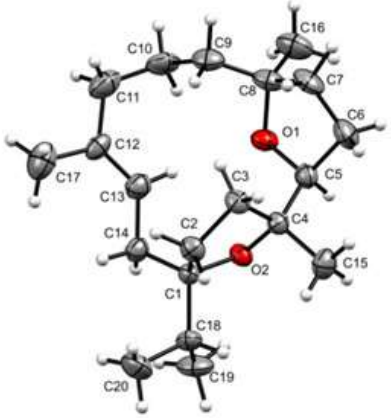
The NF-κB in complex with the ligands (a) compound 1, (b) 2, (c) 3 and (d) 4. The ligands atom are depicted in stick model, while protein is shown in golden ribbon. The H-bonds are shown in green lines with their bond length.

17.1.6. Chemical, molecular and structural studies of Boswellia sacra: Isolation of β-Boswellic Aldehyde and 3-epi-11β-Dihydroxy BA as precursors to support the enzymatically driven biosynthetic pathway of boswellic acids

Despite the numerous reports on the chemistry and biological activities of boswellic acids (BAs), the literature on their chemical diversity and biosynthesis is scarce. The current study aim to elucidate the BAs biosynthetic pathway and its distribution in the resin of *Boswellia sacra* and *Boswellia papyrifera*. The detailed chromatographic and spectroscopic techniques helped in the isolation and structural elucidation of two new precursors namely β-boswellic aldehyde and 3β, 11β-dihydroxyBA from the resins of *B. sacra* and *B. papyrifera* respectively along with α-amyrin. Furthermore, the quantification and distribution of amyrins (3-epi α-amyrin, β-amyrin and α-amyrin) and BAs in the resin from different *Boswellia* species showed highest amyrin and BAs in resin of B. *sacra* as compared to *B. serrata* and *B. papyrifera*. The occurrence of BAs significantly varied in resin of B. sacra growing in mountainous dry areas than coastal areas. In *B. sacra* tree parts, a high content of α-amyrin in roots which lacked β-amyrin and BAs. The leaf part showed traces of β-ABA and β-AKBA but deficient in amyrin. This was further confirmed by the lack of transcript accumulation of amyrin-related biosynthesis gene using RT-PCR analysis of leaf. In Contrary, stem showed the presence of all six BAs which has been attributed to the presence of resin secretory canals and sacs in the hypodermal regions. Thus, the boswellic acids can be considered a genus-specific biomarker for Boswellia species albeit the variation of the amounts among different *Boswellia* species and grades.

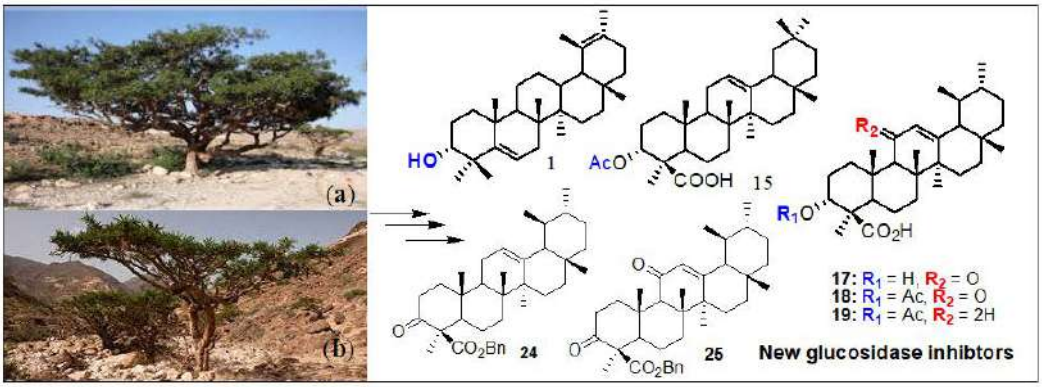






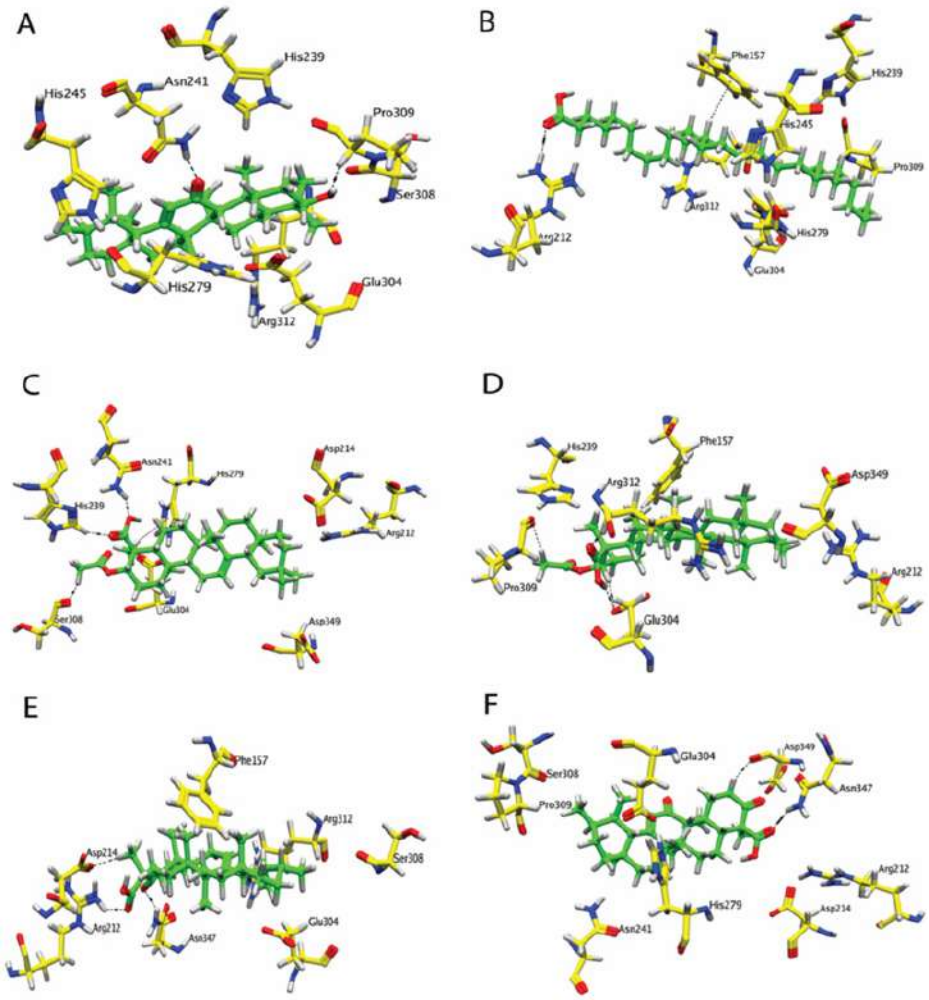
A new cembrane diterpenes named incensfuran (3), biogenetically derived from incensole, was isolated from crude extracts of the *Boswellia papyrifera* Hochst. The compound 3 was elucidated by 1D and 2D NMR studies, and its absolute configuration was determined by single crystal X-ray diffraction analysis and electronic and vibrational circular dichroism spectroscopy (ECD, VCD).

17.1.7. New α-glucosidase inhibitors from Boswellia sacra and Boswellia papyrifera.



a) *Boswellia sacra*; b) *Boswellia papyrifera*

Phytochemical investigation of the oleo-gum resins from *Boswellia papyrifera* afforded one new triterpene, named 3α-hydroxyurs-5:19-diene (1) together with twelve compounds including eight triterpenoids (2-9), two diterpenoids (10 and 11) and two straight chain alkanes (12 and 13). Similarly ten compounds were isolated from the resin of *Boswellia sacra* including one triterpene (20) and nine boswellic acids (14-19 and 21-23). The complete NMR assignment of 2 is reported, to our knowledge, for the first time as a natural product while compounds 3–11 are known but reported for the first time from the resin of *B. papyrifera*. The structure elucidation was done by advance spectroscopic ^{1}D and ^{2}D NMR techniques viz., ^{1}H, ^{13}C, DEPT, HSQC, HMBC, and COSY, and NEOSY, ESI-MS and compared with the reported literature. All compounds were evaluated for their α-glucosidase inhibitory activity and as result eight of them 1, 3, 10, 11, 15, and 17–19 were found significantly active against α-glucosidase with an IC_{50} value ranging from 15.0 ± 0.84 to 80.3 ± 2.33 µM while 21 exhibited moderate activity with IC_{50} of 799.9 ± 4.98 µM. Furthermore, two compounds 24 and 25 were synthesised from 16 and 17 to see the effect of carboxyl group in structural-activity relationship (SAR) study. Compounds 24 and 25 retained good α-glucosidase inhibition as compared to 16 and 17, indicating that carboxylic group play a key role in SAR. In addition, the aforementioned activity of all the active compounds is reported, to the best of our knowledge, for the first time.



Molecular interactions of compound 3 (A), 10 (B), (C) 15 (C), 19 (D), 24 (E) and 25 (F). The ligand is shown in Green stick (Molecular color).

17.1.8. Pyrolysis of Frankincense resin

One of the challenging research topics is the investigation of the pyrolysate of frankincense resin. We have developed a technique in which the incense is captured and was turned into an analyzable material. After extraction and purification we are studying the chemical constituents of the smoke. This shall also enable us to study the mechanisms associated with possible thermal rearrangements.

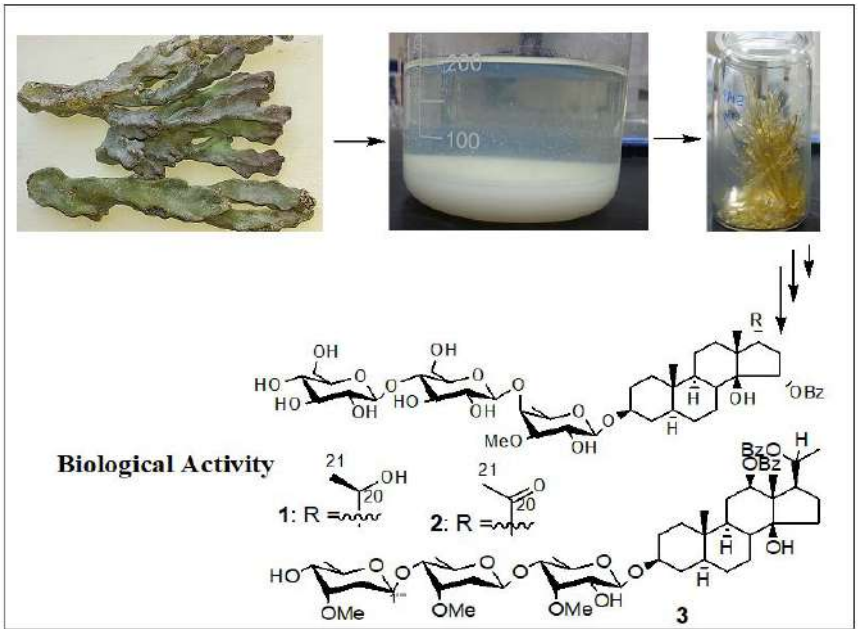
17.1.9. Discovery of Lead Compounds from Terrestrial Resources of Sultanate of Oman

Despite the major efforts by the pharmaceutical companies in the design of synthetic chemicals for the drug discovery, the terrestrial natural products are still considered as major source of unique chemical structures which provide the basis for molecular modeling and chemical synthesis in search for new drugs. The Sultanate of Oman host one of the richest biodiversity, with a number of species endemic to the country and the region. The north and central parts of the country share species with that of Iran and Pakistan, while those at the southern parts are of African affinities.

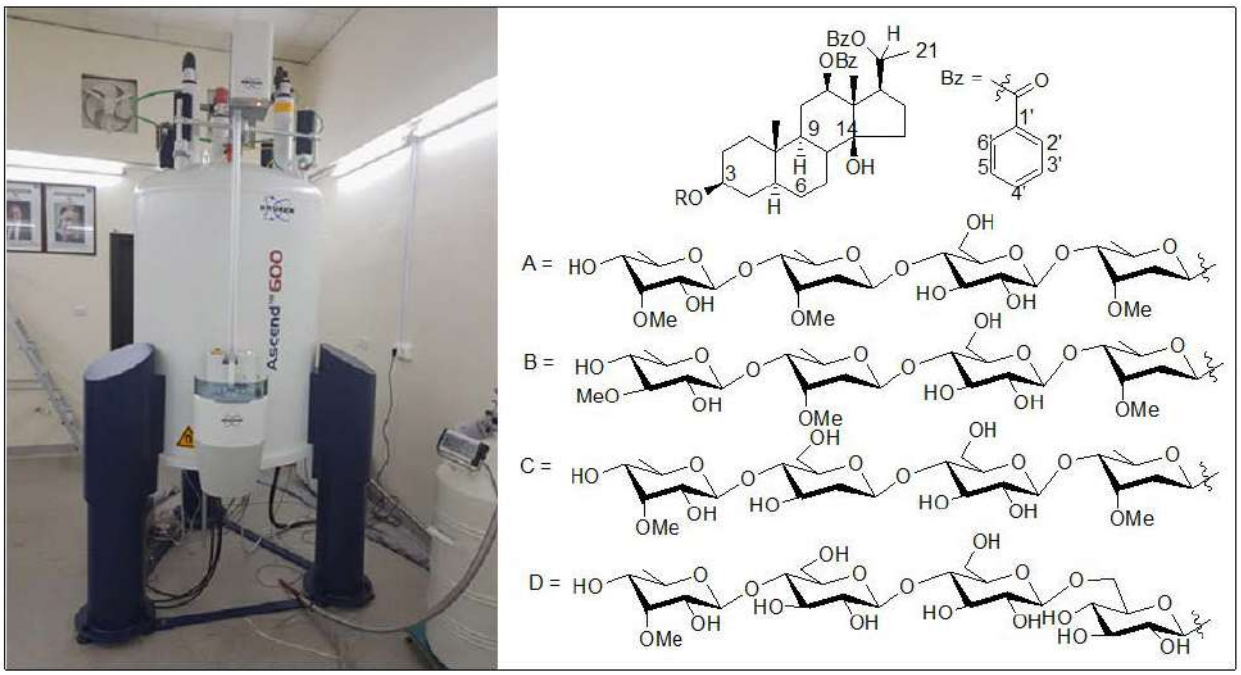
Natural products, the secondary or non-primary metabolites produced by living organisms, have been exploited by people for a variety of purposes including use as food, fragrances, pigments, insecticides, and medicines. Historically, plants have served as the major source of medicinally useful natural products, developed from a legacy of folk medicine based on herbal remedies. Today, more than one fourth of all pharmaceutical sales are drugs derived from plant natural products.

Our mission is to develop an interdisciplinary research in the Chemistry/Pharmacology of medicinal plants and to apply the advances in knowledge that emanate from these to develop novel plant based bio-actives for health and disease.

17.1.10. Desmiflavasides A and B: Two new bioactive pregnane glycosides from the sap of Desmidorchis flava

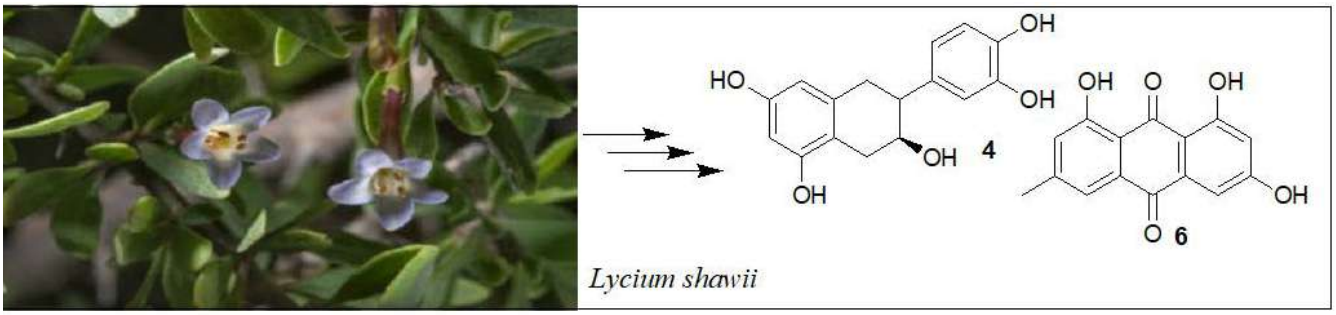


Three new pregnane glycosides named desmiflavasides A (1), B (2) and nizwaside (3) were isolated from the sap of *Desmidorchis flava* and have had their structures confirmed from 1D and 2D NMR spectroscopic techniques and mass spectrometry (ESIMS). Further, the effects of desmiflavasides C (1) and D (2) on the proliferation of breast and ovarian cancer cells as well as normal breast epithelial cells in culture were examined. Interestingly, desmiflavasides C (1) and D (2) were able to cause a substantial decline in the viability of cancer cells in a concentration-dependent manner. Moreover, treatment of normal cells with compound 2 resulted in no significant growth inhibition, indicating that its cytotoxicity was selective towards cancer cells.

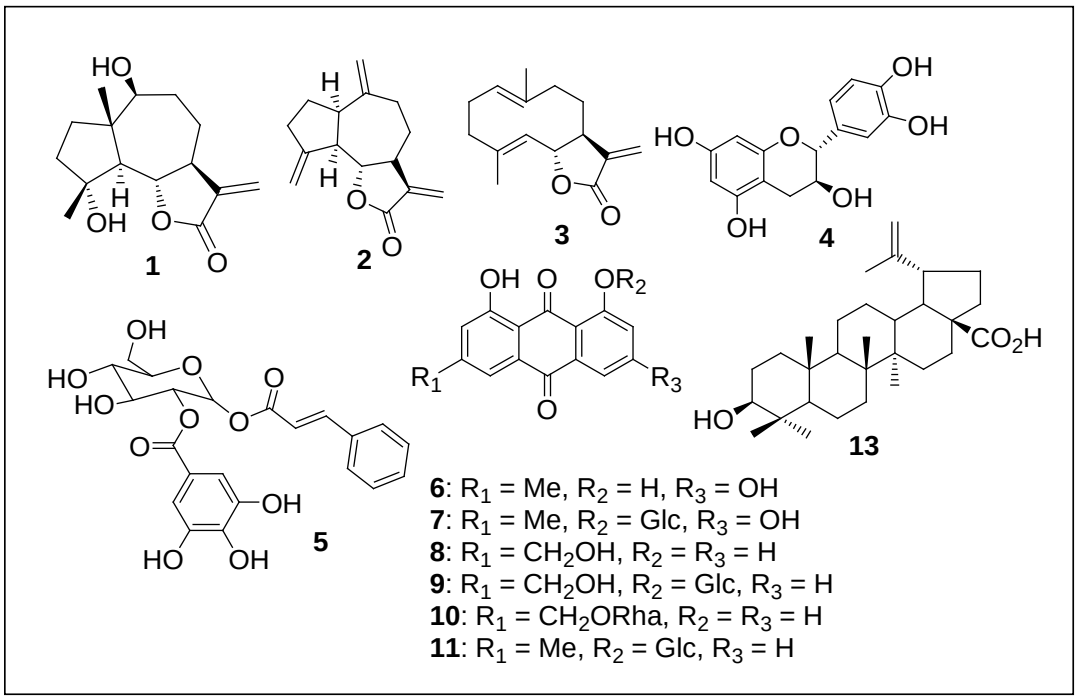


Four new pregnane glycosides named desflavasides A-D (1–4) were isolated from the sap of *Desmidorchis flava*. The structures of all new compounds were elucidated based on 1D and 2D NMR spectroscopic techniques coupled with mass spectrometry (ESIMS and HRESIMS).

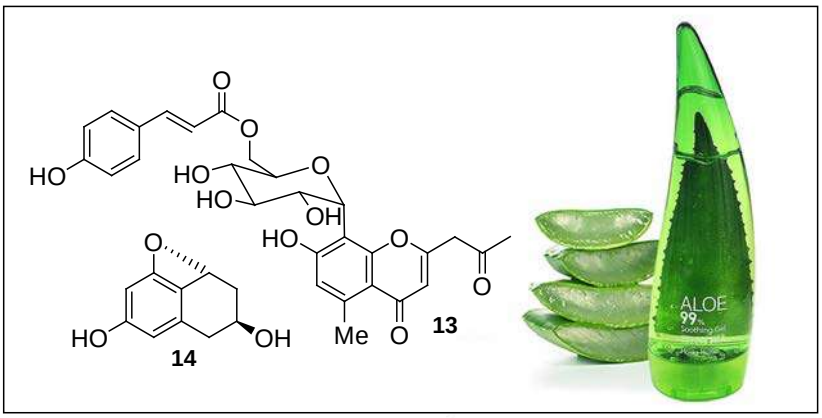
17.1.11. Bioactive chemical constituents isolated from Lycium shawii



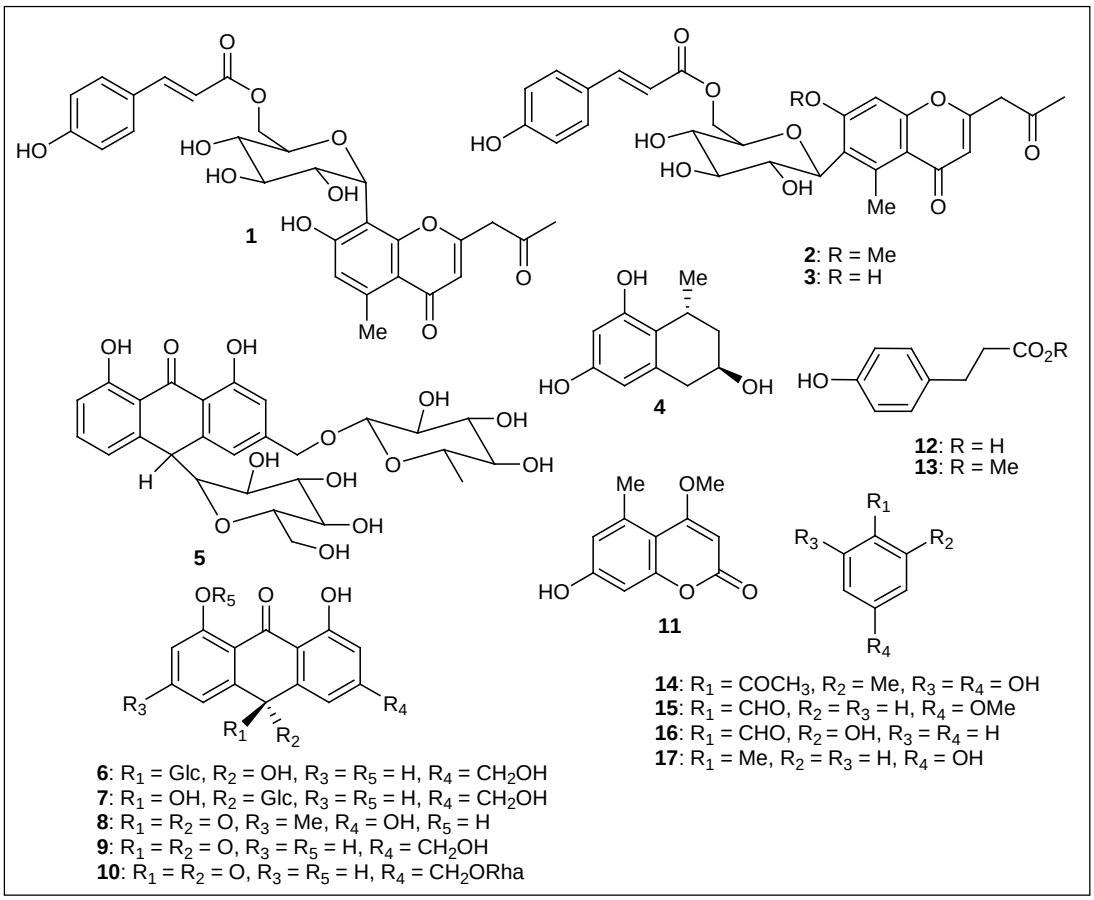
Phytochemical investigation of *Lycium shawii Roem*. & Schult provided fourteen compounds, including lyciumate (1), dehydro costuslacton (2), costunolide (3), catechin (4), lyciumaside (5), emodin (6), emodin-8-O-β-D-glucoside (7), aloe-emodin (8), aloe-emodin-8-O-β-D-glucoside (9), aloe emodin-11-O-rhamnoside (10), chrysophanol-8-O-β-D-glucoside (11),nonacosane-10-ol, betulinic acid(13)and β-sitosterol glucopyranoside (14). All structural assignments were made by comparing the NMR spectral data of the pure isolates with that published in the quoted literature. Among the isolated compounds from L. shawii, 4 showed highest α-glucosidase (81%) and antioxidant (78%) activities followed by 6 (71%). Compound 9 was found to be the most effective anti-proliferative constituent in inhibiting the growth of breast cancer cells (MDA-MB-231). Preliminary evaluations demonstrated lyciumaside (1) possesses strong antioxidant activity with an IC50 = 30 lg/ml (80% inhibition) while it was inactive in a-glucosidase and urease enzymes assays.



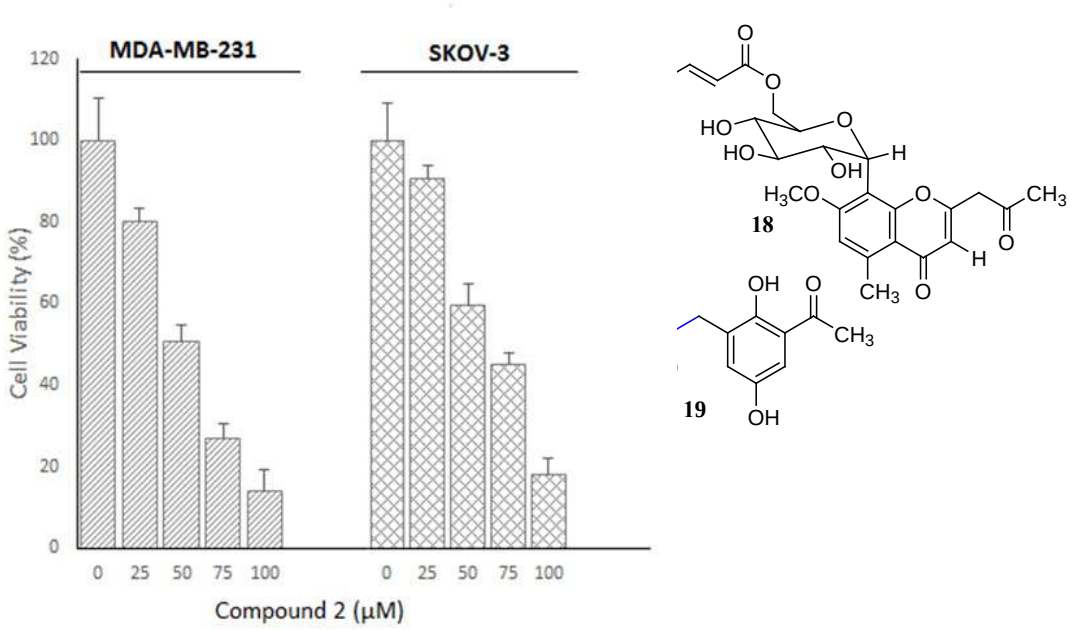
17.1.12. Bioactive constituents from Aloe vera resin



Chromatographic separation of *Aloe vera* resin resulted in the isolation of seventeen compounds 1–17 and were identified as 6′-O-coumaroylaloesin (1), aloeveraside A (2) and aloeveraside B (3), feroxidin (4), aloinoside B (5), 10-hydroxyaloins A (6) and B (7), emodin (8), aloe-emodin (9), aloe-emodin-11-O-rhamnoside (10), 7-demethylsiderin (11) (16), 3-(4-hydroxyphenyl)propanoic acid (12), methyl 3-(4-hydroxyphenyl)propionate (13), 1-(2,4-dihydroxy-6-methylphenyl)ethanone (14), p-anisaldehyde (15), salicylaldehyde (16), *p-cresol* (17), respectively, by advance NMR techniques and published findings. The compound 14 exhibited promising antioxidant (80%) activity followed by 13 (73%). Aloeveraside A (2) and B (3) displayed good urease enzyme inhibition activities (62 and 55%, resp.), as well as antioxidant activity in which aloeveraside A (2) had a value of 60% inhibition, while aloeveraside B (3) demonstrated a more potent antioxidant activity with 80% inhibition.

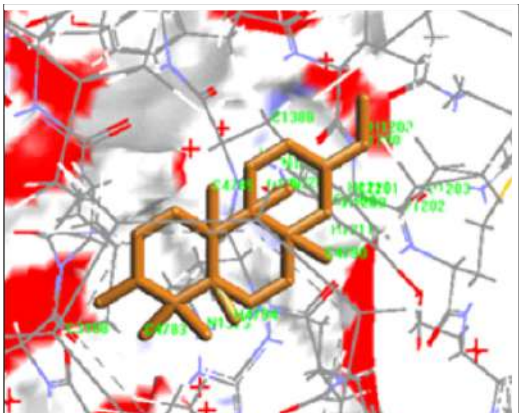


Bioassay-guided fractionation of *Aloe vera* (L.) Burm.f. resulted in the isolation and characterization of one new *C*-glucosyl chromone, 7-methoxy-6′-*O*-coumaroylaloesin (18), along with the known dihydroisocoumarin feralolide (19). The structure of 1 was elucidated on the basis of 1D, 2D-NMR, and mass spectrometry. Both compounds 1 and 2 were tested for their effects on the growth of cancer cells in culture and it was observed that unlike compound 18, compound 19 displayed concentration-dependent antiproliferative effects on breast cancer cells (MDA-MB-231) and ovarian cancer cells (SKOV-3). Additionally, only feralolide (19) demonstrated good urease, weak α-glucosidase enzyme inhibition, and weak antioxidant effects.



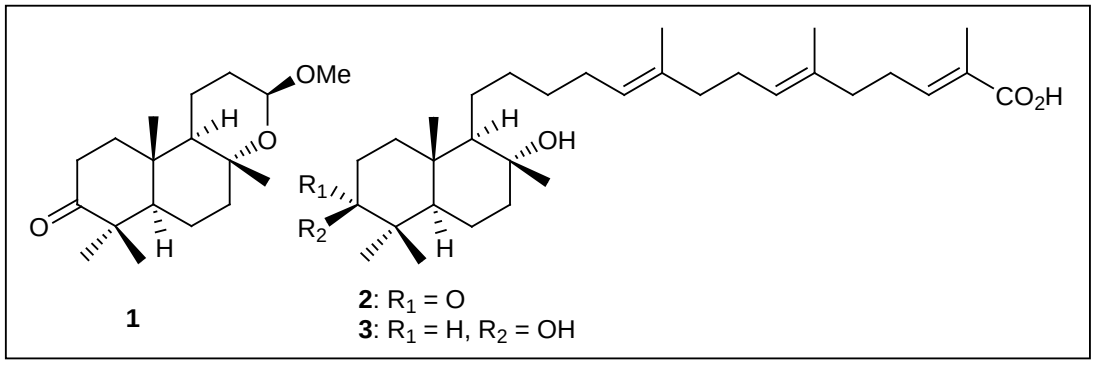
Cells from MDA-MB-231 and SKOV-3 cancer cell lines were incubated with indicated concentrations of Compound 2 for 24 hours. The effect on cell proliferation was evaluated by performing MTT assay as described in ‘Methods’. All results are expressed as percentage of control ± S.D.

17.1.13. A norterpenoid and tripenoids from Commiphora mukul: isolation and biological activity

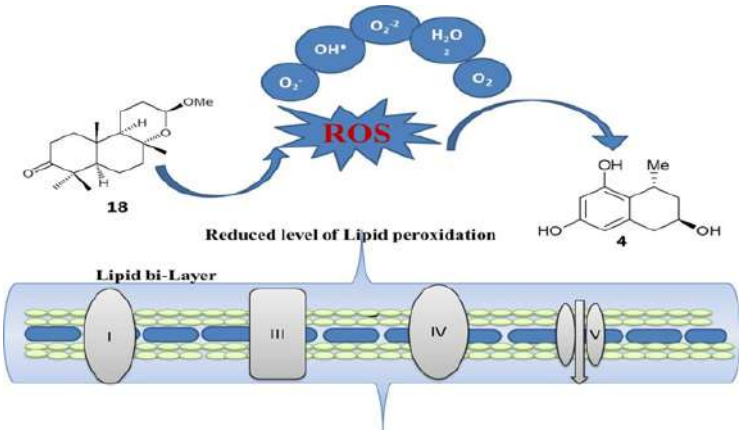


Bio-guided fractionation of the guggul gum resin of *Commiphora mukul* HOOK using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide assay for the breast cancer cell line MDA-MB-231 led to the isolation of a new C17 norditerpene named myrrhanone C (1) along with two known polypodane-type triterpenes, namely, myrrhanone B (2) and myrrhanol B (3). The structures of the isolated compounds were elucidated by means of 1D (1H and ^{13}C) and 2D (correlation spectroscopy, heteronuclear single-quantum coherence, heteronuclear multiple-bond correlation, and nuclear Overhauser effect spectroscopy) NMR spectroscopy as well as mass (electrospray ionization- mass spectroscopy) spectral analyses. Interestingly myrrhanone C (1) was able to induce a substantial decline in cell proliferation. It reduced the viability of cancer cells

by almost 81% and 87% at concentrations of 50 and 100 (g /mL), respectively. Myrrhanone B (2) and myrrhanol B (3) showed a concentration-dependent growth inhibitory effect on cancer cells, with the latter being slightly more cytotoxic than the former at both the concentrations tested. Furthermore, myrrhanone C (1) and myrrhanone B (2) showed good α-glucosidase and urease inhibition.

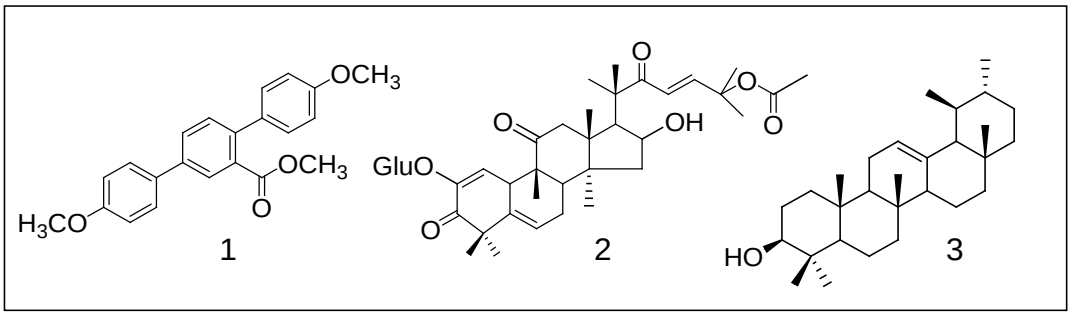


17.1.14. Metabolites from resins of Aloe vera and Cammiphora mukul mitigatelipid peroxidation



The bio-guided isolation of bioactive fractions from both resins afforded 20 pure chemical constituents (seventeen from *A. vera* and three from *C. mukul*). These compounds belonged to anthraquinones, anthraquinones glycosides, quinones, chomarins, polypodane type terpenoids, and benzene derivatives. Major chemical constituents were from quinones and terpenoids classes from the resins of *A. vera* and *C. mukul*. Feroxidin (4, from *A. vera*) showed higher inhibition (IC_{50} = 201.7 ± 0.94 µgmL-^{1}) followed by myrrhanone C (18, from *C. mukul*; IC_{50} = 210.7 ± 0.01 µgmL-^{1}) and methyl 3-(4-hydroxyphenyl) propionate (13, IC_{50} = 232.9 ± 0.21 µgmL-^{1}) as compared to the other compounds. Structure–activity relationship showed that the existence of hydroxyl, methoxy and ether groups might play a major role in countering the oxidative stress. The anti-LPO activity, up to the best of our knowledge, of 2, 3 and 18 are reported for the first time. Such chemical constituents with high anti-lipid peroxidation activity could be essentially helpful in synthesizing candidate drugs.

17.1.15. New p-Terphenyl from the Fruit of Citrullus colocynthis (Cucurbitaceae)



One new p-terphenyl derivative (1) has been isolated along with the known metabolites; cucurbitacin E 2-O-β-D-glucoside (2) and α-amyrin (3) from ethyl acetate and dichloromethane fractions of fruit extract of *Citrullus colocynthis*. The structure of the new metabolite was elucidated by combined analysis of 1D (1H and 13C) and 2D (HSQC and HMBC correlations) NMR and MS spectral data. The known metabolites were characterized by comparison of the spectral data with those reported in literature.

17.1.16. Antimicrobial, Antioxidant, Anticancer, and Enzyme Inhibitory Activities of Saponins and other Polar Secondary Metabolites from the Polar/Aqueous Extract of the Endemic and Near Endemic Omani Medicinal Plants Aloe dhufarensis, Zygocarpum dhofarense and Euphorbia smithii for the Development of Lead Compounds

The Sultanate of Oman is bestowed by a rich diversity of medicinal plants; a great number of which is endemic (Aloe dhufarensis) and near to endemic (Zygocarpum dhofarense and Euphorbia smithii; found in Oman, Yemen) to Oman or Arabia but a very limited research work has been carried out in the field of natural product chemistry with the direction towards the phytochemical analysis to isolate secondary metabolites, especially of the high polar nature.Thus the focus of our work is on the isolation, characterization, and spectroscopic identification of the high polar chemical constituents along with various biological activities of targeted isolated compounds.

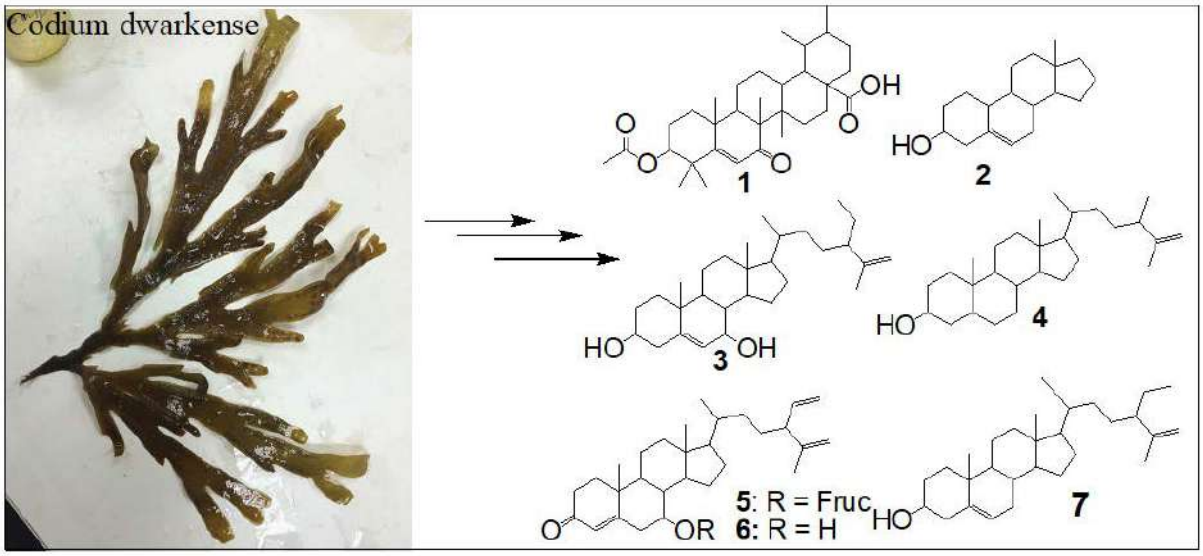
17.1.17. Discovery of Lead Compounds from Marine Resources of Sultanate of Oman

Being an exceptional reservoir of a diverse array of bioactive natural products, the marine environment provides novel leads against fungal, parasitic, bacterial, and viral diseases. The unique structural features of these natural products are not found in terrestrial plants. With rare exceptions, marine organisms from the deep-sea floor, mid-water habitats, and high-latitude marine environments have still not been studied. Especially, the Omani marine resources have not yet been explored, except a few reports regarding the maintenance and the preservation of the marine environment. Therefore, the potential for discovery of

novel bio- products (with applications in medicine, industry, and agriculture) from yet-to-be discovered species of marine macro- and micro-organisms, especially from Omani Waters is very high.

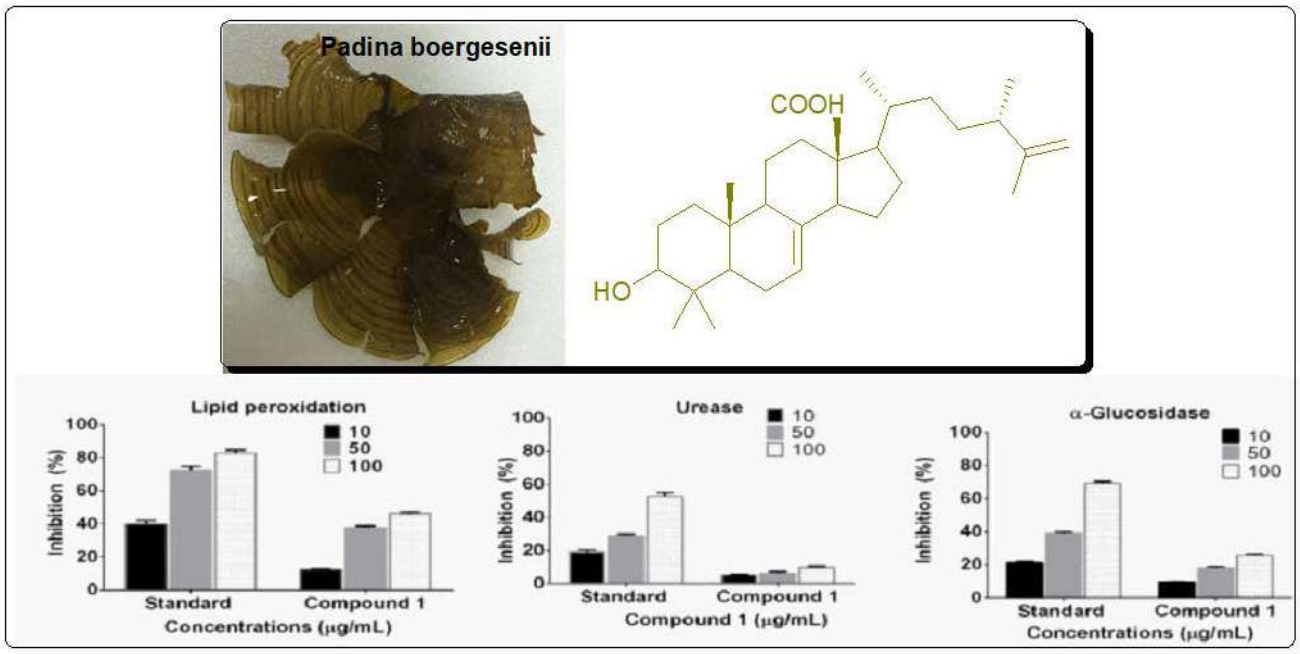
Our research group is involved in the isolation, structure assignment using NMR and synthesis of marine natural products with activity against cancer, malaria, tuberculosis and neurological disorders etc. Metabolites are isolated from a variety of sources including marine invertebrates, algae (especially the seaweeds), bacteria and dinoflagellates. NMR structure assignments are made utilizing two dimensional methods to assign gross, relative and absolute configuration. Some of the classes of marine natural products characterized can be generated effectively utilizing total synthesis however for many classes a combination of biosynthesis and chemical synthesis are essential to generate a product cost-effectively.

17.1.18. New α-Glucosidase Inhibitory Triterpenic Acid from Marine Macro Green Alga Codium dwarkense Boergs.



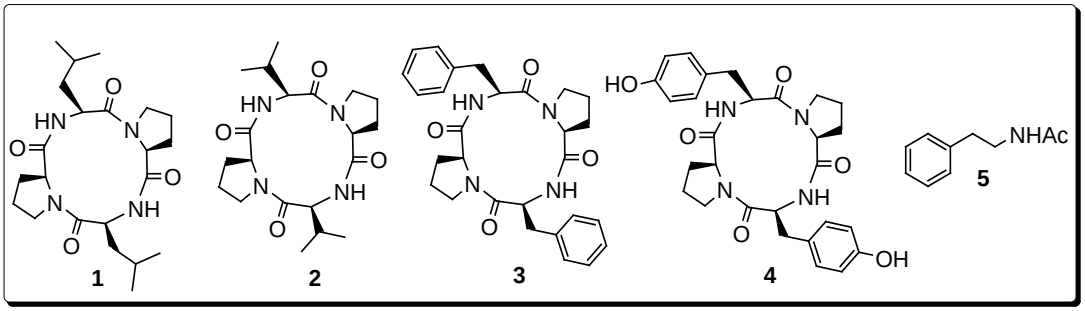
The marine ecosystem has been a key resource for secondary metabolites with promising biological roles. In the current study, bioassay-guided phytochemical investigations were carried out to assess the presence of enzyme inhibitory chemical constituents from the methanolic extract of marine green alga—*Codium dwarkense*. The bioactive fractions were further subjected to chromatographic separations, which resulted in the isolation of a new triterpenic acid; dwarkenoic acid (1) and the known sterols; androst-5-en-3β-ol (2), stigmasta-5,25-dien-3β,7α-diol (3), ergosta-5,25-dien-3β-ol (4), 7-hydroxystigmasta 4,25-dien-3-one-7-O-β-D-fucopyranoside (5), 7-hydroxystigmasta-4,25-dien-3-one (6), and stigmasta-5,25-dien-3β-ol (7). The structure elucidation of the new compound was carried out by combined mass spectrometry and 1D (1H and 13C) and 2D (HSQC, HMBC, COSY, and NOESY) NMR spectroscopic data. The sub-fractions and pure constituents were assayed for enzymatic inhibition of alpha-glucosidase. Compound 1 showed significant inhibition at all concentrations. Compounds 2, 3, 5, and 7 exhibited a dose-dependent response, whereas compounds 4–6 showed moderate inhibition. Utilizing such marine-derived biological resources could lead to drug discoveries.

17.1.19. New Enzyme-Inhibitory Triterpenoid from Marine Macro Brown Alga Padina boergesenii Allender & Kraft



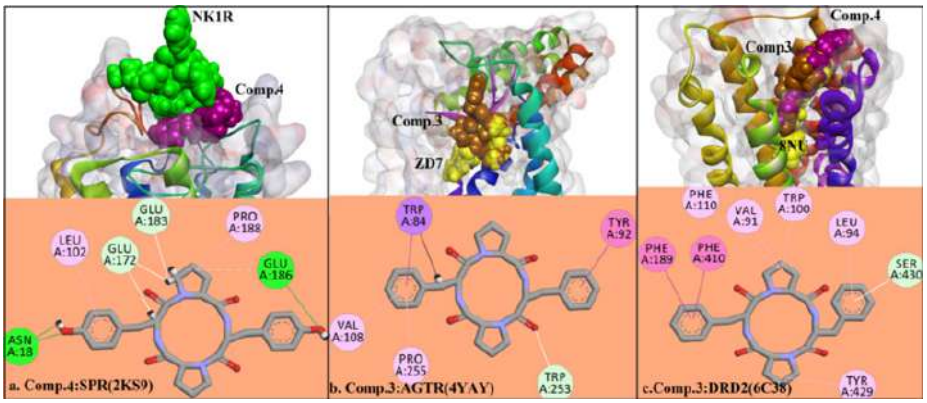
In continuation to our study of the chemical and biological potential of the secondary metabolites isolated from Omani seaweeds, we investigated a marine brown alga, Padina boergesenii. The phytochemical investigation resulted in the isolation of a new secondary metabolite, padinolic acid (1), along with some other semi-pure fractions and sub-fractions. The planar structure was confirmed through MS and NMR (1D and 2D) spectral data. The NOESY experiments coupled with the biogenetic consideration were helpful in assigning the stereochemistry in the molecule.Compound 1 was subjected to enzyme inhibition studies using urease, lipid peroxidase, and alpha-glucosidase enzymes. Compound 1 showed low to moderate glucosidase and urease enzyme inhibition, respectively, and moderate anti-lipid peroxidation activities. The current study indicates the potential of this seaweed and provides the basis for further investigation.

17.1.20. Anti-proliferative potential of cyclotetrapeptides from Bacillus velezensis sp. RA5401 and their molecular docking on G-Protein-Coupled Receptors



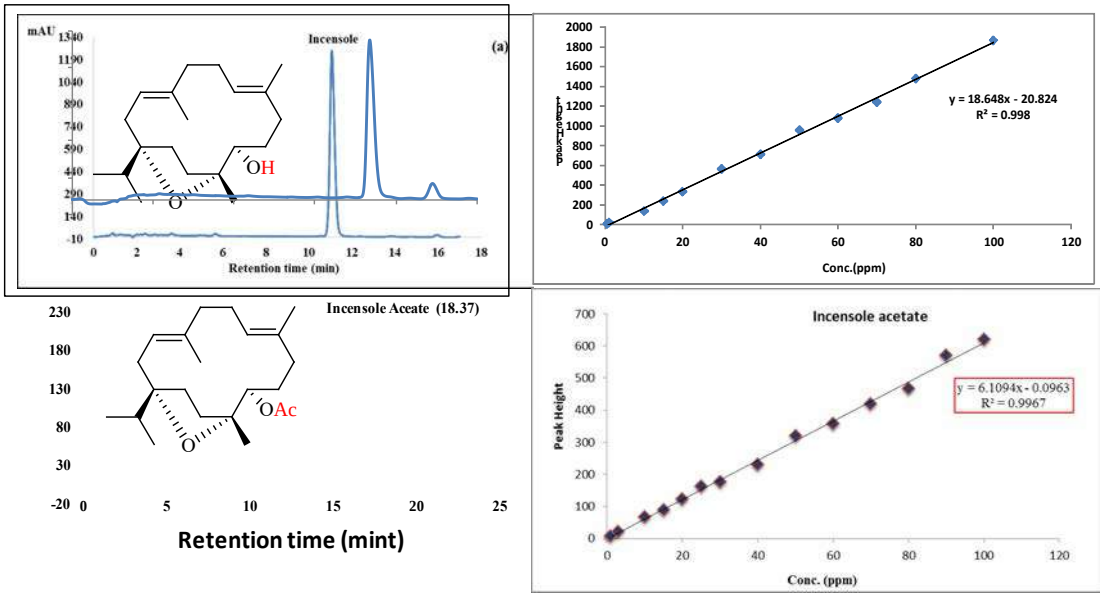
Four cyclopeptides along with one phenyl amide have been isolated from the ethyl acetate extract of *Bacillus velezensis* sp. RA5401. Their structures were determined and characterized as cycle (L-prolyl-L-leucyl)$_2$(1), cyclo (L-prolyl-L-valine)$_2$(2),cycle (L- phenylanalyl-L-propyl)$_2$(3), cyclo (D-pro-L-tyr-L-pro-L-tyr)$_2$ (4) and N-(2-phenylethyl)acetamide (5) on the basis of their electron spray ionization mass

spectrometry (ESI-MS), nuclear magnetic resonance (NMR) techniques and comparison with the literature data. It was found that 1 and 2 induced concentration-independent anti-proliferative effects, while 3, 4 and 5 inhibited cancer cell proliferation in a concentration-dependent manner



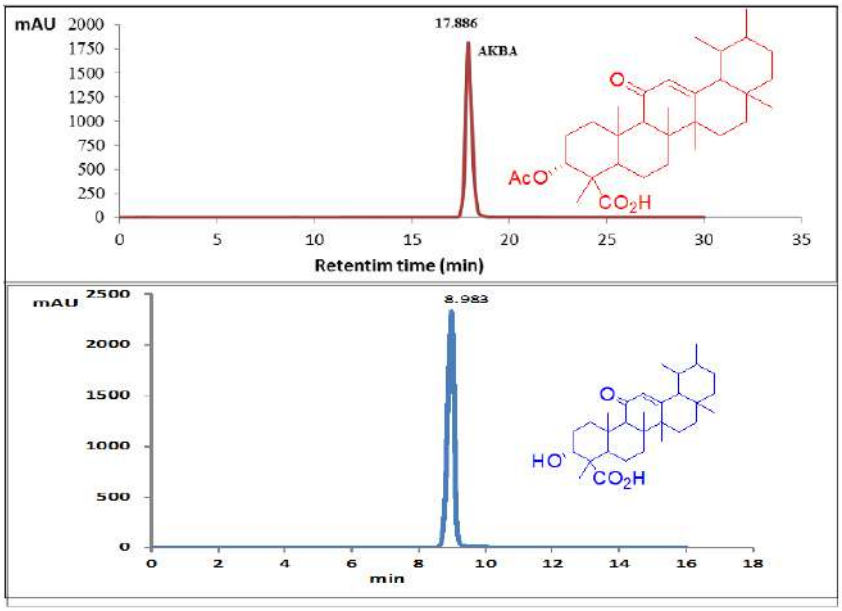
17.1.21. Analytical Section

17.1.21.1. Quantification of Incensole and Incensole Acetate by NIR spectroscopy coupled with PLSR and cross-validated by HPLC.



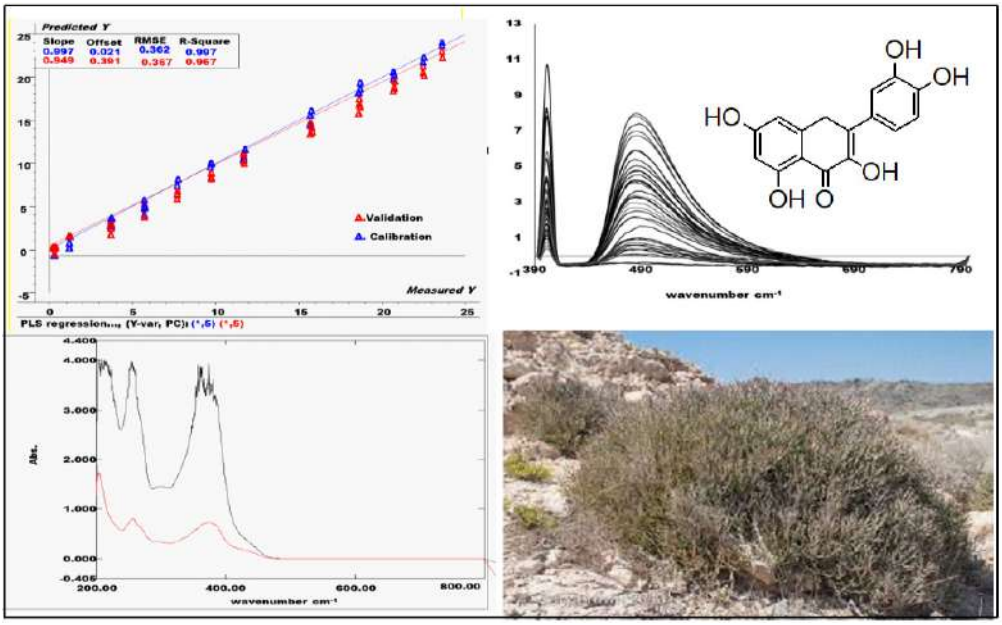
Incensole and Incensole acetate have received a significant pharmacological interest due to its potent anti-inflammatory and anti-depressant activity in recent years. NIRS coupled with PLSR as a robust and alternative method was used to quantify the content of incensole and incensole acetate in three *Boswellia* species and cross validated by HPLC. The findings obtained were in total agreement with the HPLC analysis suggesting that NIRS coupled with PLS regression is a robust and non-destructive alternate method for the quantification of incensole.

17.1.21.2. Quantification of AKBA and KBA by NIR spectroscopy coupled with PLSR and cross validated by HPLC.



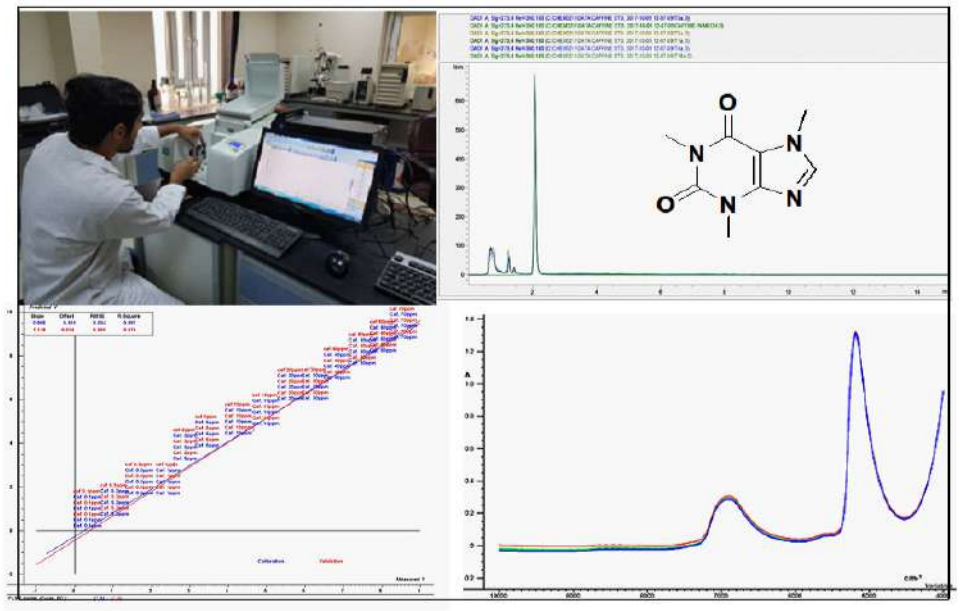
3-O-Acetyl-11-keto-*β*-boswellic acid (AKBA) and 11-keto-*β*-boswellic acid (KBA), one of the pentacyclic triterpenoids, is a main biologicallyactive constituentin the resin of *Boswellia sacra* and has received significant pharmacological interest in the recent years. It was aimed to develop a robust method to quantify the AKBA and KBAcontents in methanol extracts of different parts of *B. sacra* plant and various fractions of its resinexudates through near-infrared (NIR) spectroscopy coupled with partial-least squares (PLS) regression. The results showed that 50% CHCl3/n-hexane sub-fraction has the highest concentration of AKBA (14.8%), followed by 55% CHCl3/n-hexane (13.6%), and 40% CHCl3/n-hexane (6.1%). The sub-fraction at 4% MeOH/CHCl3 (4.1% of KBA) was found to contain the highest percentage of KBA followed by another sub-fraction at 2% MeOH/CHCl3. As the results achieved with the proposed NIRS methodology are in close agreement to the results of AKBA and KBA analysis using HPLC, therefore we suggest that our proposed NIRS method is a fast alternative and non-destructive method for the analysis of AKBA and KBA in different samples of *Boswellia sacra*.

17.1.21.3. Fluorescence spectroscopy-partial least square regression method for the quantification of quercetin in Euphorbia masirahensis



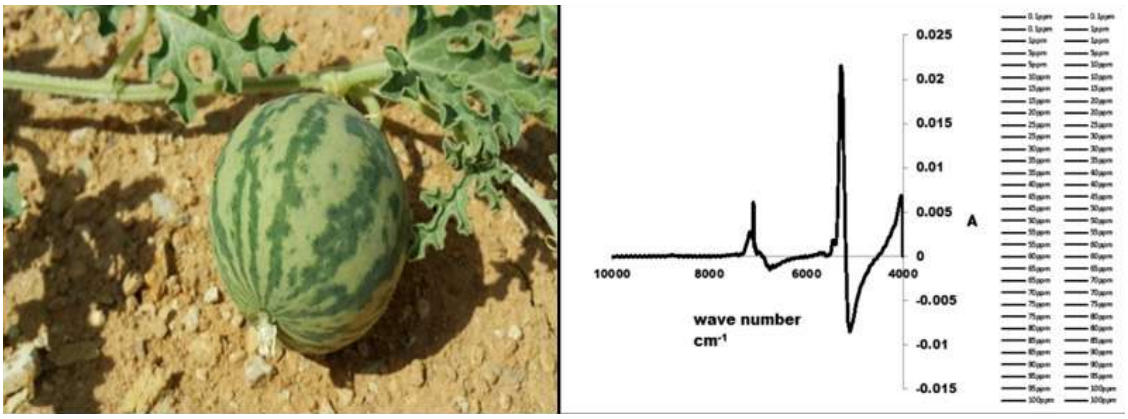
In this study, a new sensitive fluorescence emission spectroscopy coupled with partial least square regression (PLSR) was developed as a new method for the estimation of quercetin in different fractions of *Euphorbia masirahensis* and the obtained results were cross validated by UV–visible spectroscopy. Different fractions of dried plant material were extracted with methanol and then submitted for emission spectroscopic analysis, followed by PLS regression. The results indicated that n-butanol fraction contained the higher quercetin contents i.e. (5.83 ± 0.09%) followed by ethyl acetate fraction i.e. (4.25 ± 0.06%). The newly proposed fluorescence method was also parallel cross validated with UV–visible spectroscopy. The results from both methods were found to be very consistent but the fluorescence-PLSR method was found to be of higher accuracy due to its high sensitivity with slope value of 0.997 and RMSE values of 0.355%. This newly proposed emission spectroscopic method coupled with PLSR is sensitive, reproducible, simple, ecofriendly and non-destructive.

17.1.21.4. Quantification of caffeine in tea samples by near-infrared spectroscopy coupled with PLS regression & cross validation by HPLC.



Standard methods are expensive and time-consuming, and are being associated with high economic losses and public health threats. In the quantification of caffeine in the commercially available tea samples, the development of fast analytical techniques able to overcome these limitations is crucial and spectroscopic techniques might constitute a reliable alternative. Near-infrared reflectance (NIRS) spectroscopy coupled with partial least square regression (PLSR) was used to quantify the amount of caffeine in commercially available tea samples. A total of 25 samples were scanned by NIRS, and also validated by high performance liquid chromatography (HPLC) to evaluate the caffeine contents. Partial least squares (PLS) algorithm was built on the spectral data of the caffeine standards were recorded by using Frontier NIR spectrophotometer by Perkin Elmer in absorption mode in the wavenumber range from (10000 to 4000 cm-1). Both techniques provided good results for predicting the content of caffeine in the commercially available tea samples. The present study was successfully validated in 25 commercially available tea samples proving that this technique possesses a high potential to be routinely used for the detection and quantification of caffeine.

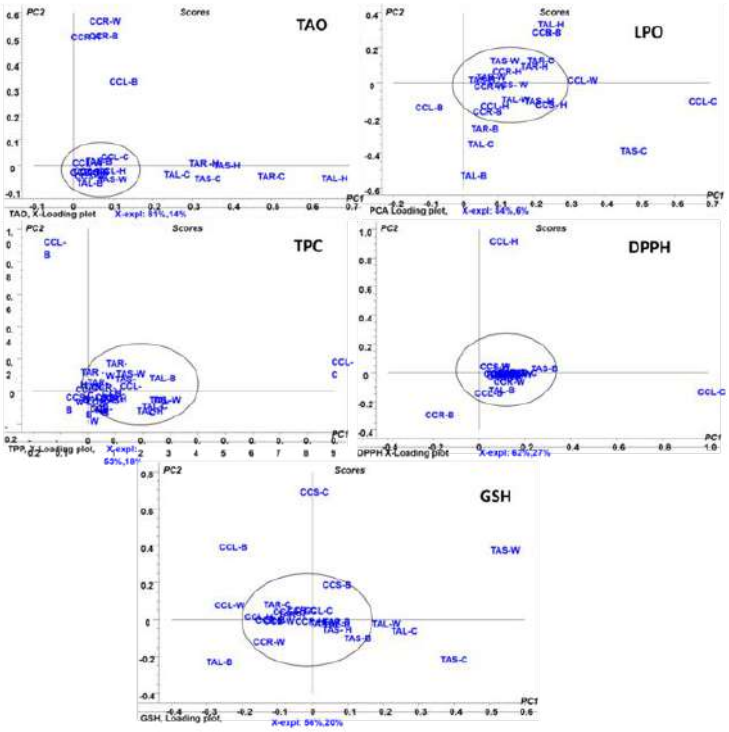
17.1.21.5. Application of NIRS coupled with PLS for quantification of total polyphenol contents from the fruit & aerial parts of Citrullus colocynthis



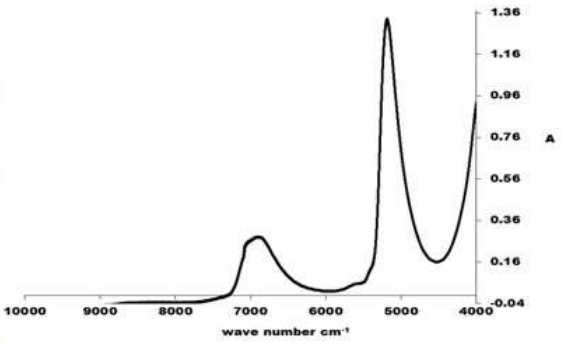
Standard methods are expensive and time-consuming, and are being associated with high economic losses and public health threats. In the quantification of caffeine in the commercially available tea samples, the development of fast analytical techniques able to overcome these limitations is crucial and spectroscopic techniques might constitute a reliable alternative. Near-infrared reflectance (NIRS) spectroscopy coupled with partial least square regression (PLSR) was used to quantify the amount of caffeine in commercially available tea samples. A total of 25 samples were scanned by NIRS, and also validated by high performance liquid chromatography (HPLC) to evaluate the caffeine contents. Partial least squares (PLS) algorithm was built on the spectral data of the caffeine standards were recorded by using Frontier NIR spectrophotometer by Perkin Elmer in absorption mode in the wavenumber range from (10000 to 4000 cm-1). Both techniques provided good results for predicting the content of caffeine in the commercially available tea samples. The present study was successfully validated in 25 commercially available tea samples proving that this technique possesses a high potential to be routinely used for the detection and quantification of caffeine.

17.21.6. In vitro oxidative stress regulatory potential of Citrullus colocynthis and Tephrosia apollinea

The potential role of medicinal plants *Citrullus colocynthis* and *Tephrosia apollinea* in ameliorating the oxidative stress developed during reactive oxygen species (ROS) generation is investigated. The organic extracts of different organs (leaf, stem and root) of these medicinal plants obtained in *n*-hexane, chloroform, *n*-butanol and water were assayed for radical scavenging, total antioxidant capacity, anti-lipid peroxidation and reduced glutathione activity. The results revealed the higher bioactivity of *C. colocynthis* than that of *T. apollinea* in various antioxidant assays. Various plant parts including leaf stem, and root within each plant were also compared for their biological potential.



17.1.21.7. Near infrared spectroscopy with PLS regression multivariate method for rapid and non-destructive analysis of total polyphenolic contents in Cassia senna Linn.



Near Infrared spectroscopy (NIRS) coupled with partial least square (PLS) regression analysis was used to evaluate the polyphenol profile of *C. senna*. The methanol extract and its various fractions obtained in *n*-hexane, dichloromethane, ethyl acetate, n-butanol, and water were subjected to NIR spectral measurements in the wavelength range of 700 to 2500 nm. The results of the total polyphenol contents, thus obtained, were further confirmed through UV-Vis spectroscopy, and it is found that the n-hexane faction has the maximum value for polyphenolic contents (118.6 mg/100g by NIR and 116.960mg/100g by UV-Vis).

17.1.22. Secondary Metabolites from marine

1	Identification of anti-fouling agents from marine derived sponges and algae
2	Anti-microbial, anti-corrosion properties of microbial agents from marine resources
3	Phytochemical and Biological Investigations of Codium dwarkense
4	Phytochemical and Biological Investigations of Padina boergesenii
5	Application of Natural Colors of Pigmentation In Fishes

17.1.23. Phytochemical and Biological Investigations of Some Selected Omani Medicinal Plants

6	Phytochemical investigation of Boswellia elongate
7	Isolation and characterization of biologically active compounds from Boswellia socotrana
8	Isolation of anti-proliferative and cytotoxic compounds from the resin of Cammiphora kua.
9	Isolation, characterization of urease inhibiting metabolites from Aurobasidenum BSS6
10	Isolation of allelochemicals from Sphingomonas sp LK11
11	Isolation, characterization of urease inhibiting metabolites from BSL10 and its responses to increased CHO ratio during bioactor-based growth
12	Bioactivities (enzyme inhibition and molecular docking) of extracts and metabolites from medicinal plants and resins
13	Bioactivities (enzyme inhibition and molecular docking) of extracts and metabolites from medicinal plants and resins
14	GC/MS and Phytochemical investigation of Amberlyst
15	Phytochemical investigation of Bhoreavia elegans. More than 10 compounds were isolated out of which one is new and submitted to Z. Naturforsh. The anti-lipid peroxidation activity of the known compounds is done and ready to be submitted.
16	Biological Activities and Phytochemical Investigation of C. Colocynthis
17	Phytochemical and Biological Investigations of Euryop spinifolius
18	Isolation and Identification of Secondary metabolites from Aurobasidenum sp. BSS6 and its biological activities.
19	Phytochemical and Biological Investigations of Aloe dhufarensis
20	Phytochemical and Biological Investigations of Anogeissus dhofarica
21	Phytochemical and Biological Investigations of Cissus quadrangularis
22	Phytochemical and Biological Investigations of Pteropyrum scoparium
23	Phytochemical and Biological Investigations of Pluchea Arabica

17.1.24. Secondary metabolites and Bioactivities

24	Isolation, characterization of urease inhibiting metabolites from Aurobasidenum BSS6
25	Isolation of allelochemicals from Sphingomonas sp LK11
26	Isolation, characterization of urease inhibiting metabolites from BSL10 and its responses to increased CHO ratio during bioactor-based growth
27	Bioactivities (enzyme inhibition and molecular docking) of extracts and metabolites from medicinal plants and resins
28	Bioactivities (enzyme inhibition and molecular docking) of extracts and metabolites from medicinal plants and resins

17.1.25. Analytical Chemistry Projects using NIR, IR, HPLC.

29	Development of a robust sensitive fluorescence spectroscopic method coupled with PLSR for the estimation of quercetin in different fractions of Ochradenus aucheri and Capparis cartilaginea.
30	Application of a Newly Developed Fluorescence Spectroscopy Coupled with PLSR for the Estimation of Quercetin in Four Medicinal Plants.
31	Quantification of Aloe emodin and other anthraquinones in Aloe species using NIR coupled with PLSR, HPLC, Fluorescense and UV-vis spectroscopic techniques.
32	Estimation of total polyphenols in Teucrium species using NIR, FTIR and HPLC.
33	Finding markers in avascular bone necrosis when compared with healthy ones. This project is in collaboration with Dr. Sultan Al-Maskary (a well-known knee surgeon in Oman) from Sultan Qaboos Hospital.
34	Applying NIR as a diagnostic tool for high cholesterol LDL patients. This project is in collaboration with Dr. Khalid Al-Rasady and Dr. Khalid Al-Waily from SQUH.
35	Applying NIR for human viral diseases like H1N1, Hepatitis B, Hepatitis C, HIV and bacterial like H. Pyroli using blood samples. This project is in collaboration with Nizwa hospital and GANA Clinic.
36	Applying NIR for animal viral and/or bacterial diseases. This project is in collaboration with the Diwan of Royal Court to provide the blood samples. We have signed MOU with them.
37	Applying NIR as a rapid and noninvasive diagnosis for the presence and severity of coronary heart disease.
38	Primary metabolites variation across different B. sacra population and its NIRS based Chemometric analysis.

17.1.26. Food chemistry

39	Adulteration in different honey samples and identifying marker.
40	Quantification of Secondary metabolites including incensole and boswellic acids using HPLC, NIR and NMR chemometrics.
41	Quantification of Caffeine by HPLC and NIR in various brands of coffee, tea and soft drinks.
42	Quantification of Quarcetin, Morin and total phenols in plant samples by Fluorescence, UV and NIR.
43	Detection & quantification of adulteration in Saffron samples
44	New spectroscopy coupled with PLS for quantification of BDDE in cream.

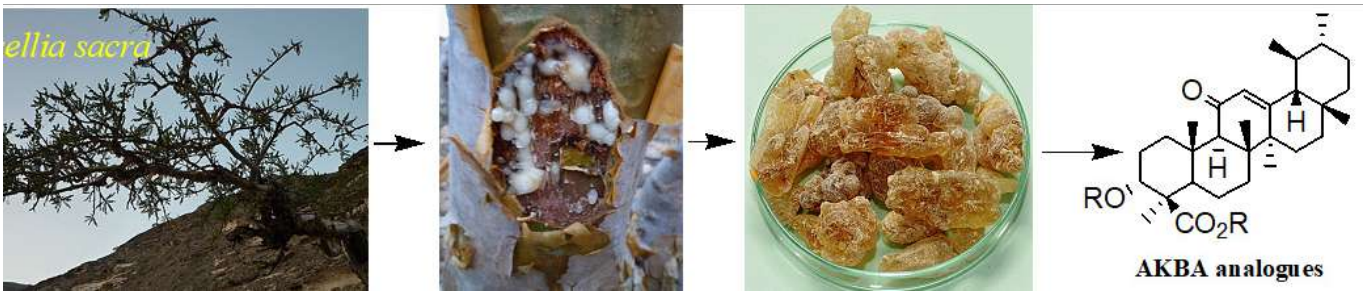
17.1.27. NMR & Chemometrics

45	STD-NMR studies of urease in the presence of Boswellia sacra essential oil, limonene, ß-pinene and α-pinene.
46	1H-NMR fingerprinting of glycosides present in the extract of Desmidorchis flava.
47	Application of DOSY INEPT NMR experiment based on diffusion coefficient of quercetin dihydrate and rutin trihydrate in various plant samples.
48	STD-NMR studies of acetylcholinesterase in the presence of essential oil from Boswellia sacra, limonene, ß-pinene and α-pinene: Binding epitopes of acetylcholinesterase with Boswellia sacra essential oil, limonene, ß-pinene and α-pinene inhibitors will be discovered and studied. New parameters e.g. the STD amplification factor (ASTD) and STD NMR based determination of KD will also be included. STD build-up NMR experiment will be setup and applied in these studies.
49	Experimental setup of STD-TOSCY: STD-TOCSY will be setup on our instrument using ligand and enzyme. The experiment will be a milestone in studying the protein ligand interactions.
50	STD NMR study of receptor–ligand interactions in living cancer cells: Experimental setups in 1 & 2 will be used in this project and receptor ligand interaction will be studied in living cancer cells available in our cancer lab.

17.1.28. Medicinal Plants from the Sultanate of Oman

1. *Citrullus colocynthis* (Jable Akhdar)
2. *Cassia Senna* (Al-Hamra)
3. *Bosia Arabica* (Nizwa in Al-Dhakhliya).
4. *Haplophyllum tuberculatum* (Al-Hamra)
5. *Euphorbia Smithi* (Salalah)
6. *Heliotropium longiflorum* (Dokha valleys in Dhofar)
7. *Zygocarpum Dhofarense*:(Salalah)
8. *Aloe dhufarensis* (Dhofar)

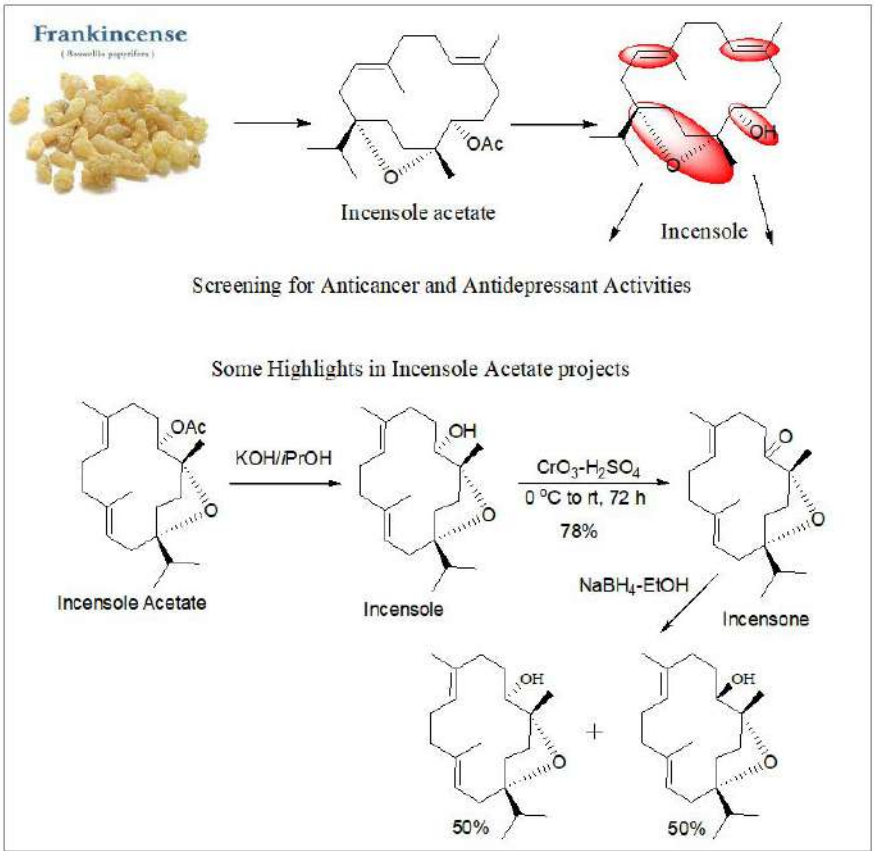
17.1.29. Synthesis of AKBA Analogs



Boswellic acids are therefore very fascinating molecules and there is an increasing demand for these substances for pharmaceutical and medicinal studies. The gum exudate of *Boswellia sacra* comprises of four major triterpenic acids known as boswellic acids (BAs) viz., β-boswellic acid (BA), 3-O-α-acetyl-β-boswellic acid (ABA), 11-keto-β-boswellic acid (KBA) and 3-O-α-acetyl-11-keto-β-boswellic acid (AKBA). Their bioactivities against different cancer cells, inflammation, arthritis, ulcerative colitis, chronic colitis, asthma, and hepatitis are well documented. However, they have gained a great deal of focus in recent past owing to their anti-cancer activity and ability to induce apoptosis to camptothecin, amsacrine or etopside, using pure topoisomerase assay. Thus, prompted by the potential of BAs and our interest in

the identification and development of potent anticancer leads based on the natural products including BAs, we have synthesized different AKBA analogs (Figure 2) and synthesized derivatives showed promising anticancer activity against different cancer cell lines.

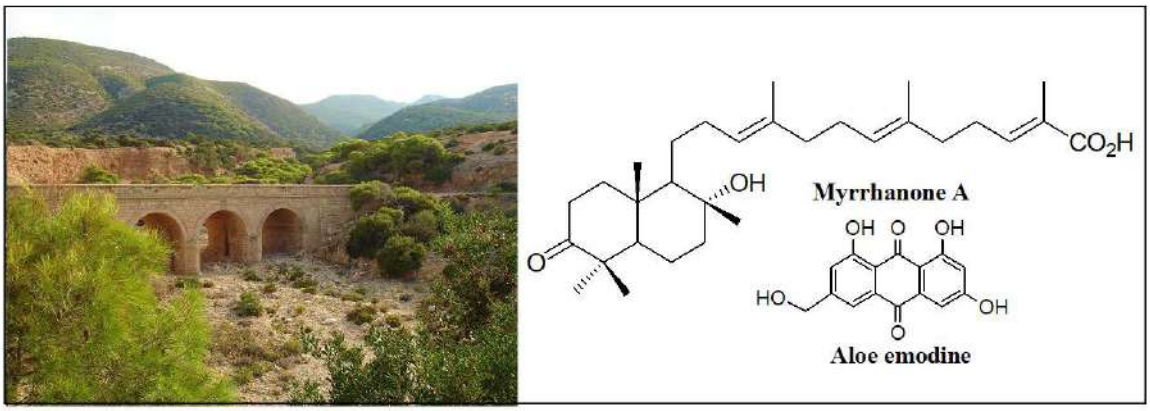
17.1.30. Synthesis, Antidepressant and Anticancer Activities of Incensole Acetate Analog



Incensole acetate and its nonacetylated form, incensole, both cembrene-type diterpenes, were isolated from the resin of *Boswellia* papyrifera. They have several pharmacological activities such as anti-inflammatory and neuroprotective, antiproliferative effect, cytotoxic activity, and antidepressive-like action. Therefore, prompted by the potential of incensole and its acetate, we have synthesized different analogs and synthesized derivatives and will test for antidepressant activity along with to check anticancer activity against different cancer cell lines.

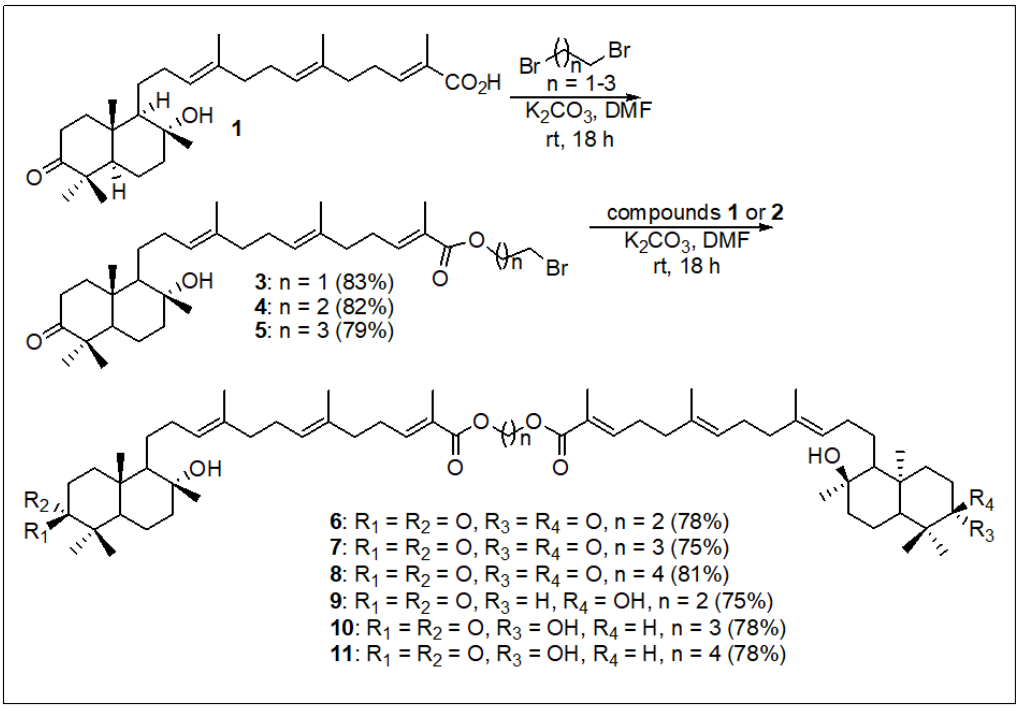
17.1.31. Synthesis of Other Natural Products Analogs

Natural products have been recognized since ancient times as potential sources of human medicine. The Arabian Gulf is considered the land of traditional healing, and herbal remedies were the primary form of health care in the region until recently. Oman has 1204 terrestrial plants, many of which are reported to be used in traditional medicine; however, less than 10% of terrestrial species in the Gulf region have been screened for medicinal use. We have isolated some interesting compounds viz., myrrh none A and aloe-emodin along with other natural products in large amount during phytochemical investigation of Oman medicinal plants. Interestingly, these compounds demonstrated promising biological activities. Currently we are synthesizing different analogs of natural products in order to test them for different biological activities

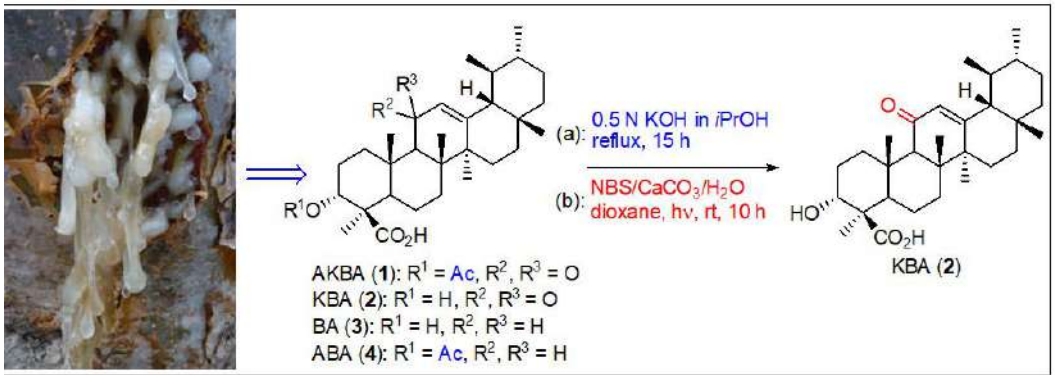


17.1.32. Synthesis of new triterpenic monomers and dimers as potential antiproliferative agents and their molecular docking studies

In the current investigation, new monomers of myrrhanone B and lupeolic acid were prepared via reaction of triterpenic acids with linkers in the presence of K2CO3. In addition, new bis-myrrhanone B homodimers, myrrhanone B-myrrhanol B heterodimers, and bis-myrrhanone β-boswellic acids heterodimer were prepared. Evaluation of these compounds on the proliferation of four different human cancer cell lines, viz., FaDu (pharynx carcinoma), A2780 (ovarian carcinoma), HT29 (colon adenocarcinoma) and A375 (malignant melanoma) has been performed. It is worth mentioning that compounds 4, 7, 8, 10, and 11 possess potent antiproliferative effect towards HT29 cancer cells with IC50 values of 8.1 mM, 5.4 mM,8.8 mM, 6.8 mM, and 8.2 mM, respectively. In addition, these compounds display good to moderate antiproliferative activities towards A2780 and A375 with IC50 values ranging from 10.4 to 24.2 mM. Moreover, the molecular docking studies of most active compounds (4, 7, 8, 10 and 11) with six anticancer drug targets DHFR, VEGFR2, HER-2/neu, CDK6, hCA-IX and LOX also carried, in order to know the mode of binding interaction and energy of this class of compounds.



17.1.33. Synthesis of New Boswellic Acids as Potential Antiproliferative Agents and their Molecular Docking Studies



In the current investigation, a series of heterocyclic derivatives of boswellic acids were prepared along with new monomers of acetyl-11-keto-β-boswellic acid (AKBA, 1) and 11-keto-β-boswellic acid (KBA, 2) with three linkers. Furthermore, new bis-AKBA and KBA homodimers, and AKBA-KBA heterodimers were prepared. The effects of these compounds on the proliferation of different human cancer cell lines, viz., FaDu (pharynx carcinoma), A2780 (ovarian carcinoma), HT29 (colon adenocarcinoma), A375 (malignant melanoma) and SW1736 (thyroid carcinoma), have been evaluated. KBA homodimer 21 effectively inhibited the growth of FaDu, A2780, HT29 and A375 cells with EC_{50} values below 9 μM. The same compound was also active against SW1736 cells with an EC_{50} = 11 μM. In addition, compounds 7, 8, 11, 12, 15, 16 and 17 also exhibited antiproliferative effects against A2780, HT29 and A375 cancer cells. In particular, the pyrazine analog 8 demonstrated potent cytotoxic effects against A375 cancer cells with an EC_{50} value of 2.1 μM.

17.1.34. Nuclear Magnetic Resonance Unit

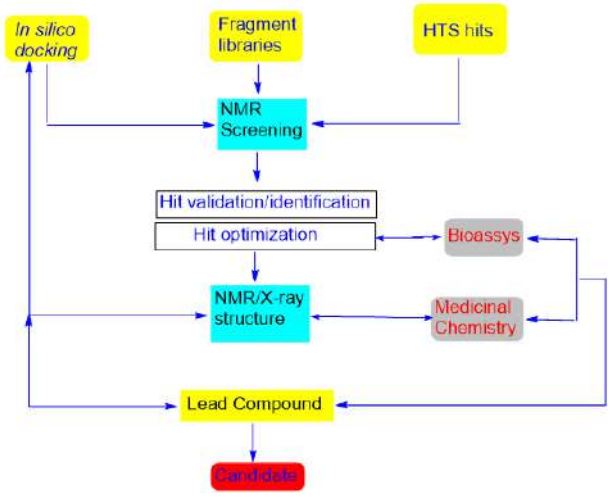
Today, NMR has become a sophisticated and powerful analytical technology that has found a variety of applications in many disciplines of scientific research, medicine, and various industries. We are recording various NMR techniques in our Center viz., ^{1}H-NMR, ^{13}C-Broadband, ^{13}C-DEPT 135, 13C DEPT 90, 1D selective COSY, 1D selective NOESY, 1D selective TOCSY, 19Flourine with 1H coupled, ^{19}Flourine with ^{1}H decoupled, 2D COSY (H-H connectivity through J coupling), 2D NOESY (H-H spatial proximity), 2D CAMELSPIN or ROESY (H-H spatial proximity), 2D HOHAHA or TOCSY (H-H connectivity through J coupling), 2D INADEQUATE (Carbon-Carbon connectivity), 2D J-RESOLVED, 2D HSQC (Carbon-proton connectivity through J coupling direct correlation : one bond), 2D HMBC(Carbon-proton connectivity through J coupling long range correlation : 2 to 3 bond), 2D DOESY, and STD NMR spectroscopy.

We are planning to establish a spectral database (CENTER database) of natural products and synthetic compounds in University of Nizwa. The CENTER database will create a single location to store all spectra of natural products and synthetic compounds. Initially, we will establish paper-based (hard copy) database which will be converted to computerized (electronic) database gradually. The prime advantages of this CENTER database will be: (i) To create a trustable work environment among all the Center members; (ii) To provide simplify and centralize updates about all spectra of natural products and synthetic compounds;

(iii) To improve quality of research work; (iv) To save time and reduce errors; (iv) To increase efficiency and focus on higher-value work; (v) To guide junior researchers to understand and solve the spectra of different classes of compounds.

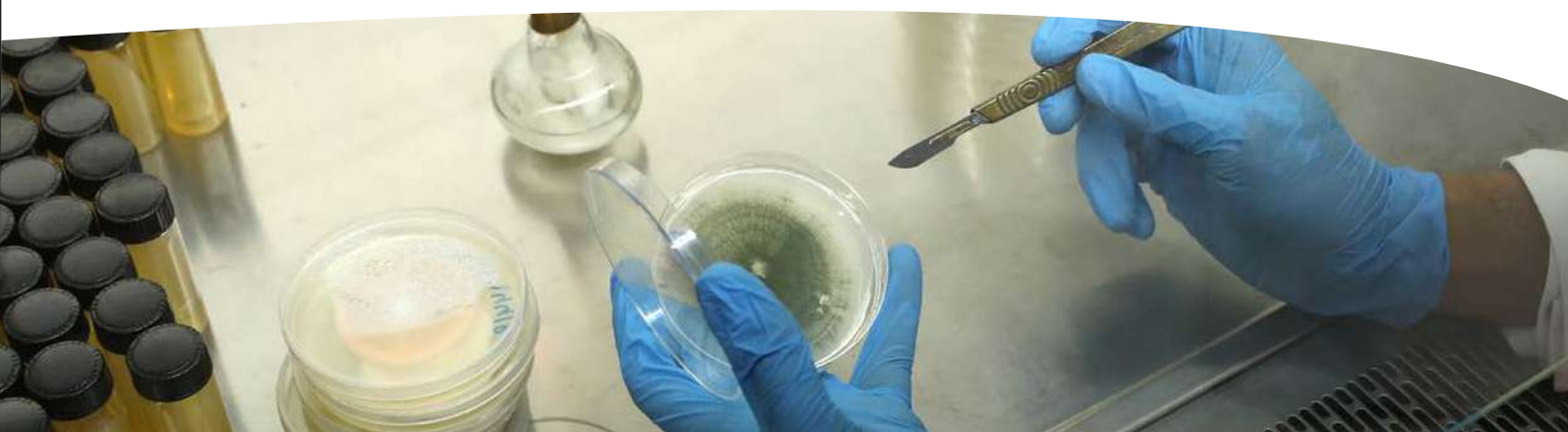
17.1.34.1. The Role of Nuclear Magnetic Resonance (NMR) Spectroscopy in Rational Drug Discovery

NMR diffusion measurements are a useful tool for probing molecular interactions, especially ligand–protein binding, because the diffusion coefficient measured for the ligand can reflect the binding affinity. This technique is useful for determining relative affinities of multiple ligands and quantitating binding constants to a specific biomolecular target, such as an enzyme. In detecting ligand binding, rather than observing the NMR spectra of the target upon complex formation, the so-called ligand-based experiments focus on the observation of the perturbations induced by a substoichiometric amount of target on the NMR spectra of the ligand. The NMR samples examined vary from small molecules to proteins, solid samples, cell samples and some synthetic samples. A wide range of homonuclear and heteronuclear one-dimensional and multi- dimensional NMR experiments can be performed. Examples of these approaches are the saturation transfer difference (STD). STD-NMR is a highly versatile technique for NMR-based screening.

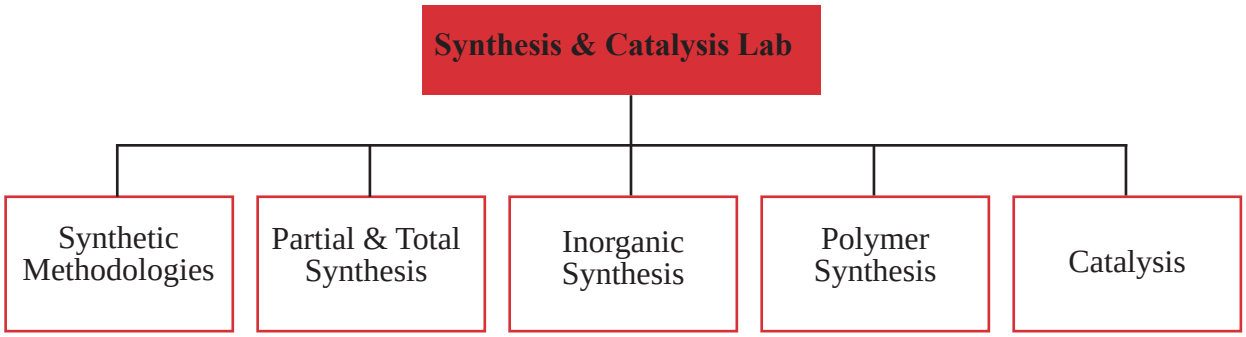


Natural and synthetic compounds will be evaluated for anti-cancer potential and inhibition of α-glucosidase, urease, and acetyl cholinesterase enzymes. STD NMR will be recorded for those compounds which show significant activity. Therefore, STD NMR method is used to detect high-affinity ligands and can be used for compound library screening to identify both high- and low-affinity ligands, and to rank order analogs rapidly during the hit-to-lead optimization process in drug discovery.

NMR spectroscopy can provide critical information at early stages of hit validation and identification. NMR measurements for binding studies can represent a key step to eliminate false positives from high-throughput (HTS) campaigns to identify novel scaffolds in fragment-based programs. NMR and X-ray crystallography can also provide unique information to subsequently guide hit-to-lead optimization.

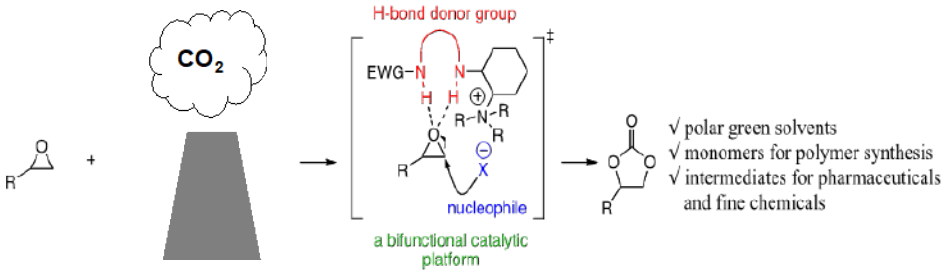


17.2 Synthetic chemistry Lab



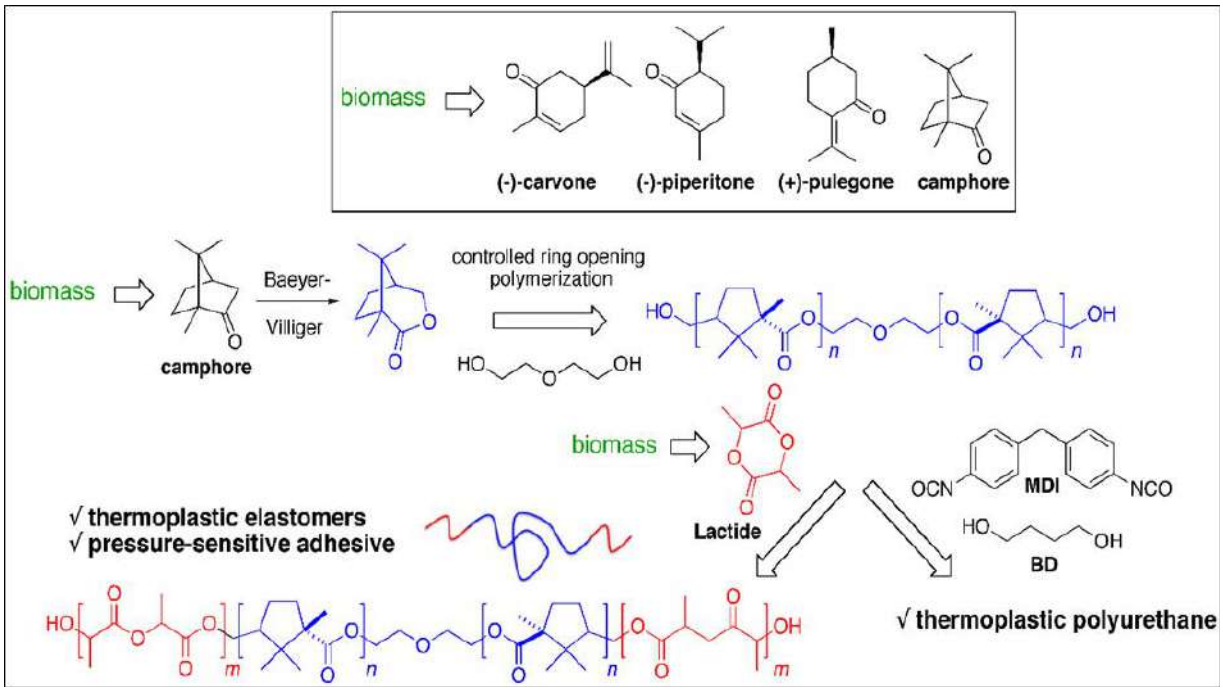
17.2.1. CO_2 Organocatalysis: a sustainable approach in turning greenhouse gas into chemical feedstock

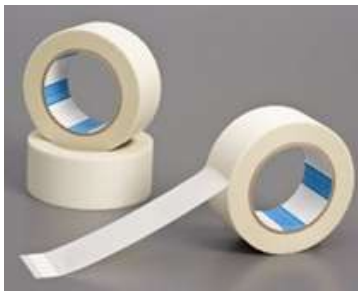
The major sources for the manufacturing of more than 90 % of commercially available chemicals are the unsustainable energy resources such as crude oil, natural gas, and coal that are going to be consumed in the near future. Although we may have already arrived at the oil production peak, attentions towards biomass, as a sustainable replacement source of organic chemicals, has been slow to catch on in chemical production technologies. Biomass is nothing but carbon dioxide, which is removed by the atmosphere and transformed into organic chemicals by means of sustainable energies e.g. sunlight in farm fields. Utilizing green media and reagents, organocatalysis has proven to be an innovative area in catalysis that evades the employment of metal-containing species. As a result of increasingly demanding impurity specifications, the requisite absence of metal residue as well as efficient catalyst removal from the final products for biomedical and microelectronic applications advocate the use of such sustainable approaches versus metal-catalyzed processes. In general, CO_2 fixation technologies could be widely employed in the preparation of valuable building blocks with commercial settings such as polar green solvents, monomers for polymer synthesis, intermediates for pharmaceuticals and fine chemicals. Hence, designing mild, tunable, metal-free and economically viable organocatalytic systems that will meet increasingly demanding environmental regulations remain in attractive, yet unfulfilled, demand.



17.2.2. Bio-renewable polyesters and polyurethanes from bio-derived monomers: a step towards sustainable thermoplastic elastomers.

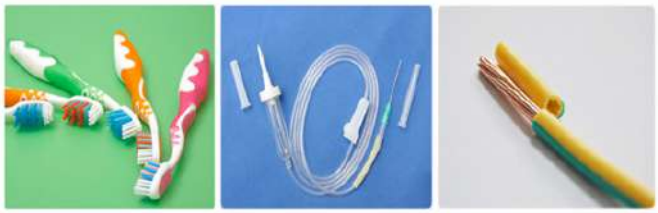
Future sustainable polymers and materials will count on the discovery and exploration of biocompatible, biodegradable and renewable alternatives to petroleum based products with the desire to reduce dependency on fossil fuels. In this regard, the synthesis of useful bio-based resources, e.g., forest, agriculture and other biomass, are excellent candidates as substitutes since they can be both renewable and sustainable. In this context, the abundance and diversity provided by terpenes and terpenoids make them valuable candidates and focuses will be on Oman's medicinal plants and marine natural products.





Pressure-sensitive elastomers

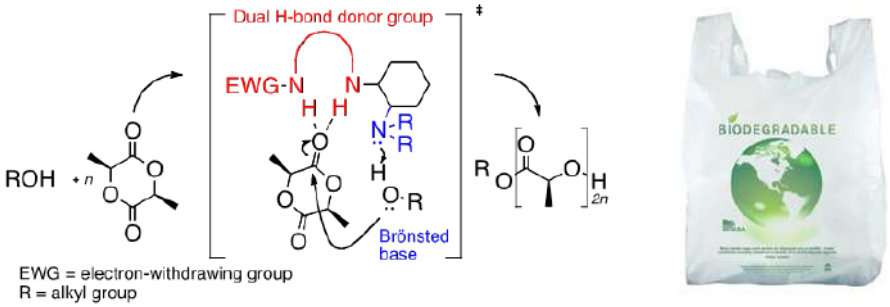
Thermoplastic polyurethane



Thermoplastic elastomers

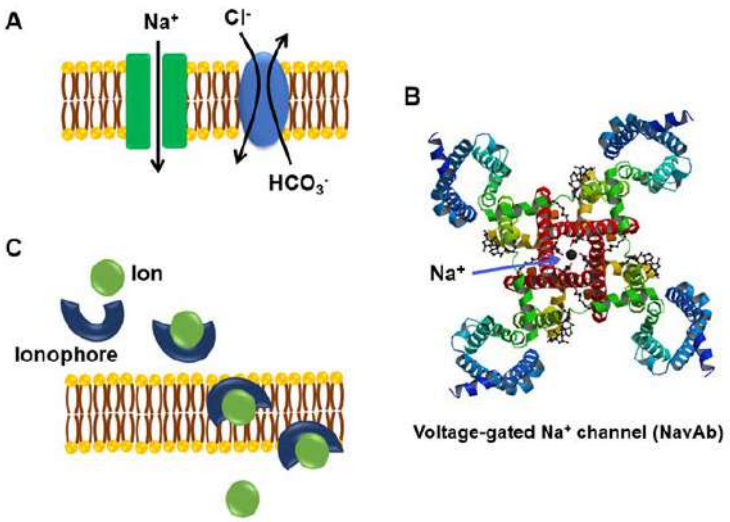
17.2.3. Development of new organocatalytic systems for preparation of biodegradable polymers

Biodegradable polymers such as poly(ester)s and poly(carbonate)s as renewable biomaterials are excellent candidates in the production of biodegradable thermoplastic elastomers (TPEs) for range of different applications from packaging and microelectronics to biomedical fields. Of the existing living polymerization techniques, organocatalytic ring-opening polymerization (ROP) is featured by its ability to provide a variety of structurally well-defined polymers. These polymers are featured with remarkably low degree of poly dispersity and excellent end-group fidelity, making this procedure particularly attractive for the preparation of advanced polymeric materials. Here we will design new organocatalytic systems for the production of biodegradable polymers with enhanced properties for biomedical applications.



17.2.4. Molecular recognition and biological transport

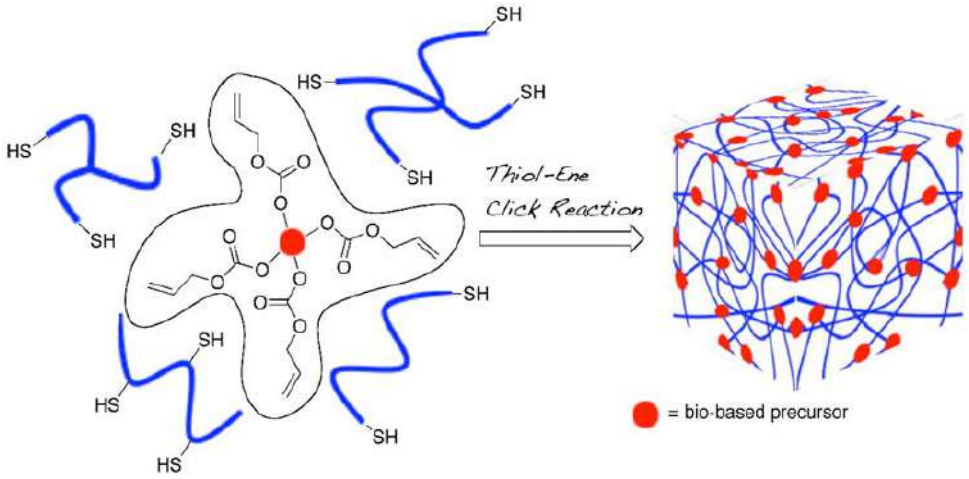
Living cells are surrounded by phospholipid membranes that are impermeable to many natural substances. Cells tightly control the process of material exchange (e.g. ions and nutrients exchange) across cellular membranes using specialised proteins called ion channels and transporters (Figure A). Many of these proteins have molecular recognition mechanisms, which facilitate their specificity to a molecule (Figure B). Hundreds of human diseases are caused by the failure of ion channels and transporters, including cystic fibrosis, Bartter's syndrome, long QT syndrome, and generalized epilepsy. Traditional treatment approaches of these diseases include the management of associated symptoms, increasing the activity of defective proteins, or activation of alternative transport pathways. However, these options are not available for the treatment of many diseases. One emerging approach is the design of artificial chemical compounds (e.g. ionophores) that mimic the activity of ion channels and transporters (Figure C).



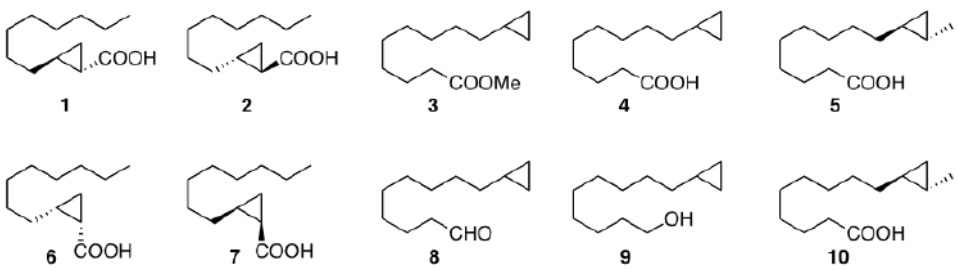
Our aim is to design, synthesis and evaluate compounds that mimic the molecular recognition and transport machineries found in ion channels and transporters. We will use in vitro cellular transport assays to test the efficiency, specificity and toxicity of the designed compounds. Upon identification of candidate compounds, there is the potential of testing them on animal models of human diseases.

17.2.5. Bio-based Hydrogels

Polymeric hydrogels are soft and wet materials, composed of a 3-dimentional cross-linked network of hydrophilic polymers swollen with large amount of water. Hydrogels are well fitted for biomedical applications since they are homogenous soft materials with hydrophilic character, porous arrangement, and tailored stiffness. They generally impose low levels of unwanted species into the host and provide high levels of metabolite and biomolecule transport. The similarity of their physiochemical properties to those of living tissues make them biocompatible and suitable for biomedical/pharmaceutical applications. They exhibit promising applications in different arenas including regenerative medicine, cell encapsulation, drug delivery, tissue engineering, wound dressing, biomedical devices such as biosensors, and separation systems. These gels are made of either covalent bonding or non-covalent interactions such as hydrogen bonding, π-π interactions, or metal-ligand coordination. Our goal is to design polymeric hydrogels containing cheap, abundant and bio-based precursors with a plethora of potential usage in bio-medical fields including self-healing materials, RNA/DNA delivery and cell encapsulation.

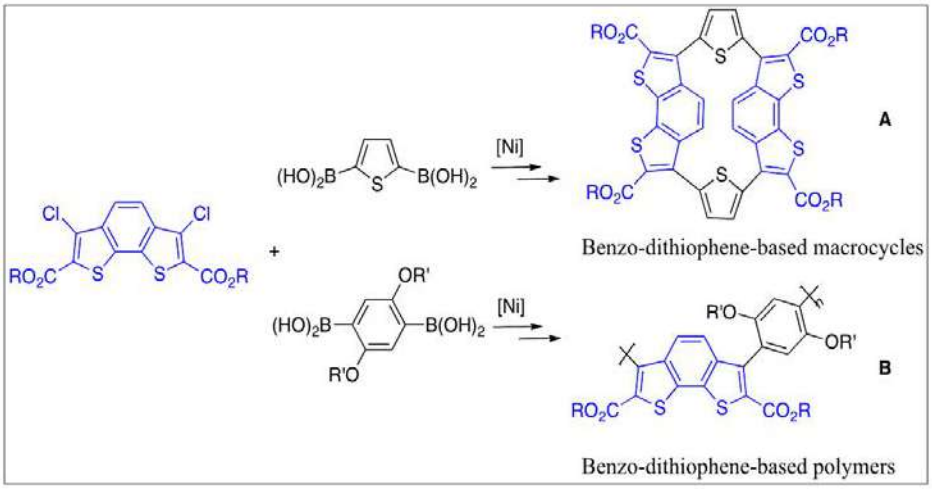


17.2.6. Olibanic acid analogs: mimicking the key odorants of Frankincense



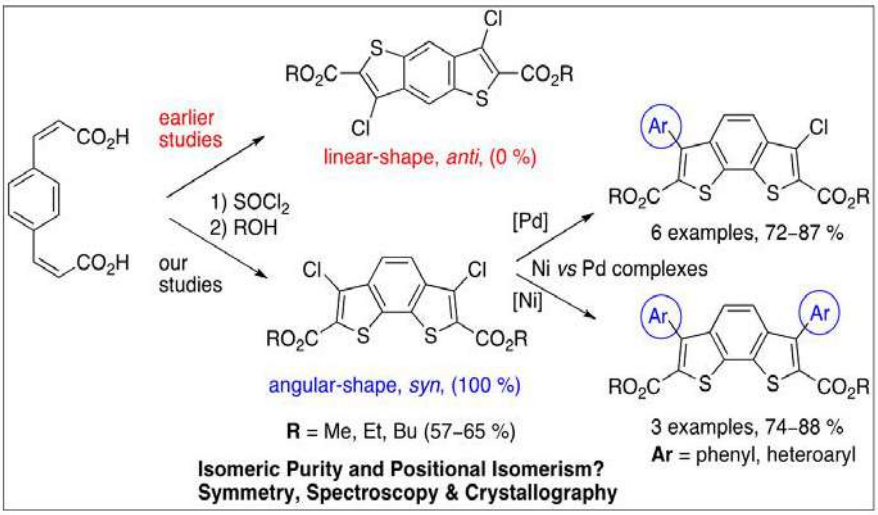
Olibanic acids & their analogs

17.2.7. Towards new benzo-dithiophene macrocycles & polymers



17.2.8. Arylated benzo-dithiophenes by regioselective Suzuki–Miyaura reaction

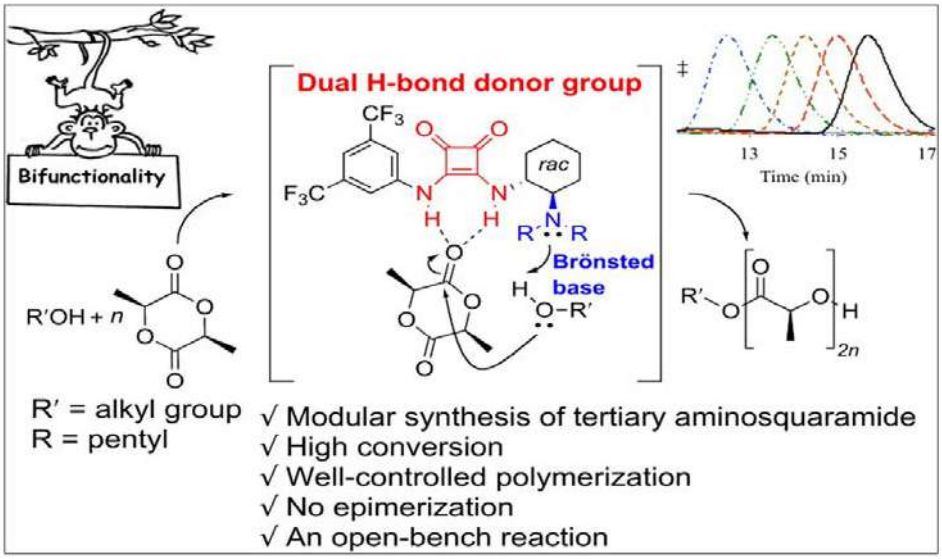
Selective synthesis of isomerically pure, angular-shaped ben- zo[1,2-b:6,5-b′] dithiophenes and various aryl-substituted analogues via the regioselective Suzuki–Miyaura cross-coupling reaction is described. The structural assignments of symmetrical and unsymmetrical derivatives of benzodithiophenes and coumarin-type are based on X-ray crystallography and spectroscopic studies. A comparative study of nickel versus palladium complexes demonstrated that the nickel complex NiCl2(dppe) is more effective in terms of reactivity and yields than palladium catalysis in the Suzuki–Miyaura cross-coupling of hindered 3,6-dichlorobenzo[1,2-b:6,5-b′] dithiophenes with arylboronic acids.



17.2.9. Exploration of tertiary aminosquaramide bifunctional organocatalyst in controlled/living ring-opening polymerization of l-lactide

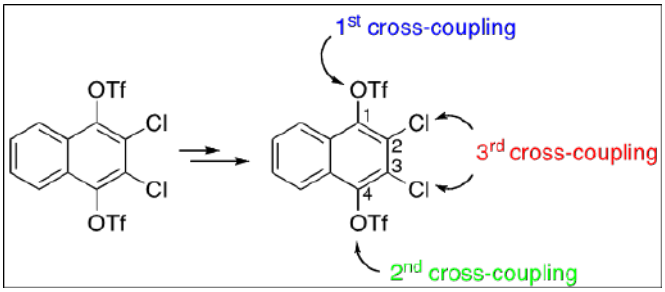
The present contribution describes a new class of bifunctional organocatalytic systems composed of a squaramide functional group as the dual hydrogen-bond donor component and a tertiaryamine group as the hydrogen-bond acceptor for controlled/living ROP of l-lactide. The polymerization has occurred by a living-like smooth process through weak hydrogen bonding interactions and has displayed resistance to

trans-esterification and epimerization reactions, giving rise to poly(l-LA) with narrow polydispersity and high end-group fidelity.



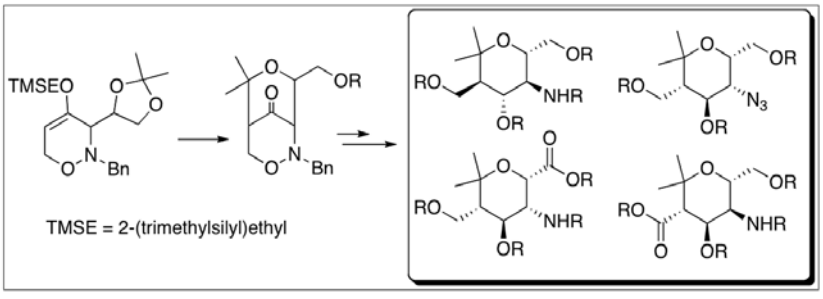
17.2.10. Palladium-catalyzed chemo- and regioselective cross-coupling reactions of 2,3-dichloronaphthalene-1,4-bistriflate

Palladium-catalyzed chemoselective and regioselective cross-coupling reactions of 2,3-dichloro-1,4-(trifluoromethanesulfonyloxy) naphthalene with aryl boronic acids selectively afforded a variety of mono-, di- and tetraphenylnaphthalenes. These reactions proceeded with excellent chemoselectivity in favor of the triflate functional group at the C-1 and C-4 positions of naphthalene.



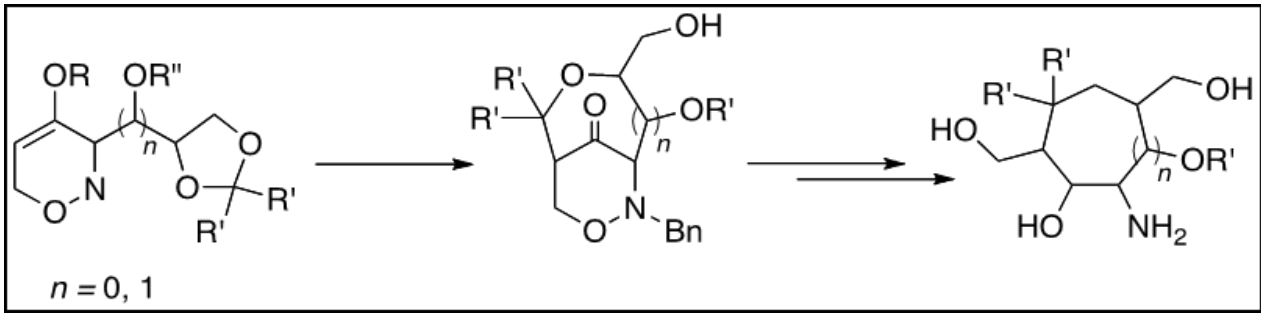
17.2.11. Enantiopure Aminopyrans by a Lewis Acid Promoted Rearrangement of 1,2-Oxazines: Versatile Building Blocks for Oligosaccharide and Sugar Amino Acid Mimetics

Enantiopure 1,3-dioxolanyl-substituted 1,2-oxazines rearrange under Lewis acidic conditions to provide bicyclic products. Subsequent transformations afford a set of 3-aminopyran derivatives and a 3-azidopyran, which can be used as carbohydrate and sugar amino acid mimetics.



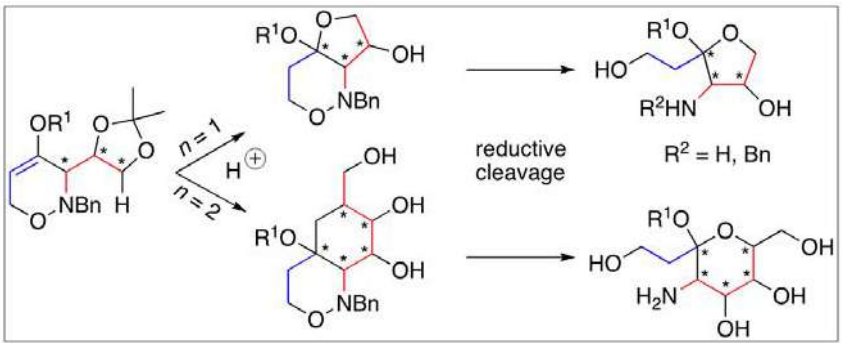
17.2.12. Synthesis of Enantiopure Carbohydrate Mimetics by Lewis Acid Catalyzed Rearrangement of 1,3-Dioxolanyl- Substituted 1,2-Oxazines

Lewis acids induce an unexpected rearrangement of 1,3-dioxo- lanyl-substituted 1,2-oxazines to provide bicyclic compounds in a stereo controlled manner. They are precursors for enantio- pure carbohydrate mimetics containing 3- aminotetrahydropyran or 4-aminooxepane substructures (see scheme; Bn=benzyl).

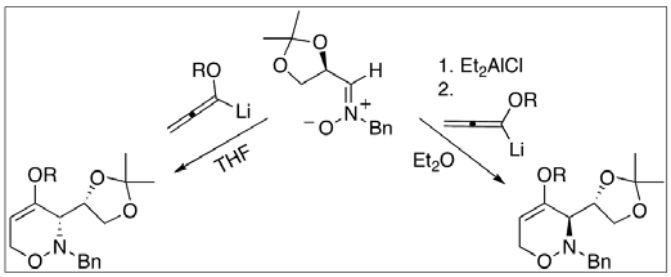


17.2.13. Acid-Induced and Reductive Transfor¬mations of Enantiopure 3,6-Dihydro-2H-1,2-oxazines – Synthesis of Dideoxyamino Carbohydrate Derivatives

Acid-catalyzed transformations of carbohydrate-derived 3,6-dihydro-2*H*-1,2-oxazines such as 1, 5 and 13 provided a set of enantiopure furano-1,2-oxazines or pyrano-1,2-oxazines. The reaction conditions determined the degree of solvolysis of the compounds. An X-ray analysis of product 6 revealed an interesting network of hydrogen bonds. Reductive cleavage of the N–O bond of the 1,2-oxazines either by hydrogen/ palladium or by samarium diiodide furnished enantiopure aminofuran and -pyran derivatives, e.g. 9 and 11 or compound 16, which can be regarded as protected 4-amino-1,4-dideoxyhex-3-ulose or 4-amino-1,4-dideoxyoct-3-ulose derivatives. We thus have established a short and stereocontrolled route to amino carbohydrate derivatives with 1,2-oxazines as crucial relay compounds.

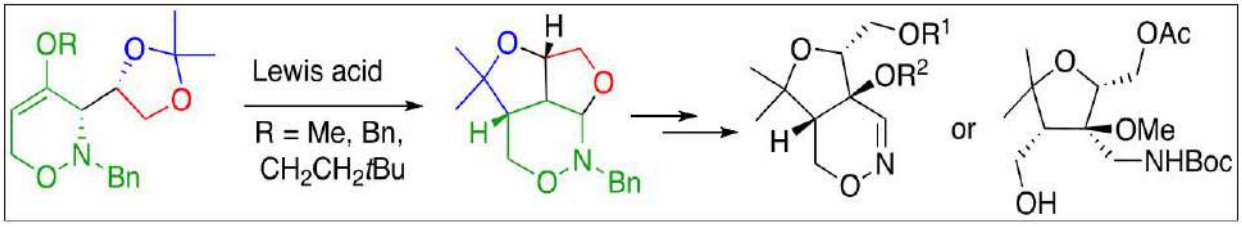


17.2.13. Acid-Induced and Reductive Transfor¬mations of Enantiopure 3,6-Dihydro-2H-1,2-oxazines – Synthesis of Dideoxyamino Carbohydrate Derivatives



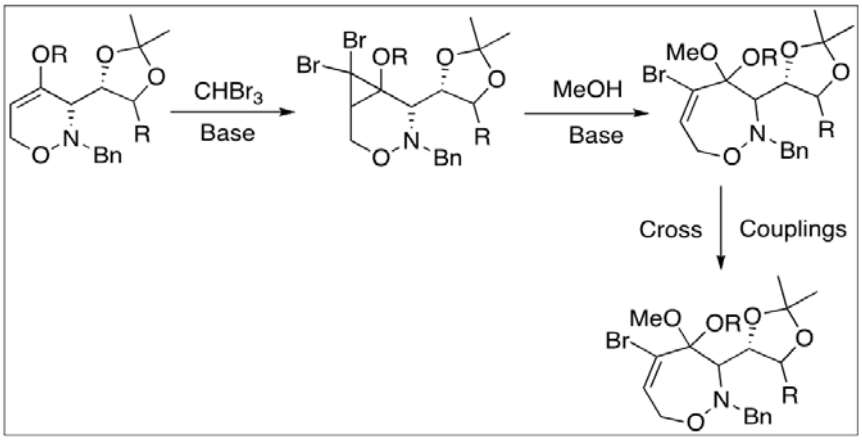
17.2.15. Unusual Enantiopure Heterocyclic Skeletons by Lewis Acid Promoted Rearrangements of 1,3-Dioxolanyl-Substituted 1,2-Oxazines

1,3-Dioxolanyl-substituted 1,2-oxazines rearrange under Lewis acidic conditions to provide novel tricyclic products with complex skeleton. Reductive transformations of these tricycles allow the synthesis of a range of enantiopure heterocycles.



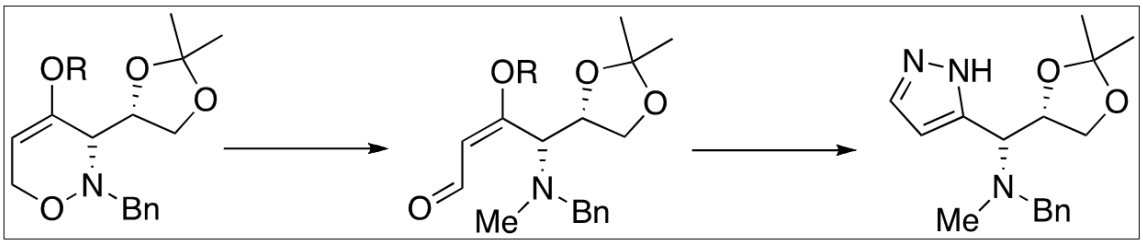
17.2.16. Ring Enlargement of Carbohydrate-Derived 1, 2-Oxazines to Enantiopure 5-Bromo-1, 2-oxazepines and Subsequent Palladium-Catalyzed Reactions

Dibromocarbene addition to D-glyceraldehyde-derived 1, 2-oxazines *syn*-1 and *anti*-1 provided dibromocyclopropane intermediates *syn*-3 and *anti*-3 which smoothly reacted with methanol under ring enlargement to furnish 5-bromo-1, 2-oxazepine derivatives *syn*-4 and *anti*-4. Related 1, 2-oxazines such as arabinose-derived compounds furnished the 1, 2-oxazine derivatives *syn*-4e and *anti*-4f with fair efficacy. The alkenyl bromide moiety of 1, 2-oxazepine derivatives *syn*-4 and *anti*-4 was then exploited for the introduction of new substituents via palladiumcatalyzed C-C bond forming processes (Sonogashira-, Suzuki-, Stille-, and Heck-reactions). These transformations led to a series of new highly substituted 1, 2-oxazepine derivatives *syn*-5 or *anti*-5-11 being of considerable interest for further synthetic elaborations.



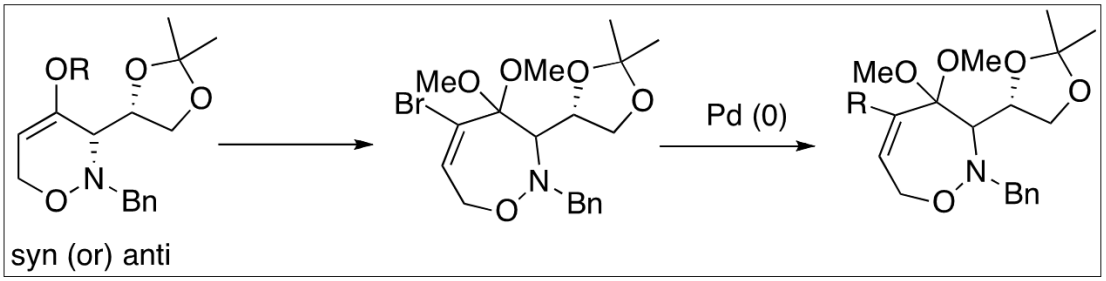
17.2.17. Synthesis of Enantiopure Functionalized β-Alkoxy γ-Amino Aldehydes by a New Internal Redox Ring Cleavage of Carbohydrate-Derived 1, 2-Oxazines

N-Methylation of 3,6-dihydro-2H-1,2-oxazines such as *syn*- or *anti*- followed by treatment with triethylamine smoothly furnished enantiopure β-alkoxy γ-amino aldehydes (*syn* and *anti*) in excellent yields. This mild N-O bond cleavage may be classified as internal redox process. Similar transformations of related 1, 2-oxazines led to the expected compound anti or to protected 4-amino hexose derivative. Starting from *syn*-2 or *anti*-2 condensation with hydrazine afforded new pyrazole derivatives (*syn* and *anti*) with stereo defined and protected amino diol side chain.



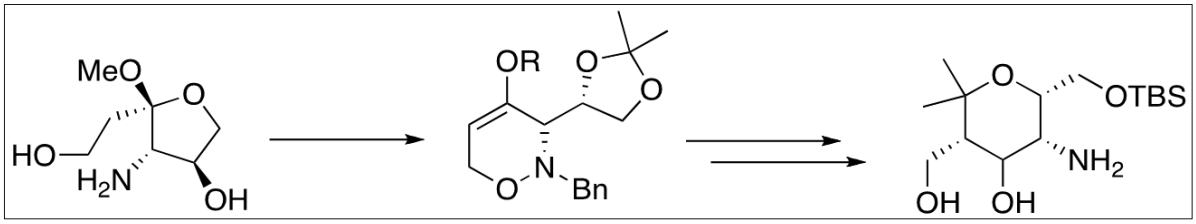
17.2.18. Ring Enlargement of Enantiopure 1, 2-Oxazines to 1, 2-Oxazepine Derivatives and Their Palladium-Catalyzed Couplings

Phase-transfer-catalyzed cyclopropanation of enantio¬pure 1,2-oxazine derivatives (*anti* or *syn*) followed by solvo¬lysis of the resulting geminal dibromocyclopropane intermediates afforded the expected ring-expanded products, namely 1,2-oxazepines (*anti* or *syn*). These heterocycles could be further substituted by use of their bromoalkenyl group employing ¬palladium-catalyzed coupling reactions, which smoothly led to new enantiopure 1, 2-oxazepine derivatives (*anti*).



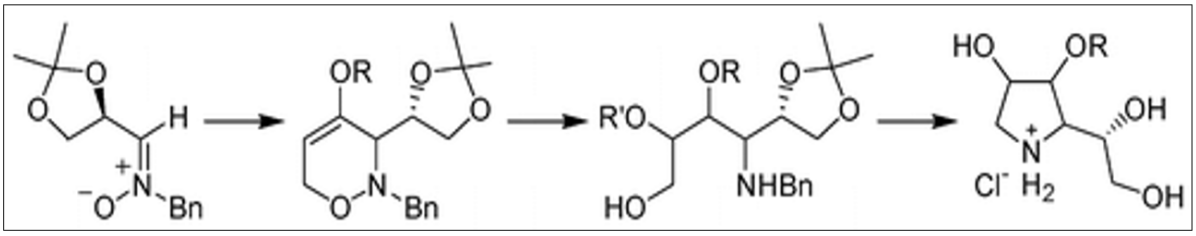
17.2.19. Acid Promoted Syntheses of New Enantiopure Amino Sugar Derivatives from 3,6-Dihydro-2H-1,2-oxazines

The acid promoted rearrangement of *syn*-1 with HCl led to bicyclic acetal from which enantiopure furan derivative was obtained by hydrogenolysis. The same sequence was applied to *anti*-1 leading to bicyclus and diastereomeric tetrahydrofuran . Treatment of syn-6 with pyridinium hydrogen fluoride provided either semiacetal or bicyclic acetal , depending on the ratio of HF and pyridine. Lewis acid mediated intramolecular aldol reaction of *syn*-6 afforded bicyclic 1, 2-oxazine . Protection and subsequent stereoselective reduction followed by hydrogenation yield enantiopure amino substituted pyran derivative.



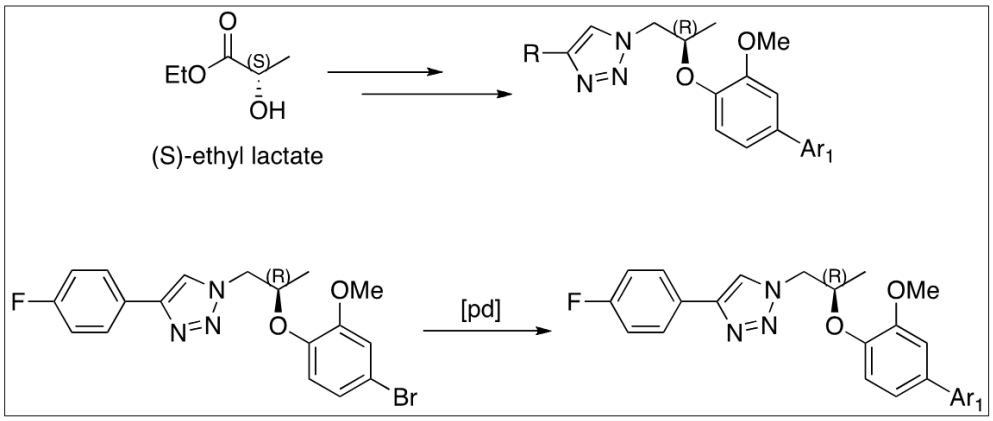
17.2.20. New Polyhydroxylated Pyrrolidines Derived from Enantiopure 3, 6-Dihydro-2H-1,2-oxazines

Diastereoselective hydroborations of enantiopure 3, 6-dihydro-2*H*-1, 2-oxazines led to dihydroxy-substituted 1,2-oxazines. Samarium diiodide induced N-O bond cleavage generated 1, 4-amino alcohols which were recyclized to polyhydroxylated pyrrolidines which are potential glycosidase inhibitors.



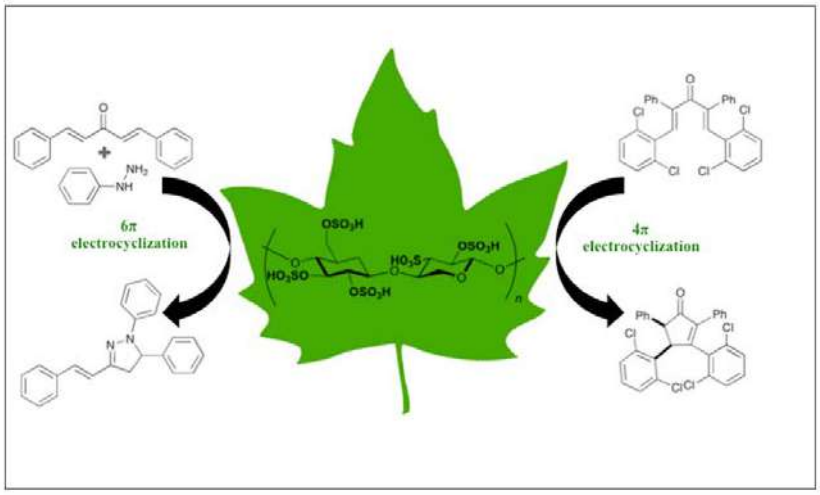
17.2.21. Synthesis and biological evaluation of (R)-1-(2-(4-bromo-2-methoxyphenoxy) propyl)-4-(4-(trifluoromethyl) phenyl)-1H-1, 2, 3-triazole derivatives as a Novel class of α-glucosidase inhibitors and their molecular docking studies

α-glucosidase is a promising target for the treatment of diabetes mellitus and obesity. A series of (*R*)-1-(2-(4-bromo-2-methoxyphenoxy) propyl)-4-(4-(trifluoromethyl) phenyl)-1*H*-1, 2, 3-triazole derivatives were designed and synthesized as a novel class of α-glucosidase inhibitors. Their structures were determined by spectroscopic analysis and their α-glucosidase inhibitory activities were investigated in *vitro*. Moreover, the molecular docking studies of most active compounds with α-glucosidase inhibitor activities also carried, in order to know the mode of binding interaction and energy of this novel class of compounds.



17.2.22. Cellulose sulfonic acid as a green, efficient, and reusable catalyst for Nazarov cyclization of unactivated dienones and pyrazoline synthesis

A high yielding, eco-friendly and simple procedure for the synthesis of five membered carbo- and heterocycles through cellulose sulfonic acid (CSA) mediated electrocyclization processes has been developed. Cellulose sulfonic acid (CSA) not only was able to induce the cyclization of "unactivated" dienones generating



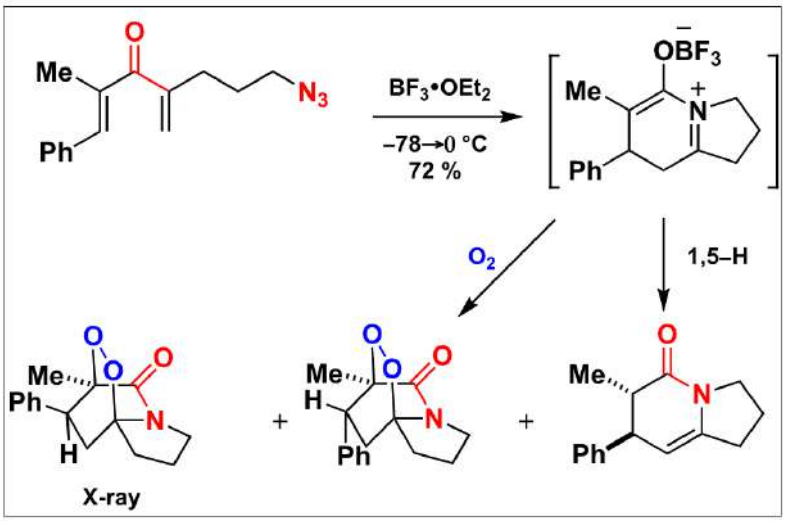
cyclopentenoids; it was also able to trigger the cyclization of α,β-unsaturated hydrazones giving rise to pyrazolines in excellent yields under green reaction conditions. The ease of catalyst recovery and reusability, short reaction time, simple experimental and work-up procedure; compared to the conventional methods, makes this protocol practical, environmentally friendly and economically desirable. The cellulose-SO3H (CSA) was characterized by FT-IR spectroscopy, powder X- ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) analyses, and catalyst stability was judged by Thermogravimetry/Differential Thermal Analysis (TG/DTA). The catalyst can be recycled several times without significant loss of catalytic activity.

17.2.23. Structure activity Relationships for Anion-Responsive Poly(squaramides): Support for an Analyte-Induced Noncovalent Polymer Cross-Linking Mechanism

Poly(squaramides) are a novel class of anion- responsive macromolecules that incorporate the diaminocyclobutened ione hydrogen bond donor group into the polymer backbone. Herein, the synthesis and properties of a series of Fluorene-based poly(squaramides) varying in conformational rigidity, squaramide content, and propensity for aggregation are described. Structure activity relationships for the anion sensory behavior of these polymers (as probed by Fluorescence titrations, dynamic light scattering, confocal Fluorescence microscopy, and transmission electron microscopy) indicate that anion-induced polymer aggregation leads to a cooperative response with enhanced levels of sensitivity and selectivity. These observations are consistent with a mechanism involving noncovalent cross-linking of polymer chains through squaramide anion hydrogen- bonding interactions and point toward new applications of polyamides as stimulus-responsive materials.

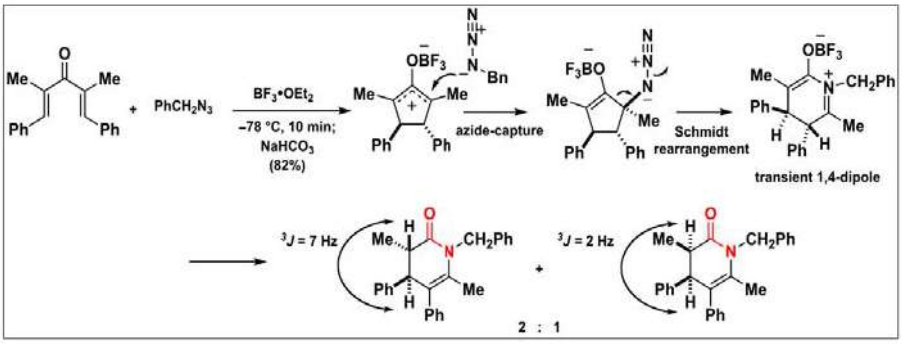
17.2.24. Intramolecular Azide Trapping of the Nazarov Intermediate: Formation of Peroxy-Bridged Indolizidinones via a Deep-Seated Rearrangement and Aerobic Oxidation

Cross-conjugated dienones with pendent azide side chains undergo interrupted Nazarov trapping, leading to peroxy-bridged indolizidinones in good yields. This process is proposed to involve skeletal rearrangement of the initial trapping product, with loss of dinitrogen, to give an intermediate 1,4-betaine, which then undergoes reaction with atmospheric oxygen. The endoperoxide products can be reduced under catalytic hydrogenation conditions to furnish α-hydroxylactams.



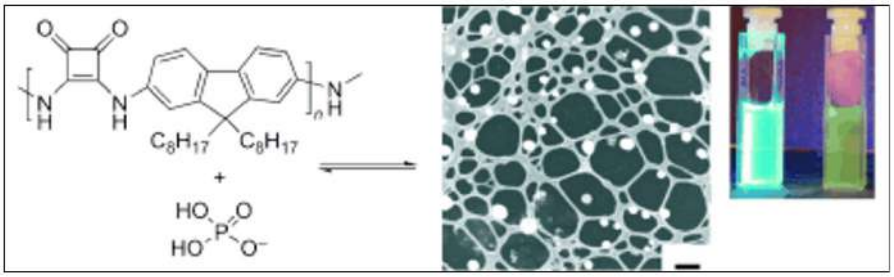
17.2.25. Domino Electrocyclization/Azide-Capture/Schmidt Rearrangement of Dienones: One-Step Synthesis of Dihydropyridones from Simple Building Blocks

Simple 1,4-dien-3-ones undergo Lewis acid-catalyzed Nazarov electrocyclization and intermolecular trapping by various azides to furnish 3,4-dihydropyridin-2-ones in moderate to good yields. The reaction is proposed to proceed via nucleophilic trapping of the 2-oxidocyclopentenyl intermediate, followed by Schmidt-type rearrangement to give a transient 1,4-dipole. In unsymmetrical examples, complete regioselectivity in favor of attack on the less substituted side was observed. The 1,4-dipole intermediate then rearranges to the observed dihydropyridone, via either proton transfer or 1,5-hydride shift.



17.2.26. Anion Detection by a Fluorescent Poly(squaramide): Self-Assembly of Anion-Binding Sites by Polymer Aggregation

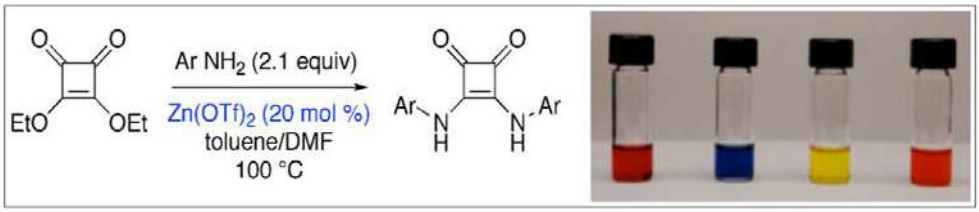
Incorporating an anion-binding squaramide group into a polymeric architecture results in drastic alterations in the selectivity and magnitude of its anion-induced response, resulting in a sensitive and discriminating turn-on fluorescence sensor for dihydrogenphosphate ions. This unusual behavior is the result of a cooperative, anion-triggered aggregation process.



17.2.27. N,N'-Diarylsquaramides: General, High-Yielding Synthesis and Applications in Colorimetric Anion Sensing

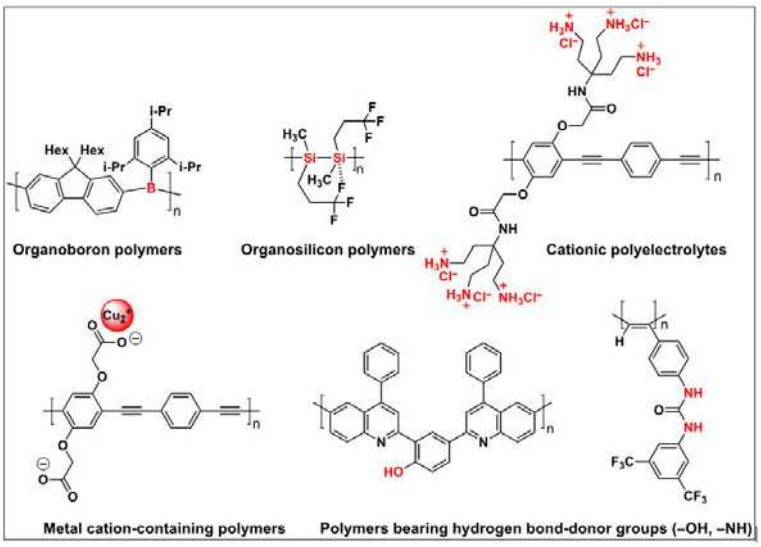
Zinc trifluoromethanesulfonate promotes efficient condensations of anilines with squarate esters, providing access to symmetrical and unsymmetrical squaramides in high yields from readily available starting materials. Efficient access to electron-deficient diaryl squaramides has enabled a systematic investigation of the colorimetric anion-sensing behavior of a p-nitro-substituted squaramide. Its behavior differs in dramatic and unexpected ways from that of structurally similar p-nitroaniline- based ureas, an effect that highlights the remarkable differences in acidity between the squaramide and urea functional groups. Computational

studies illustrating the enhanced hydrogen bond donor ability and acidity of squaramides in comparison to ureas are presented.



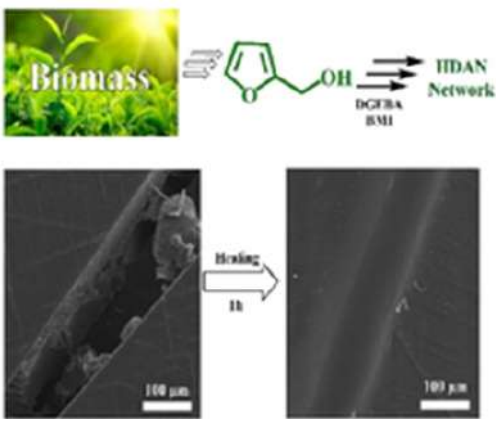
17.2.28. Polymers for Anion Recognition and Sensing

In biological systems, the selective and high-affinity recognition of anionic species is accomplished by macromolecular hosts (anion-binding proteins) that have been "optimized" through evolution. Surprisingly, it is only recently that chemists have systematically attempted to develop anion-responsive synthetic macromolecules for potential applications in medicine, national security, or environmental monitoring. Recent results indicating that unique features of polymeric systems such as signal amplification, multivalency, and cooperative behavior may be exploited productively in the context of anion recognition and sensing are documented. The wide variety of interactions—including Lewis acid/base, ion-pairing, and hydrogen bonding—that have been employed for this purpose is reflected in the structural diversity of anion-responsive macromolecules identified to date.



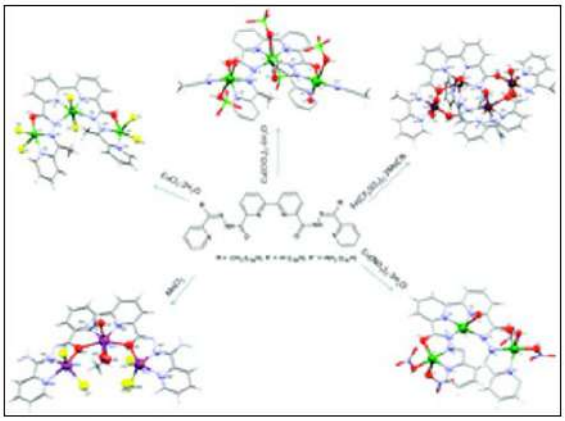
17.2.29. Biobased Diels-Alder Engineered Network from Furfuryl Alcohol and Epoxy Resin: Preparation and Mechano-Physical Characteristics

Diels-Alder chemistry to engineer a novel hybrid epoxy-furan network (HDAN) from DGEBA resin and the fully bio-resourced monomer furfuryl alcohol (FA) have been reported. HDAN network has been shown to have several beneficial properties including thermostability, reusability (re-cyclability), re-mendability and weldability without using additional ingredient such as catalyst, monomer, or special treatment of the surfaces/interfaces/parts to be repaired, welded or patched.



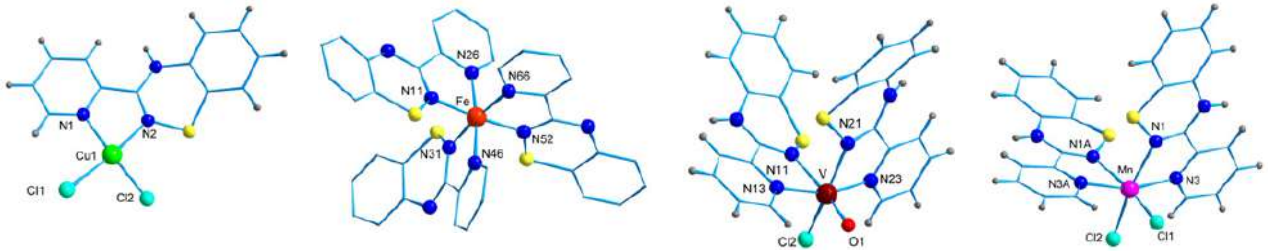
17.2.30. A new nitrogen rich open chain diazine ligand system: synthesis coordination chemistry and magneto-structural studies

A new series of open chain diazine ligands that have a central bipyridne unit with two side-arms offering a range of ketone/alkoxide oxygen donors, diazine and pyridine terminal groups show a strong preference for binding three metals.



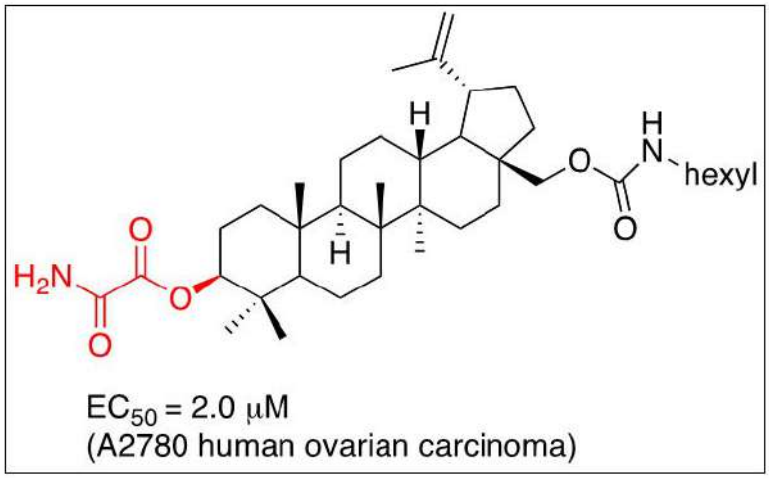
17.2.31. Thiadiazine Coordination Chemistry

The benzothiadiazine heterocycle is known in the S (II), S (IV) and S (VI) oxidation states. The S (VI) thiadiazine ring system is well established and is central to a range of commercial pharmaceuticals ubiquitously referred to as 'thiazide drugs' as diuretics, for the treatment of hypertension inter alia and more recently in osteoporosis. Our recent structural studies revealed that the N(2) atom of the Benzothiadizines ring (adjacent to S) exhibited some basicity as a hydrogen-bond acceptor and the 2-pyridyl derivative act as an N,N′-chelate ligand. We are currently working on developing new N-donor benzothiadiazines derivatives and their reactivity with paramagnetic transition metal ions including Lanthanides.



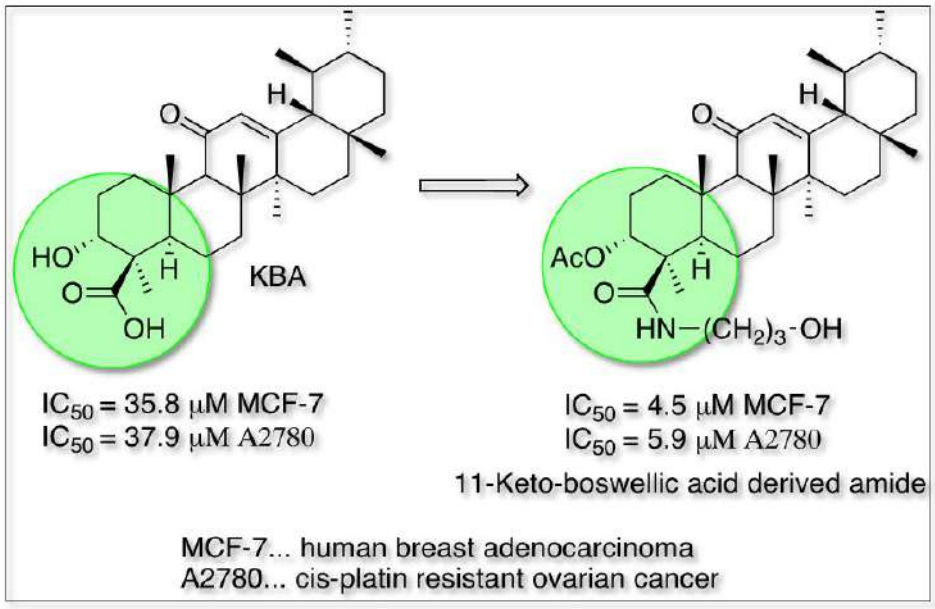
17.2.32. Amino(oxo)acetate moiety: A new functional group to improve the cytotoxicity of betulin derived carbamates

While 3-O-acetylated betulin derivatives carrying a carbamate moiety at position C-28 are of rather low cytotoxicity for human tumor cell lines, the corresponding C-3 amino(oxo) acetates show good cytotoxicity. For example, an EC50 as low as 2.0 µM was found for (3β) 28-{[(hexylamino)carbonyl]oxy}lup-20(29)-en-3-yl amino(oxo)acetate (16) employing the ovarian cancer cell line A2780.



17.2.33. 11-Keto-boswellic acid derived amides and monodesmosidic saponins induce apoptosis in breast and cervical cancers cells

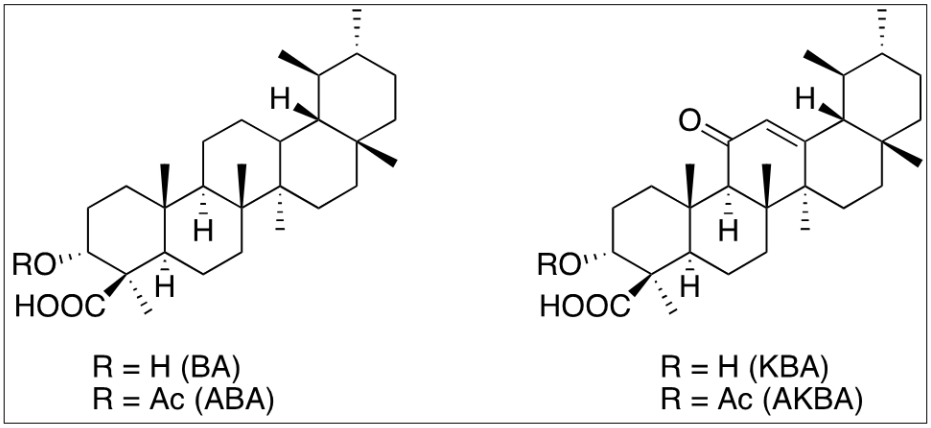
Beta-boswellic acids are considered the main bioactive components of frankincense. Their potential to act as cytotoxic agents, as well as that of their derivatives remained unexploited so far. In this study we were able to prepare derivatives of 11-keto-β-boswellic acid (KBA) that showed lower IC50 values as determined by a sulphorhodamine B (SRB) assay using several different human tumor cell lines. Monodesmosidic saponins of KBA are as cytotoxic as 3-acetyl-KBA. The presence of a free hydroxyl group at position C-3 seems to lower cytotoxicity while the presence of an amide function at C-24 improves cytotoxicity. The most active compound of this series gave IC_{50} values as low as 4.5 μM. Cell death proceeded mainly via apoptosis.



17.2.34. Synthesis and cytotoxic screening of beta-boswellic acid derivatives

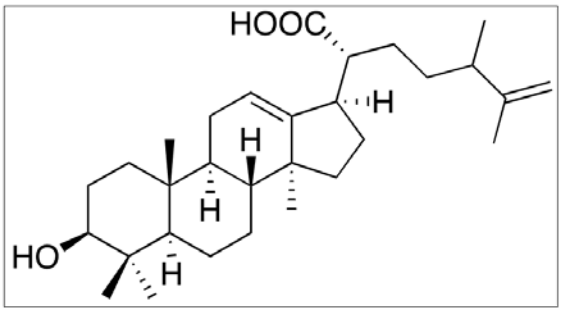
Beta-boswellic acids are triterpenoids being generic to the plants of genus Boswellia. Although they were shown to exhibit different biological activities, the cytotoxic potential of b-boswellic acid derivatives remained by and large unexploited. To expand the potential of these compounds we developed simple procedures for the interconversion of the most important b-boswellic acids and prepared several other derivatives. These

compounds were screened for their cytotoxic activity in sulforhodamine B assays employing several human tumor cell lines and nonmalignant mouse fibroblasts. One of these compounds, a difluoromethylester of 3-*O*-acetyl-11-keto-beta-boswellic acid, was cytotoxic for human breast adenocarcinoma cells MCF-7 (EC_{50} = 6.5 mM) while being significantly less cytotoxic for the mouse fibroblasts.



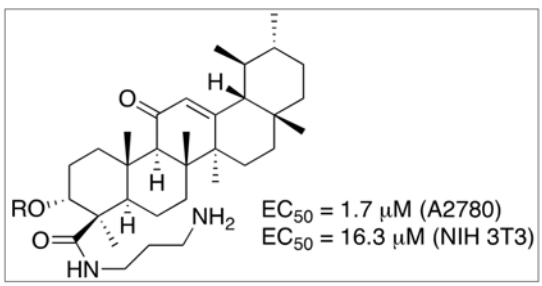
17.2.35. Floccosic Acid, a New Triterpenic Acid from Nepeta floccose

The isolation and structure elucidation of a new triterpenic acid named floccosic acid (1) is reported on the basis of the 1D- and 2D-NMR assignments. This secondary metabolite was isolated as a new constituent, along with the known triterpenoids, betulinic acid and *β*-amyrin. All these compounds were purified by repeated column chromatography of the MeOH extract of *Nepeta floccosa*. The structure elucidation of the new compound was accomplished by the combined mass spectrometry (MS), infrared (IR) and ultraviolet (UV) absorption spectroscopy, one- (^{1}H- and ^{13}C-) and two-dimensional (H-C correlations; HMBC and HSQC) NMR techniques. The known compounds were identified by comparison of their physical and spectroscopic data with those reported in the literature.



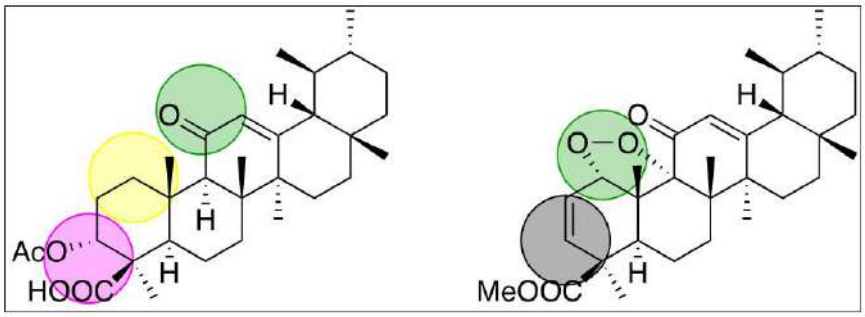
17.2.36. Synthesis and cytotoxic screening of b-11-keto-boswellic acid derivatives modified at C- 24: s

The aim of this study was to prepare 11-keto-b-boswellic acid derivatives modified at C-24 and to evaluate their in *vitro cytotoxicity*.



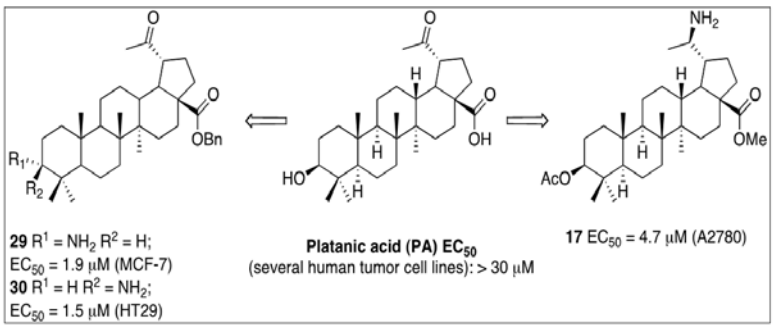
17.2.37. Oxidative and reductive transformations of 11-keto-β-boswellic acid

Extraction of frankincense—a fragrant resin obtained from plants of the genus *Boswellia*—followed by an oxidation furnished high yields of (3β) 3-*O*-acetyl-11-keto-β-boswellic acid (β-AKBA), a valuable starting material for accessing boswellic acid derivatives. Boswellic acids are fascinating triterpenoic acids that exhibit different biological activities. However, their biological potential, as well as that of their derivatives, remained unexploited due to their limited availability. In this study we were able to prepare derivatives of 11-keto-β-boswellic acid in good to excellent yields by oxidative and reductive transformations mainly in rings A and C of the triterpenoid skeleton. Among other transformations, a highly cytotoxic endoperoxide was obtained in excellent yields.



17.2.38. Platanic acid: A new scaffold for the synthesis of cytotoxic agents

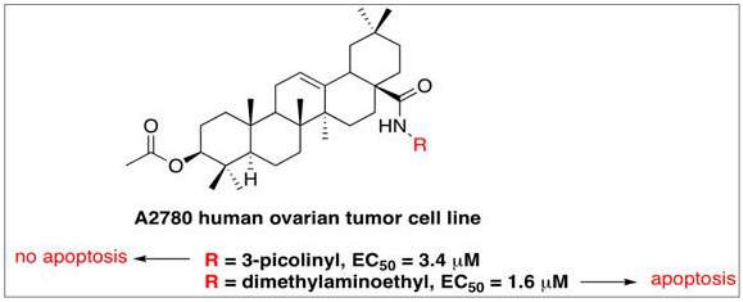
Thirty-seven different derivatives (2-38) have been prepared from platanic acid, a natural occurring triterpenoid. Main emphasis was the introduction of several N-containing functional groups such as amines, amides and oximes and their screening for cytotoxic activity employing several human tumor cell lines using SRB assays. In these SRB assays, nearly all compounds showed good cytotoxicity for these human tumor cell lines. Two compounds (17 and 38), however, were submitted to extended biological testing and investigated with respect to their mode of action using fluorescence microscopy and FACS analysis. Compound 17, a methyl (3β, 20R) 3-acetyloxy-20-amino-30-norlupan-28-oate, induced apoptosis in A2780 ovarian carcinoma cells.



17.2.39. Synthesis and proapoptotic activity of oleanolic acid derived amides

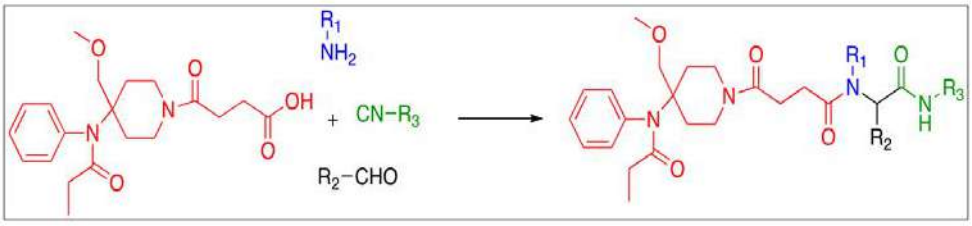
Thirty-one different 3-*O*-acetyl-OA derived amides have been prepared and screened for their cytotoxic activity. In the SRB assays nearly all the carboxamides displayed good cytotoxicity in the low μM range for several human tumor cell lines. Low EC50 values were obtained especially for the picolinylamides 14–16, for a *N*-[2-(dimethylamino)-ethyl] derivative 27 and a *N*-[2-(pyrrolinyl)-ethyl] carboxamide 28. These compounds were submitted to an extensive biological testing and proved compound 15 to act mainly by an

arrest of the tumor cells in the S phase of the cell cycle. Cell death occurred by autophagy while compounds 27 and 28 triggered apoptosis.



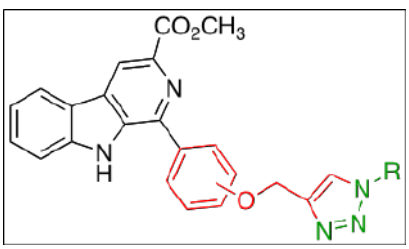
17.2.40. Synthesis of Novel Norsufentanil Analogues via a Four-component Ugi Reaction and in *Vivo*, Docking, and QSAR Studies of their Analgesic Activity

Novel substituted amino acid tethered norsufentanil derivatives were synthesized by the four- component Ugi reaction. Norsufentanil was reacted with succinic anhydride to produce the corresponding carboxylic acid. The resulting carboxylic acid has undergone a multicomponent reaction with different aldehydes, amines, and isocyanides to produce a library of the desired compounds. In all cases, amide bond rotation was observed in the NMR spectra. In vivo analgesic activity of the synthesized compounds was evaluated by a tail flick test. Very encouraging results were obtained for a number of the synthesized products. Some of the synthesized compounds such as 5a, 5b, 5h, 5j and 5r were found to be more potent than sufentanil, sufentanil citrate, and norsufentanil. Binding modes between the compounds and mu and delta opioid receptors were studied by molecular docking method. The relationship between the molecular structural features and the analgesic activity was investigated by a quantitative structure-activity relationship (QSAR) model. The results of the molecular modeling studies and the in vivo analgesic activity suggested that the majority of the synthesized compounds were more potent than sufentanil, and norsufentanil.



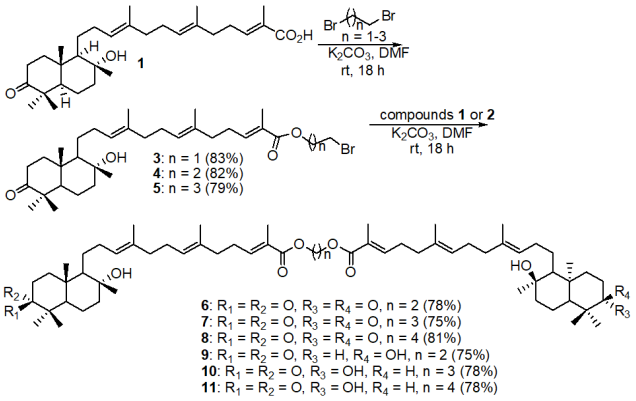
17.2.41. Synthesis of novel 1,2,3-triazole tethered 1,3-disubstituted β-carboline derivatives and their cytotoxic and antibacterial activities

In this paper new β-carboline derivatives possessing the 1,2,3-triazole ring at C-1 substituent were synthesized from L-tryptophan by Pictet–Spengler reaction followed by a Huisgen 1,3-dipolar addition. In vitro cyto- toxicity and antibacterial activity of synthetic compounds were investigated. Methyl 1-(3-((1-(3,4-dichlorophenyl)-1H-1,2,3-triazol-4-yl)methoxy)phenyl)-β-carboline-3-car- boxylate (7f) showed the highest cytotoxic activity with IC50 values of 46 and 32 μM against Hela and HepG2 cell lines, respectively. Compounds 7d and 7i (possessing 4- bromophenyl substituent) and 5c showed excellent inhibition activity for Enterococcus faecium with MIC of 8 μg/ mL. The results demonstrated that the presence of 1,2,3- triazole rings in β-carboline derivatives improve their bio- logical activities.



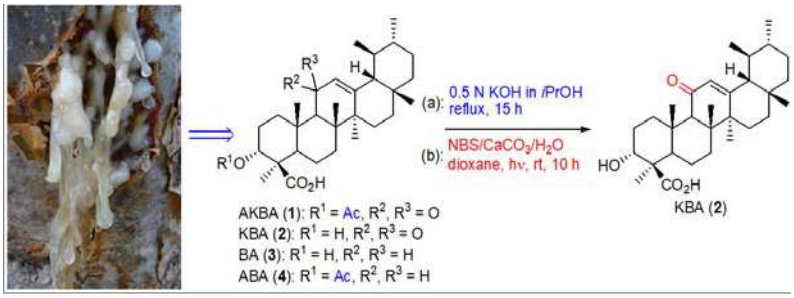
17.2.42. Synthesis of new triterpenic monomers and dimers as potential antiproliferative agents and their molecular docking studies

In the current investigation, new monomers of myrrhanone B and lupeolic acid were prepared via reaction of triterpenic acids with linkers in the presence of K_2CO_3. In addition, new bis-myrrhanone B homodimers, myrrhanone B-myrrhanol B heterodimers, and bis-myrrhanone β-boswellic acids heterodimer were prepared. Evaluation of these compounds on the proliferation of four different human cancer cell lines, viz., FaDu (pharynx carcinoma), A2780 (ovarian carcinoma), HT29 (colon adenocarcinoma) and A375 (malignant melanoma) has been performed. It is worth mentioning that compounds 4, 7, 8, 10, and 11 possess potent antiproliferative effect towards HT29 cancer cells with IC_{50} values of 8.1 mM, 5.4 mM, 8.8 mM, 6.8 mM, and 8.2 mM, respectively. In addition, these compounds display good to moderate antiproliferative activities towards A2780 and A375 with IC_{50} values ranging from 10.4 to 24.2 mM. Moreover, the molecular docking studies of most active compounds (4, 7, 8, 10 and 11) with six anticancer drug targets DHFR, VEGFR2, HER-2/neu, CDK6, hCA-IX and LOX also carried, in order to know the mode of binding interaction and energy of this class of compounds.



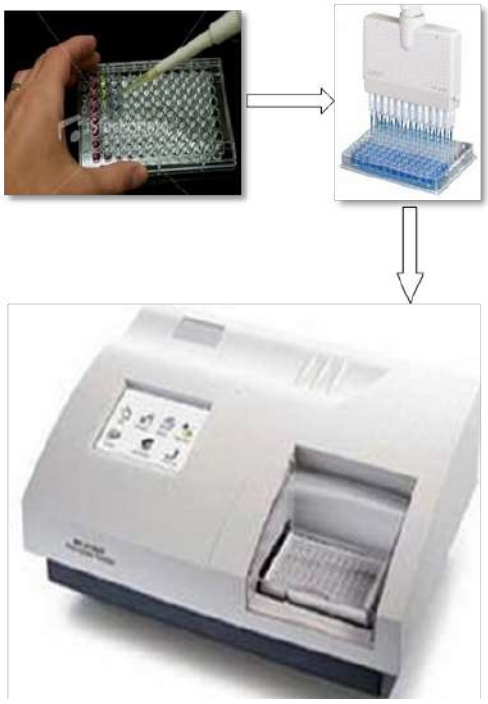
17.2.43. Synthesis of new BOSWELLIC acids as potential antiproliferative agents and their molecular docking studies.

In the current investigation, a series of heterocyclic derivatives of boswellic acids were prepared along with new monomers of acetyl-11-keto-β-boswellic acid (AKBA, 1) and 11-keto-β-boswellic acid (KBA, 2) with three linkers. Furthermore, new bis-AKBA and KBA homodimers, and AKBA-KBA heterodimers were prepared. The effects of these compounds on the proliferation of different human cancer cell lines, viz., FaDu (pharynx carcinoma), A2780 (ovarian carcinoma), HT29 (colon adenocarcinoma), A375 (malignant melanoma) and SW1736 (thyroid carcinoma), have been evaluated. KBA homodimer 21 effectively inhibited the growth of FaDu, A2780, HT29 and A375 cells with EC_{50} values below 9 μM. The same compound was also active against SW1736 cells with an EC_{50} = 11 μM. In addition, compounds 7, 8, 11, 12, 15, 16 and 17 also exhibited antiproliferative effects against A2780, HT29 and A375 cancer cells. In particular, the pyrazine analog 8 demonstrated potent cytotoxic effects against A375 cancer cells with an EC_{50} value of 2.1 μM.



17.3. Computational and Molecular Docking La

17.3.1. Enzyme Inhibition

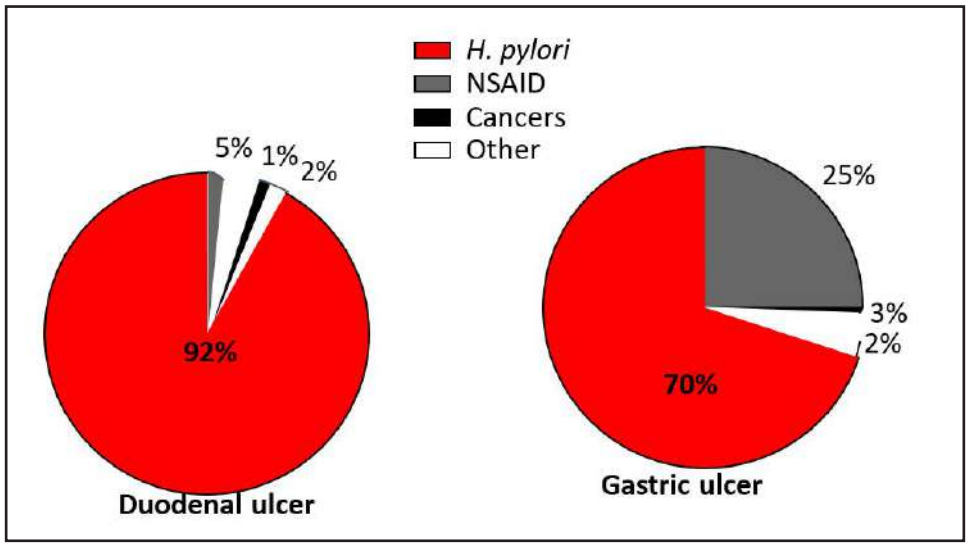


Discovery of inhibitors of clinically relevant enzymes is an important area in drug discovery and development. A large number of synthetic and natural inhibitors have been developed which are now used as drugs against a variety of diseases. Specific inhibitors interact with enzymes and block their activity towards their corresponding natural substrates, thus treating a number of pathological conditions. The binding of inhibitor can be reversible or irreversible. Irreversible inhibitors chemically alter the active site residues of the enzymes by binding covalently, whereas, reversible inhibitors bind through hydrophobic interactions, hydrogen bonding, and ionic bonds. There are four classes of reversible inhibitors: competitive, un-competitive, non-competitive, and mixed-type inhibitors.

Enzymes are important targets for drug discovery. This process involves the use of various mechanism-based biochemical assay of varying throughput. To design, develop and validate robust enzyme inhibition assays, it is critical to have a thorough understanding of the enzyme biochemistry and the kinetics of enzymatic action. Understanding the mechanism of action of the target enzyme is critical in early discovery and development of drug candidates through extensive Structure-Activity Relationship (SAR) studies.

17.3.2. High-throughput biochemical screening of urease

Urease is well known for the pathologies induced by Helicobacter pylori. It plays a crucial role in the pathogenesis of gastric and peptic ulcers as well as cancer by facilitating the survival of H. pylori in the acidic environment of stomach. It is reported that ureases also cause urolithiasis. Urolithiasis infectionis is caused by Yersinia enterocolitica and Proteus mirabilis. The urease is also responsible for the development of infection-induced reactive arthritis and acute pyelonephritis.



The main nitrogenous byproduct of biological system is urea, that quickly metabolized by the action of microorganisms. The urease enzymes are present in a number of fungi, bacteria and plants. Ureases play a vital function in nitrogen cycle as it supply nitrogen for the growth of microorganisms by catalyzing the degradation of urea degradation. In agriculture, the high level of urease activity is associated with several environmental and economical hazards. Globally the urea is commonly used as fertilizer. In agriculture, the high activity of ureolytic bacteria increases the amount of ammonia in the soil *via* rapid degradation of urea. Primarily the plants are damaged due to lack of necessary nutrients and secondly the plants are damaged by the toxicity of ammonia and carbon dioxide which are released from the degradation of urea. During the seed germination process, urease plays a vital role in the metabolism of nitrogen and the urease of many soil microorganisms helps them to obtain nitrogen for their growth. The discovery of effective and safe urease inhibitors have been an important area of pharmaceutical research due to the association of ureases with several pathological and agriculture applications.

17.3.3. High-throughput biochemical screening of α-Glucosidsae

Diabetes is a group of metabolic disorders characterized by the presence of uncontrolled blood glucose levels. Type 2 diabetes mellitus is a metabolic disorder, associated with deficiency of insulin secretion and insulin sensitivity. The defect in insulin functioning results in high blood glucose levels in diabetic patients. The late insulin secretion, right after meal, results in a sudden increase in blood glucose level, known as post-prandial hyperglycemia. The post-prandial plasma glucose level, in diabetic individuals is greater than 200 mg/dL (impaired glucose tolerance). Post-prandial hyperglycemia is a major risk factor for cardiovascular diseases (CVD). It is also related to macro- and micro-vascular diabetic complications. The α-Glucosidase enzymes are located in the brush borders of the enterocytes of the jejunum in the small intestine. They cleave unabsorbed oligo- and disaccharides into monosaccarides, which are absorbed in the upper jejunum, resulting in hyperglycemia. α-Glucosidase inhibitors (AGIs) were developed to reduce the risk of post-prandial hyperglycemia in diabetic individuals. AGIs slow down the digestion process and decrease the post-prandial blood glucose levels by competing with oligoscaaharides for enzyme´s active site and prevent their cleavage to monosaccharides. Acarbose, voglibose and miglitol are currently available AGIs, which are commonly used as oral antidiabetic drugs for the management of hyperglycemia.

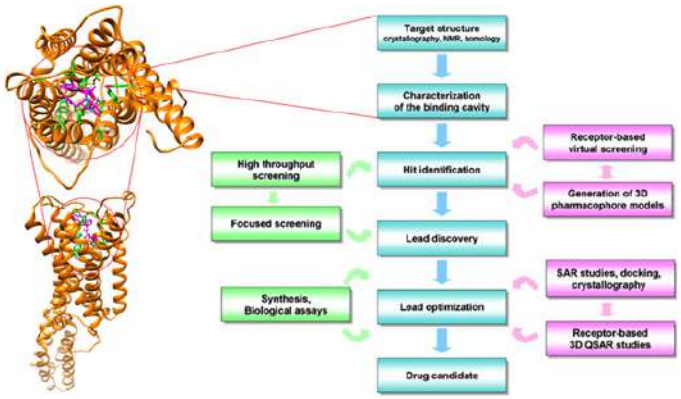
However, these drugs have several gastrointestinal side effects, such as diarrhea, flatulence, and abdominal discomfort. In addition, all three drugs have law efficacy with high IC50 values. With the crucial role of α-glucosidase enzyme in hyperglycemia and the adverse effects of existing drugs, there is a need to discover the safe and effective compounds to effectively control the diabetic disorders due to hyperglycemia.

Antioxidant Assay: Oxidation reactions can produce free radicals. In turn, these radicals can start chain reactions with biological molecules such as lipids, proteins, carbohydrates and others. When the chain reaction occurs in a cell, it can cause damage or death to the cell. Antioxidant molecule can terminate these chain reactions by removing free radical intermediates and inhibit other oxidation reactions.

Lipid peroxidation Inhibition Assay: It refers to the oxidative degradation of lipids. It is a process in which free radicals capture electrons from the lipids in the cell membranes, resulting in cell damage. This process is proceeding by a free radical chain reaction mechanism. If the reaction is not terminated quickly, there will be damage to the cell membrane, which consists mainly of lipids. Phototherapy may cause hemolysis by rupturing the red blood cell and cell membranes in this way.

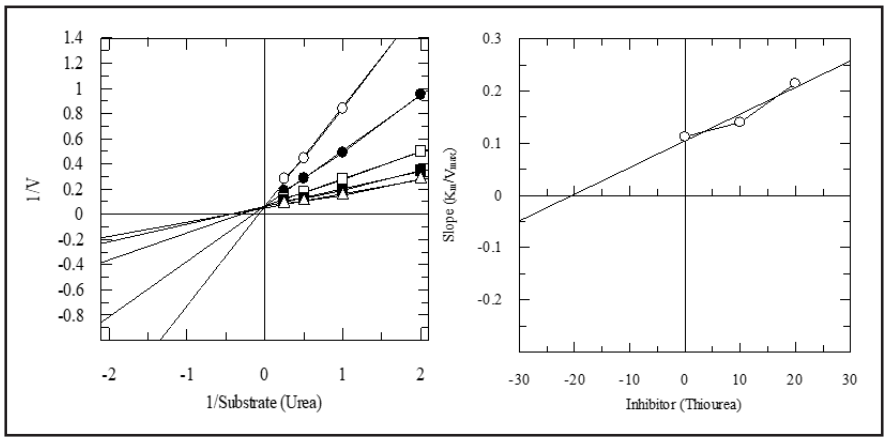
17.3.4. Computational and Molecular Docking

Recent advancement in the field of computational chemistry makes it feasible to study protein-ligand interaction and predict their activities quickly and accurately. Theoretical and computational approaches enhance the reproducibility of protein ligand interactions studies. Instead of using random biochemical screening which consume a lot of time and resources. Computational approach allows us to identify better and potent candidate in a better way for drug development.



17.3.5. Determination of Kinetics Parameters

The inhibitory potential of compounds is represented in IC_{50} value. The IC_{50} value of the compounds represents the concentrations of test compounds that inhibited the hydrolysis of substrate (urea) by 50%. In order to find out the IC_{50} value of the test compounds, various concentrations (from high to low) of the test compounds were evaluated for their inhibitory effect. The line weaver-Burk plot is used to determine the type of inhibition, while Dixon plot and secondary replots are used for the determination of dissociation constants (*Ki*). The *Ki*, K_m, and V_{max} are determined by non-linear regression equation. The *Ki* value is determined from lineweaver-Burk plot. For the calculation of *Ki* values, initially the $1/V_{maxapp}$ values are determined on y-axis of lineweaver-Burk plot at each junction point of lines of every inhibitor concentration. Secondly the slope of the inhibitor at concentration of each line are determined on Lineweaver-Burk plot and re-plotted against the inhibitor concentrations.



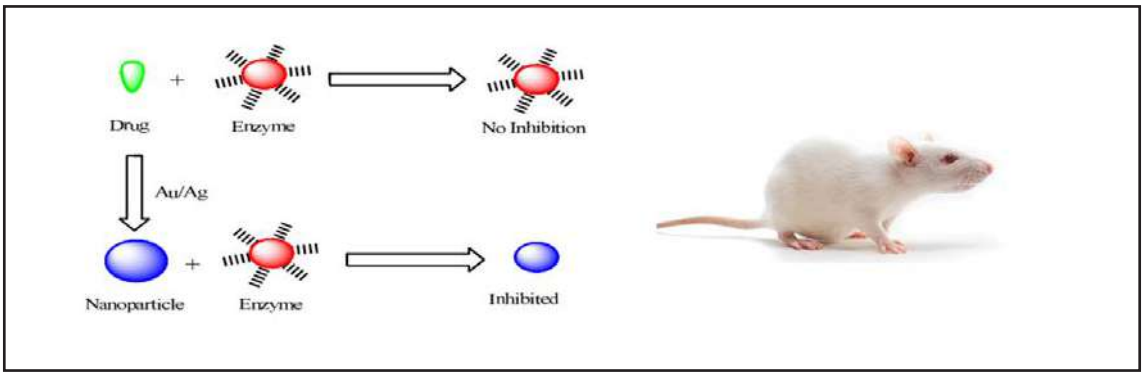
17.3.6. Saturation Transfer Difference (STD) NMR Studies on Selected Inhibitors of Urease Enzyme

Screening of compound libraries is the first step in the drug discovery process in order to identify potential lead molecules, capable of binding with the target macromolecules. STD (Saturation Transfer Difference)-NMR is a robust spectroscopic technique which is used for the screening of inhibitors of biological macromolecules, and epitope mapping. For the determination of binding epitopes of inhibitors of macromolecules, docking is used which is a virtual simulation technique. However, it is not a high-throughput technique and has only a predictive significance. STD-NMR on the other hand is an experimental method, which is widely used for the determination of binding epitopes with nearly 100% certainty.

NMR Spectroscopy is an advance technique, extensively used in the field of drug discovery as a direct tool to detect the small molecule-receptor interactions. NMR as a biophysical screening tool can identify interesting low affinity and low molecular weight compounds that may otherwise be overlooked by conventional mechanism-based biochemical high-throughput assays. The NMR technique has the additional advantage of providing structural information that can be exploited for the transformation of low affinity compounds into novel potent leads. The STD-NMR technique is used for mapping of binding epitopes in a robust and precise manner.

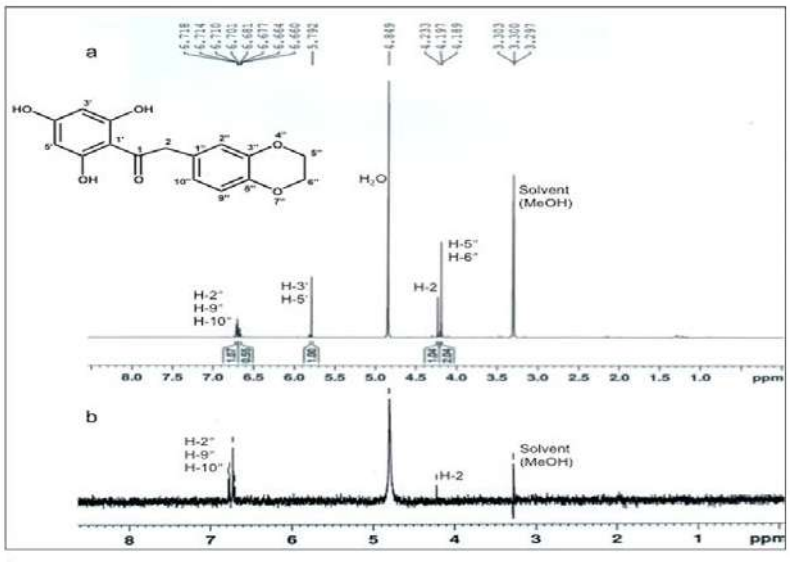
17.3.7. Nanotechnology

The area of nanotechnology emerges out with wide range of applications in electronics, cosmetics, energy, catalysis and medicines. Diverse range of optical, chemical and mechanical properties of nanomaterial is related to its large surface area. It is well known that controlling the particle size at nano scale can help to control surface energy, surface area, and bring specificity in the mode of action of the synthesized material. Nanoparticles alone are unstable because of high surface energy and small size, so they are stabilized with suitable capping agent.



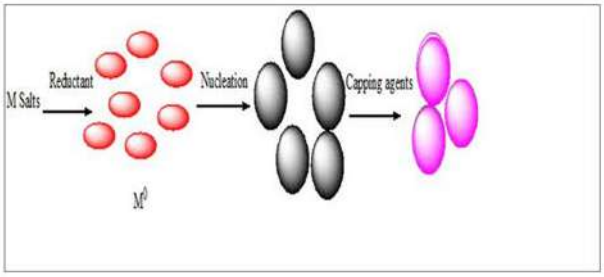
17.3.8. Drug loaded nanoparticles

The nano drugs are proved to be an effective medication in treatment of diverse dreadful diseases like cancer, hepatitis and diabetes. Some of the nano drugs used for such kind of diseases are in trial and some of them are commercially available. Nano medicine offers many possibilities to improve the diagnosis and therapy. Nano medicine can tackle a series of diseases and make therapies more effective and affordable. Pronounced effect of silver nanoparticles was reported against human immune deficiency virus type 1 and hepatitis B virus. Nano silver have similar bactericidal effect against drug resistant and susceptible pathogens and their bactericidal activity is not affected by the structure of cell membrane structure so they will affect gram positive and gram-negative bacteria equally. Efficiency, therapeutic value and specificity of medicinal drugs increase with the formation of nanoparticles. Nano medicines have a lot of advantages like enhancement of absorption into tissues, selectivity in their mode of action and improvement of intracellular tissues.



17.3.9. Plant derived nanoparticles

Plant-mediated nanoparticles have also been screened for antibacterial activity. Silver nanoparticles are good antimicrobial agent and, in some studies, silver-based antimicrobial material was used to achieve a wide spectrum of functionalities. Despite silver nanoparticles, gold nanoparticles were also screened for antibacterial potential. The green chemistry synthesis of nanoparticles, using plant is well document process. The added advantage of using plant extracts that it simultaneously acts as a reducing, capping and stabilizing agent.

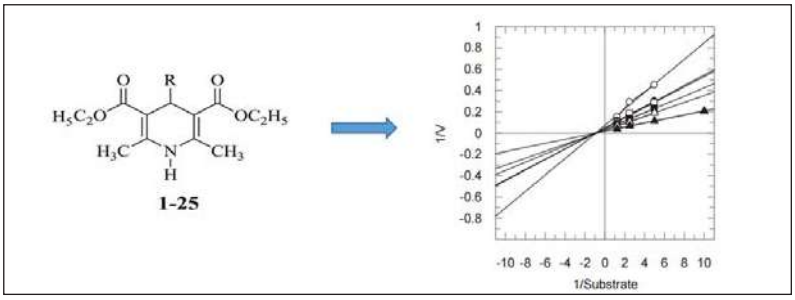


17.3.10. Discovery of Natural Products and Synthetic α-Glucosidase for the Management of Diabetes Mellitus and Late Diabetic

In this area we are interested to conduct studies on type-2 diabetes mellitus and late diabetic complications at molecular level and to identify potential natural products and synthetic lead molecules to inhibit these biological disorders. It includes discovery of new antagonists of glucagon receptor, α-glucosidase and DPP-4 enzyme inhibitors by establishing standard bio-assays and evaluation of natural products and synthetic compounds against these bio-assays. It also includes identification of oxidative stress inhibitors (antioxidants) and antiglycation agents for the management of diabetes and late diabetic complications. We are also interested to find out the mechanism of action of new potent inhibitors and to establish structure-activity relationship studies.

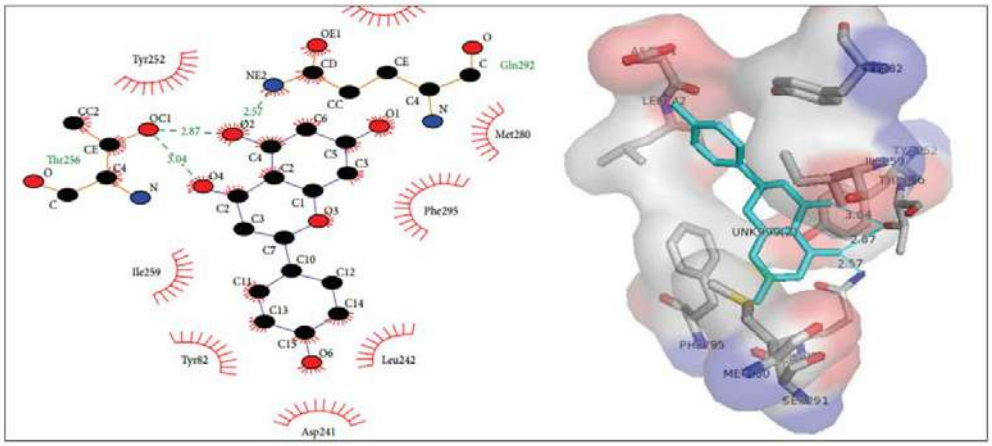
17.3.11. Synthesis of diethyl 4-substituted-2,6-dimethyl-1,4-dihydropyridine-3,5-dicarboxylates as a new series of inhibitors against yeast α-glucosidase

1,4-Dihydropyridine-3,5-dicarboxylate derivatives (1–25) were synthesized in high yields via Hantzsch reaction and evaluated for their α-glucosidase inhibitory activity. Compounds 1, 2, 6–8, 11, 13–15, and 23–25 showed a potent inhibitory activity against yeast α-glucosidase with IC50 values in the range of 35.0–273.7 μM, when compared with the standard drug acarbose (IC_{50} = 937 ± 1.60 μM). Their structures were characterized by different spectroscopic techniques. The kinetics, selectivity, and toxicity studies on these compounds were also carried out. The kinetic studies on most active compounds 14 and 25 determined their modes of inhibition and dissociation constants K_i. Compound 14 was found to be a non-competitive inhibitor with K_i = 25.0 ± 0.06, while compound 25 was identified as a competitive inhibitor with K_i = 66.0 ± 0.07 μM.



17.3.12. Phosphodiesterase-1 Inhibitory Activity of Two Flavonoids Isolated from Pistacia integerrima J. L. Stewart Galls

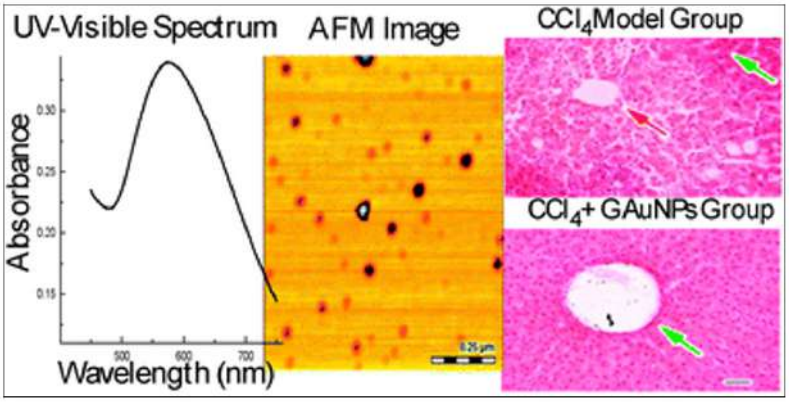
Pistacia integerrima is one of twenty species among the genus Pistacia. Long horn-shaped galls that develop on this plant are harvested and used in Ayurveda and Indian traditional medicine to make “karkatshringi”, an herbal medicine used for the treatment of asthma and different disorders of respiratory tract. However, until now, the molecular mechanisms of action of “karkatshringi” and its chemical characterization are partially known. This study deals with the isolation and characterization of the active constituents from the methanolic extract of P. integerrima galls and it was also oriented to evaluate in vitro and in silico their potential enzymatic inhibitory activity against phosphodiesterase-1 (PDE1), a well-known enzyme involved in airway smooth muscle activity and airway inflammation. Our results showed that the methanolic extract of P. integerrima galls and some of its active constituents [naringenin (1) and 3,5,7,4′-tetrahydroxy-flavanone (2)] are able in vitro to inhibit PDE1 activity (59.20 ± 4.95%, 75.90 ± 5.90%, and 65.25 ± 5.25%, resp.) and demonstrate in silico an interesting interaction with this enzymatic site. Taken together, our results add new knowledge of chemical constituents responsible for the biological activity of P. integerrima and contextually legitimate the use of this plant in folk medicine.



17.3.12. Phosphodiesterase-1 Inhibitory Activity of Two Flavonoids Isolated from Pistacia integerrima J. L. Stewart Galls

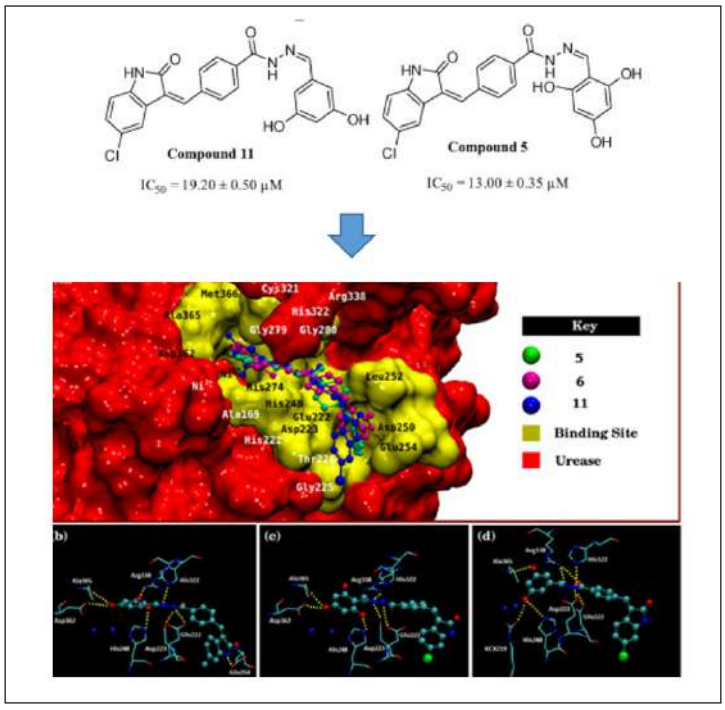
A robust synthetic method is reported for the synthesis of highly stable, poly disperse and spherical gold nanoparticles conjugated to an aqueous garlic extract (G-AuNPs). An ionic solution of gold was mixed and stirred with a dilute aqueous garlic extract at room temperature for 4 hours. The G-AuNPs were characterized by UV-Visible spectroscopy. The morphology and size of the G-AuNPs were determined by atomic force microscopy. FTIR spectroscopy revealed that secondary metabolites present in the garlic extract worked as capping agents around the gold nanoparticles. The G-AuNPs were quite stable even at

higher temperature or with salt concentrations up to 10 mM or with various pH ranging from 4 to 11. Two different model systems were tested for evaluating the biological roles of G-AuNPs. They showed excellent hepatoprotective activity in a CCl_4-induced acute hepatic injury model which was better than the positive control, silymarin. They also showed urease inhibitory activity with an IC_{50} value of 180.61 ± 1.06 µg mL^{-1}. Therefore, the G-AuNPs can be useful in the treatment of diseases caused by injury or inflammation.



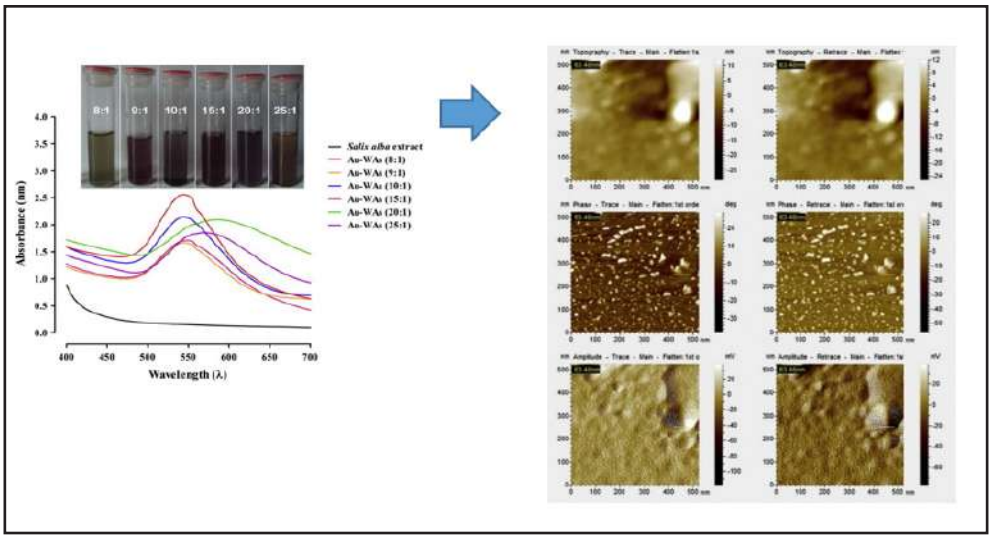
17.3.14. Synthesis of novel derivatives of oxindole, their urease inhibition and molecular docking studies

We synthesized a series of novel 5–24 derivatives of oxindole. The synthesis started from 5-chlorooxindole, which was condensed with methyl 4-carboxybezoate and result in the formation of benzolyester derivatives of oxindole which was then treated with hydrazine hydrate. The oxindole benzoylhydrazide was treated with aryl acetophenones and aldehydes to get target compounds 5–24. The synthesized compounds were evaluated for urease inhibition; the compound 5(IC_{50} = 13.00 ± 0.35 µM) and 11 (IC_{50} = 19.20 ± 0.50 µM) showed potent activity as compared to the standard drug thiourea (IC_{50} = 21.00 ± 0.01 µM). Other compounds showed moderate to weak activity. All synthetic compounds were characterized by different spectroscopic techniques including ^{1}H NMR, ^{13}C NMR, IR and EI MS. The molecular interactions of the active compounds within the binding site of urease enzyme were studied through molecular docking simulations.



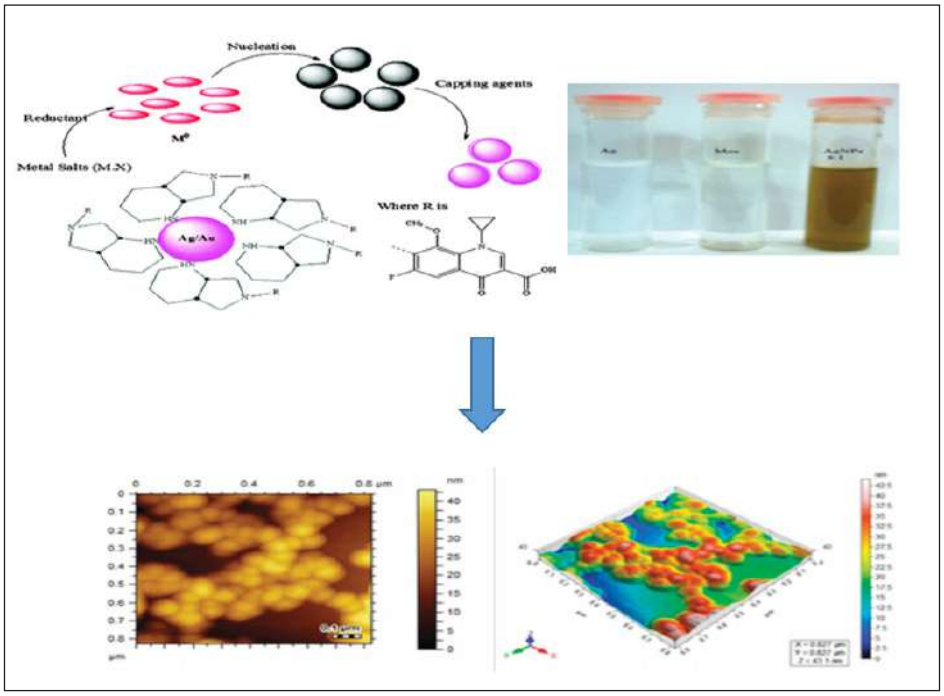
17.3.15. Green synthesis and biological activities of gold nanoparticles functionalized with Salix alba

This study reports a facile and reproducible green extracellular synthetic route of highly stable gold nanoparticles. The aqueous gold ions when exposed to *Salix alba*. Leaves extract were bioreduced and resulted in the biosynthesis of gold nanoparticles (Au-WAs). The nanoparticles were characterized by UV–Visible spectroscopy (UV–Vis), Fourier transform infrared spectroscopy (FTIR), atomic force microscopy (AFM) and scanning electron microscopy (SEM). Their stability was evaluated against varying volumes of pH and sodium chloride as well as at elevated temperature along with enzymes inhibition, antibacterial, antifungal, anti-nociceptive, muscle relaxant and sedative activities. The UV–Vis spectra of the gold nanoparticles gave surface Plasmon resonance at 540 nm while the AFM and SEM nanoparticles analyses revealed the particle size of 63 nm and 50–80 nm respectively. FTIR spectra confirmed the involvement of amines, amide and aromatic groups in capping and reduction of the gold nanoparticles. Au-WAs showed remarkable stability in different volumes of salt and various pH solutions however, Au-WAs were relatively unstable at elevated temperature. Au-WAs possessed good antifungal activity and showed significant antinociceptive and muscle relaxant properties. These results revealed that the leaves extract of *S. alba* is a very good bio-reductant for the synthesis of gold nanoparticles that have potential for various biomedical and pharmaceutical applications.

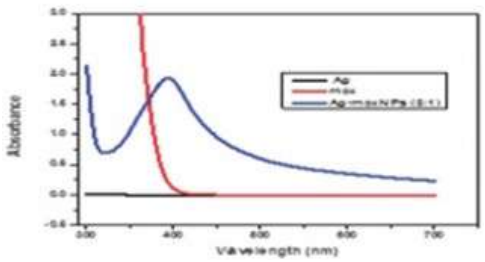


17.3.16. Moxifloxacin-capped noble metal nanoparticles as potential urease inhibitors

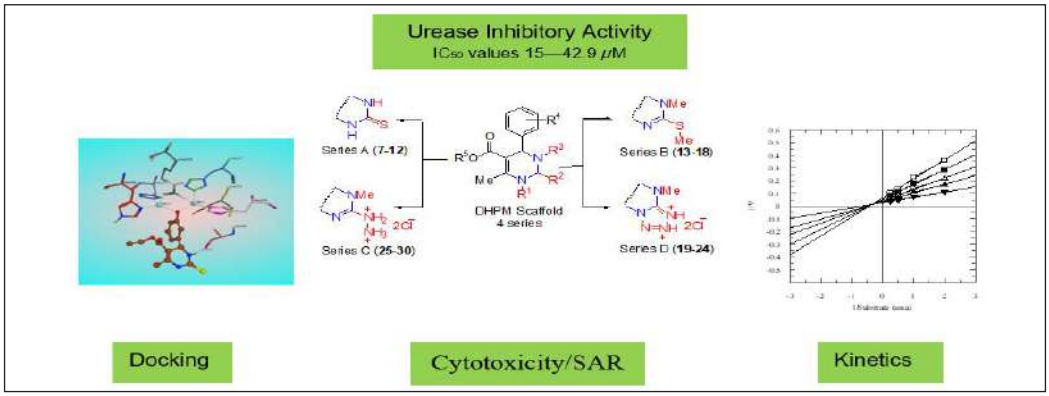
Silver–moxifloxacin (Ag–Mox) and gold–moxifloxacin (Au–Mox) nanoparticles were successfully synthesized by a rapid and convenient method, which exhibited good stability against variations in NaCl solution, pH and temperature. The structural features of these nanoparticles were ascertained by UV-Vis, AFM, FTIR, SEM and EDX techniques while EDX analysis revealed the inorganic composition of the synthesized moxifloxacin-capped Ag and Au NPs. Similarly, the stability of the nanoparticle complex may be attributed to the binding of the amino group to the silver and gold surface, respectively. Silver–moxifloxacin nanoparticles (Ag–Mox) exhibited significant urease enzyme inhibitory activity (0.66 ± 0.042 μg mL^{-1}) even 250 times better compared to moxifloxacin (183.25 ± 2.06 μg mL^{-1}). On the contrary, gold nanoparticles (Au–Mox) remained inactive to the same enzyme. Antibacterial assay was also carried out for the parent compound as well as its noble metal nano-conjugates, which gave encouraging results.



17.3.17. Dihdropyrimidine Based Hydrazine Dihydrochloride Derivatives as Potent Urease Inhibitors

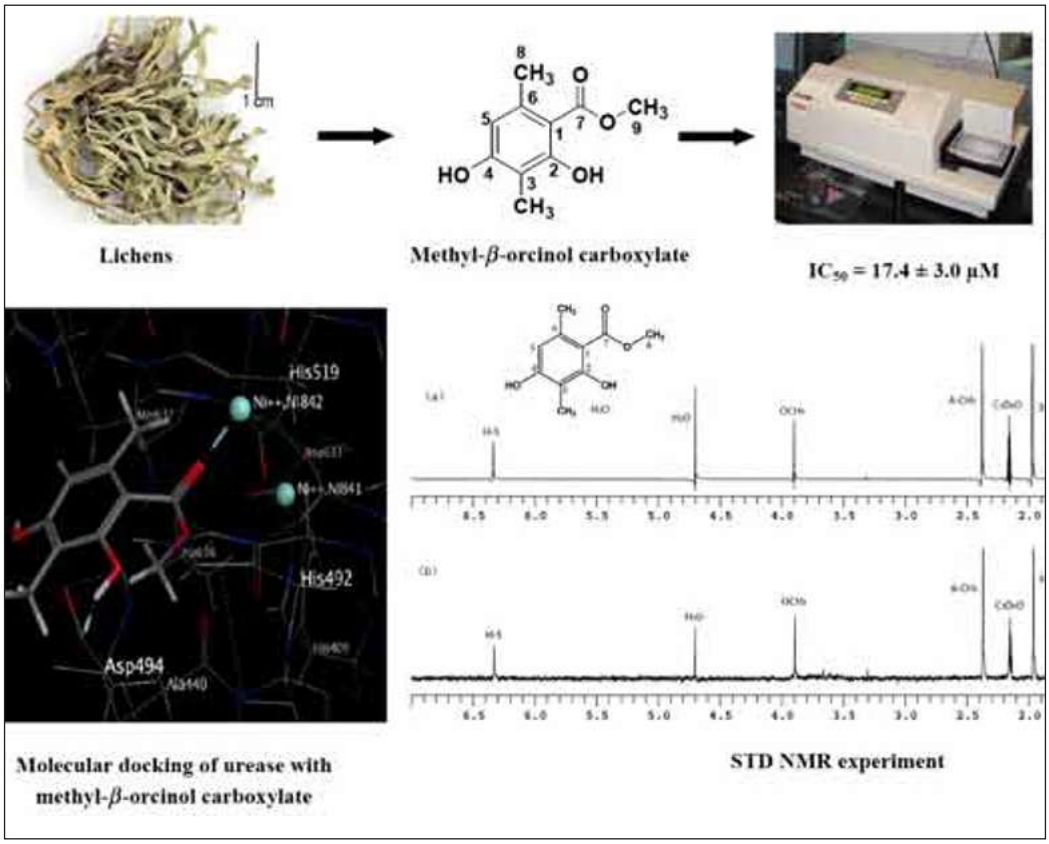


Four series of heterocyclic compounds 4-dihydropyrimidine-2-thiones 7–12 (series A), *N,S*-dimethyl-dihydropyrimidines 13–18 (series B), hydrazine derivatives of dihydropyrimidine 19–24 (series C), and tetrazolo dihydropyrimidine derivatives 25–30(series D), were synthesized and evaluated for in vitro urease inhibitory activity. The series B–D were first time examined for urease inhibition. Series A and C were found to be significantly active with IC_{50} values between 34.7–42.9 and 15.0–26.0 µM, respectively. The structure–activity relationship showed that the free S atom and hydrazine moiety are the key pharmacophores against urease enzyme. The kinetic studies of the active series A (7–12) and C (19–24) were carried out to determine their modes of inhibition and dissociation constants K_i. Compounds of series A (7–12) and series C (19–24) showed a mixed-type of inhibition with K_i values ranging between 15.76–25.66 and 14.63–29.42 µM, respectively. The molecular docking results showed that all the active compounds of both series have significant binding interactions with the active sites specially Ni-ion of the urease enzyme. Cytotoxicity of all series A–D was also evaluated against mammalian mouse fibroblast 3T3 cell lines, and no toxicity was observed in cellular model.



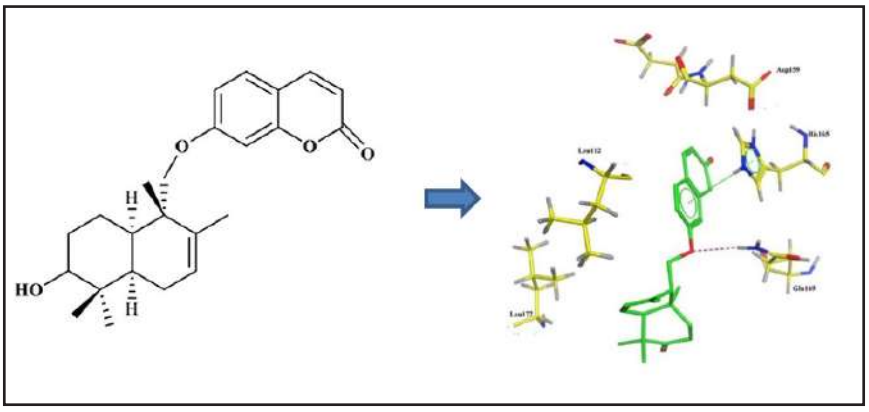
17.3.18. Study of Binding Epitopes by STD-NMR Spectroscopy and Molecular Docking of Urease Inhibitors from Lichens

Lichen polyketides (1−14), isolated from Roccella montagnei and Parmotrema cooperi were evaluated for their urease inhibitory potential. Compound 5 (methyl-β-orcinol carboxylate) was found to be the most potent inhibitor among the series with the IC_{50} = 17.4 ± 3.0 μM, as compared to the standard thiourea (IC_{50}= 21.0±0.1 μM). SAR studies revealed that mononuclear polyketidesare more potent inhibitors as compared to depsides, diphenylethers, and dibenzofurans. Saturation transfer difference (STD) NMR experiments were used to identify the structural features responsible for the inhibition of urease enzyme at the atomic levels. STD-NMR technique revealed that aromatic moiety and methyl protons of the compound 5 are involved in interactions with the receptor protein. Since C-8 and C-10 methyl protons received the maximum saturation from the receptor protein, this indicated their close proximity to the protein. Weak STDNMR signals for lecanoric acid (8) could be attributed to its larger size. Molecular docking studies predicted that carboxylic moieties of these polyketides act as anchors to bind with the bimetallic active site of the urease enzyme.



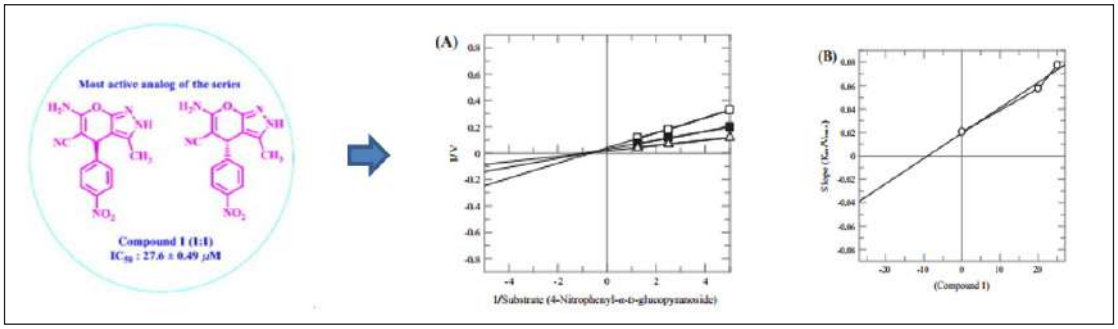
17.3.19. Bioassay-Guided Isolation of Sesquiterpene Coumarins from Ferula narthex Bioss: A New Anticancer Agent

The main objective of cancer management with chemotherapy (anticancer drugs) is to kill the neoplastic (cancerous) cell instead of a normal healthy cell. The bioassay-guided isolation of two new sesquiterpene coumarins (compounds 1 and 2) have been carried out from Ferula narthex collected from Chitral, locally known as "Raw." Anticancer activity of crude and all fractions have been carried out to prevent carcinogenesis by using MTT assay. The n-hexane fraction showed good activity with an IC_{50} value of 5.434 ± 0.249 µg/mL, followed by crude MeFn extract 7.317 ± 0.535 µg/mL, and CHCl3 fraction 9.613 ± 0.548 µg/mL. Compounds 1 and 2 were isolated from chloroform fraction. Among tested pure compounds, compound 1 showed good anticancer activity with IC_{50} value of 14.074 ± 0.414 µg/mL. PASS (Prediction of Activity Spectra) analysis of the compound 1 was carried out, in order to predict their binding probability with anti-cancer target. As a results the compound 1 showed binding probability with human histone acetyltransferase with Pa (probability to be active) value of 0.303. The compound 1 was docked against human histone acetyltransferase (anti-cancer drug target) by using molecular docking simulations. Molecular docking results showed that compound 1 accommodate well in the anti-cancer drug target. Moreover the activity support cancer chemo preventive activity of different compounds isolated from the genus Ferula, in accordance with the previously reported anticancer activities of the genus.



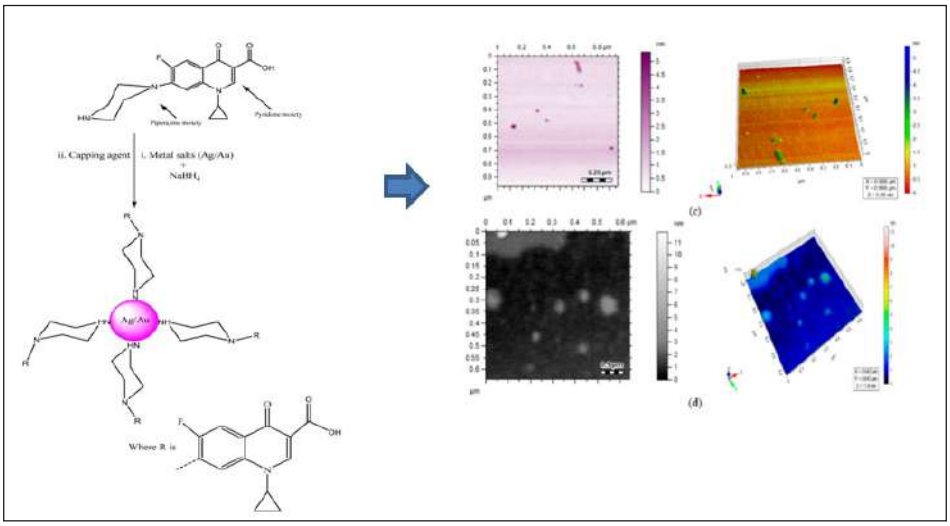
17.3.20. Dihydropyrano [2,3-c] pyrazole: Novel in vitro inhibitors of yeast α-glucosidase

Inhibition of α-glucosidase enzyme activity is a reliable approach towards controlling post-prandial hyperglycemia associated risk factors. During the current study, a series of dihydropyrano[2,3-c] pyrazoles (1–35) were synthesized and evaluated for their α-glucosidase inhibitory activity. Compounds 1, 4, 22, 30, and 33 were found to be the potent inhibitors of the yeast α-glucosidase enzyme. Mechanistic studies on most potent compounds revealed that 1, 4, and 30 were non-competitive inhibitors (K_i = 9.75 ± 0.07, 46 ± 0.0001, and 69.16 ± 0.01 µM, respectively), compound 22 is a competitive inhibitor (Ki = 190 ± 0.016 µM), while 33 was an uncompetitive inhibitor (K_i = 45 ± 0.0014 µM) of the enzyme. Finally, the cytotoxicity of potent compounds (i.e. compounds 1, 4, 22, 30, and 33) was also evaluated against mouse fibroblast 3T3 cell line assay, and no toxicity was observed. This study identifies non-cytotoxic novel inhibitors of α-glucosidase enzyme for further investigation as anti-diabetic agents.



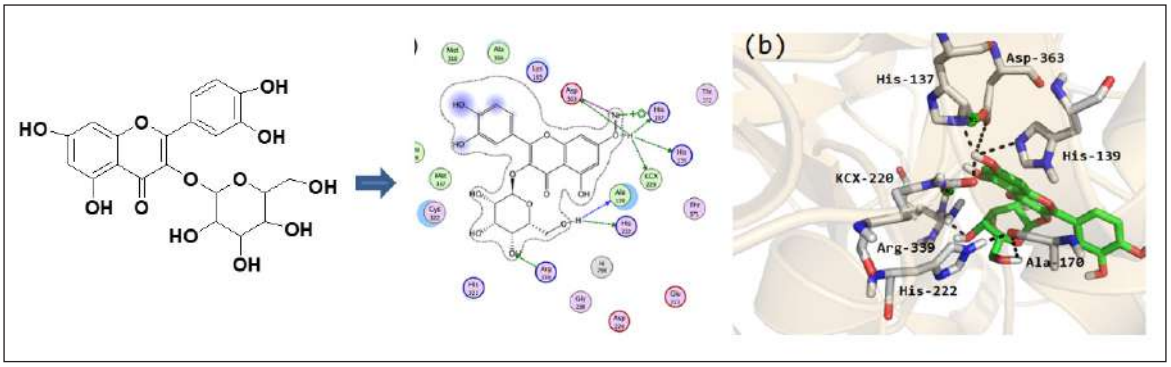
17.3.21. Robust Synthesis of Ciprofloxacin-Capped Metallic Nanoparticles and Their Urease Inhibitory Assay

The fluoroquinolone antibacterial drug ciprofloxacin (cip) has been used to cap metallic (silver and gold) nanoparticles by a robust one pot synthetic method under optimized conditions, using $NaBH_4$ as a mild reducing agent. Metallic nanoparticles (MNPs) showed constancy against variations in pH, table salt (NaCl) solution, and heat. Capping with metal ions (Ag/Au-cip) has significant implications for the solubility, pharmacokinetics and bioavailability of fluoroquinolone molecules. The metallic nanoparticles were characterized by several techniques such as ultraviolet visible spectroscopy (UV), atomic force microscopy (AFM), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and energy dispersive X-ray (EDX) methods. The nanoparticles synthesized using silver and gold were subjected to energy dispersive X-ray tests in order to show their metallic composition. The NH moiety of the piperazine group capped the Ag/Au surfaces, as revealed by spectroscopic studies. The synthesized nanoparticles were also assessed for urease inhibition potential. Fascinatingly, both Ag-cip and Au-cip NPs exhibited significant urease enzyme inhibitory potential, with IC_{50} = 1.181 ± 0.02 µg/mL and 52.55 ± 2.3 µg/mL, compared to ciprofloxacin (IC_{50} = 82.95 ± 1.62 µg/mL). MNPs also exhibited significant antibacterial activity against selected bacterial strains.



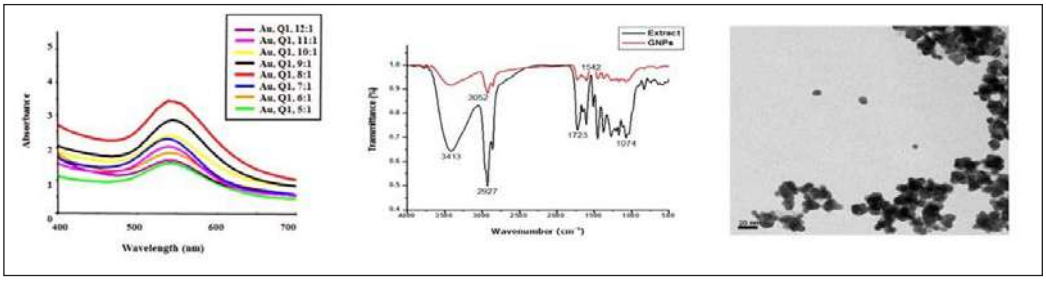
17.3.22. Bioassay- guided Isolation of New Urease Inhibitory Constituents from Monotheca buxifolia (Falc.) Fruit and Their Molecular Docking Studies

The aim of the study is to explore the inhibitory potential of extract/fractions, and compounds of Monotheca buxifolia fruit against urease enzyme. Crude hydro-ethanolic extract showed a mild inhibitory activity against urease, among fractions ethylacetate fraction was more active followed by n-butanol fraction while there was no inhibitory activity in n-hexane soluble fraction. Ethylacetate fraction was subjected to activity guided isolation yielding four pure compounds, among them two were new i.e. buxifoline-A (1) (First time isolated from natural sources) and buxilide (2) while the other two were first time isolated from the fruit that are isoquercetin (3) and oleanolic acid (4). Their structures were elucidated using spectroscopic and spectrometric techniques. Among the isolated compounds compound 3 showed maximum inhibition. In order to understand the binding interactions of the compound 3, it was docked into the active site of urease enzyme. Our study validates the traditional use of the fruit in the treatment of gastritis and urinary tract infections, which is strongly supported by the isolated compound isoquercetin (3).



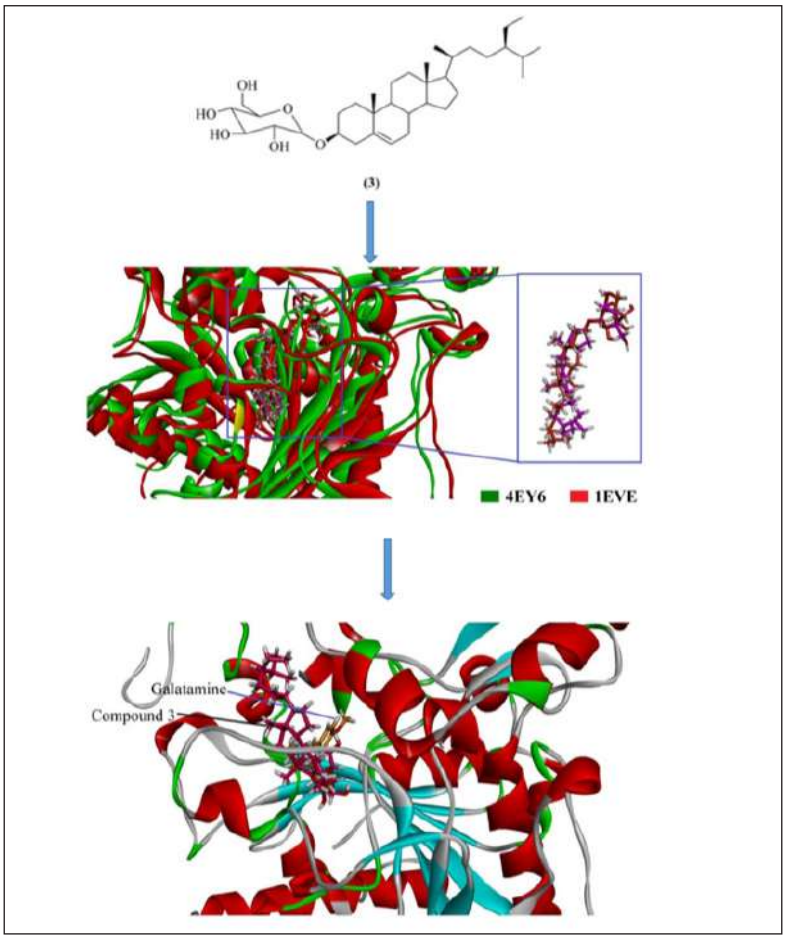
17.3.23. Rapid Synthesis of Gold Nanoparticles from Quercus incana and Their Antimicrobial Potential against Human Pathogens

In current study, bioreduction of tetrachloroauric acid ($HAuCl_4 \cdot 3H_2O$) was carried out using leaves extract of *Quercus incana* for nanoparticle synthesis. The nanoparticles were characterized by ultraviolet visible spectrum (UV), Fourier-transform infrared (FT-IR), and transmission electron microscopy (TEM) analysis. The gold nanoparticles (GNPs) were generally clumpy agglomerates of polydispersed particles, with an average size in the range 5.5–10 nm. The Gas chromatography–mass spectrometry (GC–MS) qualitative analysis and FT-IR data supported the presence of bioactive compounds, which are responsible for the metal reduction and nanoparticles stabilization. The biocompatibility of synthesized GNPs was evaluated via antibacterial activity by using human bacterial pathogens. The results showed that synthesized GNPs showed enhanced antibacterial activity against all bacterial pathogens.



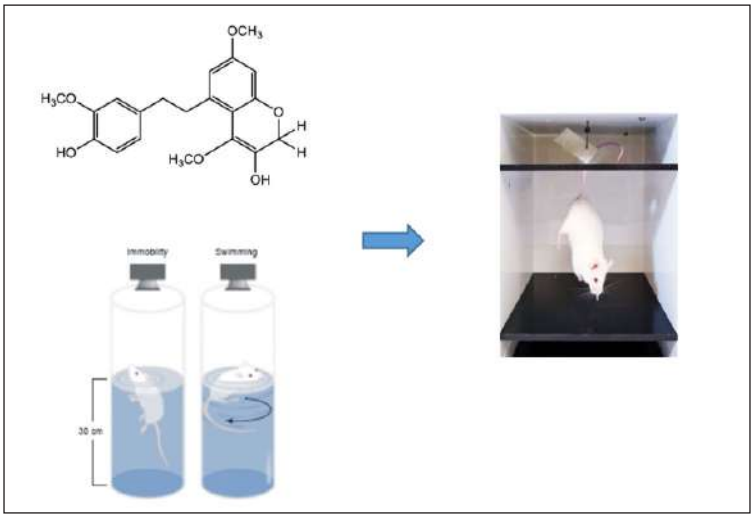
17.3.24. Neurologically Potent Molecules from Crataegus oxyacantha; Isolation, Anticholinesterase Inhibition, and Molecular Docking

Crataegus oxyacantha is an important herbal supplement and famous for its antioxidant potential. The antioxidant in combination with anticholinesterase activity can be considered as an important target in the management of Alzheimer's disease. The compounds isolated from *C. oxyacantha* were evaluated for cholinesterases inhibitory activity using Ellman's assay with Galantamine as standard drug. Total of nine (1–9) compounds were isolated. Compounds 1 and 2 were isolated for the first time from natural source. Important natural products like β-Sitosterol-3-*O*-β-D-Glucopyranoside (3), lupeol (4), β-sitosterol (5), betulin (6), betulinic acid (7), oleanolic acid (8), and chrysin (9) have also been isolated from *C. oxyacantha.* Overall, all the compounds exhibited an overwhelming acetylcholinesterase (AChE) inhibition potential in the range 5.22–44.47 µM. The compound 3 was prominent AChE inhibitor with IC_{50} value of 5.22 µM. Likewise, all the compounds were also potent in butyrylcholinesterase (BChE) inhibitions with IC_{50}s of up to 0.55–15.36 µM. All the compounds, except 3, were selective toward BChE. Mechanism of the inhibition of both the enzymes were further studied by docking procedures using Genetic Optimization for Ligand Docking suit v5.4.1. Furthermore, computational blood brain barrier prediction of the isolated compounds suggests that these are BBB+.



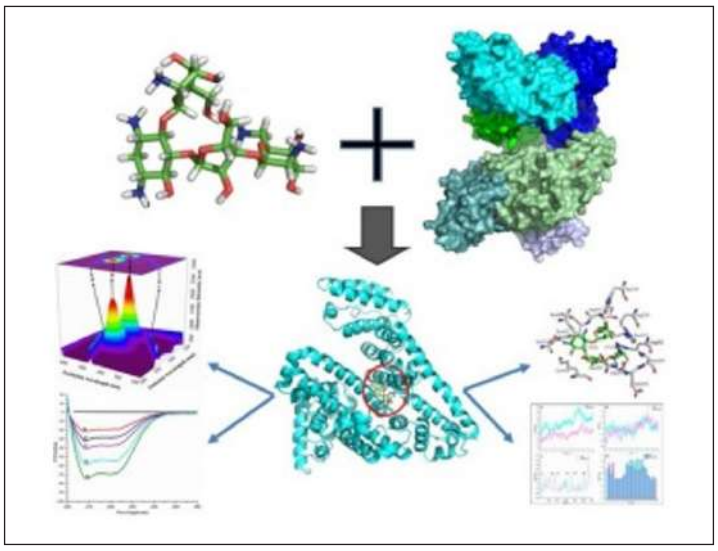
17.3.25. Antidepressant Effect of Two New Benzyl Derivatives from Wild Strawberry Fragaria vescavar. nubicola Lindl. ex Hook.f.

Two new benzyl derivatives were isolated from ethyl acetate fraction of wild strawberry, *Fragaria vescavar. nubicola* Lindl. ex Hook.f. The structures of these compounds were elucidated to be 5-(4-hydroxy-3-methoxyphenethyl)-7-methoxy-2H-chromen-3-ol (1) and 5-(4-hydroxy-3-methoxyphenethyl)-4,7-dimethoxy-2H-chromen-3-ol (2) based on spectroscopic data through IR, UV, ^{1}H-NMR, ^{13}C-NMR along with two dimensional (2D) techniques HMBC, HMQC, and COSY. Both compounds 1 and 2 were studied in tail suspension and forced swim tests for antidepressant like effects. A significant dose dependent antidepressant like effect was observed by causing spontaneous anti-immobility at various test doses upon intraperitoneal administration.



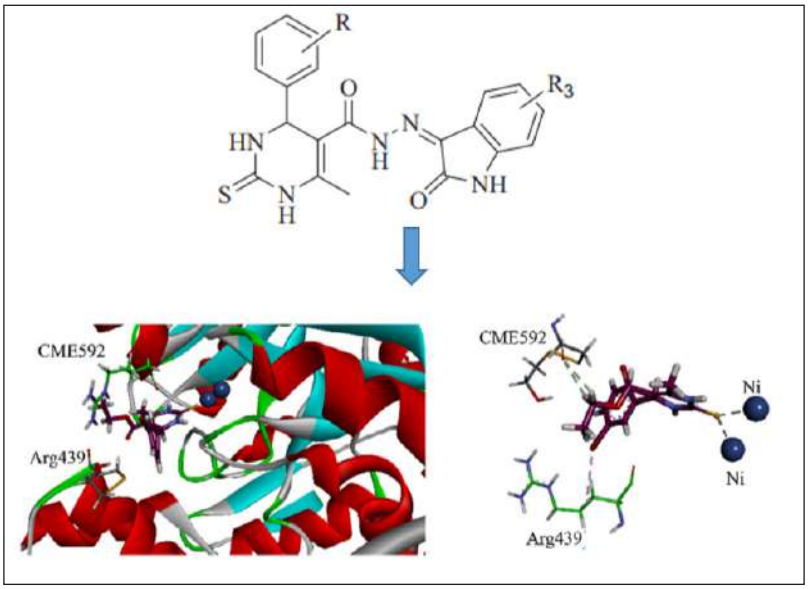
17.3.26. Insights from spectroscopic and in-silico techniques for the exploitation of biomolecular interactions between Human serum albumin and Paromomycin

The study of molecular interactions of drug-protein are extremely important from the biological aspect in all living organisms, and therefore such type of investigation hold a tremendous significance in rational drug design and discovery. In the present study, the molecular interactions between paromomycin (PAR) and human serum albumin (HSA) have been studied by different biophysical techniques and validated by *in-silico* approaches. The results obtained from Ultraviolet–visible spectroscopy (UV) and Fourier transform infrared spectroscopy (FT-IR) demonstrated a remarkable change upon the complexation of PAR with HSA. Circular Dichroism (CD), Dynamic Light Scattering (DLS) and Resonance Rayleigh scattering (RRS) results revealed a significant secondary structure alteration and reduction of hydrodynamic radii upon the conjugation of PAR with HSA. The fluorescence spectroscopy results also apparently revealed the static quenching mechanism. The number of binding sites, binding constants, and Gibbs free energy values were calculated to illustrate the nature of intermolecular interactions. Similarly, the *in-silico* docking and molecular dynamics simulation clearly explain the theoretical basis of the binding mechanism of PAR with HSA. The experimental and docking approaches suggested that PAR binds to the hydrophobic cavity site I of HSA. The finding of present investigation will provide binding insight of PAR and associated alterations in the stability and conformation of HSA.



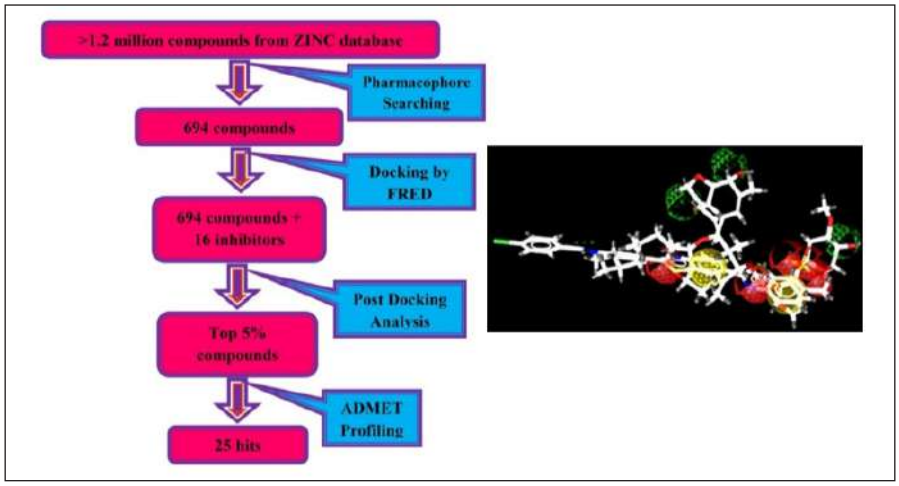
17.3.27. Design, synthesis, in vitro Evaluation and docking studies on dihydropyrimidine-based urease inhibitors

In our previous report, we have identified 3,4-dihydropyrimidine scaffold as promising class of urease inhibitor in a structure based virtual screen (SBVS) experiment. In present study, we attempted to optimize the scaffold by varying C-5 substituent. The elongation of the C-5 chain was achieved by the reaction of C-5 ester with hydrazine leading to C-5 carbohydrazides which were further used as building blocks for the synthesis of fifteen new compounds having diverse moieties. A significantly higher in *vitro* urease inhibitory activity with IC_{50} values in submicromolar range was observed for semithiocarbazide derivatives (4a-c, 0.58–0.79 µM) and isatin Schiff base derivative 5a (0.23 µM). Docking analysis suggests that the synthesized compounds were anchored well in the catalytic site and extending to the entrance of binding pocket and thus restrict the mobility of the flap by interacting with its key amino acid residues. The overall results of urease inhibition have shown that these compounds can be further optimized and developed as lead urease inhibitors.



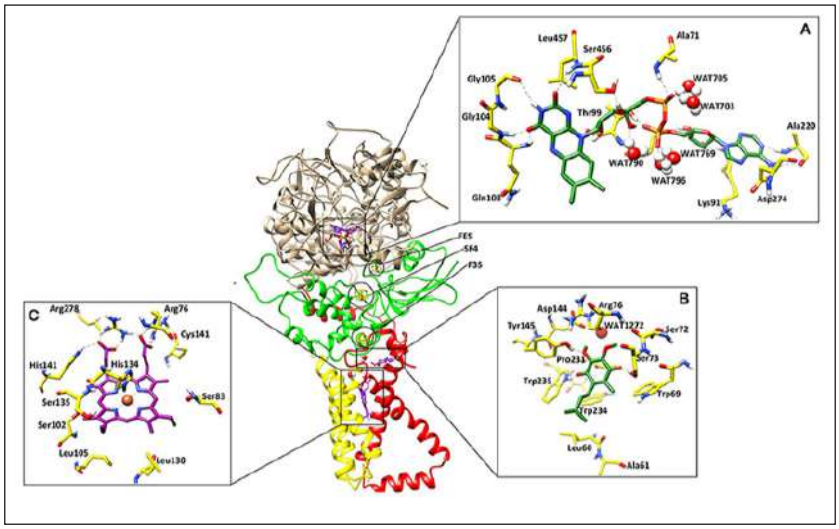
17.3.28. Targeting Dengue Virus NS-3 Helicase by Ligand based Pharmacophore Modeling and Structure based Virtual Screening

Dengue fever is an emerging public health concern, with several million viral infections occur annually, for which no effective therapy currently exist. Non-structural protein 3 (NS-3) Helicase encoded by the dengue virus (DENV) is considered as a potential drug target to design new and effective drugs against dengue. Helicase is involved in unwinding of dengue RNA. This study was conducted to design new NS-3 Helicase inhibitor by *in silico* ligand- and structure based approaches. Initially ligand-based pharmacophore model was generated that was used to screen a set of 1201474 compounds collected from ZINC Database. The compounds matched with the pharmacophore model were docked into the active site of NS-3 helicase. Based on docking scores and binding interactions, 25 compounds are suggested to be potential inhibitors of NS3 Helicase. The pharmacokinetic properties of these hits were predicted. The selected hits revealed acceptable ADMET properties. This study identified potential inhibitors of NS-3 Helicase *in silico*, and can be helpful in the treatment of Dengue.



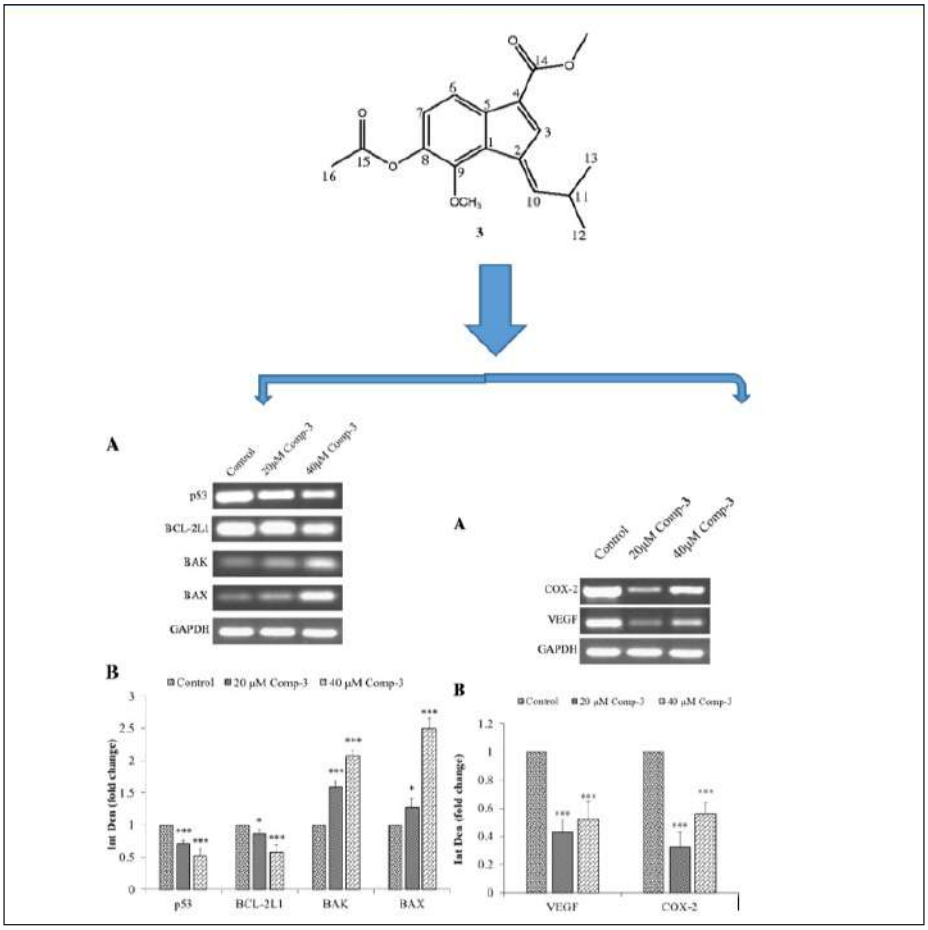
17.3.29. Discovering Novel Alternaria solani Succinate Dehydrogenase Inhibitors by in Silico Modeling and Virtual Screening Strategies to Combat Early Blight

Alternaria blight is an important foliage disease caused by *Alternaria solani*. The enzyme Succinate dehydrogenase (SDH) is a potential drug target because of its role in tricarboxylic acid cycle. Hence targeting *Alternaria solani* SDH enzyme could be efficient tool to design novel fungicides against *A. solani.* We employed computational methodologies to design new SDH inhibitors using homology modeling; pharmacophore modeling and structure based virtual screening. The three-dimensional SDH model showed good stereo-chemical and structural properties. Based on virtual screening results twelve commercially available compounds were purchased and tested *in vitro* and *in vivo*. The compounds were found to inhibit mycelial growth of A. solani. Moreover *in vitro* trials showed that inhibitory effects were enhanced with increase in concentrations. Similarly, increased disease control was observed in pre-treated potato tubers. Hence the applied *in silico* strategy led us to identify novel fungicides.



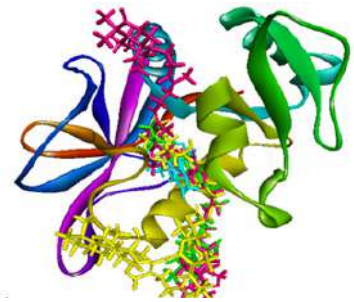
17.3.30. Isolation and characterization of three new anti-proliferative Sesquiterpenes from Polygonum barbatum and their mechanism via apoptotic pathway

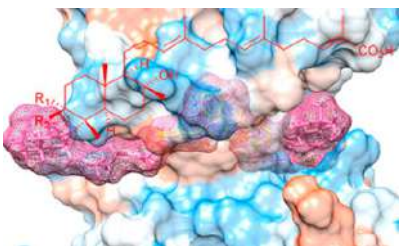
The emergence of chemoresistant cancers and toxicity related to existing chemotherapeutic agents, demand the search for new pharmacophore with enhanced anti-cancer activity and least toxicity. For this purpose, three new sesquiterpenes were isolated from ethyl acetate fraction of the aerial parts of the plant *Polygonum barbatum* and evaluated for their anti-cancer potential. The structural elucidation and characterization of the isolated compounds 1–3 were performed using various spectroscopic techniques such as mass, UV, IR, and extensive 1D/2D–NMR spectroscopy. Furthermore, the compounds 1–3 were subjected to screening of anti-cancer activity against different cell lines followed by brief analysis of apoptotic and anti-angiogenic potentials of the potent hit against non-small cell lung carcinoma cell line. All the compounds 1–3 were subjected to anti-proliferative potential against non-small cell lung carcinoma (NCI-H460), breast cancer (MCF-7), cervical cancer (HeLa) and normal mouse fibroblast (NIH-3 T3) cell lines. Among these, compound 3 was found to be more cytotoxic against NCI-H460 and MCF-7 cells (IC_{50} = 17.86 ± 0.72 and 11.86 ± 0.46 µM respectively). When compared with the standard drug cisplatin compound 3 was found to have more potent activity against NCI-H460 (IC_{50} = 19 ± 1.24 µM) as compared to MCF-7 cell lines (IC50 = 9.62 ± 0.5 µM). Compound 3 induced apoptosis in NCI-H460 cells in a dose dependent manner. It significantly down regulated, the expression of anti-apoptotic (BCL-2 L1 and p53) and increased the expression of pro-apoptotic (BAK and BAX) genes. Besides apoptosis, it also significantly reduced the cell migration and down regulated the angiogenic genes (i.e. VEGF and COX-2), thereby, inhibiting angiogenesis in NCI-H460 cells. Compound 3 possesses potent anti-proliferative potential as well as induced apoptosis and inhibited the cell migration of the cancerous cells by altering the gene expression, responsible for it.



17.3.31. Synthesis of new triterpenic monomers and dimers as potential antiproliferative agents and their molecular docking studies

In the current investigation, new monomers of myrrhanone B and lupeolic acid were prepared via reaction of triterpenic acids with linkers in the presence of K2CO3. In addition, new bis-myrrhanone B homodimers, myrrhanone B-myrrhanol B heterodimers, and bis-myrrhanone β-boswellic acids heterodimer were prepared. Evaluation of these compounds on the proliferation of four different human cancer cell lines, viz., FaDu (pharynx carcinoma), A2780 (ovarian carcinoma), HT29 (colon adenocarcinoma) and A375 (malignant melanoma) has been performed. It is worth mentioning that compounds 4, 7, 8, 10, and 11 possess potent antiproliferative effect towards HT29 cancer cells with IC50 values of 8.1 μM, 5.4 μM, 8.8 μM, 6.8 μM, and 8.2 μM, respectively. In addition, these compounds display good to moderate antiproliferative activities towards A2780 and A375 with IC50 values ranging from 10.4 to 24.2 μM. Moreover, the molecular docking studies of most active compounds (4, 7, 8, 10 and 11) with six anti-cancer drug targets DHFR, VEGFR2, HER-2/neu, CDK6, hCA-IX and LOX also carried, in order to know the mode of binding interaction and energy of this class of compounds.



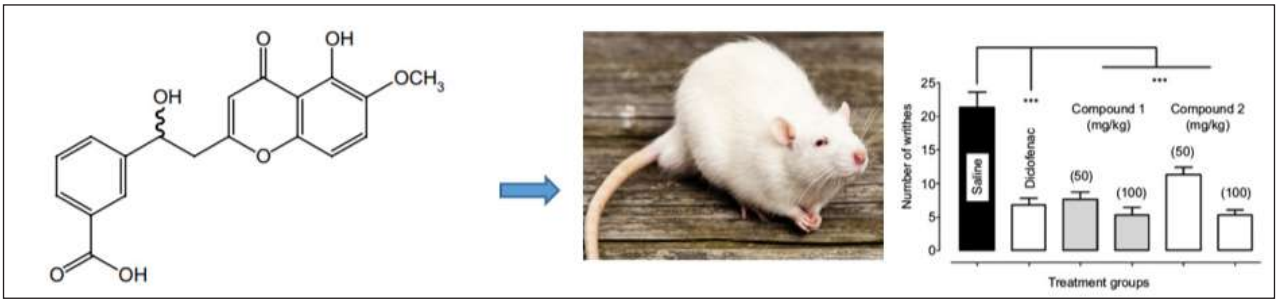


17.3.32. Bioactive chromone constituents from Vitex negundo alleviate pain and inflammation

Vitex negundo L. has been widely studied for its beneficial effect in inflammatory and pain conditions. The present study describes the isolation of two new bioactive chromone constituents from *V. negundo* and their *in vivo* evaluation for anti-inflammatory and antinociceptive activities.

Two new chromone derivatives, namely, methyl 3-(2-(5-hydroxy-6-methoxy-4-oxo-4H-chromen-2-yl) ethyl)benzoate (1) and 3-(1-hydroxy-2-(5-hydroxy-6-methoxy-4-oxo-4H-chromen-2-yl)ethyl)benzoic acid (2) were isolated from *V. negundo* and their structures were determined through various spectroscopic techniques including mass spectrometry, UV, IR, ^{1}H NMR, ^{13}C NMR, and two-dimensional-NMR like correlation spectroscopy and heteronuclear multiple bond correlation techniques. The isolated compounds (1–2) were tested for their prospective antinociceptive activity in acetic acid-induced abdominal constriction assay and anti-inflammatory activity in the carrageenan-induced paw edema assay in mice.
Results: Significant attenuation ($P<0.001$) of tonic visceral nociception was demonstrated by compound 1 and 2 at doses of 50 and 100 mg/kg. At similar doses, these compounds (1–2) also showed potent amelioration ($P<0.001$) of carrageenan-induced paw swelling.

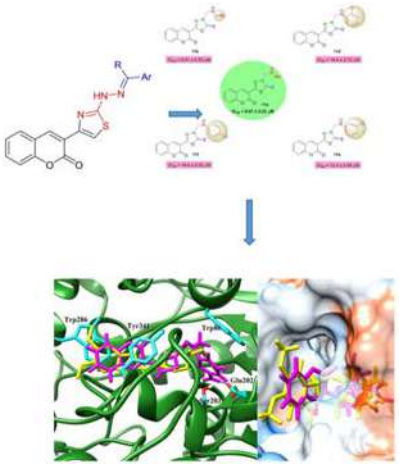
The isolated chromone derivatives (1–2) from *V. negundo* are able to alleviate nociception and inflammation and the findings corroborated that *V. negundo* may be used as a potential source of antinociceptive and anti-inflammatory candidates.



17.3.33. Combined in Vitro and in Silico Studies for the Anticholinesterase Activity and Pharmacokinetics of Coumarinyl Thiazoles and Oxadiazoles

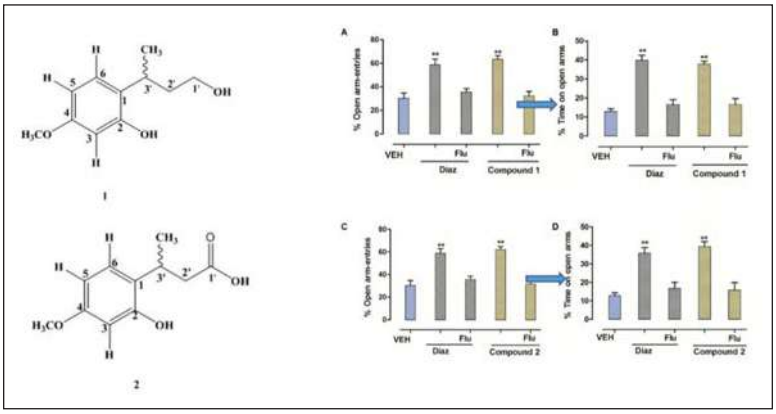
In a continuation of our previous work for the exploration of novel enzyme inhibitors, two new coumarin-thiazole 6(a–o) and coumarin-oxadiazole 11(a–h) hybrids have been designed and synthesized. All the compounds were characterized by ^{1}H- and ^{13}C-NMR spectroscopy and elemental analysis. New hybrid analogs were evaluated against acetylcholinesterase (AChE) and butyrylcholinesterase (BuChE) in order to know their potential for the prevention of Alzheimer's disease (AD). In coumarinyl thiazole series, compound 6b was found as the most active member against AChE having IC_{50} value of 0.87 ± 0.09 µM, while the compound 6j revealed the same efficacy against BuChE with an IC50 value of 11.01 ± 3.37 µM. In case of coumarinyl oxadiazole series, 11a was turned out to be the lead candidate against AChE with an IC_{50} value of 6.07 ± 0.23 µM, whereas compound 11e was found significantly active against BuChE with an IC_{50} value of 0.15 ± 0.09 µM. To realize the binding interaction of these compounds with AChE

and BuChE, the molecular docking studies were performed. Compounds from coumarinyl thiazole series with potent AChE activity (6b, 6h, 6i, and 6k) were found to interact with AChE in the active site with MOE score of −10.19, −9.97, −9.68, and −11.03 Kcal.mol^{-1}, respectively. The major interactions include hydrogen bonding, π-π stacking with aromatic residues, and interaction through water bridging. The docking studies of coumarinyl oxadiazole derivatives 11(a–h) suggested that the compounds with high anti-butyrylcholinesterase activity (11e, 11a, and 11b) provided MOE score of −9.9, −7.4, and −8.2 Kcal.mol^{-1}, respectively, with the active site of BuChE building π-π stacking with Trp82 and water bridged interaction.

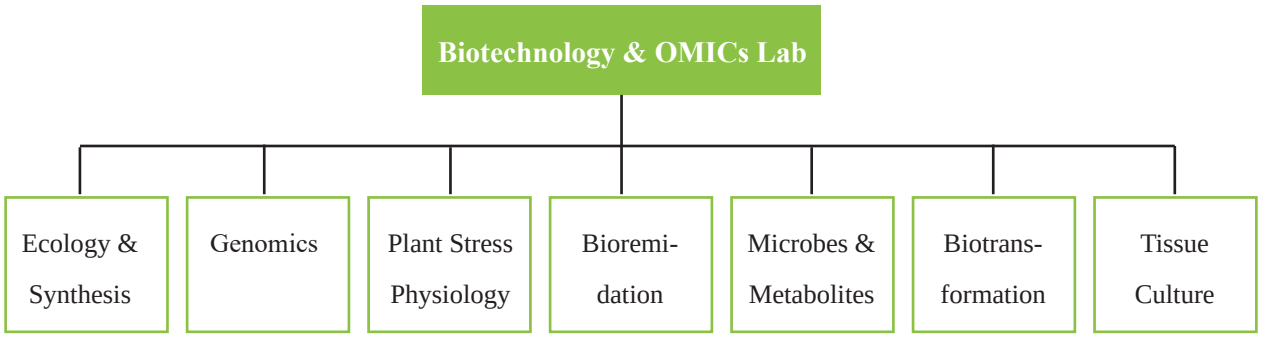


17.3.34. Isolation and Characterization of Two New Secondary Metabolites from Quercus incana and Their Antidepressant- and Anxiolytic-Like Potential

The ethyl acetate fraction of *Quercus incana* yielded two new compounds [1 and 2]. The characterization and structure elucidation of these compounds were carried out through various spectroscopic techniques such as mass spectrometry along with one- and two-dimensional NMR techniques. The structural formula was deduced to be 2-(4-hydroxybutan-2-yl)-5-methoxyphenol [1] and 4-hydroxy-3-(hydroxymethyl) pentanoic acid [2]. The elevated plus maze (EPM) and light–dark box (LDB) tests (classical mouse models) were performed in order to reveal the anxiolytic potential of both compounds [1 and 2]. Both compounds displayed dose-dependent increases in open-arm entries and time spent in open arms in EPM (*P < 0.05, **P < 0.01), and increased the time spent in the lit compartment and increased transitions between the two compartments in LDB test (*P < 0.05, **P < 0.01). Co-administration of selective benzodiazepine (BZP) receptor antagonist, flumazenil (2.5 mg/kg) with compounds [1 and 2] decreased the anxiolytic-like activity of both compounds in the EPM indicating BZP-binding site of GABA-A receptors are involved in the anxiolytic-like effect. Similarly, both compounds at the dose level of 10 and 30 mg/kg, i.p. exerted pronounced antidepressant-like effect in both forced swimming as well as tail suspension tests (*P < 0.05, **P < 0.01; ANOVA followed by Dunnett's *post hoc* test). The effect at 30 mg/kg was comparable to the reference drug imipramine (60 mg/kg).



17.4. Biotechnology & OMICs Lab



The Lab offers unique research opportunities to perform a multidisciplinary research work related plant and microbial biotechnology. Some of the major research areas are given below:

(i) Ecology and Systematics

a. Understanding the Genetic Diversity of different populations of economically and ecologically important plant species of Oman

b. DNA barcoding of medicinally and ecologically unique plants species of Oman

c. Chemo-taxonomic marker analysis and their diversity using molecular, and spectroscopic methods

d. *Ex-situ* conservation strategies for economical important plants of Oman

   i. Herbarium establishment

   ii. Gene pool preservation

e. Tissue culture based callus and cambium meristematic cell growth (CMCs)

(ii) Bioactivities of Natural and Synthetic products

a. Performing the biological role and significance of semi-pure and pure chemical constituents extracted and isolated from the Omani medicinal plants.

b. Presently, activities like, ABTS, DPPH, superoxide anion, acetylcholinesterase, a-Glucosidase, urease, xanthine oxidase, total flavonoids, and phenolic have been established and performed in the lab to screen and elucidate the potential activity of constituents

c. Besides the above, the anti-microbial, phytotoxic and allelopathic effects of these semi-pure and pure chemical constituents are also performed

(iii) Plant Microbe Interaction and Crop Stress Physiology

a. Isolation, identification and characterization of bacterial and fungal endophytes from medicinal plants and Frankincense tree growing in semi-arid, desert and marine ecosystems of Oman

b. Exploring the potential role of endophytes in improving crop growth and physiology under extreme environmental conditions of drought, salinity and heavy metal stress

c. Assessing the transcriptomic and proteomic expressions of crop plants during stress conditions and plant microbe interaction

d. Isolating and assessing the potential symbiotic endophytes with Frankincense tree and their role in secretion of essential bioactive secondary metabolites

e. Investigation on plant viruses and various diseases to date palm, frankincense tree and tomato plants using improved diagnostics, epidemiology and management

(iv) Bioremediation potential of microbes

a. Screening of potential endophytes against various levels of metal toxicity and identification of their tolerance and bioaccumulation/complexation potential

b. Assessing the regulation and responses of various oxidative stress enzymes during heavy metal exposure of endophytic microbes

c. Degradation of Poly Aromatic Hydrocarbons by endophytic microbes from different pollutant environments

d. Exploring the microbes for secretion of extracellular enzymes using florescence spectrophotometer

(v) Biotransformation of organic compounds

a. Assessing the role of selected microbes as biocatalysts to transform the organic compounds into novel and active metabolites

b. Enzyme based biotransformation of secondary metabolites

(vi) Secondary metabolites from microbes

a. Bioactive metabolites from microbes isolated from different plant specially endophytes (bacteria and fungi)

b. Understanding the production of metabolites from microorganisms during their growth conditions in bioreactor

c. Identifying metabolites with significantly higher level of enzyme inhibition potentials

(vii) Next Generation Sequencing and OMICS

a. Whole genome sequencing of potential and novel endophytic strains

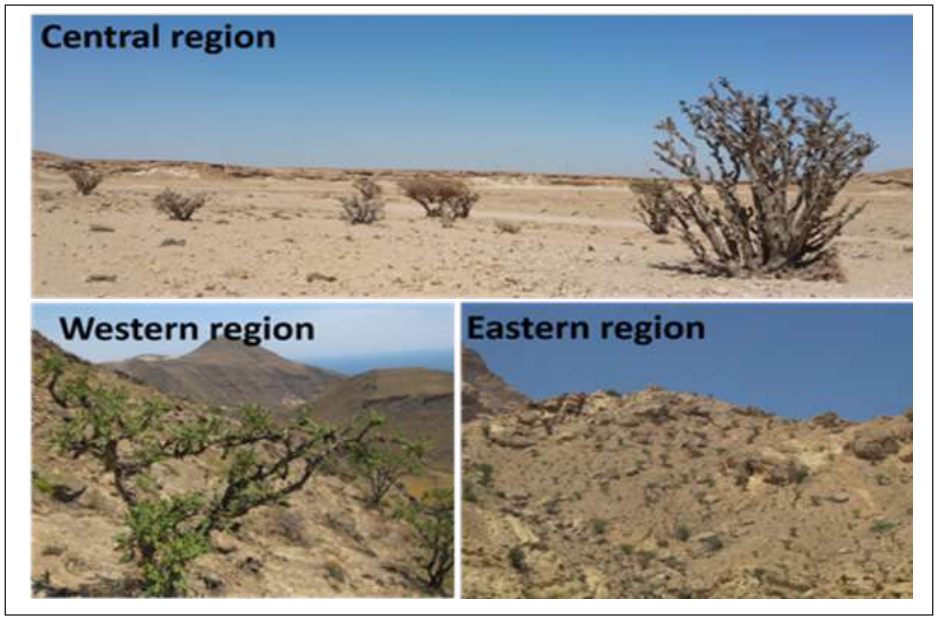
b. Transcriptomic expression profiles of potential metal bioremediating microbial strains

c. Chloroplast genome sequencing of endemic plants of Oman

d. Whole/Draft genome sequencing and analysis of economically important crops, landraces, native and endemic plants of Oman

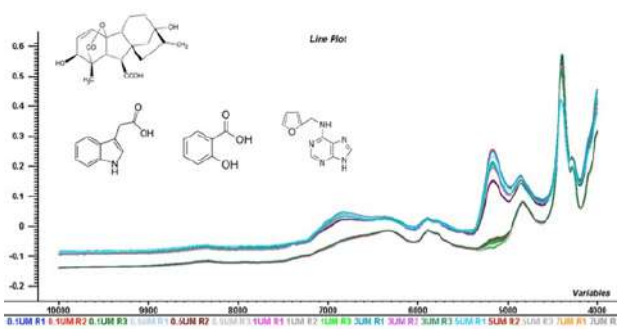
e. Transcriptomics of various process and mechanisms of important ecological phenomenon

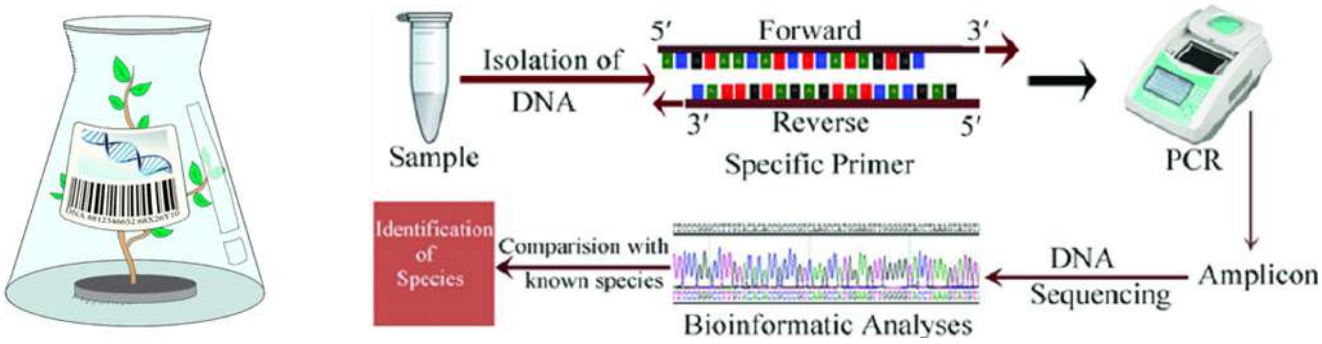
f. Proteomic expression profile of crop stress physiology, plant processes, venomics and disease incidences



17.4.1. Ecology and Systematics

Situated in the southeastern corner of the Arabian Peninsula covering 309,500 km^2 and with a coastline of 3,165km, the Sultanate of Oman is blessed with a wealth of unique genetic resources. Some of the important medicinal plants includes, *Moringa peregrina*, *Acacia nilotica* and *Rhazya stricta*, *Aloe barbadense*, *Petropyrum scoparium*, *Ephedra intermedia*, *Monsonia helitropoides*, and *Petropyrum scoparium* are some of the famous medicinal plants, which are used by the local communities for various ailments and disease. In non-timber forest products (NTFPs), Omani Frankincense (*Boswellia sacra*) is internationally famous and has been used in fragrance and medicine. The traditional home of

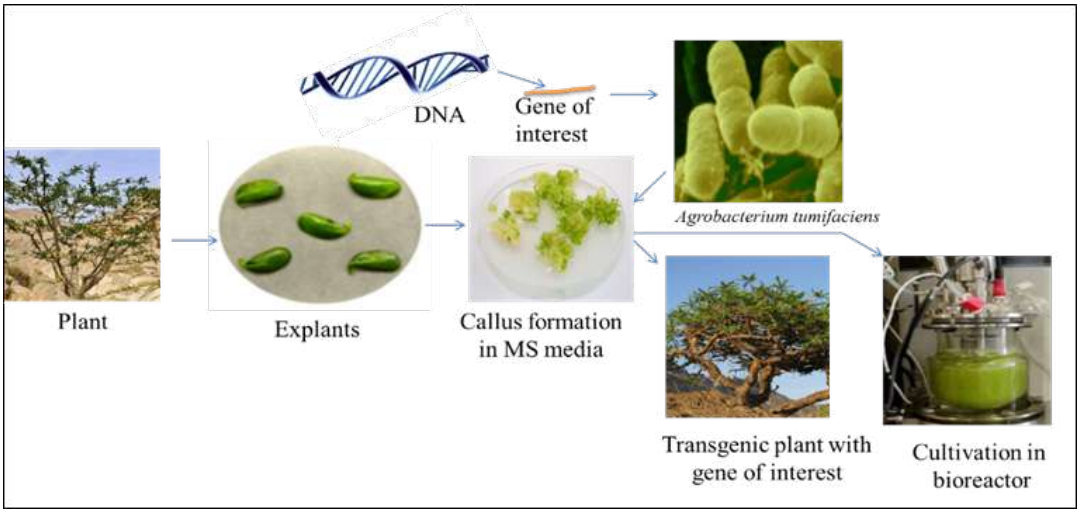




frankincense is Dhofar, the southernmost region of the Sultanate bordering the Arabian Sea. We are interested to conserve the endangered plants of Oman by establishing a plant tissue culture system. In addition, we have started extensive efforts to understand the ecology, systematics, and genetic diversity within and among populations of not only *Boswellia sacra* but also many other economically and ecologically important plant species of Oman. In this regard, various studies have been performed, to collect the samples from 13 different populations of *B. sacra*, and to assess the tree physiology and related secondary metabolites in responses to varying climatic conditions. In addition to harsh arid-land environmental factors and grazing by animals, the tree is exposed to unsustainable extraction of frankincense, which has cultural and economic important to the local people. These threats in combination with rejuvenation and regeneration issues have influenced the survival of the species. In this regard, effective genetic resources conservation strategy is essential to understand the genetic diversity and pattern of genetic differentiation across the different populations of *B. sacra*. Hence, we evaluated thirteen major populations growing in Dhofar region of Oman for genetic diversity using four different molecular markers, amplified fragment length polymorphism (AFLP), Simple Sequences Repeat (SSR), random-amplified polymorphic DNA (RAPD) and SDS-PAGE. Besides, assessment of endogenous phytohormones (gibberellic acid (GA), indole-acetic acid (IAA), salicylic acid (SA) and kinetin) can help to understand population health and growth dynamics. Hence, it was aimed to devise a robust method for phytohormones analysis using Near-Infra Red spectroscopy (NIRS) coupled with multivariate methods of thirteen different populations of *B. sacra*. Secondary metabolites are molecules which are synthesized within the plant when they are under stress and these molecules attracted much attention by plant biologist due to their considerable medicinal properties. Proper identification of plant species is a difficult task, usually done through plant taxonomists and botanists with sample field-based research knowledge. Even today, the number of plant species currently in existence is not clear. New species are still being identified and calculating anything like an accurate number is further complicated by the many examples of the same species in different areas being known by different names. However, it is estimated that the total number of plants is of the order of 400,000 species; around 350,000 species have accepted names (see 'The Plant List' (2013), Version 1.1., http://www.theplantlist.org/). Medicinal plants are often collected by local untrained collectors based on their indigenous plants knowledge. Sometimes closely related species are also collected and used under the same name. Therefore, it is necessary to collect the species with the scientific support of expert taxonomists with experience in the relevant region. DNA barcoding is a molecular-based approach identifying species by using a standardized DNA sequence (s) known as "DNA barcode". Nevertheless, the DNA barcoding technology can be utilized for the identification of plants by using two or three DNA markers for each species. The CBOL Plant Working Group recommended the combination *rbcL* + *matK* as a core plant barcode, and advocated the

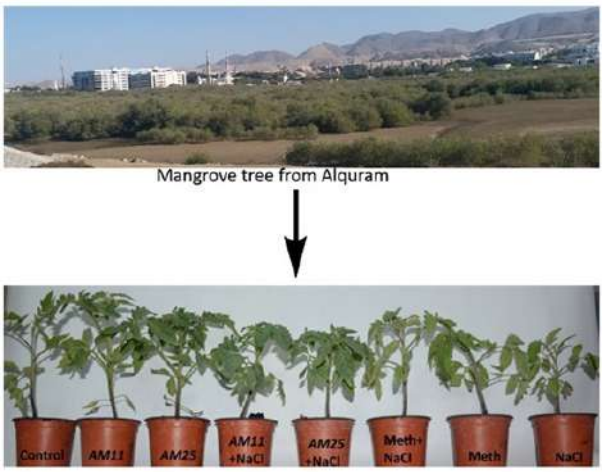
plastid *trnH-psbA*, *rpoC1* and *ITS* as complementary markers. We are using both nuclear and chloroplast based DNA barcodes for the endemic plants of Oman.

17.4.2. Micropropagation of *Boswellia sacra*



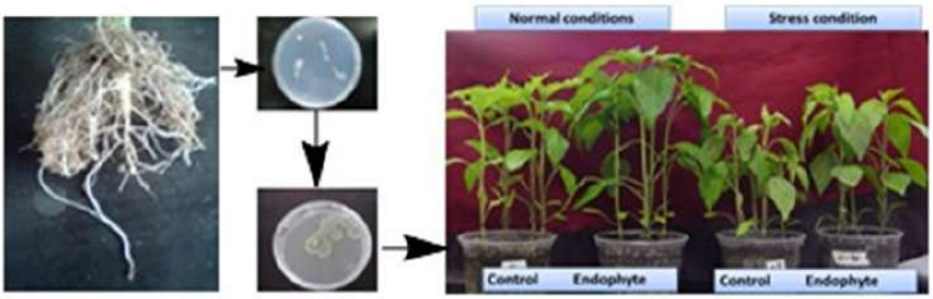
Boswellia sacra is one of the medicinally important plant species found in rocky slopes and ravines of arid region. This species mostly grows in calcareous soil and inhabitant to the woodland region of Oman. This plant is a Frankincense and belongs to the family Bursaraceae. It produces economically important resin gums that are used in incense, fumigants as well as fixatives in perfumes for its superior aroma. Boswellic acid is the characteristics triterpene molecule found in the genome Boswellia. Beta-boswellic acid, acetyl-keto-beta boswellic acid and keto-beta boswellic acid play significant role in the apoptosis of cancerous cells. Acetyl boswellic acid is also show anti-inflammatory function via inhibition of leukotriens. But, due to enormous cultivation of gum resins from Boswellia, the species is in great threat of extinction. Therefore, it is important to find an alternative ways for the production of gum resins of Boswellia to preserve the species from further exploitation. Molecular farming approach through cell/tissue culture of Boswellia can greatly helpful to overcome the exploitation of naturally occurring Boswellia genus. Tissue and cell culture of Boswellia species followed by its industrial production through bioreactor will be of particular interest. Further, genetic manipulation or modifications of pathway enzymes of Boswellia genome can enhance the productivity of important phyto-constituents.

17.4.3. Plant Microbe Interaction and Crop Stress Physiology



Increases in human population have raised the demand for food over the last three decades. The green revolution has increased per acre grain yields, but advances in industrialization have also added intangible side effects. Most of the environmental stresses experienced by crops are caused by the results of anthropogenic activity, such as global warming and pollution. Such changing environmental conditions pose a threat to agricultural sustainability, as they introduce new problems such as high salinity, drought, heat and heavy metal exposure. Some studies have shown that Si application can play apivotal role in crop production under conditions of environmental stress; however, these interactions still mimic our understanding.

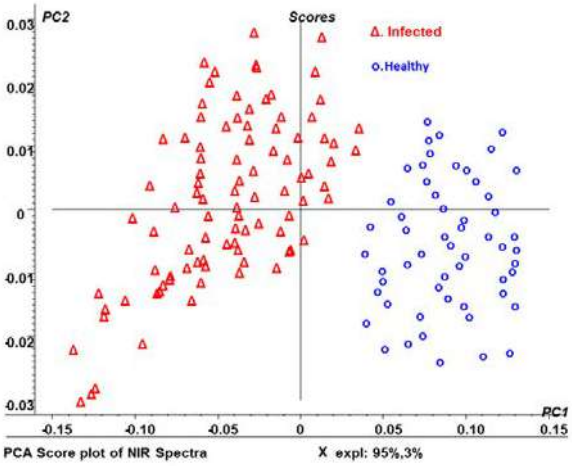
Abiotic stresses, such as salinity, heavy metals and drought, are some of the most devastating factors hindering sustainable crop production today. Plants use their own defensive strategies to cope with the adverse effects of these stresses, via regulation of the expression of essential phytohormones, such as gibberellins (GA), salicylic acid (SA), jasmonates (JA), abscisic acid (ABA) and ethylene (ET). However, the efficacy of the endogenous defensive arsenals of plants often falls short if the stress persists over an extended period. Various strategies are developed to improve stress tolerance in plants. The isolation, identification and characterization of bacterial and fungal endophytes from medicinal plants and Frankincense tree growing in semi-arid, desert and marine ecosystems of Oman is very important. One of our objectives is to explore the potential role of endophytes in improving crop growth and physiology under extreme environmental conditions of drought, salinity and heavy metal stress.



The beneficial effects of endophytes on plant growth are important for agricultural ecosystems because they reduce the need for fertilizers and decrease soil and water pollution while compensating for the environmental perturbations. Endophytic fungi are a novel source of bioactive secondary metabolites; moreover, recently they have been found to produce physiologically active gibberellins as well. The symbiosis of gibberellins producing endophytic fungi with crops can be a promising strategy to overcome the adverse effects of abiotic stresses. The association of such endophytes has not only increased plant biomass but also ameliorated plant-growth during extreme environmental conditions. Endophytic fungi represent a trove of unexplored biodiversity and a frequently overlooked component of crop ecology.

17.4.4. Investigation on plant viruses, fungal diseases to understand the occurrence, improved diagnostics, epidemiology and management

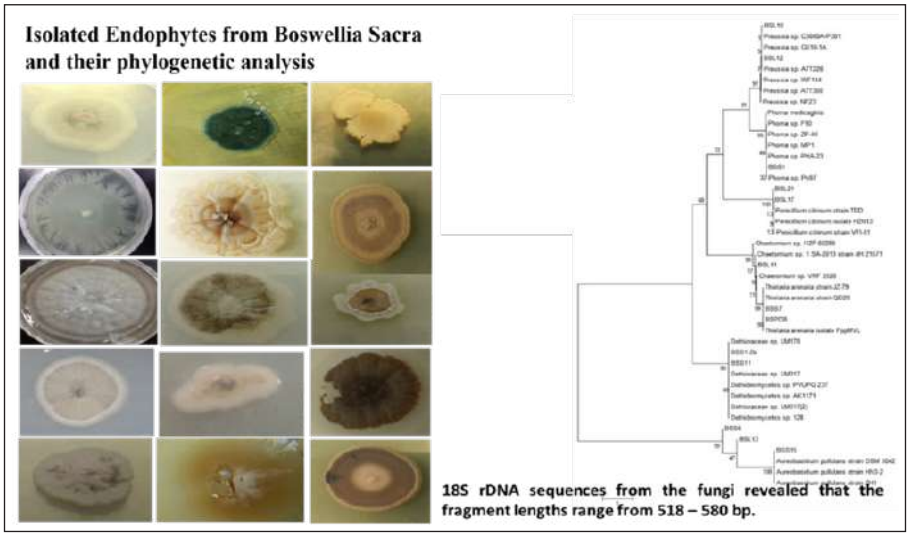
Unlike other microbial pathogens, plant viruses appear to be proliferating at ever increasing rates and the number of recognized plant viruses has grown exponentially due to their high rate of mutation and natural recombination. Recently, Oman has been shown to be a nexus for geminiviruses and their associated satellites from diverse geographic origins. With their propensity to recombine, it became the major mechanism for evolution of geminiviruses. In addition, Oman (and several other Arabian countries) is a major hub for trade and travel by air and sea with the possibility of further spread of these pathogens. Noticeably, tomato yellow leaf curl (*TYLC*) disease, caused by whitefly transmitted geminiviruses (WTGs) pose a serious threat to the cultivation of tomato in Oman and capable of 100% destruction of tomato crops if infected at seedling stage. Yield losses of these crops can vary from 0 – 100% depending on management practices, which were recorded in Nizwa, Al-Batinah, Musandam, Bureimi, Salalah and interior regions of Oman. The substantial revenue losses and socio economic improvement warrants to undertake a study on the devastating viral pathogens to provide sustainable and profitable outcome. We are specifically interested in Biomolecular characterization of different virus isolates from economically important Omani crops and to develop genetically engineered multiple virus resistance transgenic plants against potential viruses. Currently, we are using a multidisciplinary approach to investigate the occurrence of disease incidences in plants and economically important crops using advance robust spectroscopic, NMR and molecular approaches.



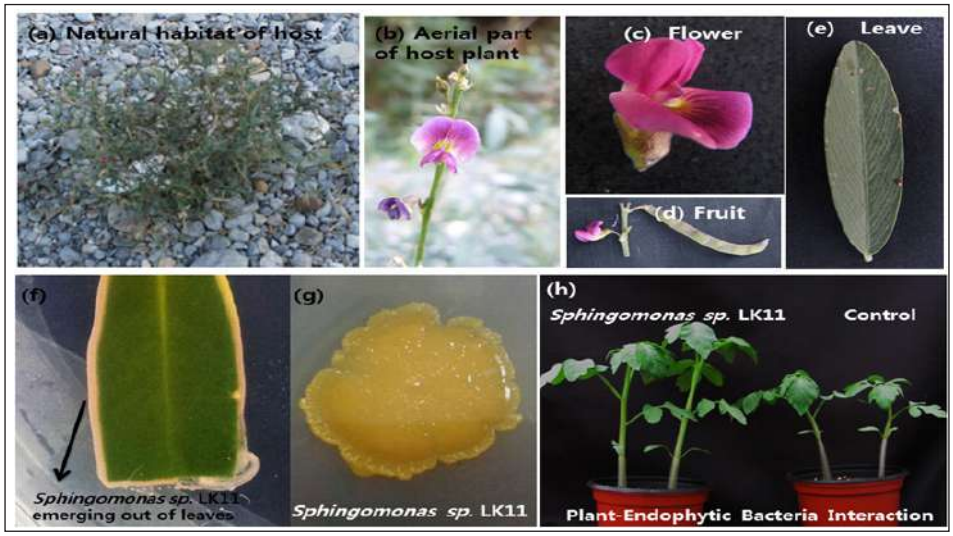
17.4.5. Microbes: Oman as hub for Extremophiles

Endophytic microbes are residing in the plant tissues without showing any disease symptoms. Endophytic microbes including bacteria or fungi have been known to ameliorate the host plant growth and negative impacts of abiotic stresses (salinity, drought, heat, metal etc.). In our group, we are focusing on some of the following important aspects in this regard:

- Secondary metabolites from microbes
- Extra and intra-cellular enzymes from microbes
- Diversity and abundance of microbial resources from different ecosystems
- Metagenomic analysis of contaminated sites and rhizosphere
- Bioremediation strategies



Tephrosia apollinea growing in the wild of Jabal Al-Akhadar and its potential to harbor endophyte (a - e) the host plant*T. apollinea* growing in its habitat and showing aerial, flower, fruit and leaf parts. (f) *Sphingomonas sp*. LJK11 surrounds the outer edges of crushed leaf tissue. (g) *Sphingomonas sp*. LK11 growing in the culture plate. (h) Effect of *Sphingomonas sp*. LK11 inoculation on the growth tomato plants.



17.4.6. Bioremediation by microbes

Heavy metals discharged from various industrial and mining processes adversely affect ecological systems, agriculture, and human health. The antagonistic effects on the ecosystem will ultimately reduce the level of human-derived benefits from these environments. Phytoremediation is argued as a promising alternative to rehabilitate the contaminated sites however, due to poor biomass and slow growth, the metal-reclamation potential is often reduced. Conversely, the interactions of plant-microbe-metals have attracted much attention because of its biotechnological potential to remove metals from polluted ecosystem. Due to the wider physiological properties, endophytic microbes can act as bio-sensors and bioremediators. Looking into this perspective, our research interest includes identification of potential endophytes against various levels of metal toxicity. Endophyte *Penicillium janthinellum* LK5 and GA3 application improves Aluminum phytoextraction in tolerant *Solanum lycopersicum* (Khan et al. 2015 – J Hazardous Materials).

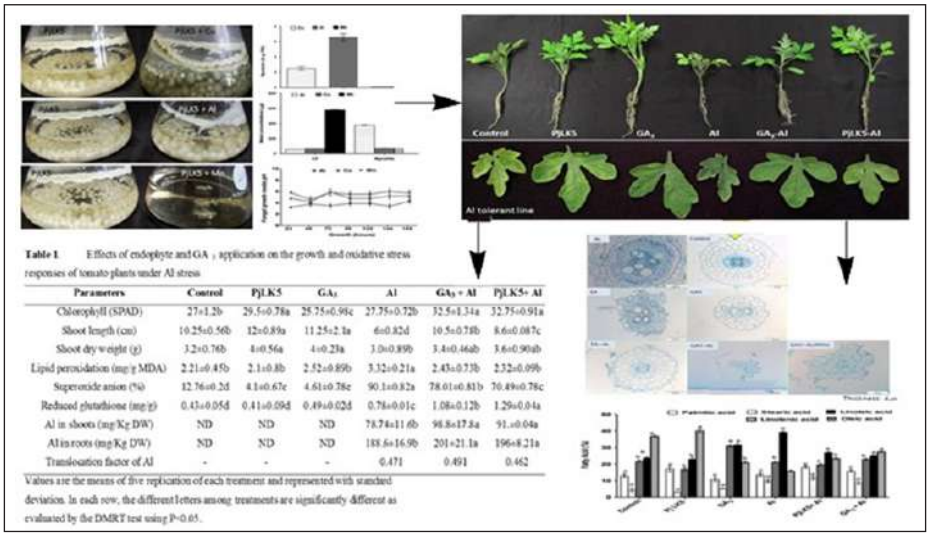


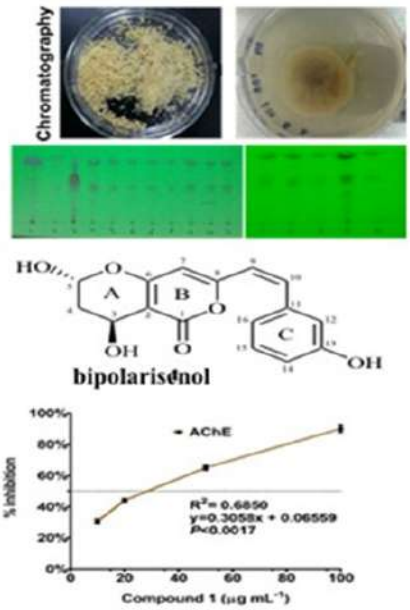
Table 1 Effects of endophyte and GA 3 application on the growth and oxidative stress responses of tomato plants under Al stress

Parameters	Control	PJLK5	GA3	Al	GA3 + Al	PJLK5+ Al
Chlorophyll (SPAD)	27±1.2b	29.5±0.78a	25.75±0.95c	27.75±0.72b	32.5±1.34a	32.75±0.91a
Shoot length (cm)	10.25±0.56b	12±0.89a	11.25±2.1a	6±0.82d	10.5±0.58b	8.6±0.087c
Shoot dry weight (g)	3.2±0.76b	4±0.56a	4±0.23a	3.0±0.89b	3.4±0.46ab	3.6±0.90ab
Lipid peroxidation (mg/g MDA)	2.21±0.45b	2.1±0.8b	2.52±0.89b	3.32±0.21a	2.43±0.73b	2.32±0.09b
Superoxide anion (%)	12.76±0.2d	4.1±0.67e	4.61±0.78e	90.1±0.82a	78.01±0.81b	70.49±0.78c
Reduced glutathione (mg/g)	0.43±0.05d	0.41±0.09d	0.49±0.02d	0.76±0.01c	1.08±0.12b	1.29±0.04a
Al in shoots (mg/Kg DW)	ND	ND	ND	78.74±11.6b	98.8±17.8a	91.±0.04a
Al in roots (mg/Kg DW)	ND	ND	ND	188.6±16.9b	201±21.1a	196±8.21a
Translocation factor of Al	-	-	-	0.471	0.491	0.462

Values are the means of five replication of each treatment and represented with standard deviation. In each row, the different letters among treatments are significantly different as evaluated by the DMRT test using P<0.05.

17.4.7. Secondary metabolites from Microbes

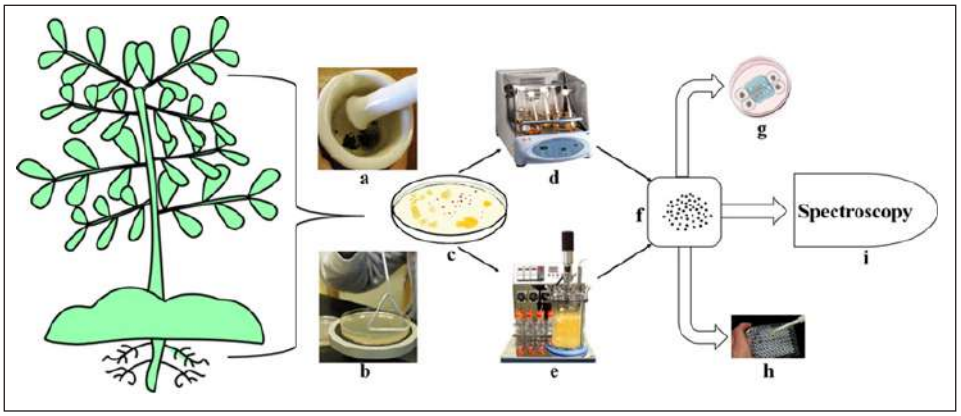
In eukaryotic organisms, endophytic fungi are among the most important group that are well known for producing many novel metabolites while many of endophytic fungi will be recently reported to produce bioactive metabolites such flavonoids, peptides, alkaloids, steroids, phenolics, terpenoids and lignans with antimicrobial, anticancer and antiviral potentiality. The discovery of taxol producing fungi increased the importance of endophytes and shifted natural products research from plant to endophytic fungi (Yang et al. 2014). Schulz et al (2006) revealed that more than 50% of biologically active metabolites originate from endophytes and many novel bioactive compounds with antimicrobial, insecticidal, cytotoxic, and anticancer properties have been successfully isolated and characterized from endophytic fungi (Khan et al. 2015).



Looking at the bioactive potential of endophytes for metabolomics, bioactive chemical constituents are isolated through a bioassay guided approach of using advance chromatographic techniques. The isolated compounds are characterized through advance spectroscopic techniques viz., UV-Vis, IR, 1D (1H and 13C NMR, NOE, and TOCSY), 2D NMR (COSY, HSQC, HMBC, NOESY, INADEQUATE), Mass spectrometry and X-ray crystallography. The isolated endophytes and their fractions are assessed for their role in inhibiting α/ß-Glucosidases (antidiabetics), breast cancer, and human pathogenic microorganism. Bioactive secondary metabolites isolated from endophytic fungi and its role in the inhibition of acetyl cholinesterase enzymes.

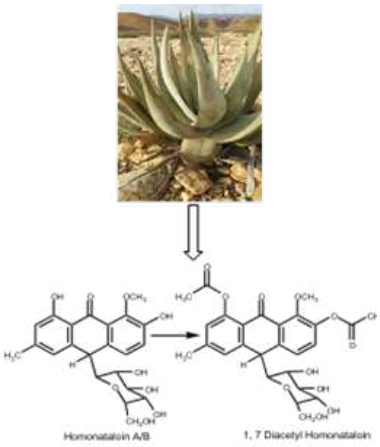
In addition, the microbes (fungi and bacteria) have been known to live asymptomatically with plants throughout the different

growth stages. Endophytic microbes provide an additional resource to the plant with beneficial secondary metabolites, enzymes and nutrients, which help the host to combat diverse arrays of stressful conditions of biotic and abiotic stresses. Extracellular enzymes are the product of microbial cell growth and it performs its function outside the cell in many biological or environmental processes. Xylanases, hemicellulases, phytases, proteases, asparaginase, cellulases, β-glucosidase, pectinases, celluloses, tyrosinase, protease, gelatinase, chitinase and amylases are some of key enzymes produced by the endophytic bacteria and fungi. Most of these enzymes have been reported from endophytes living with medicinal or crop plants, whereas they are detected through agar-based methods. We have developed spectroscopic and fluorescence based methodologies to quantify various kinds of exozymes from soil, water and microbial growth cultures.



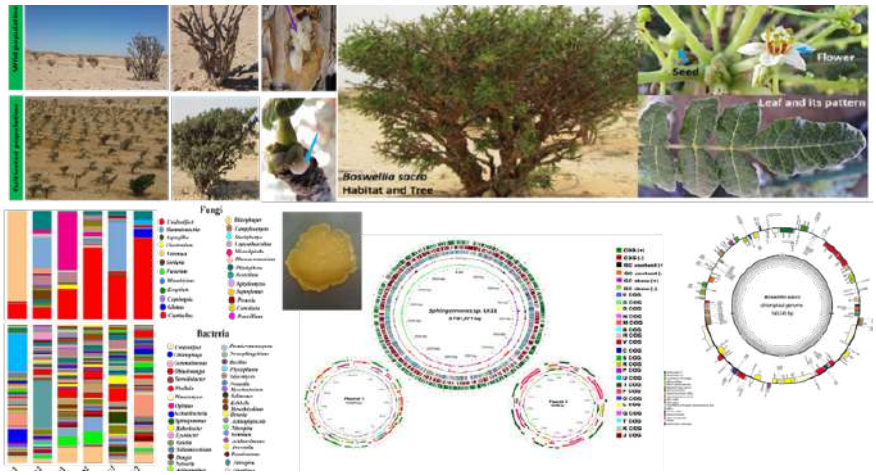
17.4.8. Biotransformation strategies

We are using two approaches to perform the biotransformation strategies (i) assessing the role of selected microbes as biocatalysts to transform the organic compounds into novel and active metabolites and (ii) enzyme based biotransformation of secondary metabolites. In the first case, we are screening a large number of fungal and bacterial isolates originated from various environments and natural floral resources to perform the transformation strategies of selected novel skeletons. In the second case, we are utilizing various enzymes such as catalase, peroxidase and cytochrome P450 to convert the novel skeletal into more potent bioactive compounds. An example of diasteriomeric mixture of homonatalion A/B extracted from the sap (ethyl acetate extract) of *Aloe dhufarensis*. *A. dhufarensis* Lavranos is a perennial stem less herb, which is endemic to Dhofar region of the Sultanate of Oman and found in the drier areas of the region. The peroxidases are enzymes whose primary function is to oxidize hydrogen donors at the expense of peroxides. They are highly specific for hydrogen peroxide, but they accept a wide range of hydrogen donors, including polyphenols. The result from the 1D and 2D NMR experiment showed that the reaction between diasteromeric mixture of Homonatalion A/B and H_2O_2 produced 1, 7-diacetyl Homonataloin. In the case of whole cell-based biotransformation, we used Sphingomonas sp. LK11 and *Aspergillus niger* for converting smaller functional groups into bioactive compounds.



17.4.9. Genomic, transcriptomics and proteomics behind Frankincense

Boswellia sacra is an economically important frankincense producing endemic tree of the Sultanate of Oman. The tree activates its physiological defense mechanisms by producing volatile and non-volatile chemical messengers in the form of milk-like sap to counteract the negative impacts of resin production through wounds. Such defense responses have been extensively studied in pine trees. However, during wounding of *Boswellia* species, especially *B. sacra* nothing is known. Through the resin the internal physiological response toward wound, but this could also be facilitated by fungal pathogens/symbionts to convert the sap into crystalline resin, which is not understood till now. In addition, the underlying mechanisms involved during resin production are not known at genomics, transcriptomics and proteomics levels. In this regard, our research is aimed to understand the physiological, molecular and biosynthetic mechanisms involved in resin production in *Boswellia sacra*.



Whole genome sequencing and transcriptomics of the resin producing parts of *Boswellia sacra* will be performed for the first time. These approaches will help to preserve the essential gene pool of this endemic tree. Next generation sequencing (genomics/ transcriptomics), bioinformatics and proteomic analysis will be performed for the results obtained through Ion Torrent PGM, Illumina HiSeq 2500, MALDI-ToF, ESI-MS/MS, UPLC-MS/MS, HPLC, NMR and RT-PCR.

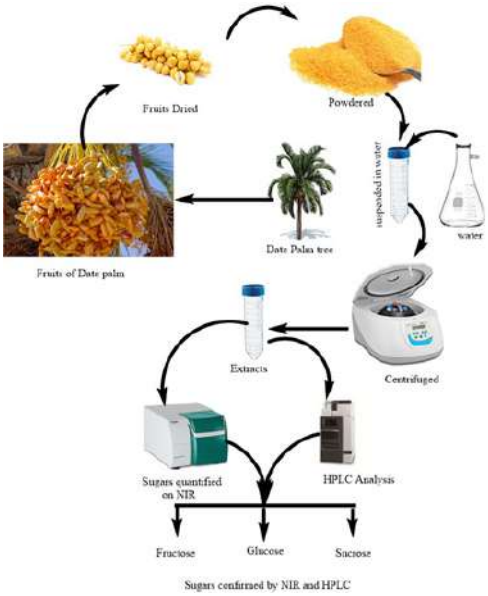
Bioactive microbial strains are analyzed for their genome size, structure, composition and function. In this regard, novel strains are subjected to Illumina and PacBio RS II NGS sequencing to dig-out the draft/whole genome of the microorganisms. Various online annotation pipelines are used to assemble the sequence data and understand the gene function and composition. Presently two microorganisms, a bacterium and a fungus are in process of bioinformatics analysis.

Frankincense tree (*Boswellia sacra*) growing in Dhofar, Oman. Image (A) shows the hot and dry habitat of Frankincense tree, (B) the milk-like resin oozing out from the lower epidermal layer of the tree, (C) resin coming out from the mature leaf of tree branches, (D) the inner bark or the cortex region of the tree doesn't contain resinous duct and was also subjected for endophyte presence, (E) leaf pattern of Frankincense tree, (F) smaller parts of the tree (leaf, stem and bark parts) used for different experiments.

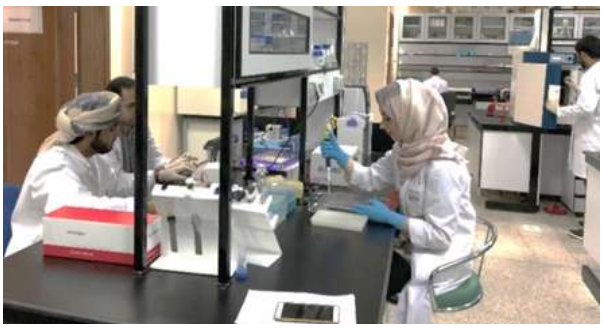
17.4.10. Proximate Analysis, FT-IR Analysis, Genetic Diversity and DNA Barcoding of Date Palm Trees and Selected Medicinal Plants

Our research interests in this area include proximate analysis and FT-IR analysis of different reducing sugars in Omani date palm fruits. We are also interested in sequence and, genetic diversity, DNA barcoding and chemical diversity of date palm as well as of endangered, endemic and important medicinal plants of the Sultanate of Oman using molecular and chemical approaches. Molecular studies include DNA Barcoding and genetic diversity while chemical studies include GCMS and LCMS analyses of medicinal plants extracts.

An approximately 180 female and 48 male date palm cultivars have been reported but there are more than 300 date palm cultivars are found in Oman. However, it would be interesting to evaluate whether these cultivars with different local names are the same or different cultivars. It is expected that genetic and chemical diversity would be higher among different cultivars. For this purpose, microsatellite markers and DNA barcoding using chloroplast gene markers would help in distinguishing between these cultivars. Genetic diversity would also be evaluated among date palm cultivars of Oman. The chemical diversity studies would be conducted by GCMS and LCMS analyses. GCMS and LCMS analyses of seeds/fruits of date palm would give better idea about the overall quantitative variations of the chemical compounds among date palm cultivars.



Moreover, reported flora of Oman is 1,208, among which, 93 species are endemic and 37 species are reported as threatened. From the list of endemic, threatened, and economically important medicinal plants, four to five species would be selected. The leaves from several accessions from their localities would be collected. These accessions would be evaluated for important gene sequences, sequence diversity and genetic diversity using molecular markers, and chemical diversity studies using GCMS and LCMS analyses. It is expected that there would be higher genetic and chemical diversity among accessions of selected medicinal plants species. Accessions with higher genetic diversity/chemical diversity may be selected for future breeding or commercial purposes. In addition, we are also working towards primary sugar analysis and development of fruit across different kinds of Omani date palm cultivars using NIRS, chemoinformatics and molecular techniques.



We used near-infrared spectroscopy (NIRS) coupled with chemoinformatics to determine variations in fructose, glucose, and sucrose among five different developmental stages of eight *Phoenix dactyliferacultivars* viz. *Handal*,

Naghal, *Khasab*, *Mabshi*, *Hasas*, *Halal*, *Khanaizi*, and *Mammor*. The NIRS-analysis showed that fructose and glucose levels significantly increased in ripening stages of *Handal*, while sucrose significantly decreased. Comparison of sugars showed that glucose content was five-times higher than other sugars at all stages. Conversely, fructose content was found ten-times higher only in final stage. Similar trends of increasing fructose and glucose content were observed in all cultivars. The NIRS results were cross-validated by high performance liquid chromatography, which showed comparable fructose and glucose contents in all stages of eight cultivars. In conclusion, the present study indicates that NIRS in combination with chemoinformatics can be used as a robust method for the quantification of sugars in date fruits.

17.4.11. Transcriptome analysis of date palm

The date palm Phoenix dactylifera is an erect palm tree belonged to family Arecaceae is grown for its edible date fruit. The plant is terminating with a crown of 20-30 pinnately divided feather-like leaves. The leaves contain spiny petiole and a thick midrib. The thick mid rib of the plant gets infected with pathogen. Upon injury to the plant, the leave produces honey dews which later dry and became a source for the growth of pathogenic microorganism. The pathogenic microorganisms enter into the plant through the injury and damage the plant development which ultimately leads to death of the leaves and subsequently the whole plant. This leads to the loss of productivity of the date palm. Therefore, it is highly important to understand how the molecular events happening towards the death of the plants. Comparative transcriptome analysis of diseased and healthy plant can able to decipher the responsible genes involved in the molecular events associated with the death of leaves. Upon finding of the responsible genes involved in pathogenesis, it will be useful to implement them to produce disease tolerant date palm variety.

17.4.12. Tissue culture and conservation strategies

One of the objectives of our lab is to establish tissue culture-based methodologies of Boswellia in general and *B. sacra* in particular. A series of different methods are currently operating to generate callus from the *B. sacra*. In addition, two parallel approaches of culturing dedifferentiated plant cells and undifferentiated cambial meristematic cells have been planned to grow the plant cell for industrial scale. This technology has been patented by Lee et al., (2010), however, a bioreactor based approach will be adopted to enable highly efficient plant cell development for metabolites production.

The dedifferentiated cells will also be grown to promote the growth of ex-plant regeneration. Currently, experiments are in process to grow the cambial cells in MS media supplemented with diverse conditions and concentrations of phytohormones to facilitate cell development. Furthermore, growing tree saplings at the greenhouse have been initiated to grow plants for student research and development.

174.13. Current Research Projects

Ecology and Systematics

1	Genetic diversity of different populations of B. sacra
2	Chemo-diversity (Phytohormones, primary and secondary metabolites) of different population of B. sacra though robust NIRS and PLS methods
3	Tissue culture-based callus and cambium meristematic cell growth (CMCs) of ecologically important trees specially Boswellia sacra
4	Gene pool preservation and conservation through Herbarium establishment
5	Genetic diversity assessment of selected economically important native/landraces plants/or animals (DNA extraction, and PCR analysis using SSR, rbcL, matK, ycf3 and ITS markers)
6	Genetic database for important plant resources of Oman
7	Survey morphological trait analysis of different tree population to understand the various ecological and man-made stresses using photosynthetic flux, soil chemistry and chlorophyll fluorescence
8	Primary/secondary metabolites variation across different B. sacra population and its NIRS based Chemometric analysis
9	NIRS and chemometrics using specific organic solvent extract of stem samples to elucidate the variations among and within population whereas comparing with 5 different BAs

Plant Physiology

10	Understanding the mechanisms behind thermo-tolerance and drought resistance in tomato and cucumber crops by Preussia sp. BSL10
11	Primary sugar quantification in 14 date palm cultivars and their variation across different stages of fruit development using NIRS
12	Gender differentiation trait analysis in date palm through NIRS in three male and three female date palm cultivars
13	Gender differentiation trait analysis in date palm through PCR/qPCR in three male and three female date palm cultivars
14	HPLC based quantification and validation of 5 BAs in all the samples from 13 populations to understand population based chemotaxonomic marker analysis to understand ecotypic variation
15	Silicon regulating plant growth under abiotic-induced oxidative stress in date palm
16	Exogenously GA3 and Nitric oxide regulates the macronutrients, endogenous phytohormones and proteomics expressions in B. sacra sampling
17	Site specific wounding stress gene expression patterns in B. sacra for resin production
18	Changes in the mechanisms behind Boswellia resin production in high heat and drought stresses
19	Regulation of heavy metal transport gene family in tomato and influence on the flowering
20	Whole cell transcriptome of fungi during symbiosis with resin and transports of metabolites through COG-pathways

Biotransformation

21	Enzyme-based (Peroxidase-H2O2) conversion of a-pinene/KBA/a-amyrin to Bio-aroma/related products
22	Microbial whole-cell based transformation of a-pinene/KBA/a-amyrin to biologically active products
23	Biotransformation of Benzamine by Sphingomonas sp. LK11
24	Degradation of Persistent Aromatic Hydrocarbons by Sphingomonas sp. LK11
25	B. sacra callus growth in bioreactor and potential to secret Boswellia acid and related metabolites

Secondary metabolites from Microbes

26	Isolation and identification of bioactive secondary metabolites from Sphingomonas sp. LK11 and Aurobesidenum sp. BSS6
27	Role of secondary metabolites from microbes in:
28	Isolation of allelochemicals from Sphingomonas sp LK11
29	Isolation of secondary metabolites from microbes isolated from marine and terrestrial environments
30	Desert rhizospheric soil from eight different desert plants using NIRS, ELISA, Fluorescence spectrophotometer

Bioremediation

31	Heavy metal remediation by microbes (Fungi, bacteria)
32	Degradation of Persistent Aromatic Hydrocarbons
33	Exozyme analysis (cellulose, glucosidase, phosphatase, esterase)
34	Understanding the role and function of Aurobesidenum sp. BSS6 in enhancing the phytoremediation potential of cucumber plants
35	Role of microbes in assisting crop's potential to bioremediate the environmental pollutants
36	Gene expression analysis of related transcripts during PMI
37	Isolation, identification and growth of potential microbe at pilot scale (from petri-dish to fermenter) to understand the oil recovery/quality,
38	Coupled with in situ Field trails for oil spill remediation using specific co-culture of microbe(s)
39	Microbe-based enhancement of Oil recovery using in situ continuum through native microbial communities / microorganism
40	Full scale metagenome sequencing and transcriptomic to understand first the microbial flora and their role in oil contamination
41	Isolation, identification and growth of the potential microbe at pilot scale (from petri-dish to fermenter) to understand the oil recovery/quality
42	Product analysis can be correlated with NIRS based chemometric and NMR and other recovery analysis tools.

17.4.14. Future Projects in OMICS areas

1) Chloroplast genome sequencing of 50 endemic medicinal plants

In Oman there are various medicinally important endemic plants species. In next two years we are planning to extract the chloroplast DNA from these important plant and chloroplast genome sequencing through next generating sequence Ion S5.

2) Mitochondrial genome sequencing of 50 endemic medicinal plants.

Mitochondrial genome sequence is also very important and plays a significant contribution in plant phylogeny and diversity.

3) Transcriptomic of

a) *Boswellia sacra* resins/wound response

b) Date palm bug/ disease incidences

Boswellia sacra (Burseraceae), a keystone endemic species, is famous for the production of fragrant oleo-gum resin. However, its wound and resins response has not been studied on transcriptomic level. Therefore, we are going to study the gene expression level of *Boswellia sacra* to wound at different time duration.

Similarly, Date palm (*Phoenix dactylifera*) is a major crop in Sultanate of Oman and Gulf countries. More than 250 varieties of date palms are grown throughout Oman with a total production of about 281,000 tons per year. The Dubas bug, *Ommatissus lybicus* is considered the most destructive sucking insect pest attacking Omani date palms, causing serious damage by affecting growth and yield. Therefore, we are going to do transcriptomic level study to check the gene expression level of both Dubas bug and Date palm during the disease incidence to control this disease. In addition, followings are some more areas of interest:

- Transcription factors involved in community based oil-recovery from contaminated sites
- Transcriptome of Sphingomonas LK11/microbe(s) in biotransformation of Boswellic acids
- Engulfing Transcription of drought induced B. sacra tree
- Whole Transcription analysis of wounded, unwounded, wild and cultivated B. sacra (stem, root, leaf, flower and seed)

4) Genomics of Omani crops/landraces

a) Pomegranate

b) Garlic

c) Banana

d) Some other medicinally important plants

Crop production needs to increase to secure future food supplies and reducing its impact on ecosystem. Detail characterization of Omani crops/landraces genomes and genetic diversity is crucial for meeting these challenges. Advance genome sequencing and characterization will be used to access the large and complex genomes of crops and their wild relatives.

5) Whole genome sequencing of *Boswellia sacra*

Boswellia sacra (Burseraceae), a keystone endemic species, is famous for the production of fragrant oleo-gum resin. The genomic studies of medicinal plants lag behind those of model plants and important crop plants. The genome sequences encompass essential information of plant origin, evolution, development, physiology, inheritable traits and epigenomic regulation, many other aspects. High-throughput sequencing of medicinal plants could not only shed light on the biosynthetic pathways of medicinal compounds, especially secondary metabolites, and their regulation mechanisms but also can play a major role in the molecular breeding of high-yielding medicinal cultivars and molecular farming of transgenic medicinal strains. WGS of keystone specie of Resinosphere

6) Bacterial and fungal genome sequencing and their comparative analysis

Microbial genomes are widely variable and reflect the enormous diversity of bacteria, archaea and lower eukaryotes. The study of microbial genomes helps us to better understand the broader biology of bacteria and fungi, and how their genetic composition contributes to their tangible characteristics. The study of genomics is also important to study the genetic makeup and to infer the evolution of important microbes in Oman.

7) Metagenomics of important endemic trees

A fundamental step in the microbial ecology is to describe the taxonomic distribution of microbial community members. Thus, the precise taxonomic assignment of sequencing reads is one of the most important issues in the analysis of metagenomic and amplicon sequencing data. There are various economically and ecologically important endemic trees in Oman. Therefore, it is necessary to check the microbial community of these important trees from different location.

8) Genomics of important hazardous insects

There are various hazardous insects reported nowadays. To study the genome sequencing of these insect and host gene expression is very important to know the disease pattern and its control.

Genomics of

- Ghazals
- Arabian mice
- Tahr
- Arabian oryx

Future Projects in OMICS are in eight major areas

Chloroplast genome sequencing

- *Phoenix dactylifera* Naghal and *Phoenix dactylifera* Khanizi
- *Punica granatum* L. Jabal Al-Akhdhar

Whole genome sequencing

- *Phoenix dactylifera* Naghal and Phoenix dactylifera Khanizi
- Whole/draft genome sequencing and annotation
- *Punica granatum* L. Jabal Al-Akhdhar
- Whole/draft genome sequencing and annotation de novo assembly
- Whole genome sequencing of *B. sacra*
- 3rd tier sequencing strategy will include using PacBio Seq in Macrogen Korea
- Assembling the whole data set to arrange the whole genome in the USA
- Whole genome sequencing of beneficial microbes
- *Sphingomonas* sp. LK11 whole genome
- *Preussia* sp. BSL10 whole genome

Metagenomics

- Metagenomics of rhizosphere of desert plants
- Cissus, Jatropha, Cleome: Microbial community structure, diversity, composition, core microbiome
- Metagenomics of rhizosphere of cultivated and wild population of B. sacra
- Microbial community structure, diversity, composition, core microbiome
- Functional analysis of the nutrient transport, activation of defense responses

Mitochondrial genome of marine corals/ sea weeds

Nowadays various researchers working on projects related to corals and seas weeds and have made a huge breakthrough after successfully genetically sequencing whole coral organism and associated symbiotic organisms. As coral have an incredibly complex relationship with their symbionts, the algae and microbes that live inside their tissues. The mitochondrial genome sequencing will help us to understand their phylogeny and diversity.

Proteomics

- Proteomic profiling of essential biofactors for changing the *Aspergillus niger's* behavior to increased Boswellic acid concentration
- Changes in protein expression in the *B. sacra* tree communities during dry and normal growth conditions
- Proteomic expression profiling of venoms of various endemic snakes

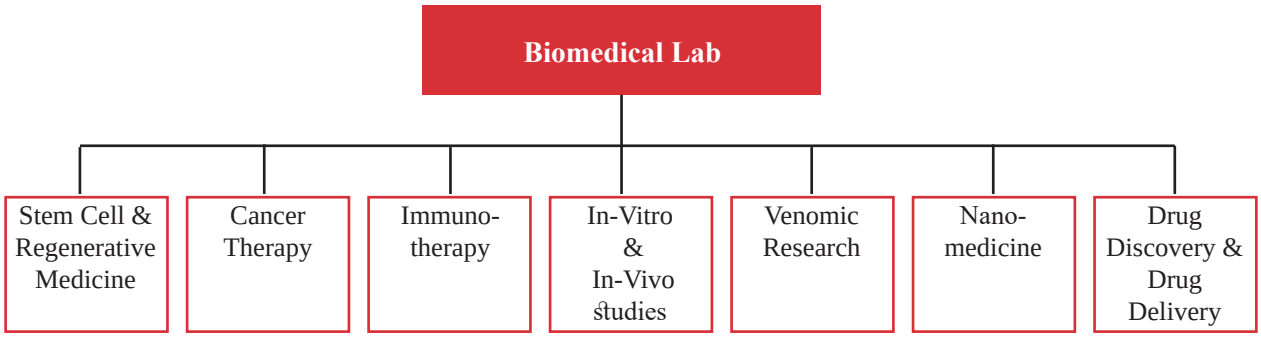
Plant Physiology

- Primary metabolites variation across different B. sacra population and its NIRS based chemometric analysis.
- NIRS and chemometric based primary and secondary metabolites variation across different populations of Boswellia sacra (in final process) and its influence on tree growth dynamics (in process)
- Combination of molecular and chemometric approaches to differentiate gender differentiation in date palm
- Economically important crop plant diseases and their robust NIRS-chemometric based detection with validation through PCR/RT-PCR
    a. Witches broom and acid lime disease to the lime trees
    b. Tomato leaf curl Sudan virus to tomato crops
    c. Pythium infection to cucumber
    d. Panama disease to banana trees
- Assessment of abiotic stress signaling (salinity, drought, heavy metal and heat) NIRS-chemometric based detection with validation through PCR/RT-PCR
- Understanding the growth dynamics versus date palm sap production and related disease incidence through NIRS-Chemometric and PCR/RT-PC

Marine resources

- Identification of anti-fouling agents from marine derived sponges and algae
- Anti-microbial, anti-corrosion properties of microbial agents from marine resources

17.5. Biomedical Lab



The main lab was established to perform experiments in different areas such experiments include preparation of required reagents, and preparation of nanoparticles, and scaffolds. Moreover, the lab contains different equipment set-up such as the *in-vivo* imaging system for florescent and luminesce screening of cells, nanoparticle and drugs *in vivo* as well as X-ray screening of bone defects The lab also contains other equipment such as, blood analyzer, centrifuges, microscopes, PH meter, balances and freezers.

17.5.1. Animal Cell Culture rooms

Cell culture room was established to isolate, expand and differentiate different types of cell-lines and primary cells for *in-vitro* tests. The rooms are equipped with Laminar flow hood, Centrifuges, Incubator, Vortex and Inverted microscope.

17.5.2. Genetic Engineering Lab

The main missions of this lab is cloning specific genes in different type of vectors and also collecting various vectors as a gene bank for studying of the process of genetic modification and molecular biology of different genes in in vitro and *in vivo* studies.

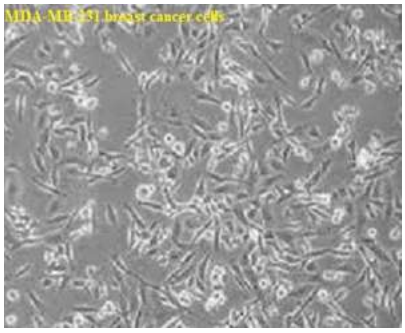
17.5.3. Animal House

Animal lab was established to develop and test various treatments on animal models, also studying how animal's bodies function, asseing the effect of different compounds for their possible treatment on human. This Animal house currently contains mice and rats, which are housed in different types of cages including the individually ventilated cages (IVC).

17.5.4. Animal Resources

A collection of live reptiles including venomous and non-venomous snakes is hosted in one area for research, education and as museum. The museum is containing living and mummified animals. Production of anti-venom is one of the main future goals. Proteomics studies will be done in different snakes' venom

17.5.5. Exploring Natural Products for Cancer Chemoprevention and Therapy

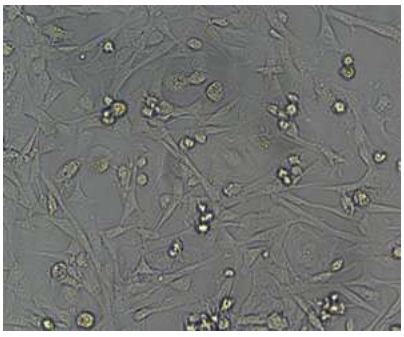


Cancer is one the leading causes of human deaths and, hence, represents one of the most important health issues worldwide. It has long been realized that the existing therapies used to treat cancer are just not enough as they also render significant adverse effects on the patients. In this context, developing new and safe therapeutic options is one of the critical challenges in cancer research. One such approach that has attracted considerable interest over the years is the use of plant-derived natural compounds as complementary or alternative therapeutic options, especially because of their easy availability and relative lack of toxicity against normal human cells. In this regard, we have committed ourselves to exploring the rich flora of Oman in the quest for finding the proverbial 'magic bullet' – a compound that may serve the purpose of treating various cancers without having any substantial side effects. Therefore, the main focus of our laboratory is to explore novel compounds isolated from various medicinal plants found in Oman for their anticancer and chemopreventive effects using cell-based assays. Moreover, we are also testing various synthetic chemical analogues of these natural products for any potential anticancer activities they might exhibit. For instance, several novel synthetically modified derivatives of the naturally occurring pentacyclic triterpene Acetyl-11-Keto-β-Boswellic Acid (AKBA), isolated from Omani frankincense (*Boswellia sacra*), are under investigation as tumor sensitizing agents. This study has been supported by an open research grant from TRC (The Research Council of Oman). Furthermore, we are planning to study miRNAs and epigenetic modifications associated with cancer stem cells and to target this association with natural compounds such as polyphenols. This would lead to devising a translational approach to overcome drug resistance in cancer. We strongly believe words of Prophet Mohammad (Peace be upon him) and Holy Quran. *"The one who sent down the disease sent down the remedy" "For every disease, Allah has given a cure"*

17.5.6. Stem Cell & Regenerative Medicine

Our research is multi-faceted and explores the following areas.

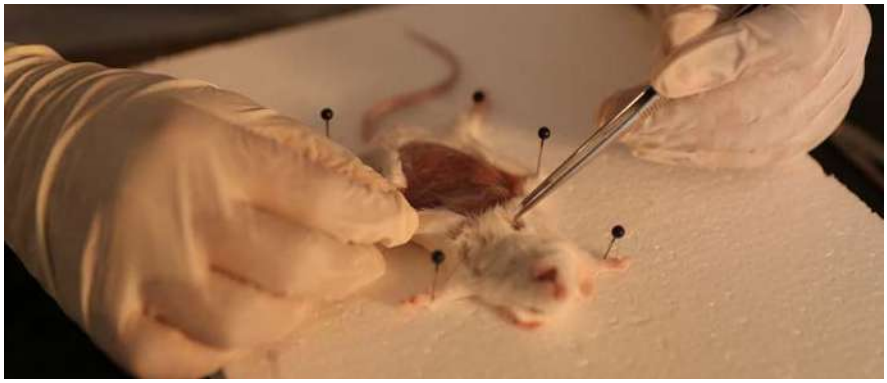
17.5.6.1. Stem Cells and GVHD



The Stem Cell & Regenerative Medicine group was aimed to study Stem Cell Therapy and Tissue Engineering. Currently, this group is studying mesenchymal stem cells (MSCs) for the treatment of graft versus host disease (GVHD) after hematopoietic stem cell transplantation (HSCT) and for other applications. Different techniques are being used for isolation and characterization of MSCs from different sources. The dose and time of infusion of these cells will be evaluated after HSCT for the treatment of GVHD and other complications.

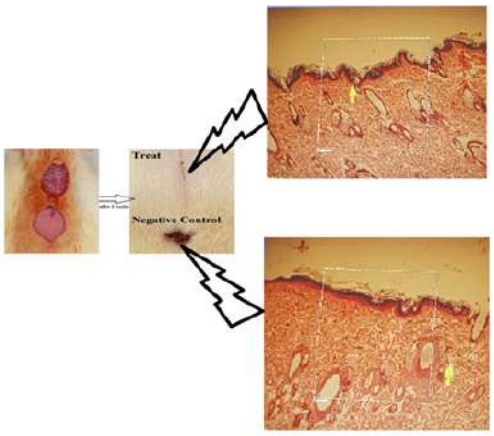
17.5.6.2. Bone Tissue Engineering

Bone tissue engineering has provided a promising platform for production of bone substitutes in patients suffering with bone loss, fracture or osteoporosis and unable to acquire improvement by current orthopedic methods. Bone is a specific connective tissue that is containing cells and extracellular matrix (ECM). In the tissue engineering bio-mimetic approach, we aim to make a suitable structure using 3D scaffolds that is similar to the native tissue. Recently, SRG was successfully established leg and calvarial bone defect in Rat. Herbal based hydrogels and oral delivery of herbal medicine was applied to treat bone defects.



17.5.6.3. Wound Healing

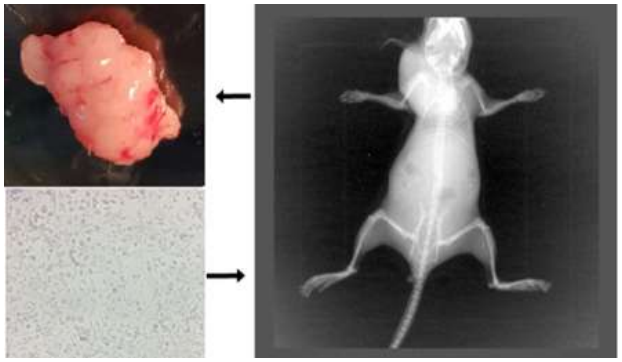
There are several challenging issues occur during the treatment of chronic wounds including inflammation, necrotic tissue, infection, scar formation and maturation of granulation tissues. To overcome this issue, natural or synthetic wound dressers such as honey, cotton and linen gauze have been commonly applied. However, these types of wound healing products are mostly accessible all over the world, novel materials should be considered to heal chronic wounds. Among these novel products biomaterial based matrixes which is mostly biomimetic to the natural tissue are broadly applied for the skin treatment. This natural derived matrix was applied as a strong tool for wound healing in rats to provide a promising structure to treat chronic wounds.



17.5.6.4. Cancer Therapy

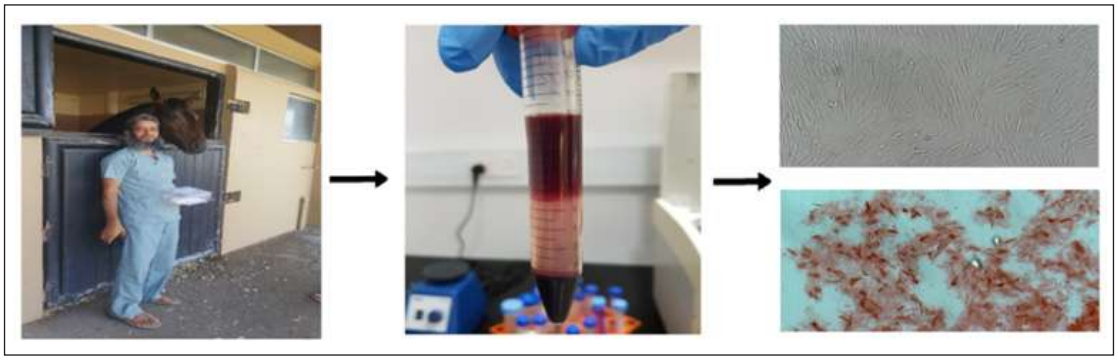
Recently, lots of patients are suffering from cancers such as Breast cancer. The 4T1 mouse mammary tumor cell line is one of only a few breast cancer models with the capacity to metastasize efficiently to sites affected in human breast cancer. For quantitation and tracking of the cells in vivo we engineered the lines for stable expression of firefly luciferase. The 4T1 tumor has numerous characteristics that make it a suitable experimental animal model for human mammary cancer. For example, the progressive range of 4T1 metastases to the draining lymph nodes and other organs is very similar to human mammary cancers well as these cells are very invasive and tumorigenic.

Finally, the effects of anti-tumor activity of herbal derivatives, snake venoms, gene constructs and nanoparticles are being evaluated on tumor growth, metastasis and molecular pathways in mice breast cancer model. Tumor progression was monitored by bioluminescence imaging with IVIS system.



17.5.6.5. Equine Stem Cell therapy

Stem cells have induced extensive interest in the veterinarians due to their promising technology that accelerate tissue regeneration for substantial injuries that promising technology that accelerate tissue regeneration for substantial injuries that natural signaling could not help too much for the recovery. In our group, we use mesenchymal stem cells (MSCs) to treat tendon, bone and cartilage. After mesenchymal stem cell isolation from bone marrow, large quantity of stem cells were expanded and injected to the defected area. The results support current encouraging outcome from clinical use in horses treated with bone-marrow-derived stem cells. Recent studies have also demonstrated that some soluble factors as small vesicles released from stem cells, named microvesicles are responsible for better tissue regeneration. These extracellular vehicles play major role in cell-to-cell communication. Both stem cells and microvesicles were applied to achieve bone regeneration *in vivo*.

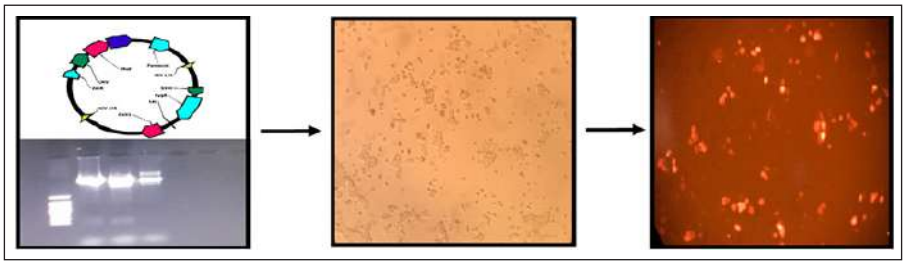


17.5.7. Prevention of adhesion bands

One of the major problems that typically occur after invasive surgery in intra abdomen area is formation of adhesion fibrous bands between organs and tissues that may cause several difficulties including female infertility, bowel obstruction, and difficult re-operative procedures. Our aim is to identify agents that would efficiently reduce the formation of adhesion in various surgical procedures without inducing side effects. In moving toward this goal, this adhesion band model was made in CD1-mice and several classes of herbal and engineered mats have been tested to prevent or at least reduce the high formation of these adhesions.

17.5.8. Genbank

Regarding to the applications of different vectors in genetic engineering, we are preparing a gene bank collected from different types of vector backbones. As well as, special genes are cloning in these vectors for different targets such as cell trackers, virus production, cancer therapy, cell therapy and various scientific applications.



17.5.9. Venom research

Snakebites as a mortality factor have globally caused over 90,000 deaths per year. Oman has long been of extraordinary herpetofauna importance because of its high habitat diversity in the special geographic position. Venomous snakes are abundant in many parts of its broad range of distribution and represent an important cause of envenoming. Venoms are deadly cocktails comprising unique mixtures of peptides and proteins with incredible specificities, showing numerous important physiological activities in apoptosis, neurotransmission, hemostasis and signal transduction. Envenoming resulting from snakebites is an important public health problem and causes considerable morbidity and mortality in many tropical and subtropical countries. On the other hand, snake venom active components can be recognized for several biomedical applications. To aid in antivenom design and to assess the range of the possible clinical applications of current commercial or experimental monospecific and polyspecific antivenoms, venom composition and variation will be assessed for proteomics and transcriptomics on the variant types of Omani snakes. The antivenomic analysis will provide qualitative and also quantitative information on the sets of venom proteins presenting antivenom-recognized epitopes and those exhibiting impaired immunoreactivity. For understanding snakebite symptoms such as local tissue damages and systemic disturbances we will arrange biological and toxinological assays, besides lethality (LD50) from the venoms of common species of Omani snake groups (Vipers and Elapids) to discover additional toxic activities that play key roles in the pathophysiology of human envenoming. We will study a series of in vitro and in vivo laboratory assays for the quantitative assessment of hemorrhagic, myotoxic, dermonecrotic, coagulant and defibrinogenating activities. In addition, histological research on different venom gland species may improve our knowledge on venom system besides evolutionary of these venomous species.

17.5.10. Depression study

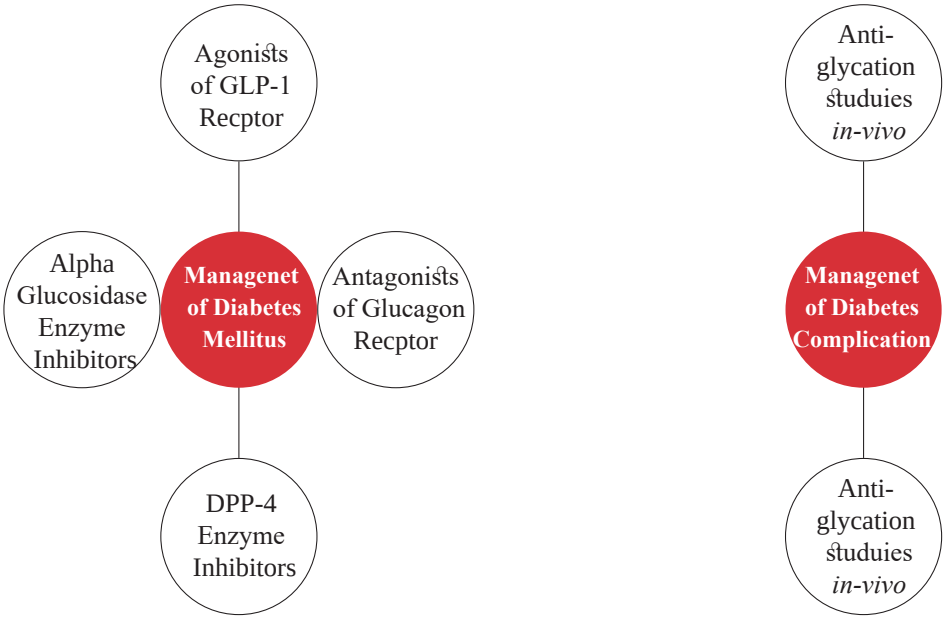
Depression is one of the complicated diseases that still do not have a cure. Herbal derivatives were applied to treat depression using established mouse model. Antidepressant-like activities were evaluated in behavioral despair tests which play an important role in the evaluation of antidepressant drugs. Reduction in the duration of immobility of animals is a behavioral model which is responsible for the antidepressant effect of these herbal drugs.

17.5.11. Diabetic projects

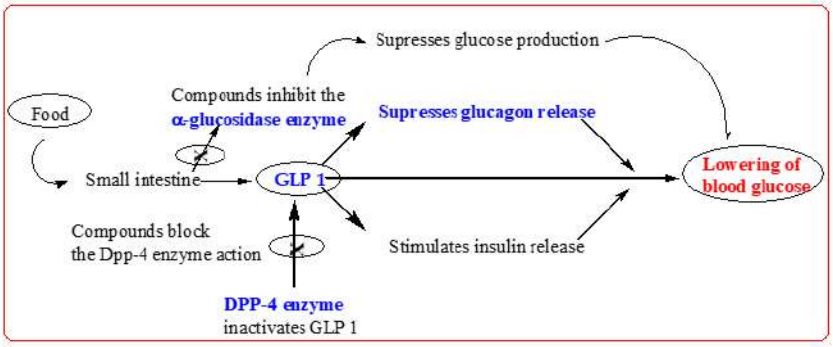
Management of diabetes mellitus and diabetic complications

Diabetes mellitus characterized by persistent elevated blood glucose level (hyperglycemia) is one of the major health problems of the 21st century.

We have focused on five excellent therapeutic targets to manage diabetes mellitus and diabetic complications Therapeutic targets for the management of diabetes mellitus and diabetic complications



Antidiabetic therapy involves the antagonists of glucagons receptor, agonists of glucagons like peptide-1 (GLP-1) receptor, inhibitors of dipeptidyl peptidase IV (DPP-4) and alpha glucosidase enzyme.



Graphical representation of anti-diabetic actions.

Studies on Glucagon receptor and Glucagon Like Petide-1 (GLP-1) receptor. Both glucagon and glucagon like peptide-1 (GLP-1) receptors are the members of large family of protein receptor known as G protein-coupled receptor (GPCR) superfamily, which are important drug targets for type-2 diabetes mellitus. Glucagon receptor exerts its effects in the liver through a messenger cyclic adenosine monophosphate (cAMP), to release glucose to counterbalances the action of insulin. GLP-1 is secreted by L-cells of the small intestine to stimulate insulin secretion. Antagonists of glucagons receptor and agonists of GLP-1 receptor have important implications for potential therapies in targeting these receptors for long-term glucose control to manage diabetic mellitus. Studies on glucagon and GLP-1 receptors are our future projects. All equipments and consumable required for these assays are in purchasing process and will be operational in near future.

Dipeptidyl peptidase IV (DPP-IV, EC 3.4.14.5) enzyme catalyzes the cleavage of GLP-1 peptide into inactive form and as a result the half life of GLP-1 peptide is decreased and glucose level in the blood increases. Hence, inhibition of DPP-4 actually increases the half life and biological activity of GLP-1 peptide as a result normal glucose level is achieved. Recently, we have started to establish standard assay protocol against DPP-4 enzyme which is in progress in our biomedical lab.
α-Glucosidase enzyme is secreted in the small intestine where it catalyzes the cleavage of oligosaccharides and disaccharides (sugars) into monosaccharides (glucose) and thus increases glucose concentration. Inhibition of α-glucosidase actually slows down or reduces the digestion and absorption of carbohydrates and thus it decreases the blood glucose level which leads to a decreased insulin demand. In our biomedical lab, we have established standard assay protocol and evaluated a library of natural and synthetic compounds isolated and synthesized by our group to identify potent α-glucosidase enzyme inhibitors. As a result several promising α-glucosidase enzyme inhibitors were discovered which were published in reputed international journals while several others are in pipeline for publication.

Antiglycation (inhibition of protein glycation) studies in vitro: Diabetes mellitus is associated with many complications including neuropathy, atherosclerosis, rheumatoid arthritis, retinopathy, end stage renal diseases, and neurodegenerative disorders which severely affect a patient's quality of life and is one of the major causes of mortality (death). Diabetic complications are mainly due to protein glycation (non-enzymatic reaction of reducing sugars, such as glucose, with free amino residues of proteins). This is a spontaneous reaction which induces changes in proteins structures and functions and plays a significant role in the pathogenesis of diabetic complications. Inhibition of protein glycation (antiglycation) is an effective therapy to control diabetic complications.

We have successfully established standard antiglycation assay protocol and evaluated several natural and synthetic compounds. As a result, several promising antiglycation agents in vitro have been identified which are in publication process.

17.5.12. Antiglycation studies in vivo (Attenuation of renal damage in diabetic nephropathy model mice)

Accumulation of glycated protein in the glomerular basement membrane of the kidney is one of the major causes of renal failure during diabetes mellitus. In our study, we aimed to examine our natural and synthetic compounds whether or not they attenuate protein glycation and renal damage in streptozotocin (STZ)-induced diabetic mice. Diabetes was induced by intraperitoneal injection of STZ (180 mg/kg) in CD1 mice. In our study, we examined the accumulation of glycated protein as well as florescence induced by glycated protein in the kidney of the treated and controlled mice. Some interesting results were obtained which are under process of publication.

Another project was aimed to find the function of bone marrow-derived mesenchymal stem cells in the treatment of diabetes in mice.

17.5.13. Future projects

Our future projects concentrate on to crucial areas.

17.5.13.1. CAR-T cell therapy

The miraculous technology of CAR-T cell therapy has revolutionized cancer therapy during previous years. In this therapy, T-cells were engineered to express a Chimeric Antigen Receptor (CAR) on their cell membrane. This receptor was designed to identify a specific tumor antigen and an internal activation domain responsible for activating the T cell when the CAR-T binds its target. The biomedical group is dedicated to develop the application of CAR-T cells for cancer therapy in Oman, because it is the first of many engineered cellular therapies to be approved in the coming decade.

17.5.13.2. 3D- Bio-Printing

The number of patients suffering from organ dysfunction or organ failure is increasing during last decades. Illnesses, such as heart attacks, cancer, bone and joint damages can drastically reduce the quality of life. 3D-bio-printing technique will have a great impact in designing and producing tissues that could substitute the need of organ donation from living or cadavers donors. With the purchase of the 3D bio-printing, the lab will be ready for this practice.

17.6. Fragrance and flavor Unit

Perfumery Unit

The objective of this project is to establish various fragrances and flavors from Omani medicinal and aromatic plants. In addition to this, marketing of the product and economic analysis will be considered. The Center has recruited an experienced fragrance specialist who is responsible for the activities and marketing of the products. This unit will allow research activities related to aroma and sense of smell. The Center is embarking on this area by collaborating with a world-leading institute in Frauenhofer in the area of neurotropic effects.

17.7. Herbarium Unit

Oman has the most diverse flora and vegetation among the Arabian Peninsula. Its represent invaluable resource and Oman is leading conservation efforts to its environments. The University of Nizwa herbarium unit composed of two main sections, the herbarium section and the greenhouse section. The herbarium section is a collection of preserved Omani's plant specimens and associated data used for research and scientific study. In collaboration with Oman Animal and Plant Genetic Resources Center (OAPGRC) the herbarium is furnished with the latest version of Object scan (1600 - Microtech) that gives high-resolution photos for plants specimens. In addition to that, it provides online database for the herbarium. Also, it is furnished with special cabinets for saving the plant's specimen and a (-15C) freezer is available in order to get rid of all insects and bugs from the specimens without using pesticide. The majority of the herbarium samples were collected from Jabal Akhdar and Dhofar regions, due to the variation in the climate and environments in these two selected places. Furthermore, the herbarium unit offers a classroom for junior students in order to increase the awareness about the environments and to teach them how to protect our flora and fauna from extinction.

The second section of this unit is the greenhouse where the condition and the environment are controlled. It is mainly focused on Omani plants and some non-Omani species. In this greenhouse, many plants from Jabal Akhdar and Dhofar are cultivated, and many endangered plants species like (Mitk) *Glycyrrhiza* Sp. are cultivated. Different seed germination condition are studied and optimized to get the optimum growth and germination conditions. The greenhouse has also been used to assess the role of endophytic microbes in offering drought and heat stress tolerance to tomato and cucumber plants. This helps in identifying potential microbes for broader field trails and production of higher yield in these vegetables during stressful conditions. Moreover, the greenhouse provides a research environment for final year student's project to study plant's physiology and pathogens. The herbarium is also supplied with an environmental growth chamber, which is used for controlled plant growth conditions. It has also been used to experiment on different abiotic and biotic stress conditions on Omani crops plants. An hydroponic system is established in herbarium unit as an example of a quick and space saving solution. It uses a non-soil plantation system with special nutrition solution.

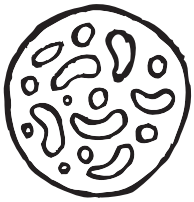
17.8. Oman GeneBank

NMSR Center proud to be the host of the first ever gene bank in Oman, which has been established in collaboration Oman Animal & Plants Genetics Resources Center (OAPGRC). The aim of this impitious project is to identify, maintain, preserve and propagate the available living genetic resources of Oman. In initial phase, the lab is hosting microbial genetic resources and seed bank for the cultivated and wild plants of Oman. Future focus is also on working on animal, marine and insect resource of the country. This also aims to conserve the unique gene pool for conservation purposes.

Current Collection Data

Plant accessions
130

Fungal species
1809



Bacterial species
142

17.9. Chemical Compounds Library

The NMSRC proud to have in-house database of chemical compounds which are collected by different research laboratories of the Center constituting a total of 760 chemical entities of natural, semi-natural and synthetic origin. This library is accessible for the research in new biological area, for hit-to-lead design and design and discovery of new drugs. The collection contains no commercially available/or compounds from any commercial/industrial chemical libraries. The natural compounds were extracted from various natural resources i.e. plants and microorganisms collected from different regions of our homeland, Oman. The synthetic compounds were prepared within institute in different research groups for purposes varying from total synthesis of natural products, their application in medicinal chemistry and improving the synthetic methodology. The details and chemical properties such as 2D and 3D structures of compounds are deposited in our database which is readily available for different studies.

ورشـــة عمليـــة فـــي
تقنيـــات الجينـــوم
والمعلوماتية الحيوية

Feb 17-20, 2019

Training Workshop on Genomics and Bioinformatics Techniques

University of Nizwa
Natural & Medical Sciences Research Center

Feb 17-20, 2019

Sponsors:

Oman Animal & Plant Genetic Resources Center

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ALLIANCE GLOBAL
IMPROVING LIVES THROUGH SCIENCE

Rainbow Emirates

Introduction

Genomics involves the study of genes, gene functions and whole genomes of organisms, and incorporates elements from genetics. It deals with the systematic use of genome information, associated with other data, to provide answers in biology, medicine, and industry. Genomics uses a combination of molecular biology, DNA sequencing methods, and bioinformatics to sequence, assemble, and analyze the structure and function of genomes. Bioinformatics is the application of computational tools to organize, analyze and visualize biological data. It is an interdisciplinary research area at the interface between computer science and biological science.

17.10. List of Investigated Plants at NMSRC

Family	Scintefic name	Local Name
Burseraceae	*Boswellia ameero*	Luban
	Boswellia bullata	Luban
	Boswellia carterii	Luban
	Boswellia dioscorides	Luban
	Boswellia elongata	Luban
	Boswellia frereana	Luban
	Boswellia globosa	Luban
	Boswellia nana	Luban
	Boswellia neglecta	Luban
	Boswellia ogadensis	Luban
	Boswellia ovalifoliolata	Luban
	Boswellia papyrefera	Luban
	Boswellia pirottae	Luban
	Boswellia popoviana	Luban
	Boswellia sacra	Omani Luban
	Boswellia serata	Luban
	Boswellia socotrana	Luban
	Commiphora kua	Aldogh
	Commiphora wightii (resin)	Moqil
	Commiphora foliaceae	Akboot
	Commiphora gileadensis	Balsan/Balsam

Family	Scintefic name	Local Name
Fabaceae	*Cassia senna*	Eshruck
	Glyceriza Sp. Oman	Mutk
	Senegalia Senegal	Sudan gum
	Tephrosia apollinea	Dafrah
	Tephrosia nubica	Eitman
	Vachellia nilotica	Talah/Sant
	Zygocarpumdhofarense	Shatt

Family	Scintefic name	Local Name
Lamiaceae	*Lavandula subnuda*	Hirak/Somar
	Teucrium nummularifolium	Ja'adah
	Teucrium nuvolum	Ja'adah
	Teucrium Stenophylum	Ja'adah
	Teucrium polium	Ja'adah
	Teucrium mascatense Boiss,	Ja'adah
	Teucrium muscatense	Ja'adah
	Teucrium stocksianum	Ja'adah

Family	Scintefic name	Local Name
Euphorbiaceae	*Chrozophora oblongifolia*	Msharia
	Euphorbia laurica	Asbuk
	Euphorbia smithii	Hibak
	Jatropha dhofarica	Sabroot
	Ricinus communis	Arash

Family	Scintefic name	Local Name
Arecaceae	*Phoenix dactylifera*	Khalas
		Khnizi
		Fahel
		Neghal
		Barni

Family	Scintefic name	Local Name
Zygophyllaceae	*Fagonia indica*	Almushka'a
	Fagonia paulayana	Shuka'a
	Tetraena Simplex	Tharmad
	Tetreana qatarensis	Haram

Family	Scintefic name	Local Name
Apocynaceae	*Calotropis procera*	Eshar
	Caralluma arabica	Dega'a
	Caralluma flava	Dega'a
	Rhazya stricta	Harmel

Family	Scintefic name	Local Name
Asteraceae	*Euryops pinifolius*	Hiqlan
	Euryops arabicus	Hinqlan
	Pluchea arabica	Kadhot

Family	Scintefic name	Local Name
Cleomaceae	*Cleome austroarabica*	Mqablout alshams
	Cleome droserifolia	Mqablout alshams
	Cleome rupicola	Mkhisah

Family	Scintefic name	Local Name
Capparaceae	*Dipterygium glaucum*	Sfirah/ Alqah
	Boscia arabica	Simer / Smir

Family	Scintefic name	Local Name
Brassicaceae	*Physorhynchus chamaerapistrum*	Khfog
	Capparis cartilaginea	Lsaf

Family	Scintefic name	Local Name
Rhamnaceae	*Ziziphus Hajarensis*	Qasam
	Ziziphus spina	Seder

Family	Scintefic name	Local Name
Cucurbitaceae	*Citrullus colocynthis*	Handal

Family	Scintefic name	Local Name
Cupressaceae	*Juniperus excelsa*	Elelan
	Juniperus seravschanica	Arar

Family	Scintefic name	Local Name
Resedaceae	*Ochradinus arabicus*	Hibab
	Ochradinus aucheri	Jysh/Asal Aljabal

Family	Scintefic name	Local Name
Solanaceae	*Lycium shawii*	Kasad
	Solanum incanum	Shrungpan

Family	Scintefic name	Local Name
Malpighiaceae	*Acridocarpus oreintalis*	Qafas

Family	Scintefic name	Local Name
Anacardiaceae	*Rhus aucheri*	Sohat ara'ai

Family	Scintefic name	Local Name
Salvadoraceae	*Salvedora persica*	Rak

Family	Scintefic name	Local Name
Poaceae	*Cymbopogon schoenanthus*	Sakhbar

Family	Scintefic name	Local Name
Aloaceae	*Aloe dhufarensis*	Seqel Dofari

Family	Scintefic name	Local Name
Asphodelaceae	*Aloe vera*	Seqel

Family	Scintefic name	Local Name
Combretaceae	*Anogeissus dhofarica*	Alsoghot/ Almshtt

Family	Scintefic name	Local Name
Acanthaceae	*Avicennia marina*	Alqourm

Family	Scintefic name	Local Name
Nyctaginaceae	*Boerhavia elegans*	Mhamrat aljabal

Family	Scintefic name	Local Name
Sapotaceae	*Sideroxylon mascatense*	Boot

Family	Scintefic name	Local Name
Sapindaceae	*Dodonea viscosa*	Shahs

Family	Scintefic name	Local Name
Frankeniaceae	*Frankenia pulverulenta*	Mllah

Family	Scintefic name	Local Name
Rutaceae	*Haplophyllum tuberculatum*	Tafer Al Tais

Family	Scintefic name	Local Name
Boraginaceae	*Heliotropium longiflorum*	Hibagh/ Shubrum

Family	Scintefic name	Local Name
Cistaceae	*Helianthemum lippii*	Biqan

Family	Scintefic name	Local Name
Lythraceae	*Lawsonia inermis*	Henaa

Family	Scintefic name	Local Name
Moringaceae	*Moringa peregrina*	Shua

Family	Scintefic name	Local Name
Myrtaceae	*Myrtus communis*	Yas

Family	Scintefic name	Local Name
Malvaceae	*Pavonia arabica*	Prihoh

Family	Scintefic name	Local Name
Rubiaceae	*Plocama aucheri*	Moukhrman

Family	Scintefic name	Local Name
Polygonaceae	*Pteropyrum scoparium*	Sidaf

Family	Scintefic name	Local Name
Punicaceae	*Punica granatum*	Ruman

18. Daris (The services arm of the Center)

Darice Center is the commercial arm of the Center particularly and University of Nizwa in general. The Center offers a various analytical services and training courses in scientific fiels. It is combining all analytical instruments under one umbrella. It is works as a link between the university and the clients (Academic or Industrial). Daris center fostering the collaboration between the research and the industrial sector. In addition to that, it encourages researchers for research by simplifying the processes of sample analyses. Moreover, Daris center providing the academics, technicianes and students with a training. Finally, yet importantly, Daris center offer different community services for the community like schools and colleges.

Daris's online services can be find in two platforms, iLab and Electronic Management System (EMS).

19. Facilities and Equipment

Natural products and Chemistry laboratories

Bruker Nuclear Magnetic Resonance (NMR) Spectroscopy:

is a research technique that exploits the magnetic properties of certain atomic nuclei. This spectroscopy determines the physical, chemical and biological properties of atoms or the molecules in which they are contained. There are more than 25 experimental techniques are being performed in our NMR.

Bruker X-ray Diffraction (XRD)*:

X-ray Diffraction (XRD) helps one to reach the science at atomic scale in the analysis of crystal structure, chemical composition, and physical properties of bulk and thin film crystalline or polycrystalline materials. XRD used to know crystallite size, lattice strain, chemical composition, and crystal orientation. While biological samples such as DNA, vitamins, protein, drug synthesis, use XRD to identify its elements and their crystal structure. It can also be used to identify arrangement of atoms in minerals, alloys, organic and inorganic complex compounds. Thus it has become the back bone of material characterization.

* Shared with National Chair of Material Science and Metallurgy

Agilent Technologies 6530 Accurate Mass Q-TOF LC/MS*:

The Agilent 6530 Accurate-Mass Quadruple Time-of-Flight (Q-TOF) LC/MS system features Agilent Jet Stream Thermal Focusing technology for significantly improved sensitivity, as well as enhanced Mass Hunter Workstation software for superior data mining and analysis capabilities. These new features, coupled with Agilent's True High-Definition TOF (True Hi-Def. TOF) technology, enable the 6530 Accurate-Mass Q-TOF to deliver exceptional sensitivity, excellent mass accuracy, fast data acquisition, and streamlined qualitative and quantitative analyses to meet your most challenging research needs.

Bruker Single Crystal X-ray diffraction*:

This is the most common experimental method of obtaining a detailed structure of a molecule, that allows resolution of individual atoms. Single crystal X-ray diffraction (SXRD) is performed by analyzing the pattern of X-rays diffracted by an ordered array of many identical molecule (single crystal). Many pure compounds, from small molecules to organometallic complexes, proteins, and polymers, solidify into crystals under the proper conditions. Computationally intensive analysis of a set images results in a solution for the 3D structure of the molecule.

* Shared with National Chair of Material Science and Metallurgy

PerkinElmer OPTIMA 8000Inductively Coupled Plasma Optical Emission Spectrometry ICP-OES*:

The widely used analytical technique for the determination of trace elements in a sample. Using the eponymous Inductively Couple Plasma, an ICP-AES produces excited atoms (by ionization in an intense electromagnetic field) that emit detectable amounts of light at characteristic wavelengths, with intensities proportional to the concentration of the ion. The intensity of this emission is indicative of the concentration of the element within the sample.

Bruker SENTERRA II Compact Raman Microscope*:

The SENTERRA II allows measuring Raman images and combines the obtained spatially resolved molecular information with high-quality microscopic images of the sample. The analysis is performed contactless and without the need of sample preparation. Chemical images of the sample surface can be achieved with a very high spatial resolution down to less than a micron. In addition, depth profiling of optically transparent samples allows non-destructive sample investigation in the third dimension.

* Shared with National Chair of Material Science and Metallurgy

Bruker Fourier Transformer Infra-Red spectroscopy (FTIR; TENSOR 37)*:

FTIR used for the determination of functional groups in the pure natural products and pharmaceutical drugs. FTIR also used for the detection of heavy and essential elements in the medicinal plants, resins, and food products.

Perkin Elmer Near Infra-Red (NIR):

Automatic Preparative HPLC used for the isolation of pure constituents from the mixture of two, three, and four compounds for samples soluble in chloroform (Solvent) only. This recycling HPLC system is being used in the isolation and purification of different types of natural products including enantiomers, diastereomers, epimers, positional isomers, and structurally related or unrelated compounds having similar retention characteristics.

* Shared with National Chair of Material Science and Metallurgy

Agilent Analytical HPLC (Agilent):

Analytical HPLC used for the qualitative and quantitative analysis of vegetables, medicinal plants and resins. It is also used for the standardization of drugs in pharmaceutical and industrial purposes.

JAI Preparative HPLC (Gradient Solvent System):

Preparative HPLC used for the isolation of pure constituents from the mixture of two, three, and four compounds for samples soluble in ethyl acetate or a mixture of ethyl acetate and n-hexane.

High Performance Liquid Chromatography- Ultra Violet detection (HPLC-UV)

Liquid chromatography UV detection is an analytical technique where by certain non-volatile group of compounds can be analyzed using the Ultra Violet (UV) detection to identify and quantify compounds of interest. This system is one of the most common instrumentation in the majority of the analytical laboratories around the world. This is mainly due to the fact that the instrumentation is relatively cheap to acquire and easy to use with minimal training for the staff. As with LC-MS this instrumentation has a wide range of uses and is applicable to compounds such as pesticides, pharmaceutical products, drugs of abuse and many other categories.

Liquid Chromatography- Mass Spectrometry (LC-MS):

Liquid chromatography–Mass spectrometry (LC-MS, or alternatively HPLC-MS) is an analytical chemistry technique that combines separation capabilities of liquid chromatography (or HPLC) with the mass analysis capabilities of mass spectrometry (MS). LC-MS is a powerful technique that has very high sensitivity and selectivity and as such is useful in many applications. Its application is wide ranging from detection of pesticides in water, blood, soil to analysis and identification of medicine and chemicals used in pharmaceutical industry, Forensic science, Hospitals.

Gas Chromatography – Flame Ionization Detector (GC-FID):

Gas chromatography with Flame Ionization Detector (GC-FID) is a common type of chromatography used in analytical chemistry for the separation and analysis of multi-residue samples that can be vaporized without decomposition. The sample migrates through the column with a flow of inert or unreactive gas, which is called the carrier gas. The mechanism of separation is influenced by many factors, for example, the components, which have low boiling points, will come out of the column earlier and will be detected faster than those that have high boiling points. Linearity and detection ranges: FIDs can measure organic substance concentration at very low and very high levels, having a linear response of 10^6.

Gas Chromatography – Mass Spectrometry (GC – MS):

Gas chromatography–mass spectrometry (GC-MS) is an analytical method that combines the features of gas-liquid chromatography and mass spectrometry to identify different substances within a test sample. GC-MS has been widely heralded as a "gold standard" for forensic substance identification because it is used to perform a specific test. A specific test positively identifies the actual presence of a particular substance in a given sample. A non-specific test merely indicates that a substance falls into a category of substances. Although a non-specific test could statistically suggest the identity of the substance, this could lead to false positive identification.

Atomic Absorption Spectroscopy (AAS):

Atomic absorption spectroscopy (AAS) is a spectroanalytical procedure for the quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state. In analytical chemistry the technique is used for determining the concentration of a particular element (the analyte) in a sample to be analyzed. AAS can be used to determine over 70 different elements in solution or directly in solid samples used in pharmacology, biophysics and toxicology research.

Inductively Coupled Plasma - Mass Spectrometry (ICP-MS):

Inductively coupled plasma mass spectrometry (ICP-MS) is a type of mass spectrometry which is capable of detecting metals and several non-metals at concentrations as low as one part in per trillion. This is achieved by ionizing the sample with inductively coupled plasma and then using a mass spectrometer to separate and quantify those ions. Compared to other atomic absorption techniques for example, Atomic Absorption Spectroscopy, ICP-MS has greater speed, precision, and sensitivity. However, analysis by ICP-MS is also more susceptible to trace contaminants from glassware and reagents. One of the largest volume uses for ICP-MS is in the medical and forensic field, specifically, toxicology. A physician may order a metal assay for a number of reasons, such as suspicion of heavy metal poisoning, metabolic concerns, and even hepatological (liver related) issues.

Cary 100 UV-Vis with S/W:

The Cary 100 is a cost-effective UV-visible spectrophotometer with a versatile set of accessories for routine laboratory work. It is controlled by the Cary WinUV software, a Windows-based software featuring an easy-to-use modular design. The instrument is shipped with liquid sample holders and can be fitted with a wide range of accessories to provide extra capabilities

PerkinElmer LS-55 Fluorescence Spectrometer (220 VAC):

Versatile, computer controlled Fluorescence spectrometer; incorporates a Watt (8.3 wati@220V), phosphorescence decay time measurements. Excitation 200-800 nm and emission 200-900 nm with zero order selectable. Standard PMT covers 200-650 nm; R928 or R955 PMT optionally available for full range.

Polarimeter:

It is used for the specific rotation of pure drugs, natural/synthetic products. This instrument will allow checking the optical purity of chiral compounds. it measures the angle of rotation caused by passing polarized light through an optically active substance.

Milestone New Microwave Essential Oil System (NEOS):

The NEOS system is based on the Solvent-Free Microwave Extraction technology for rapid extraction of essential oils from aromatic herbs, spices and dry seeds.

Kjeldahl Apparatus (KjelFlex K-360):

It is used for the quantification of nitrogen in terms of proteins in vegetables, medicinal plants and other formulations. Due to precision and reproducibility, it has become internationally recognized method for estimating the protein content in soils, waste waters, vegetables, medicinal plants, fertilizers and other food samples.

Moisture Analyzer:

It is used for the quantification of moisture in pharmaceutical drugs, medicinal plants and other formulations.

Melting Point Apparatus:

It is used for the determination of melting point of pure constituents and pharmaceutical drugs.

Microwave Synthesis Reactor (MSR):

MSR used for quick, fast, low cost and environmental friendly synthetic reactions using microwave radiation instead of heat. It provides a completely new and sophisticated approach towards microwave synthesis. Not only polar solvents but also commonly used poor microwave absorbers, such as toluene or dioxane, can be used successfully in high-temperature microwave protocols

Buchi Rotary Evaporator:

It is used for the quick evaporation of organic solvents.

Karl Fischer Coulometric Titrator:

Classic titration method in analytical chemistry that uses coulometric or volumetric titration to determine trace amounts of water or water content in organic solvents.

Buchi Medium Pressure Liquid Chromatography (MPLC):

MPLC used for the quick separation of a mixture of two, three and four compounds using pressure pump with gradient solvent system.

Differential Scanning Calorimeter (DSC):

DSC measures temperatures and heat flows associated with thermal transitions in a material, including glass transitions, "cold" crystallization, phase changes, melting, crystallization, product stability, cure / cure kinetics, and oxidative stability. ♦Applications: Common usage includes investigation, selection, comparison and end-use performance evaluation of materials in research, quality control and production applications

Particle size analyzer:

The Cilas 1190 is a versatile instrument with a measurement interval of 0.04 microns (40 nanometers) to 2,500 microns. It uses two techniques for its measurement: Laser Ray Diffraction and digitalization with a CCD Camera that measures large sizes. This instrument uses 3 laser beams for its measurement process, 2 which do the same function of a Cilas 1090 and the other laser for the process with the CCD camera.

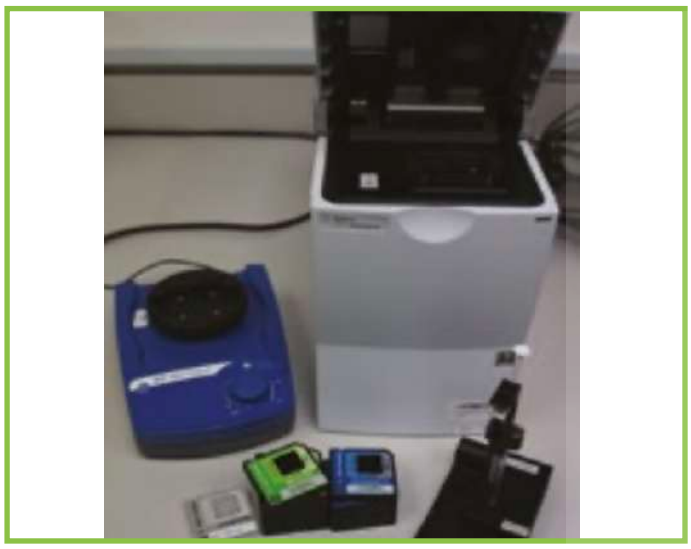
Texture analyzer:

The CT3 can calculate, through compression and tensile data, a number of physical properties that have proven to be highly correlated to human sensory evaluation of food and other consumer products.

Biotechnology and OMICS laboratories

Next Generation Sequencing set-up:

It includes IonS5, emulsion PCR, library size selector and genomic work bench server. It can do 200bp, 400bp and 600bp insert size, 60-80 million reads, 10-15 Gb data output per run of about 2 to 3hrs. It is used for microbial (bacteria, fungi), plant and human whole or partial genomics. It is used for Organelle genomes (chloroplast, mitocondria), metagenomics (soil, water, plant, animal, human), DNA methylation/mutation studies, and transcriptomics. In addition, it is used for pathogenic infections, public health, food safety and exome sequencing.



Bioanalyser 2100:

With automated electrophoresis, provides sizing, quantitation, and purity assessments for DNA, RNA, and protein samples. It can be used for DNA/RNA fragment analyses for NGS sequencing. It can do QC, size distribution, PCR validation, restriction digestion, protien expression, food analysis, cleavage/mutation detection, vector assembly analysis, microarray etc

* In collaboaration with Oman Animal Plant Genetic Resources Center (OAPGRC)

DNA 120 OP:

These complete systems provide everything needed to quickly dry and concentrate small sample volumes in one fully integrated package. It has a single program that supports all DNA/RNA applications; For evaporating PCR buffers (aqueous); Water and Ethanol from DNA/RNA samples.

QuantStudio™ 5 Real-Time PCR System:

The QuantStudio™ 5 Real-Time PCR System is an ideal high-performance instrument with features for maximum experiment control. Applications including gene expression analysis, microRNA analysis, single nucleotide polymorphism (SNP) genotyping, copy number variation (CNV) analysis, and even protein analysis. This versatile technology can be used for both relative and absolute quantification methods. Protein Assays combine the sensitive, specific protein-binding capabilities of antibodies with the superior relative quantitation capabilities of 5' nuclease real-time PCR. In addition, it can do multiplex gene expression; pathogen detection and antibiotic resistance screening; miRNA quantification and analysis; and screening annealing temperatures for rare allele detection.

PCR System (Applied Biosystems USA):

We have three advanced and normal PCR systems. ProFlex PCR System has 3 x 32-well block option can run three different cycling conditions (0.2 mL/ 6.0°C/sec). Three different cycling conditions, at three different times by one or multiple users, so it can help to reduce time in optimization of protocol. This can be monitor remotely for different runs from smartphones or desktop computers. SimpliAmp PCR system is 96-well 0.2 ml with 3-zone VeriFlex Blocks 96 reactions; 4.0°C/sec; Touch screen; efficient and accurate; cloud based technology. GeneAmp®PCR System 9700 is a 96-well 0.2 ml and can do 96 reactions. It is used DNA amplification, Genetic diversity, Microbial identification, Pathogenic identification, Genomic sequencing, Genotyping, Cloning, Mutation detection, microarray and forensics.

Qubit™ 3.0 Fluorometer:

Is the next generation of the popular benchtop fluorometer that accurately measures DNA, RNA, and protein using the highly sensitive quantitation assays. The concentration of the target molecule in the sample is reported by a fluorescent dye that emits a signal only when bound to to the target, which minimizes the effects of contaminants—including degraded DNA or RNA—on the result. It uses as little as 1 µL of sample.

Object Scan 1600*:

It is a workstation consisting of ObjectScan 1600 scanner, ScanWizard Botany software, and MiVapp Botany archive management system. This integrated workstation is characterized by, (1) On-top scan design for full-frame focus, (2) 1600 dpi (equal to 1 Gigabyte pixels) color CCD, (3) Optical Character Recognition (OCR) for specimen label and 1D barcode, and (4) image archive and privileged-account cloud management system

Fermentor:

(BioFlo 320, next-generation bioprocess control station ; Eppendorf USA) is a Research and development in cell culture and microbiology; Bench- and pilot-scale fermentation of aerobic and anaerobic bacteria, yeasts, and fungi; Cultivation of mammalian, insect, and human cell lines; Specialized applications such as stem cell culture or biofeul/biopolymer development; Specialized packed-bed impeller for vaccine production in anchorage and non-anchorage dependent cell lines; Suitable for batch, fed-batch, and continuous processes; Biotransformation of secondary metabolites by microbes and Bioremediation strategies.

* In collaboaration with Oman Animal Plant Genetic Resources Center (OAPGRC)

The ZOOM® IEF Fractionator kits:

Offers a fast, reliable method to reduce sample complexity, enrich low abundance proteins, and increase the dynamic range of detection. Solution phase isoelectric focusing with the ZOOM® IEF Fractionator provides reproducible separations in three hours. Fractionated samples are ready for further analysis by two dimensional gel electrophoresis (2DE), one dimensional gel electrophoresis (1DE), or two dimensional liquid chromatography/mass spectrometry (2D LC/MS).

Class II, Type A2 Biological Safety Cabinets:

Biological Safety Cabinets designed to protect personnel, product, and the environment from exposure to biohazards and cross contamination during routine procedures. Class II cabinet works with low to moderate risk biological agents. The existing cabinet also included UV light to keep a biosafety cabinet's interior clean when not in use.

xMark Microplate Absorbance Spectrophotometer (Biorad, USA):

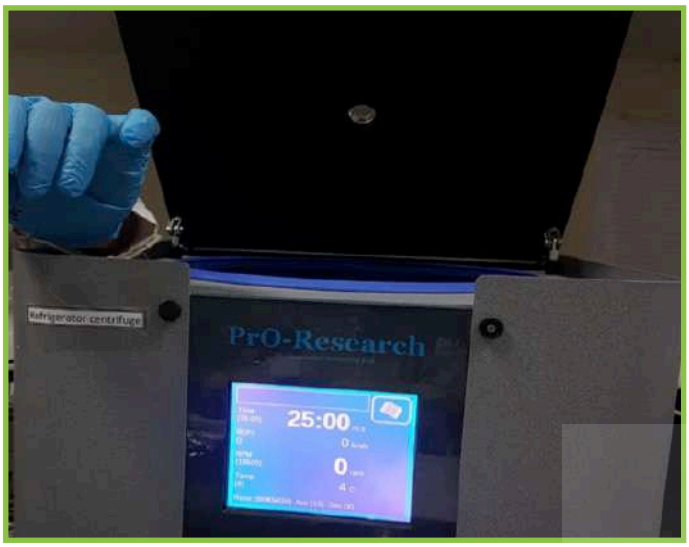
Is used for Enzyme-linked immunosorbent assay (ELISA), which can run 6- to 96 samples with wave length 200–1,000 nm and single and dual wavelength. It is used for enzyme inhibition assay and kinetics (Urease, a-Glucosidase, Acety cholenisterase; a-Amalyase, etc), anti-oxidant quantification; OD600; protein quantification; various colorimetric assays for microbiology, plant physiology, and biochemistry.

Denaturing gradient gel and Electrophoresis systems:

A set-up of DGGE is helpful for microbial diversity analysis in various samples from soil, water and plants. The electrophoresis system is both vertical and horizontal, which can run from 8 to 96 samples in one go.

Autoclave (SX 700E; Tomy; USA):

It is vertical top-open led autoclave about 550 L. It can run 25 to 250 ◦C with 7 different programs. It is used in microbiology and molecular biology and sterilization of microbial media.



Refrigerated centrifuge (ProScientific):

It can operature with various programable options. The centrifugation range is from 500 to 15,500 rpm with volume ranging from 0.2 ml to 50 mL. It is used for DNA/RNA and Protein extractions.

Digital Heating Shaking Drybath:

Speed range from 150 to 1500rpm (block dependent); 0 programs, up to 10 steps per program; 150 to 1,500rpm (96-well block); 150 to 1,200rpm (0.5mL, 1.5mL and 50mL tube blocks).

Thermo Scientific Heraeus Pico 17 microcentrifuge:

Performance up to 17,000 x g with fast acceleration and deceleration. Standard rotor runs 24 microcentrifuge tubes in a single row, from 1.5 to 2.0 mL tubes to mini-preps and spin columns.

Tissue homogenizer:

It is used for grinding and homogenization of soft and Hard Tissue for cellular, biological; and DNA/ RNA and Protein extractions.

Gel-Drier (LabTech):

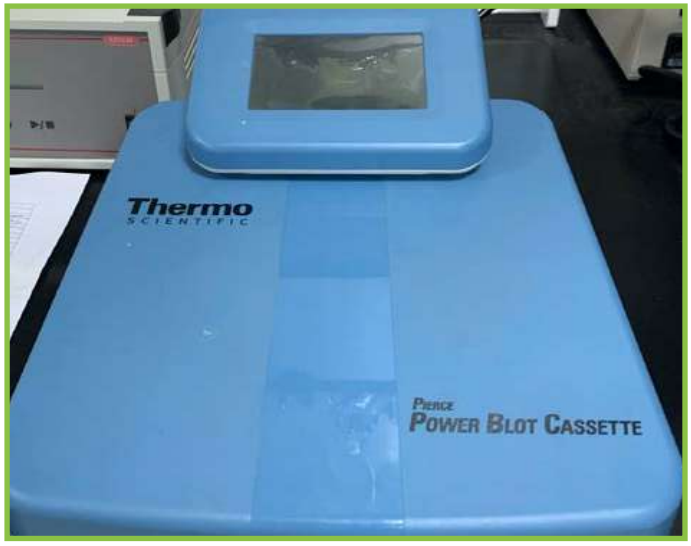
It has microprocessor control temperature and timer dryer (85 ◦C) and can dry gels 10 x 10 cm size.

Gel Documentation System:

It used for gel documentation, fitted with Pre-focused 5 mega pixel monochrome camera and Interchangeable filter slide with 620nm. It is used for DNA/RNA/Protein gel electrophoresis analysis.

Fisher Scientific™ Bead Mill 24 Homogenizer:

Used for variety of applications that require grinding, lysing, and homogenization of biological samples prior to molecular extraction: DNA/RNA extraction, tissue homogenization, protein purification.



The Thermo Scientific™ Pierce™ Power Blotter:

Is designed specifically for rapid semi-dry transfer of 10-300 kDa proteins from polyacrylamide gels to nitrocellulose or PVDF membranes in 5 to 10 minutes. The Pierce Power Blotter features an integrated power supply optimized to enable consistent, high-efficiency protein transfer when used with commonly used precast or homemade gels (SDS-PAGE).

The Mini Gel Tank:

Is compatible with a variety of Novex® gels, NuPAGE® gels, and Bolt® Bis-Tris Plus gels. Each Mini Gel Tank can accommodate up to two gels per run. The unique tank design enables convenient side-by-side gel loading and enhanced viewing during use. SDS-PAGE analysis for proteins.

Bioinformatics Server, Lenovo P910 Workstation:

It is a 2 x Intel Xeon E5-2650 v4 Processor (30MB Cache, 2.20GHz; 22 core processor), 384GB RAM (12 x 32GB 2400MHz ECC RDIMM 12) 2 x M.2 512GB PCIE SSD, and 4 x 4TB Hard Drive. It is used for de novo assembley, genome mapping, and various bioinformatic analysis to analyze genomic and transcriptomic dataset. It uses online available modules/suits as well as CLC genomic workbench for sequence analysis.

Dell Precision 7910 Tower Workstation:

For molecular docking, drug discovery and protein-ligand interaction server with 4 cores running at 3.1Ghz and 96GB RAM for simulations and modeling.

Supporting instruments

Cold storages (SANYO; LG):

It ranges between -80 ◦C (600 L); -20 ◦C (500 L); 4◦C (550 L) fridges for keeping samples for long-term uses and experimentation.

Freeze-Drier (LabTech):

It is Vacuum-Freezing (-56 ◦C), which can be used to freeze-dry samples for phytochemical, microbiology and antioxidant analysis. Its sample volume ranging from 0.1 to 1000 uL; 1 to 100 mL volumes; 1.0 mg to 250g.

Ultra sonicator Elmasonic P:

Special functions such as Sweep, Pulse and Degas can be individually activated and complete the equipment.

Vertex:

Touch and manual vertexing for volumn ranging from 0.1 to 1000 uL; 1 to 50 mL volumes. The rotation can range to 1500rpm.

Ice maker (LabTech):

It makes flakes with an out-put ranges between 1 to 2 Kg per hour.

Table top centrifuge:

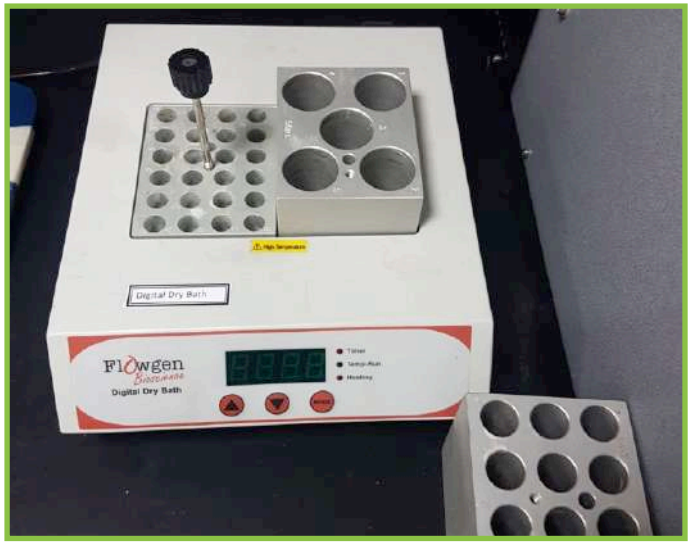
Machines for root temperature centrifugations. For RNA/DNA extractions.

Incubators:

3 different incubators are currently available with different experimental prospects. The size of these incubators ranging from 30 l to 60L and can run 25 to 85 ◦C.

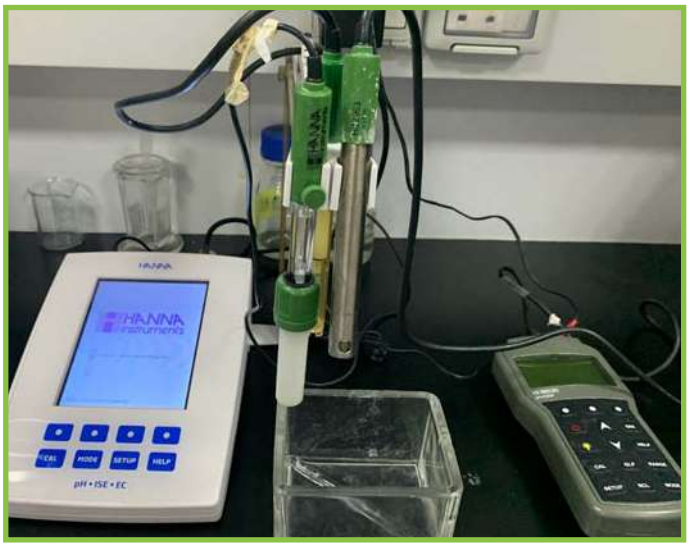
Incubators and open Shakers (Korea):

Open and closed incubator shakers are used to growth microorganisms. The capacity range from 50 ml to 2.5 L and can run on 300 rpm; orbital/ reciprocal with a temperature of 25 to 55 ◦C.



Dry Bath (Cleaver Sci):

Dry heating block which control temperature from 37 to 150◦C and volumn ranges from 1.0mL to 50mL.



HANA pH and electrical conductivity meters:

Wide ranges of pH meter for biotech, omics and microbiology parts.

Biomedical sciences laboratories

Transmission Electron Microscope (TEM):

JEOL JEM-1400 TEM with 3D Tomography System The JEOL JEM-1400 TEM is an ultra-high magnification instrument offering state-of-the-art high contrast imaging up to x1,200,000 magnification with a high resolution of up to 0.2 nm for observing the internal structure (ultrastructure) of a specimen in micrometer (µm) and nanometer (nm) ranges. The system has the capability of exporting data to a dedicated tomography system for 3D structural elucidation. The specimen chamber has the capacity to load five samples at a time, 1mm3 biological samples are sliced into ultrathin sections from 60-90nm thickness using an ultramicrotome and then loaded onto Formvar carbon coated grids.

Scanning Electron Microscope (SEM):

sJEOL JSM-6510LA SEM with SED, BSD, and EDS detectors The JEOL JSM-6510LA SEM is capable of high magnification for observing the surface structure (topography) of a specimen in micrometer (µm) and nanometer (nm) ranges. The magnification is variable from x10 to x300,000 with a resolution of up to 3 nm. Unlike conventional light microscopes the SEM uses a beam of electrons to scan the sample; the reflected electrons are then detected using different types of detectors to create a 3D image in grey scale.

IVIS Lumina XRMS In Vivo Imaging System:

It includes IonS5, emulsion PCR, library size selector and genomic work bench server. It can do 200bp, 400bp and 600bp insert size, 60-80 million reads, 10-15 Gb data output per run of about 2 to 3hrs. It is used for microbial (bacteria, fungi), plant and human whole or partial genomics. It is used for Organelle genomes (chloroplast, mitocondria), metagenomics (soil, water, plant, animal, human), DNA methylation/mutation studies, and transcriptomics. In addition, it is used for pathogenic infections, public health, food safety and exome sequencing.

Individually Ventilated Cages (IVC):

The purpose of IVC system is to provide a clean environment that is generally suitable for breeding and preservation of Specific-pathogen-free (SPF) animals. This type of environment support various animal experiments especially in the use of immunodeficiency animals.

Guava® easyCyte Flow Cytometry:

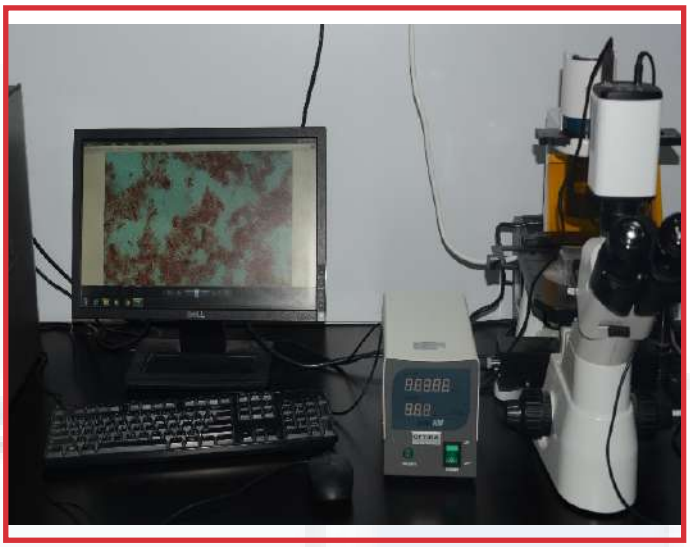
Flow cytometry is a technology that is used to analyze the physical and chemical characteristics of particles in a fluid as it passes through at least one laser. Cell components are fluorescently labelled and then excited by the laser to emit light at varying wavelengths. This flow cytometry is simpler to operate than traditional sheath-fluid based in instruments and are easier to maintain. The utilize small sample volumes and generate minimal waste a result of Guava® easyCyte flow cytomer are uniquely amenable to on-demand use in the laboratory environment and have helped many scientists achieves insightful cellular analysis. Sample Handling Formats for Both Tubes and 96-Well Plates.

CO2 incubators:

Cell culture incubator is designed to maintain a constant temperature and high humidity for the growth of tissue culture under a CO2 atmosphere. The temperature settings is 37°C and the CO2 concentrations set at 5%. This incubator has also decontamination system that can be used from time to time to obtain a clean environment for the cells. CO2 incubator is a fundamental instrument for growing cells in optimal condition.

Class II, Type A2 Biological Safety Cabinets:

Biological Safety Cabinets designed to protect personnel, product, and the environment from exposure to biohazards and cross contamination during routine procedures. Class II cabinet works with low to moderate risk biological agents. The existing cabinet also included UV light to keep a biosafety cabinet's interior clean when not in use.



Inverted and fluorescence microscope with camera:

A fluorescence microscope is an optical microscope that uses fluorescence in addition to reflection and absorption to study properties of organic or inorganic substances.

Reptile cages and Bird cages:

Different types and sizes of cages used as a suitable environment of living snakes and other reptile.

Centrifuges with different tubes volumes:

Machine with a high speed rotating rotors that applies centrifugal force to its contents, to separate fluids of different densities or liquids from solids.

PH meter:

Is an instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity. The pH meter is used in many applications ranging from laboratory experimentation to quality control.

Liquid nitrogen supply and storage tanks:

Liquid nitrogen is a cryogenic fluid that can cause rapid freezing on contact with living tissue and has a boiling point of –196°C. It used to store cells at low temperature for laboratory work.

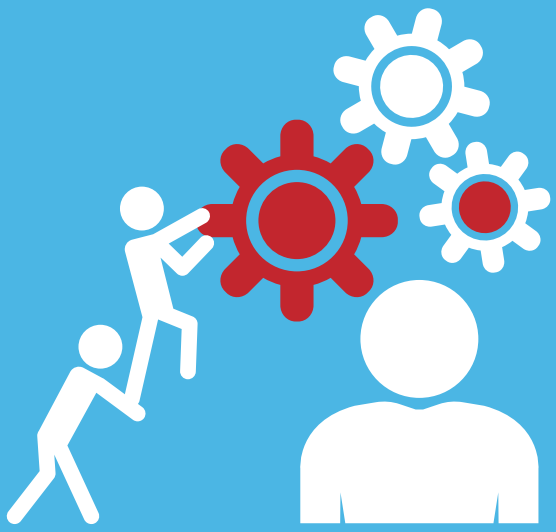
Venoms freeze dryer:

Freeze dryer or lyophilization or cryodesiccation is the removal of solvents from a material through the process of sublimation and the removal of bound water molecules through the process of desorption. This make material more convenient for transport and better for long time storage.

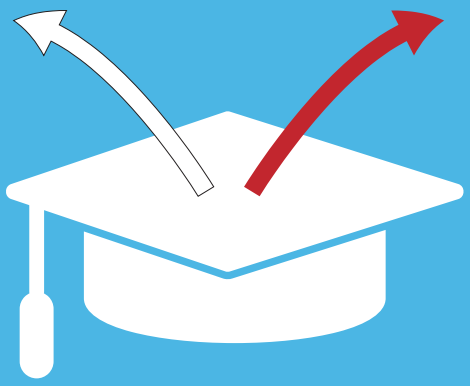
20. Staff Profiles

1 Chairperson

3 Administration team members



45 Research team members



7 PHD exchange students

Total = 56 members

Prof. Ahmed Al-Harrasi

Chairman

Major: Organic Chemistry

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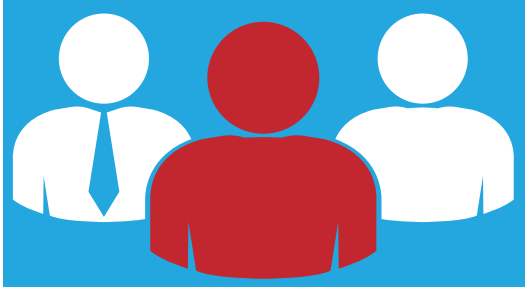

Leadership

Prof. Ahmed received his BSc in Chemistry from Sultan Qaboos University (Oman) in 1997. Then he moved to the Free University of Berlin from which he obtained his MSc in Chemistry in 2002 and then his PhD in Organic Chemistry in 2005 as a DAAD-fellow under the supervision of Prof. Hans-Ulrich Reissig. His PhD work was on New Transformations of Enantiopure 3,6-Dihydro-2H-1,2-oxazines. Then he received the Fulbright award in 2008 for postdoctoral research in chemistry for which he joined Prof. Tadhg Begely group at Cornell University where he worked on Synthesis of isotopically-labeled thiamin pyrophosphate. He is currently a Professor of Organic Chemistry and the Chairman of the Natural and Medical Science Research Center and Dean of Research at the University of Nizwa, Oman. He has several funded projects with a budget that exceeds 4 million USD. He was a Chair and invited speaker in many international conferences. He is a referee for more than 15 International chemistry and biotechnology Journals. He has authored and co-authored over 200 scientific papers and 6 book chapters.

Dr. Djamila Gabruck

Liaison Officer

Major: French Literature

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Administration team

Dr. Djamila Gabruck received her PhD in French Literature from the University of Calgary, Canada, in 2006. She also holds a MA in Economics and a MA in English Literature from the University of Montpellier, France, in collaboration with the University of Coimbra, Portugal, and the University of Preston, England. Her research interests include autobiographies, travel writings, the notion of identity in a multicultural context and second language acquisition. She worked at the University of Sana'a, Yemen, as a French Language Instructor, before joining the University of Calgary where she worked first as a French Language Lecturer and then as co-director of the French, Italian and Spanish Language Center. She received a Teaching Excellence Award in 2014. She also worked as a French and English editor for several North American publishers, with a specialization in online content and textbooks. She came to the University of Nizwa in 2015, as the Head of the French Language Section. She joined the Office of the Vice Chancellor for Research, Graduates Studies and External Relations in January 2018.

Dr. Obaid Khan

Director Technical Operations

Major: Organic Chemistry

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Dr. Khan was born in Quetta Pakistan on Dec 9, 1960. He completed his school, college and university education in Karachi, Pakistan. He received his M.Sc. Degree in Organic Chemistry from University of Karachi in 1984 and his Ph.D. Degree (Organic Chemistry) in 1991 from H.E.J Research Institute of Chemistry, University of Karachi, Pakistan. Upon completion of his education, he started his professional carrier as a quality control chemist in a multinational pharmaceutical company (MSD) and afterwards he has served as Project Director in a nationwide company providing complete solution for research institutes, universities, hospitals, pharmaceutical, food, agriculture and other industries. Dr. Khan has more than 23 years' experience in the field of development and designing of scientific research labs and complete set up of a routine quality control lab for different industries. He is also trained by world's leading manufacturers of scientific equipment on their different varieties of scientific and research equipment at their facilities in different parts of the world. Since July 2013 he is working as a Director Technical Operations at University of Nizwa, Sultanate of Oman.

Administration team

Mr. Aflah Al-Hadhrami

Administrative Director

Major: International Business Administration

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Administration team

Mr. Aflah obtained his Bachelor Degree in International Business Administration from Salalah College of Applied Sciences, 2011, Sultanate of Oman. He has completed a training course with the International Pathway and Language Center at Brunel University, London, UK. He got an opportunity to visit the capital of Europe and explore the city, meet people from different nationalities and work with them. He obtained his training at the International office at Brunel University; along with supervising a group of 60 students at Brunel. During the trip, he has enhanced his leadership skills, decision-making, and problem solving abilities. He also visited University of Wisconsin Oshkosh, Wisconsin, USA and completed an internship with the office of International Education concentrating on (i) Study Abroad Admission and Application Process (ii) Administrative Support Services (iii) Students Internship Coordination(iv) Along with supervising a group of 22 students who have got the chance to study at University of Wisconsin Oshkosh this summer. Being students chaperone taught him to be more responsible of his decisions, and a good planner as well.

Dr. Najeeb Ur Rehman

Research Assistant Professor

Major: Natural product Chemist

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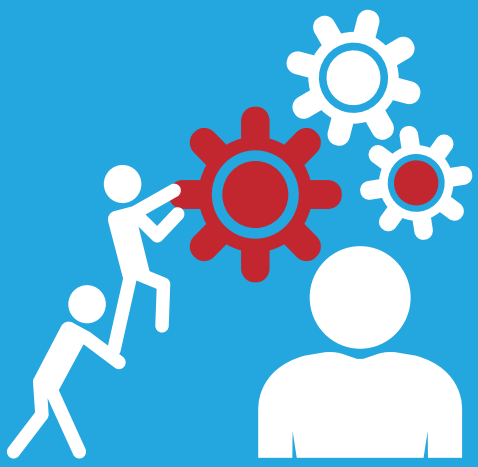

Research team

Natural Products lab

Dr. NU Rehman received his B.Sc. in Chemistry (2003) and M.Sc. degrees in Organic Chemistry (2005) from Government Post Graduate College Koha, Khyber Pakhtunkhwa, Pakistan. He obtained his Ph.D. degree in organic chemistry (2012) from Kohat University of Science & Technology, Kohat, KP-Pakistan. His PhD was on isolation, structure elucidation and biological activities of Nepeta clarkei and related species. He has published more than seventy articles along with book, reviews, and chapters in the peer reviewed and high reputed National and International Journals. In 2012, he moved to UoN Natural and Medical Science Research Center University of Nizwa, Oman as a postdoc fellow and, currently, working as a Research Assistant Professor. He is involved in the isolation, characterization, and synthesis of bioactive natural products from Omani medicinal plants and oleo-gum resins of Boswellia species. He is also concerned with the synthesis of boswellic acids, incensole, incensole acetate and other natural product derivatives, as well as NIR, FTIR and HPLC quantification.

Dr. Tania Shamim Rizvi

Research Assistant Professor

Major: Natural product Chemist

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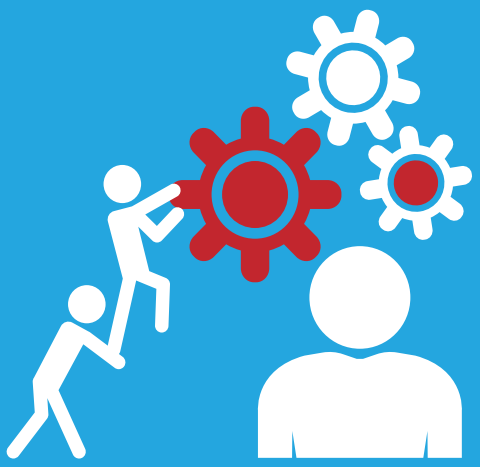

Research team

Natural Products lab

Dr. Rizvi got Master's degree in Organic Chemistry from University of Karachi. She joined the H.E.J. Research Institute of Chemistry, International Center for Chemical and Biological Sciences (ICCBS), University of Karachi and received PhD (Organic Chemistry) while working on the Solid Phase Synthesis of Anticancer Cyclic Peptides along with the Phytochemical Investigations of Medicinal Plants. Previously, she has been working as a Research Associate on an HEC funded project entitled "Synthesis and biological screening of combinatorial libraries of small drug like molecules to established structure-activity relation and drug development". Dr. Rizvi worked in National Nematological Research Centre (NNRC), University of Karachi as an Assistant Professor in 2012. Dr. Tania is the member of the chemical society of Pakistan and has published twenty-five papers in various international journals. Her current research interests involve the development of new synthetic methodologies, heterocyclic chemistry, organohalogen chemistry, natural products isolation and their biological evaluation.

Mr. Mohammed Said Saleh Al Azri

Research Assistant

Major: Chemistry

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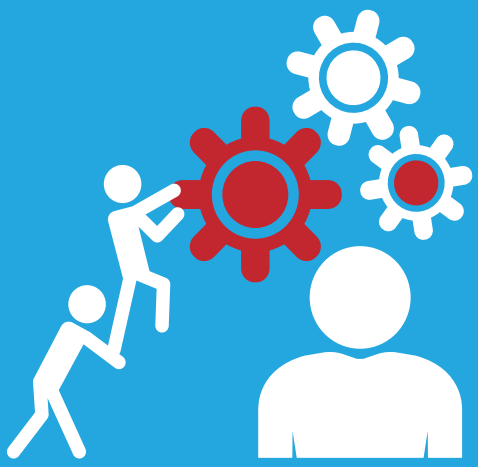

Research team

Natural Products lab

Mohammed Al Azri has received his B.Sc. degree in Chemistry from college of science at Sultan Qaboos University (SQU), Sultanate of Oman, in 2016. He has recently joined the Center in Natural Products Lab as a Research Assistant.

Mr. Kashif Rafiq

PhD Exchange Program Researcher

Major: Chemistry

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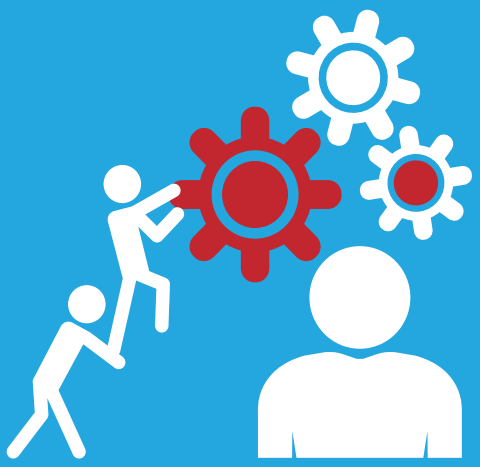
Email: kashifrafiq609@gmail.com



Research team

Natural Products lab

Kashif Rafiq has received his B.S(Hon`s) degree from Kohat University of Science and Technology (KUST) and M.Phil. degree from Abdul Wali Khan University Mardan (AWKUM) under the supervision of Dr. M. Said. He studied environmental, inorganic and polymer chemistry as major courses in the M.Phil. Currently, he is working as a PhD Exchange Program Researcher for six months at the UoN Natural and Medical Science Research Center, University of Nizwa.

Dr. Ajmal Khan

Research Assistant Professor

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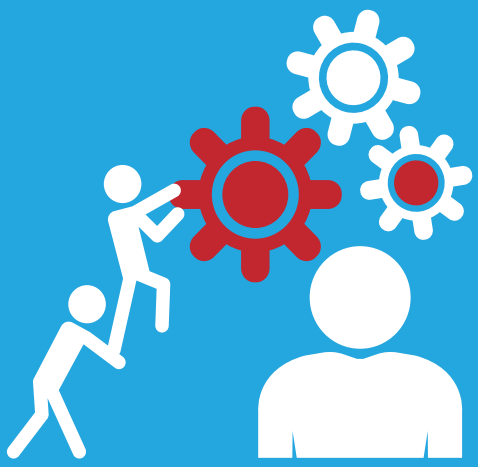

Research team

Medicinal Chemistry & Computational Drug Design lab

Dr. Ajmal Khan received his B.Sc. degree from University of Malakand and M.Sc. degree in distinction from University of Peshawar, Pakistan. In 2007 Dr. Khan got scholarship from H. E. J. Research Institute of Chemistry, International Center for Chemical and Biological Sciences, University of Karachi, Karachi-75270 for Ph.D. and completed his Ph.D. in field of enzymology. During his PhD, he received split PhD scholarship from OAED Austria, and worked as visiting scientist in University of Innsbruck, under the supervision of Univ. Prof. Dr. Bernd Michael Rode (Institute of General, Inorganic and Theoretical Chemistry University of Innsbruck, Austria). He has published more than 140 articles in international peer review journals with impact factor of more than 270 and citation more than 100. Beside this, he has four US patents, two of them published and the other two are filed in Pakistan for two years. Currently he is working on enzyme inhibition, Enzyme kinetics studies, STD NMR studies for protein-ligand interaction and QM/MM calculation for enzyme active site and DFT calculation of metal complexes.

Dr. Sobia Ahsan Halim

Research Assistant Professor

Major: Molecular docking

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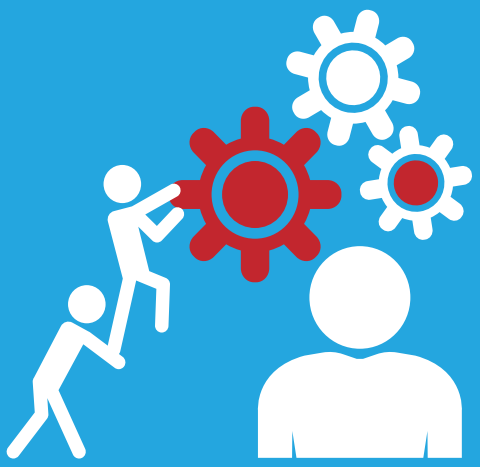

Research team

Medicinal Chemistry & Computational Drug Design lab

Dr. Sobia has graduated from Jinnah University for Women, Karachi with M.Sc. in Biochemistry and later joined Dr. Panjwani Center for Molecular Medicine and Drug Research, International Center for Chemical and Biological Sciences, University of Karachi for completing her Ph.D. research in the field of computational medicinal chemistry/Computational drug design. She has also worked as a visiting scholar in Southern Illinois University Edwardsville under the supervision of Prof. Dr. Maria Kontoyianni. Dr. Sobia has expertise in Bioinformatics, Computational Modeling, QSAR/QSPR studies, Homology Modeling, Virtual Screening, Descriptor based analysis, 2D-Similarity Searching, 3D-Pharmacophore modeling, Modeling of protein-ligand interaction, Molecular dynamic simulation, Fragments library generation, Molecular Docking and QM/MM calculation of enzymes. She has worked on diverse drug targets including different pharmaceutically important enzymes, G-Protein coupled receptors, immune-modulatory proteins and viral genomes.

Mr. Mohammed Khait

Research Assistant

Major: Enzyme inhibition biology

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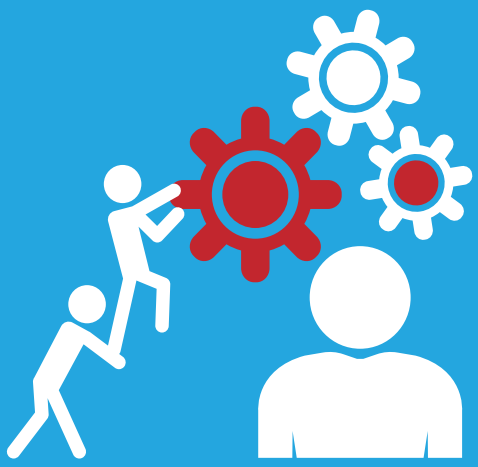

Research team

Medicinal Chemistry & Computational Drug Design lab

Mr. Mohammed working at the Center as Assistant Researcher. He holds both a Bachelor Degree (2009) Biology, Physiology and Plant Genetic" and a Master's degree (2011) "Plant Sciences and Biotechnology" from the University of Sciences and Technology Houari Boumediene (USTHB), Algiers, Algeria. Since joining the research center in 2013, He has been involved in extraction, isolation, identification and screening of natural products for anticancer, antioxidant and enzymes inhibition. Currently he is working on the enzyme inhibition of bioactive secondary metabolites.

Mr. Majid Khan

PhD Exchange Program Researcher

Major: Bio-Organic Chemistry & Protein Chemistry
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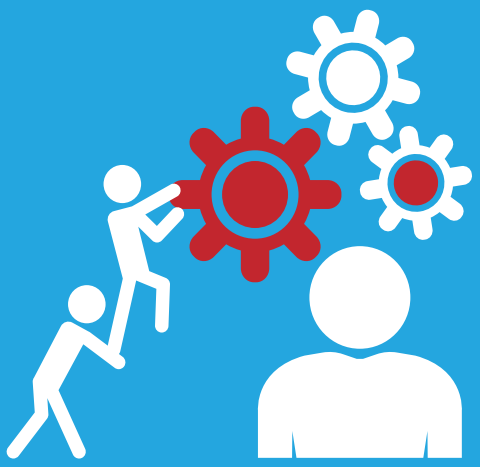
Mr. Khan pursued the BSc (Hons) degree from Hazara University Mansehra (HUM), Pakistan. Then, he joined the prestigious institute, International Center of Chemical and Biological Sciences (ICCBS) University of Karachi, Pakistan, where he completes his M.Phil. Studies in the field of Enzymology. Further, he extends his research skills and gets enrolled in Ph.D. in the same institute. All along with that, he is a member of cancer and diabetes association in Pakistan and conducts several lectures and seminars in order to aware of the common people from these life-threating diseases. During his Ph.D. he published more than 10 research articles as a principal and co-author in journals of international repute and impact factor. His research skills include Protein isolation, Enzyme activities, and computational designing of drug targets. Currently, his projects focus on the identification of new and safe drugs for the carbonic and urease enzyme to cure life-threating diseases, such as cancer, peptic ulcer, and urinary tract infections.



Research team

Medicinal Chemistry & Computational Drug Design lab

Mr. Touqeer Ahmad

Research Assistant

Major: Nanomedicines and Biosensors

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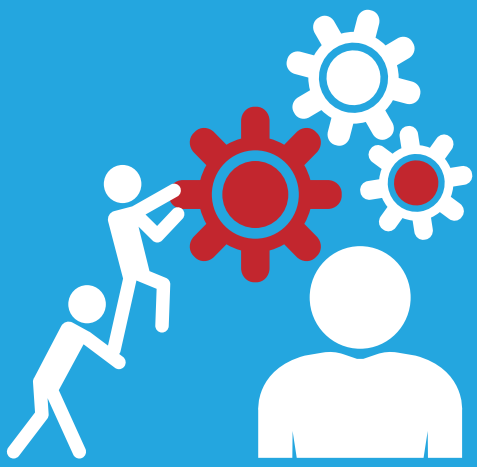
Touqeer Ahmad received his B.S degree in distinction from University of Haripur, Pakistan. Later, he joined the Department of Chemistry, COMSATS Institutes of Information & Technology, Islamabad, Pakistan to complete his MS in Material Chemistry. After his MS, he joined Natural and Medical Science Research Center at University of Nizwa Oman. He has published 3 research articles as a principal and co-author in journals of international repute and impact factor. His research activities focus on Nanomedicines, nanoparticles syntheses and Biosensors. His current projects include Biosensors and syntheses of nanoparticles of isolated compounds from *Bosweilla* species and their biological potential.



Research team

Medicinal Chemistry & Computational Drug Design lab

Dr. Usman Anwar

X-ray Facility Manager

Major: Chemistry

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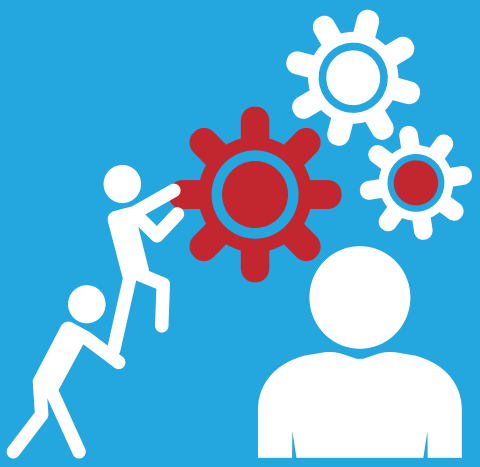

Research team

X-ray Crystallography lab

Dr. Usman Anwar received his Master degree in Chemistry from the University of Agriculture Faisalabad, Faisalabad, Pakistan. He then received M.Phil in Organic Chemistry from Quai-I-Azam University Islamabad, Pakistan. He obtained PhD degree in the field of Inorganic Chemistry from Karlsruhe Institute of Technology, Karlsruhe, Germany. He then moved to Memorial University of Newfoundland, St John's Canada where he worked as Postdoc Fellow from 2010-2012. Later on, he worked as a Senior Research Associate (2013 – 2016) at the Department of Chemistry, University of Windsor, Windsor, Canada. He has been working as an X-ray Facility Manager at Natural and Medical Sciences Research Centre at the University of Nizwa, Sultanate of Oman since October 2016. At the centre, Dr. Anwar is running single crystal/powder X-ray diffraction experiments using Bruker X-rays diffractometers. Dr Anwar is an X-ray diffraction specialist, with 10+ years' experience in materials characterisation. Dr Anwar has very strong synthetic background in both coordination chemistry and ligand synthesis, ranging from transition metal catalysis to polynuclear molecular magnetic materials and 'non-innocent ligand' chemistry. He is the author or co-author of several peer reviewed publications (predominantly ACS and RSC).

Mr. Rashid Al-Harrasi

Research Technician

Major: Chemistry

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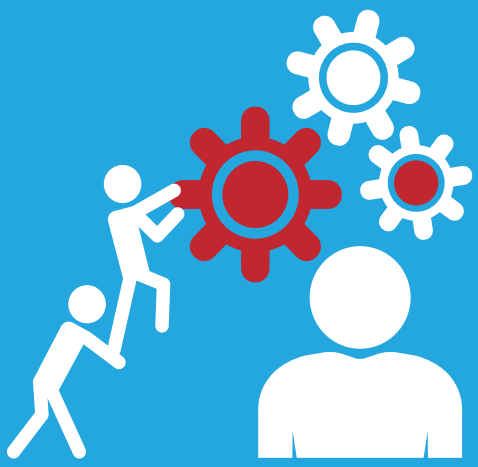
Mr. Rashid obtained his Diploma in Applied Science (Chemistry) from Higher College of Technology (Muscat). He got training in the central lab of the college of Agriculture and Marine Sciences in SQU for 6 months. His main areas of research interest are Phytochemical Investigations of Omani medicinal plants and HPLC purification of compounds.



Research team

X-ray Crystallography lab

Mr. Mohammed Sulaiyam Al Jassasi

Research Assistant

Major: Chemistry

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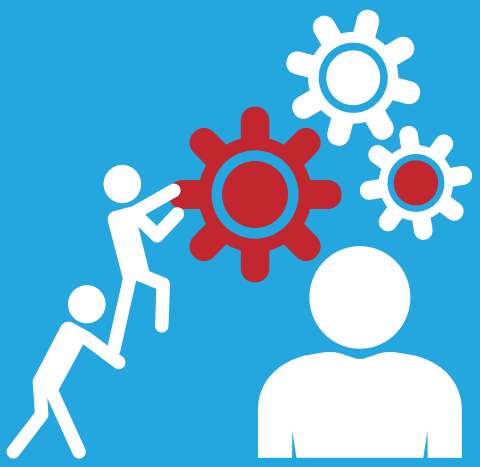
Mohammed Al Jassasi has received his B.Sc. degree in Chemistry from college of science at Sultan Qaboos University (SQU), Sultanate of Oman, in 2016. His minor is Mathematics. He has recently joined the Chemistry lab (Natural Products and Synthesis) as a Research Assistant.



Research team

X-ray Crystallography lab

Dr. Ali Rostami

Assistant Professor

Major: Synthetic chemistry

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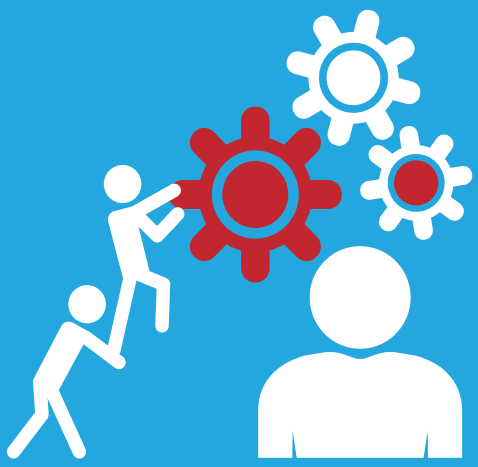

Research team

Synthetic Chemistry Lab

Dr. Rostami obtained his B.Sc. degree (Honors) in chemistry from University of Mazandaran (Iran) in 2001, and his M.Sc. degree in 2006 from University of Alberta (Canada) working on heterocyclic synthesis utilizing domino Nazarov-Schmidt processes in the group/ of Prof. F. G. West. In 2007, he started his Ph.D. studies under the supervision of Prof. Mark Taylor at University of Toronto (Canada), working on the synthesis, sensory, and self-assembly properties of polysquaramides. After completing his Ph.D., he took up a JSPS-postdoctoral fellowship at the Nagoya University (Japan) where he developed new types of helical polymers in the research group of Prof. Eiji Yashima. In 2013, he moved to Shahid Beheshti University (Iran) as an assistant professor in the Department of Chemistry, and in July 2017 he moved to UoN Natural and Medical Science Research Center (Sultanate of Oman). His current research interests are at the interface of the areas of catalysis and polymer chemistry, and include catalysts for polymerizations, CO2 fixations, and preparation of sustainable polymers from renewable resources.

Dr. Satya Kumar

Researcher

Major: Organic Chemistry

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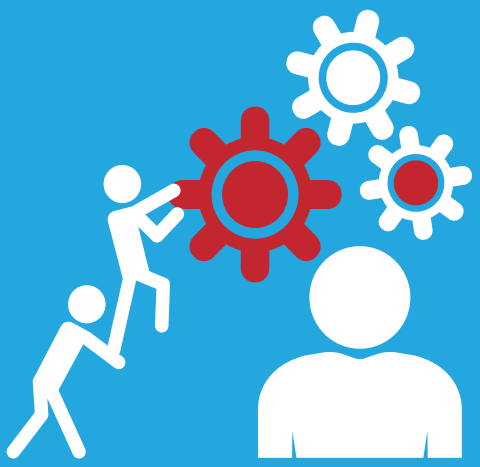

Research team

Synthetic Chemistry Lab

Dr. Satya Kumar obtained his Master's degree in Inorganic Chemistry (2004) from the Osmania University, Hyderabad. He worked as an Assistant Professor (on contract basis) in Chemistry department, Osmania University Post Graduate College (OUPGC) from 2004 to 2007. Then he moved to Indian Institute of Chemical Technology (IICT, CSIR Lab), Hyderabad to pursue his Ph.D degree (2007). He received his Ph.D. degree in Organic Chemistry from Jawaharlal Nehru Technological University Hyderabad (JNTUH-IICT), India in 2012. He then moved to the University of Kwa-Zulu Natal (UKZN), Durban, South Africa collaborated with Uppsala University, Sweden as a Postdoctoral Researcher (2012-2013) in the group of Prof. Anderson, where he worked on an effort towards the cyclization of 1,6-enynes and synthesis of chiral N, P ligands and their applications in asymmetric catalysis. He worked as an Assistant Professor in the Department of Chemistry, Vasavi College of Engineering, Hyderabad from 2013-2015. Currently, he is working as a Researcher at the Natural and Medical Science Research Center and involved in chemical transformations of natural products and total stereo selective synthesis of marine natural products with active against cancer, tuberculosis, malaria, diabetic and inflammatory etc.

Dr. Sulaiman Al-Sulaimi

Assistant Professor

Major: Organic Chemistry

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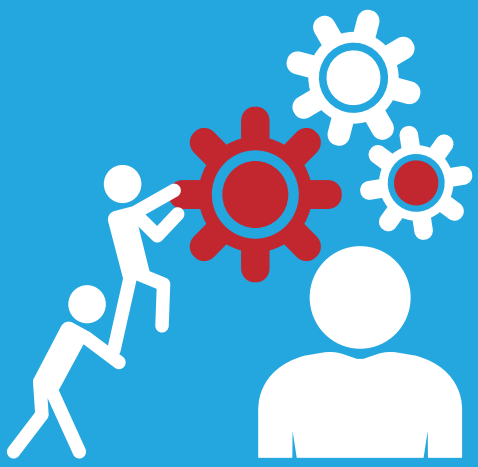
Dr. Sulaiman received his BSc in Chemistry, Sultan Qaboos University (Oman) in 2001. Then he worked as a Chemistry teacher in high secondary school, Ministry of Learning and Education (2001-2008). He obtained his MS in Analytical Chemistry in 2011, Sultan Qaboos University. Then he moved to University College of Dublin (Ireland) and received his PhD degree in Organic Chemistry under the supervision of Prof. Declan G. Gilheany in 2015. His PhD work was on Novel Alkoxyphosphonium Salts. He is currently Assistant Professor of Organic Chemistry and a member of the Natural and Medical Science Research Center.



Research team

Synthetic Chemistry Lab

Mr. Sulaiman Al Shidhani

Researcher Assistant

Major: Chemistry

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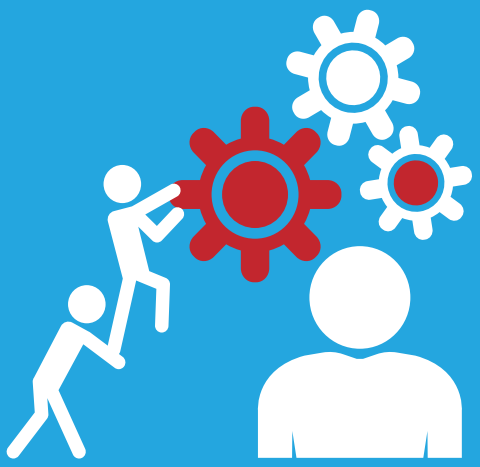
Mr. Sulaiman obtained his Bachelor in chemistry from college of science (major) with a minor in soil and water science from college of agricultural engineering and marine sciences at Sultan Qaboos University, Muscat- Oman, 2007-2014. He is working in the Center as Researcher Assistant. His current research involves in synthetic organic chemistry, and Analytical Chemistry. He is currently working on his MSc in Organic Chemistry at the University of Nizwa.



Research team

Synthetic Chemistry Lab

Dr. Muhammad Ali

Assistant Professor

Major: Synthetic Organic Chemistry

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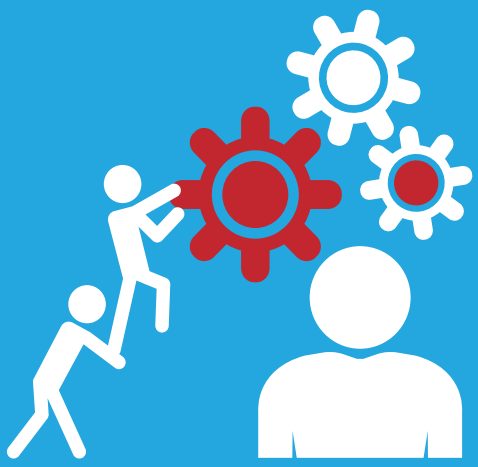

Research team

Synthetic Chemistry Lab

Dr. Muhammad Ali obtained his B.Sc. in Pre-Engg. and then M.Sc. degrees in Chemistry from the University of Punjab (Lahore, Pakistan) in 1999 and 2001, respectively. Later on, in 2003, he enrolled as PhD candidate at International Center for Chemical and Biological Sciences, University of Karachi, Pakistan. During his doctoral studies with Prof. Dr. Khalid M. Khan, in 2006, he was selected for HEC fellowship to visit Uppsala University, Sweden, where he worked with Prof. Pher G. Andersson in the field of transitional metal catalyzed asymmetric hydrogenations. Later on, he got another opportunity to work with Prof. Svetlana B. Tsogoeva in the field of origin of biohomochirality at Alexander-Fredrick University, Erlangen, Germany. In 2014, he won another prestigious HEC scholarship for his postdoctoral research at school of chemistry, University of Bristol, UK, under the supervision of Prof. Varinder. K. Aggarwal. During his stay at Bristol, he further strengthened his expertise in general synthetic organic chemistry, transitional metal catalysis, organoboron chemistry and total synthesis of natural products. His stay in Aggarwal group resulted in some very high-quality publications including one in Angewandte Chemie while another in Nature. In 2018, he moved to Natural and Medical Sciences Research Center at University of Nizwa (Sultanate of Oman). His research interests include natural product synthesis with special emphasis to organoboron chemistry and chemical modifications thereof; asymmetric catalysis and synthesis along with development of new organocatalytic systems with particular interest to CO2 capture.

Mr. Syed Raze Shah

PhD Exchange Program Researcher

Major: Inorganic Chemistry

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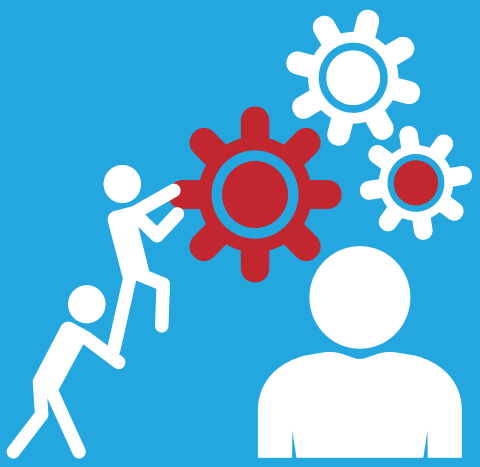
Syed Raze Shah has got his B.Sc. degree from University of Peshawar and M.Sc. degree in distinction from University of Peshawar, Pakistan. Mr. Shah has got M. Phil degree from Allama Iqbal Open University in Islamabad, Pakistan. He enrolled in Ph.D. program at Bacha Khan University Charasadda, KPK Pakistan and published two papers in international journals.



Research team

Synthetic Chemistry Lab

Mr. Amirhossein Ebrahimi

PhD Exchange Program Researcher

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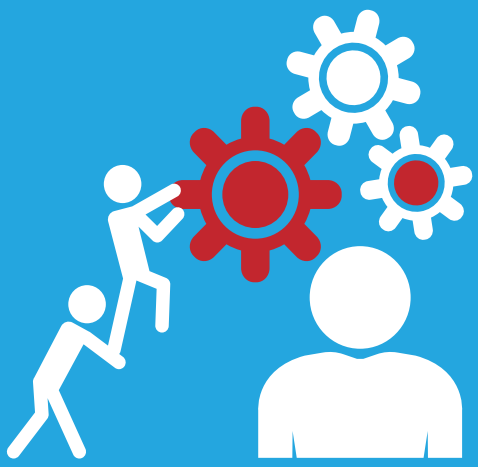

Research team

Synthetic Chemistry Lab

Amirhossein Ebrahimi received his B. Sc (Honors) and M.S. degrees in chemistry from Shahid Beheshti University (Iran) in 2016 and 2018, respectively. He joined the synthesis and catalysis research group at Natural and Medical Science Research Center (NMSRC) at the University of Nizwa as a research assistant in 2018. His research activities focus on the development of new meta-free platforms for heterocyclic synthesis and CO2 fixation processes.

Dr. Abdul Latif Khan

Research Assistant Professor

Major: Plant Physiology & Genomics

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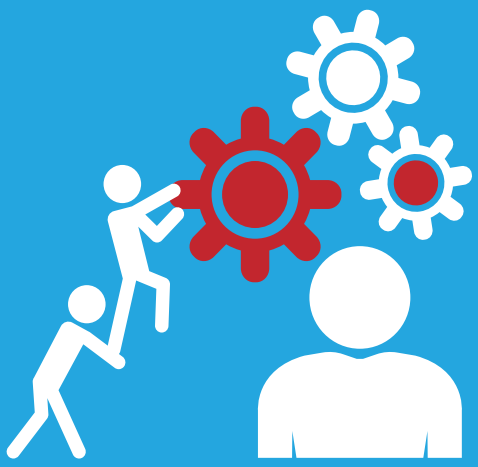

Research team

Biotechnology & OMICs Lab

Dr. Khan received his B.Sc and M.Sc. degree in distinction from University of Peshawar, Pakistan. Later, he joined the Department of Chemistry, Kohat University of Science & Technology, Kohat, Pakistan to complete his M.Phil. in Organic Chemistry and JASSO research fellowship by the Gene Research Center University of Tsukuba, Japan. Dr. Khan was selected as honorary scholarship student by Kyungpook. National University, South Korea for PhD degree in Plant Physiology. After his PhD, he remained Post-Doctorate fellow at School of Applied Biosciences. He worked as Research Professor at the Institute of Agriculture Science & Technology, Kyungpook National University, South Korea. Dr. Khan also worked as Assistant Professor at the Department of Botany, Kohat University of Science & Technology, Kohat Pakistan. He has published more than 150 research articles as a principal and co-author in journals of international repute and impact factor. His research activities focus on plant molecular physiology during environmental and microbial antagonists and plant genome sequencing. His current projects include draft and chloroplast genomes of date palm, Boswellia sacra, pomegranate and various endemic medicinal plants of Oman.

Dr. Sajjad Asaf

Research Assistant Professor

Major: Plant & Microbial Genomics

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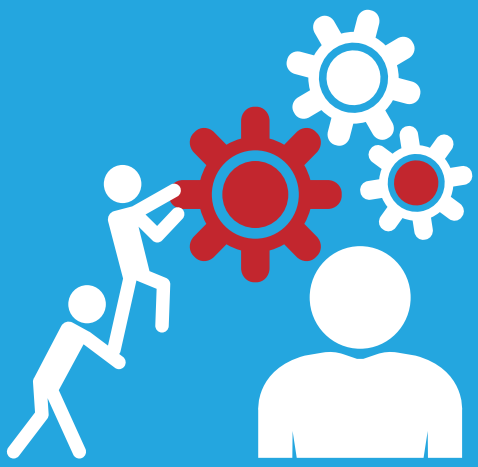

Research team

Biotechnology & OMICs Lab

Dr. Sajjad completed his Masters and M.Phil. from Kohat University of Science & Technology, Kohat Pakistan. He completed his PhD in Plant physiology and Genomics at School of Applied Biosciences, Kyungpook National University, South Korea. Latter he completed his Post-Doctoral researcher from the same lab for one year. His research interests are Pant genomics, Metagenomics, and Plant Physiology. Currently working on Genome sequencing and analysis of plant growth promoting rhizospheric bacteria, Mitochondrial genome sequencing of important fungi, Chloroplast genome sequencing and analysis of important Omani medicinal plants, Metagenomic analysis of rhizospheric bacteria associated with Boswellia sacra, Whole plant genome sequencing and analysis of date palm (*Phoenix dactylifera*) and pomegranate (*Punica granatum*).

Dr. Tapan Kumar Mohanta

Research Assistant Professor

Major: Molecular plant biology

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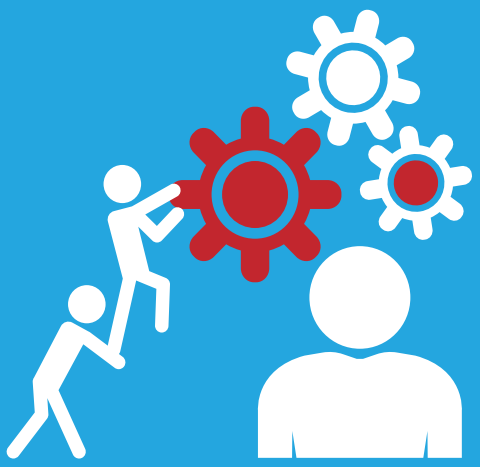

Research team

Biotechnology & OMICs Lab

Dr. Mohanta has obtained PhD and MS degree from University of Turin, Italy and M.Sc. Biotechnology degree from North Orissa University, Odisha, India. Post PhD, he worked as a postdoctoral research associate in G.B. Pant University of Agriculture and Technology, Pant Nagar, and later in National Institute of Plant Genome Research (JNU Campus), New Delhi, India. He has also worked as a research professor at the Dept. of Biotechnology, Yeungnam University, Republic of Korea. His research expertise is plant genomics, molecular biology and metabolomics aspects of plant development and biotic and abiotic stresses. Currently he is working on genetic diversity, genotyping, SNP analysis, gene expression, gene cloning and tissue culture of cambium meristematic cells of important medicinal plants.

Mr. Ahmed Nasser Salim Al Rawahi

Research Assistant, Scientific Communication & Collaboration Officer

Major: Plant & Microbial Genomics
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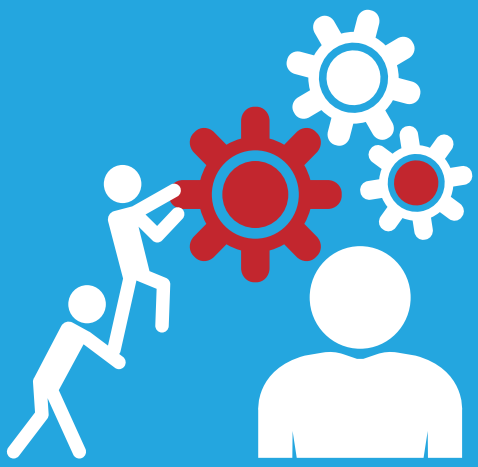
Mr. Ahmed Al Rawahi received his B.Sc. degree in Biotechnology from college of science at Sultan Qaboos University (SQU), Sultanate of Oman in 2015. During the same year, he was working as a research assistant in microbial ecology lab at the department of biology at SQU. He joined the Center as Researcher Assistant in biotechnology and OMICS lab. Later, he has been awarded fully funded scholarship by NMSRC to complete his Master degree in Microbial-Molecular biology at Sultan Qaboos University (SQU). His current researches involve isolation and identification of different microorganisms from different ecosystems, metagenomics and microbial diversity, secondary metabolites production by microorganisms and bioactive compounds assays.



Research team

Biotechnology & OMICs Lab

Mrs. Khadija Salim Al Hosni

Research Assistant

Major: Plant Microbe Interaction

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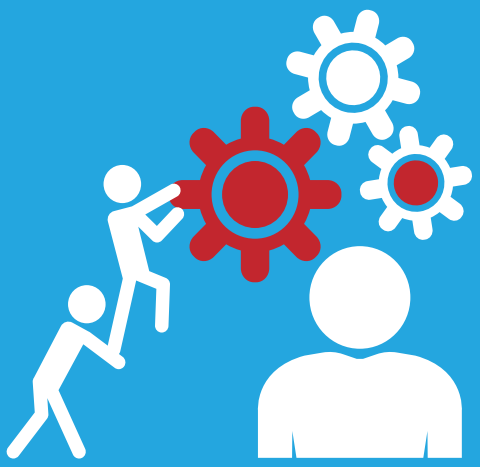

Research team

Biotechnology & OMICs Lab

Ms. Khadija AL Hosni received her B.Sc degree in Biotechnology with Distinction from Nizwa University in 2014. The same year, she started working in the Center as research assistant, and a few months later she got a scholarship from the Korean government and she left to South Korea for her master studies at Kyungpook National University. She has completed her master in Applied Bioscience. Her area of expertise is endophytic fungi, plant-microbe interaction, plant hormones regulation and secondary metabolites production by endophytic. She has published 6 research articles. Currently her study concerns on Boswellia sacra (frankincense tree).

Dr. Saqib Bilal

Research Assistant Professor

Major: Plant-Microbial Eco-Physiology and Metabolomics

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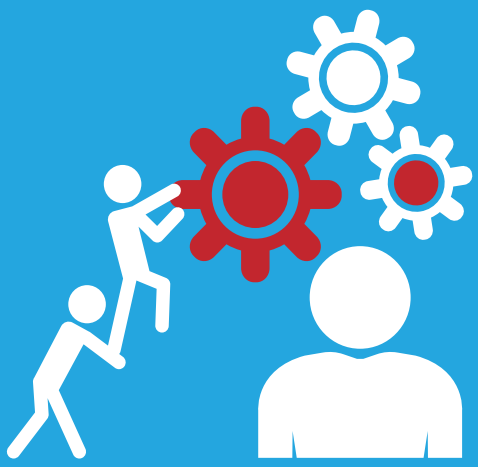

Research team

Biotechnology & OMICs Lab

Dr. Bilal obtained his B.Sc. degree (Honors) in Biotechnology from Gomal University D.I Khan, Pakistan in 2013. Later, he pursued his Master degree in agricultural Sciences in 2016 from Kyungpook National University, Korea by working on Secondary metabolites production from herbal plants and endophytic microbes. Afterwards, he was selected for KNU international graduate scholarship (KINGS) in 2016 to start his PhD studies in Plant Biosciences under the supervision of Prof. In-Jung Lee at Kyungpook National University (KNU), working on Plant ecophysiology, biochemistry, phytoremediation, biotransformation, and ecosystem ecology. After his PhD, he joined Brain Korea 21 (BK21) Post-Doctoral fellowship at School of Applied Biosciences, KNU, in 2019, where he worked on investigating the underlying proteomic and metabolomics mechanisms of Plant-Microbial interaction under hostile conditions. In Feb 2020, he joined NMRC, University of Nizwa as a research assistant professor. His current research interests are plant molecular physiology during biotic and abiotic stresses, plant genome sequencing, plant-endophytes interaction to remediate emerging contaminants in soil identification of microbial enzymes and metabolites for pollutant degradation and In-situ bioremediation strategies.

Mr. Saif Khalfan Al- Housni

Research Assistant

Major: Microbiology and biotransformation
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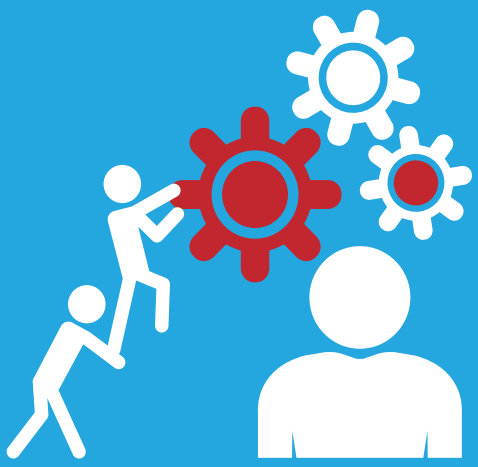

Research team

Biotechnology & OMICs Lab

Saif Al- Housni received his B.Sc. degree in Biotechnology from the College of Arts and Science at the University of Nizwa, Sultanate of Oman in 2015. He is working as a research assistant in the UoN Center. His current researches involve culturing of bacteria and fungi by using resin with different concentrations and also he works on identification and characterization of microbes. His area of expertise ischromatography and isolation antifungal compounds from *Lysinibacillus* spharicus. Currently he is performing experiments on biotransformation of secondary metabolites using enzymes and whole cell microorganism based approaches.

Mr. Adil Khan

PhD Exchange Program Researcher

Major: DNA barcoding

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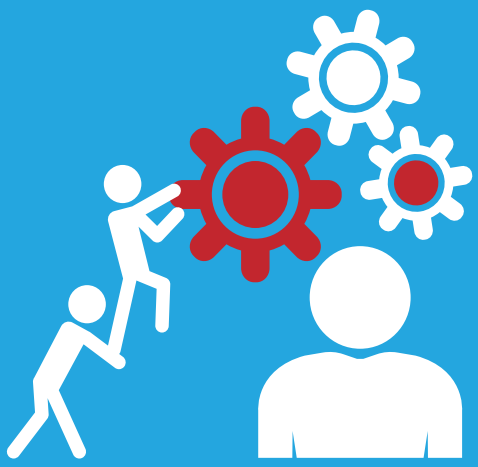
Adil khan is a M.Phil. Scholar, enrolled in Department of Biotechnology, Faculty of Biological Sciences, Quaid-I-Azam University, Islamabad, Pakistan. He has been working in Molecular Systematics and Applied Ethnobotany Lab. He is currently working on the DNA barcoding of medicinal plants Biotechnology & OMICs lab, UoN Natural and Medical Science Research Center, University of Nizwa, Nizwa, Oman.



Research team

Biotechnology & OMICs Lab

Mr. Muhammad Numan

PhD Exchange Program Researcher

Major: Molecular physiology

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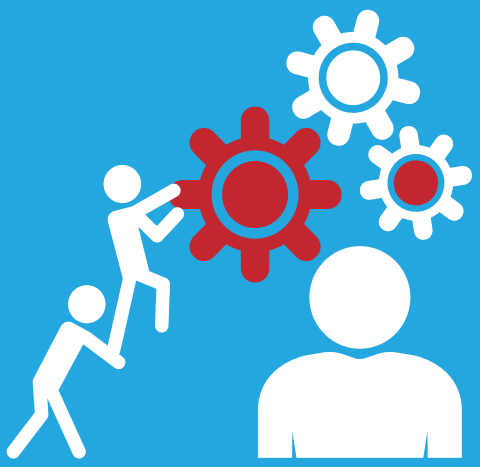
Saif Al- Housni received his B.Sc. degree in Biotechnology from the College of Arts and Science at the University of Nizwa, Sultanate of Oman in 2015. He is working as a research assistant in the UoN Center. His current researches involve culturing of bacteria and fungi by using resin with different concentrations and also he works on identification and characterization of microbes. His area of expertise ischromatography and isolation antifungal compounds from *Lysinibacillus* spharicus. Currently he is performing experiments on biotransformation of secondary metabolites using enzymes and whole cell microorganism based approaches.



Research team

Biotechnology & OMICs Lab

Mrs. Safiya Salim Mohammed Alamri

Lab Technician

Major: Biotechnology

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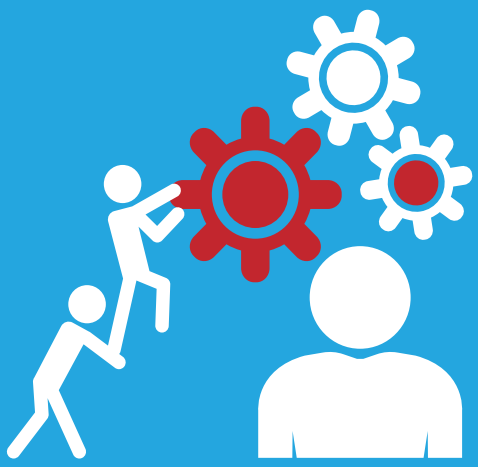
Safiya is working at the Center as Lab Technician. She holds a Diploma Degree in Biology, from the University of Nizwa, Oman. She is helping and assisting with lab materials, collecting samples and experiments preparation.



Research team

Biotechnology & OMICs Lab

Mr. Mohammed Al-Broumi

Research Assistant, Director of Daris Analytical Services Center

Major: Chemistry

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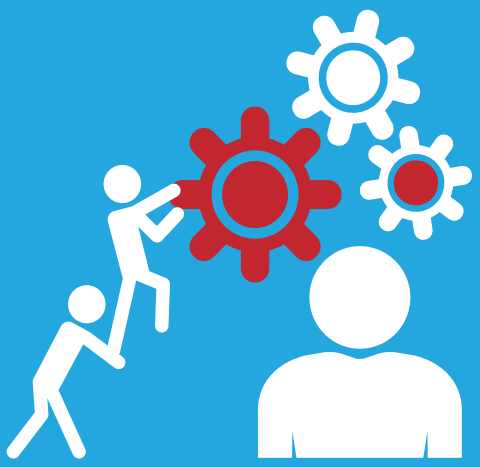
Mr. Mohammed obtained his Bachelor in Environmental Biology (Major), Chemistry (Minor) from Sultan Qaboos University Muscat, Oman 2005-2012. He is working in the Center as research assistant. His current research is focused on isolation and characterization of bioactive compounds from marine organisms. He has recently completed his MSc in Analytical Chemistry at the University of Nizwa. His interests include medicinal plants, their natural products and spectroscopic analysis.



Research team

Herbarium and Greenhouse Lab

Mr. Hilal Saud Al-Naabi

Technician

Major: Greenhouse specialist

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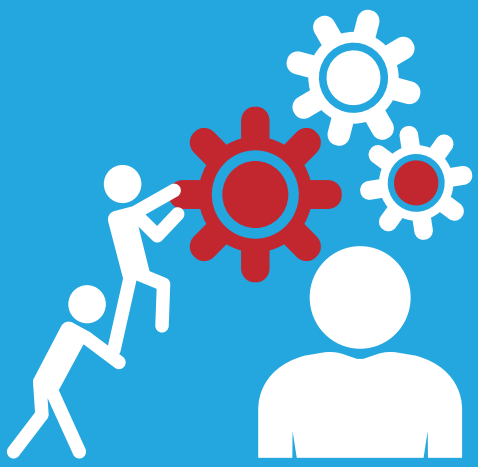
Hilal is working as a technician in the greenhouse as well as the Center's herbarium. He has been working at the University of Nizwa since 2004. He has specialized skills in plant cultivation and greenhouse management.



Research team

Herbarium and Greenhouse Lab

Dr. Sulaiman Al Hashmi

Assistant Professor

Major: Stem Cell Research & Regenerative Medicine

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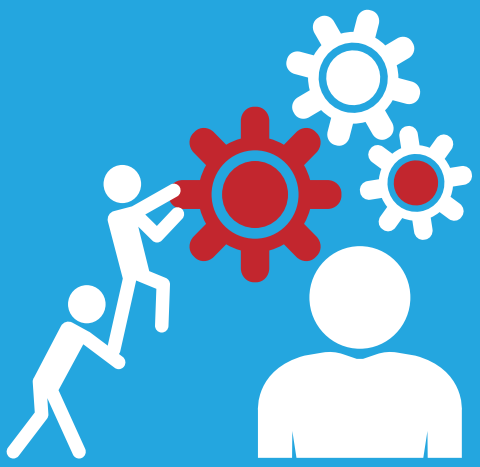

Research team

Biomedical Research Lab

Dr. Sulaiman received his B.Sc. degree in Chemistry from Sultan Qaboos University (SQU), Sultanate of Oman, in 1994. At the same year he was appointed as a biomedical scientist at the National Tissue Typing Laboratory at SQU and he was in charge of the lab for many years. During his employment, Sulaiman did his M.Sc. degree in Transfusion and Transplantation Sciences at the University of Bristol, United Kingdom, in 2000. In 2006, Sulaiman started a training program at Lund University Stem Cell Center (SCC) for 14 months, focusing on stem cell biology. He worked on stem cell differentiation and proliferation using different techniques, including cell culture, flow cytometry, cell sorting and cell staining methods. After that, Sulaiman moved to Karolinska Institute in Sweeden and he finished his Ph.D. degree there in 2011 on the pathophysiological aspects of transplantation-related complications following busulphan/cyclophosphamide conditioning regimen in mouse model.

Dr. Majid Khamis Al Salmani

Assistant Professor

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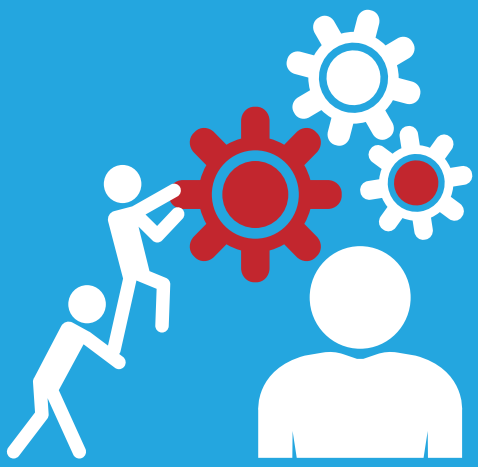

Research team

Biomedical Research Lab

Dr. Majid finished his B.Sc. (Hons) from the Institute of Infection, immunity and Inflammation at the University of Glasgow, UK. Following graduation, he returned to his home country, Oman, and joined the laboratory of Dr. Uwe W. Fass at Oman Medical College as a research assistant. He studied the genetic epidemiology of cystic fibrosis in Oman, which is an inherited disease that leads to respiratory failure due to pathophysiological changes in the lungs. After 2 years of work, he left to join the department of Physiology, Pharmacology and Neuroscience at the University of Bristol, UK, as a PhD student. He worked at the laboratory of Professor David N. Sheppard to study the molecular physiology of cystic fibrosis and finished his PhD in 2017. Then, he was appointed as an Assistant Professor at the University of Nizwa. His research interests include studying the molecular mechanisms of inherited human disorders and the development of targeted therapies. His current research area is investigating the molecular physiology of cystic fibrosis in Oman and the Middle East.

Dr. Fatemeh Jamshidi-adegani

Post-Doc Fellow

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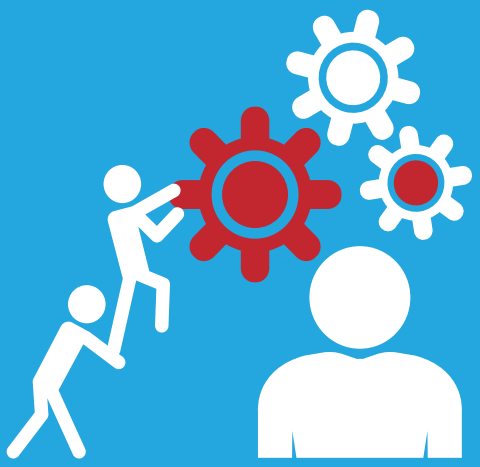

Research team

Biomedical Research Lab

Dr. Fatemeh received her B.Sc. degree in Biology from Kerman University in 2003. At the same years she has worked in medical diagnostic laboratory for 2 years. During this time, Fatemeh did her M.Sc. degree in animal physiology at the University of Isfahan and at the Pasteur Institute of Tehran in 2006. Her thesis was focused on Design and making a construct containing a mini LCR & β- globin gene expression cassette for transferring to Erythroid cell line. Between 2006 and 2009, she has worked at the Pasteur Institute as a co-investigator and started working in stem cell technology research center as a full researcher from 2009 to2017. At the Stem Cell Technology Research Center, she engaged with some projects about miRNA function in stem cells and cancers. Fatemeh started her PhD in 2011 in molecular medicine field in Qazvin University, Iran, and finished in 2016. Her PhD research project was focused on prevention of post-surgical adhesion band formation. Fatemeh has published more than 18 peer reviewed SCI papers. She is interested to extend her research field in cancer study, tissue engineering and molecular diagnostic.

Dr. Shaikh Mizanoor Rahman

Associate Professor

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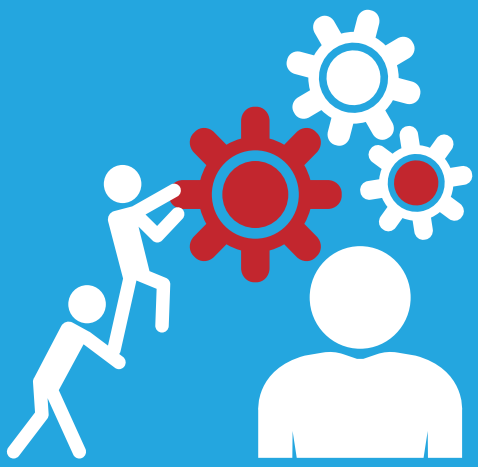

Research team

Biomedical Research Lab

Dr. Rahman received his BSc and MSc in Biochemistry from Dhaka University Bangladesh. He was awarded the Monbusho Scholarship (Japanese Government Scholarship) and pursued his MSc and Ph.D. from Saga and Kagoshima University, Japan, respectively. He then moved to the USA and completed two postdoctoral fellowships. First, at the Biochemistry Department, the University of Wisconsin Madison and Metabolism, at the University of Colorado Health Sciences Center, USA. He then worked as a Research Instructor in the same department. Later, he moved to the Nutritional Sciences, Texas Tech University, USA, and worked there as a Tenure Track Assistant Professor. During his stay at Texas Tech, Dr. Rahman mentored three Ph.D. and one Master students as dissertation committee chair and also served as a dissertation committee member of eight Ph.D. and three Master students. He was also involved in teaching both undergraduate (Survey of Biochemistry) and graduate (Vitamin & Minerals, Nutrition Immunology, Genetic Regulation of Metabolism) level courses. Dr. Rahman has published 31 significant research articles as first or co-author in high impact scientific journals like Proceedings of the National Academy of Sciences, Hepatology, Journal of Biological Chemistry, Diabetes, Atherosclerosis, Journal of Lipid Research, Journal of Nutritional Biochemistry. He also wrote four book chapters. In the past, his research was funded by the American Heart Association. His current research focuses on understanding the cellular and molecular basis of metabolic shifting in cancer cells and the role of inflammation and immune cell functions in obesity-associated metabolic disorders including breast cancer, diabetes, and atherosclerosis.

Mr. Saeid Vakilian

Researcher

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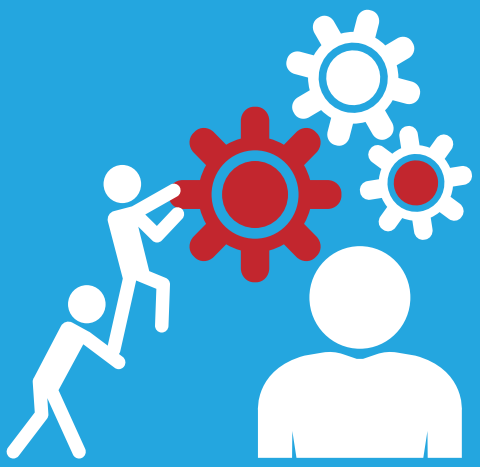

Research team

Biomedical Research Lab

Mr. Saeid has done his B.Sc. and M.Sc. in Chemical Engineering (biotechnology engineering) from respectively, Isfahan University of Technology and Sharif University of Technology, Iran. His research thesis for M.Sc. degree was focused on "multilayered nanofiber/nanoparticles composite with the capability of preservation and sustained release of proteins for bladder tissue engineering". He has worked as a researcher in Nanotechnology and Tissue Engineering Department of the Stem Cell Technology Research Center between 2012 and 2017. His research activities have mainly focused on biomaterials, nanotechnology and tissue engineering and He has accomplished over 15 peer-reviewed SCI papers. He is currently working as a researcher.

Mrs. Juhaina Hamed ALKindi

Research Assistant

Major: Biotechnology

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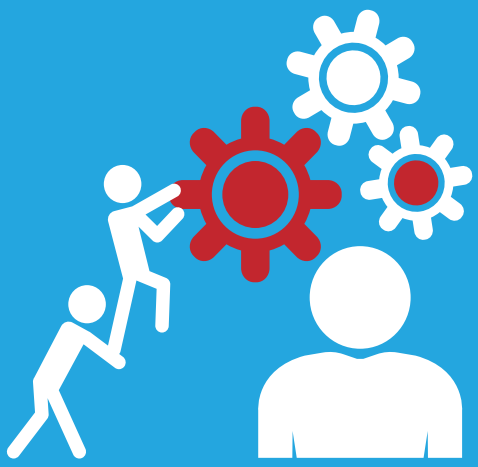

Research team

Biomedical Research Lab

Juhaina ALKindi received her B.Sc. degree in Biotechnology (Honors) from college of Arts and Science at Nizwa University (UON), Sultanate of Oman in 2019. At the same year, she got training on Plant tissue culture at Ministry of Agriculture, Oman, also on Microbiology Department of Regional Municipal and Water Ministry, Oman. she is working in the center as Researcher Assistant. Her current researches involve in Biomedical field. Such, cancer, adhesion bands, diabetes, and wound healing researches. Her Final Year project is Prevention of Postoperative Adhesion Bands by Alkali-treated Cellulosic Luffa Fibers (Journal of Natural Fibers). And she is working on Microfluidic Blood-Brain Barrier Prototype for In-Vitro Studies of Cancer Metastasis project.

Mrs. Shokoofeh Ghaemi

PhD Exchange Program Researcher

Major: Microbiology

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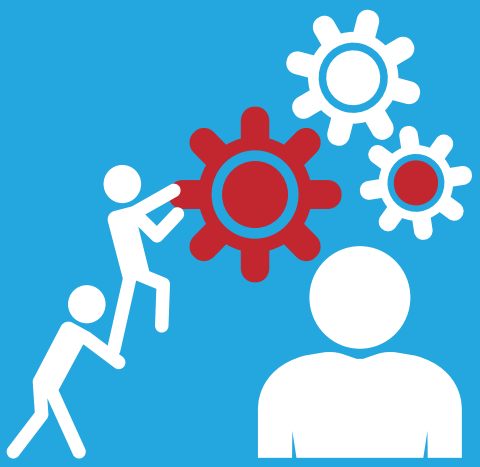
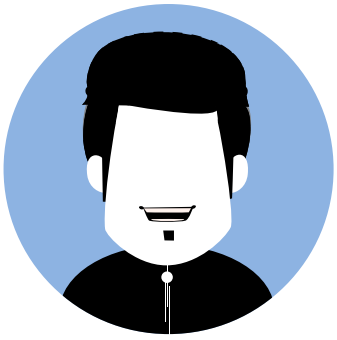


Research team

Biomedical Research Lab

Shokoofeh Ghaemi received her B.Sc. in cellular and molecular biology, microbiology, from the University of Tehran (Iran) in 2015. and then continued her master studying in Microbiology in that university and worked on the gene therapy of glioblastoma by micro RNAs and obtained her M.Sc. degree in 2018 from the University of Tehran (Iran). and now she is a Ph.D. student in Microbiology at the University of Tehran. Her current research interests are gene therapy and oncolytic viruses.



Mr. Mohammed Rashid Al Ofi

Research Assistant

Major: Genetics

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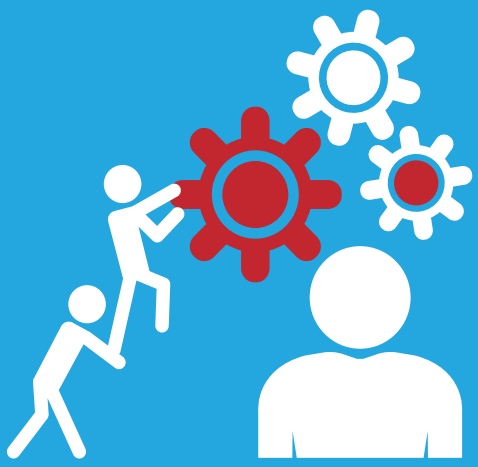
Mohammed Al Ofi has obtained his BSc Degree in Genetics from the University of Liverpool, England, in 2019. He has joined the biomedical lab recently as a research assistant.



Research team

Biomedical Research Lab

Mr. Khamis AL-Riyami

Senior application specialist

Major: Basic Health Science

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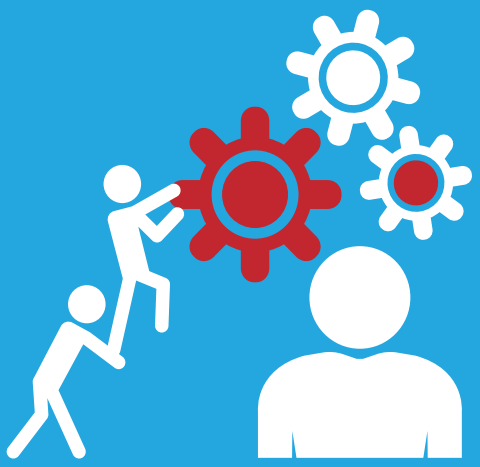

Research team

Electron Microscopy Unit

Mr. Khamis received his B.Sc degree from College of Medicine and Health Sciences, Sultan Qaboos University of Muscat, Sultanate of Oman. Later, he joined the Electron Microscopy Unit, Daris Center for Research and Technology Development, University of Nizwa, Nizwa, Sultanate of Oman to work as specialist in electron microscope. Directly after he joined University of Nizwa, He was sent to Histopathology Department, College of Medicine and Health Sciences, Sultan Qaboos University, Muscat, Sultanate of Oman as a trainee to gain an experience to be specialist in electron microscope, which was a schedule program by University of Nizwa. Additionally, he was sent to JEOL LTD., Tokyo Japan to do training in Scanning and Transmission Electron Microscopes. Hi current work at the Center involve preparing and screening all types of samples which can be done in Electron Microscopes. He is also doing some demonstration in Electron Microscopes for some courses from college of Art and Sciences at University of Nizwa. He has a well experience and required skills to perform training program for students and graduated students from University of Nizwa and other Universities and colleges.

Mrs. Sausan Suliem Mubarak Al Yaqoobi

Laboratory Technician

Major: Biotechnology

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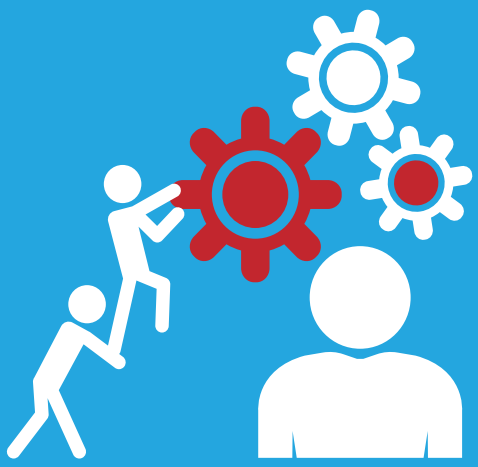
Mrs. Sausan received her Bsc. Degree in Biotechnology from college of Science, Sultan Qaboos University with a minor in business administration. She did her final year project in pathology department in college of medicine with electron microscopes in Identification of Progesterone Receptors in the Embryonic Male in the green Turtle Chylonia Mydas Ras Al Hadd Oman. She is working in the center since 2013 as a laboratory technician in Electron Microscopy Unit. She has participated in several studies and projects that were related to electron microscope investigations from different branches. She has lab experience with extensive knowledge in Biological and material specimen processing for Transmission and Scanning Electron Microscope.



Research team

Electron Microscopy Unit

Mr. Ananda Narayanan

Facility Manager-NMR Lab

Major: Chemistry

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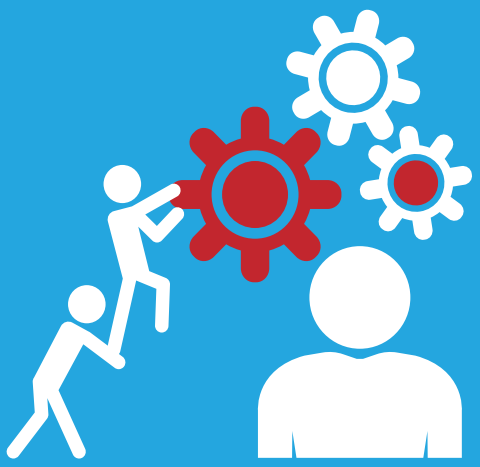
Mr. Anand obtained his B.Sc. in Chemistry (2004) and M.Sc. in Chemistry (2006) degree from Bharathidasan University, India. He has 12 years of experience in NMR spectroscopy. Strong knowledge in advanced NMR methods for structural characterization of small molecules for wide range of chemical, pharmaceutical, biological, natural products, drug molecules, polymers etc. Currently, he is working as a Facility Manager – NMR lab at the Natural and Medical Science Research Center. He is also in charge of managing and maintenance of the Bruker 600 MHz NMR spectrometer.



Research team

NMR Unit

Mr. Ahmed AL-Ghafri

Research Assistant

Major: Chemistry

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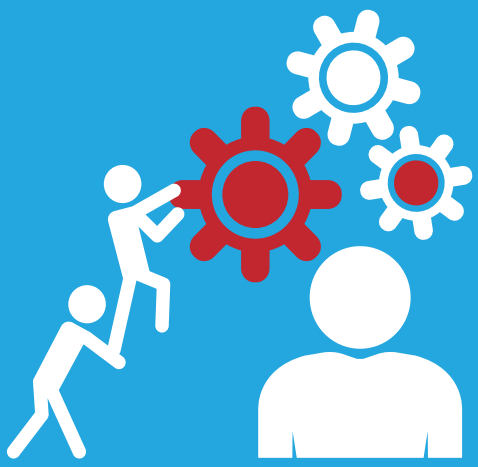
Ahmed obtained his Bachelor in Applied Chemistry (Major), Public Administration (Minor) from Kuwait University, Kuwait 2009-2014. He is working in the Center as research assistant. His current research involves operating Nuclear Magnetic Resonance (NMR) spectroscometer and its use in structure elucidation of complex compounds.



Research team

NMR Unit

Mr. Saif Ullah

Instrument Engineer

Major: Chemistry

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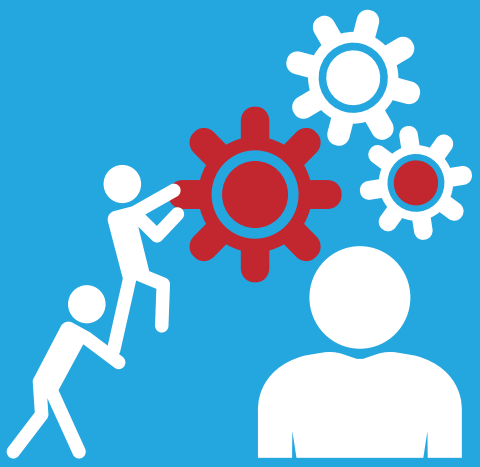
Saif has obtained his Bachelor in Electronics from the Aligar Institute of Technology, Karachi. He is working in the Center for the last two years. Previously, he has worked for 12 years with various instrument supply companies in Pakistan. He was maintaining various equipment supplied to hospitals, pharma and food industries, research institutes and universities. His current activities involve the operation, maintaining and troubleshooting of various biotechnology and chemistry related instruments.



Research team

NMR Unit

Mr. Parthasarathy Elumalai

Mass Spectrometry Specialist

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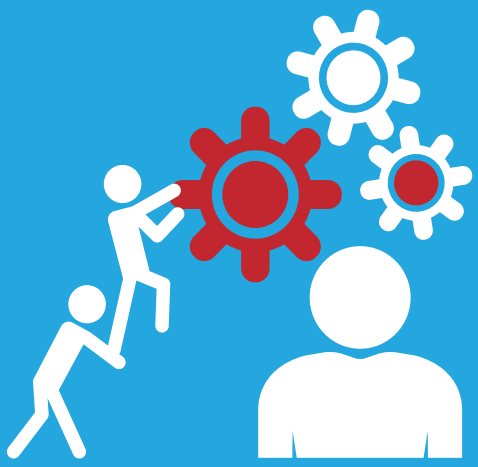

Research team

Chromatography & Mass Spectrometry Unit

Mr. Partha received his Bachelor of Engineering and M.B.A. degree from University of Madras, Tamil Nadu, India. Started his career in Analytical instrumentation field as service provider for all Spectroscopy, Chromatography, Mass Spectrometry, Magnetic Sector Instruments like GC, HPLC, GCMS, LCMSMS & NMR Spectroscopy. He has worked with all leading scientific instrument providers like Agilent, Waters, Thermo & Shimadzu with hands on experience in all wide range of analytical products from UV to NMR. He has carried out a solution-based support which includes Installation, Familiarization & complete Application supports. His current profile includes solutions for all plant molecular structure analysis and specialized MW characterization for Boswellia sacra and other medicinal plant species.

Mr. Mohammed Al Omairi

Researcher Technician

Major: Chemistry

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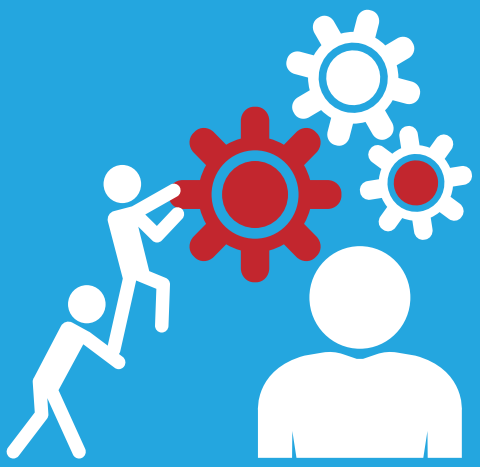
Email: m.alomairi@unizwa.edu.om

Mr. Mohammed obtained his diploma in Applied Science (Chemistry) from the Higher College of Technology (Muscat). He is working in the Center as a technician in chemistry labs. His current research involves in Organic Chemistry and running different scientific and analytical research equipment.



Research team

Chromatography & Mass Spectrometry Unit

Mr. Ghanim Salim AAl-Thani

Analysis and Appliance Technician

Major: Chemistry

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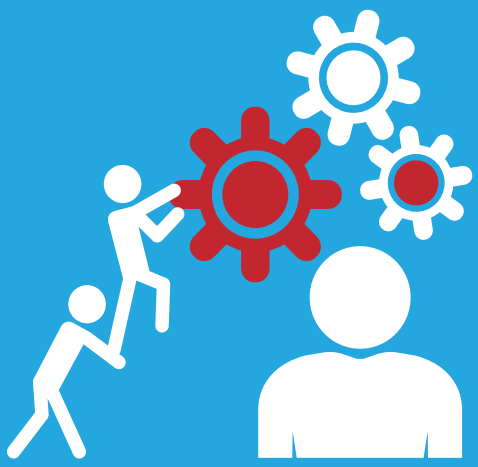
Email: aalthani@unizwa.edu.om



Research team

Chromatography & Mass Spectrometry Unit

Ghanim AAl-Thani received his B.Sc degree in chemistry from Sultan Qaboos University in 2006. He joined the Halliburton company as Mud logger, Sultanate of Oman/ Muscat.In 2007 he moved to Public Authority for Electricity and water ;water quality center ;sultanate of Oman /Muscat as chemist and in August 2008 he joined Nizwa University as analysis and Appliance Technician , he worked as application specialist in mass spectrometry unit in Daris research center and deliver training in analytical instruments for the students, like LC-MS/MS, HPLC-PDA, Gc-MS, AAS ,ICP-OES and ICP-MS. His current work at the Center involve running of the Mass spectrometry lab. His activities focus on advice and support to staff, clients and internal, external students from universities with regards to analytical instrumentation, method development and analytical techniques.

Mrs. Samia Ahmed Al-Riyami

Research Assistant

Major: Phytochemistry

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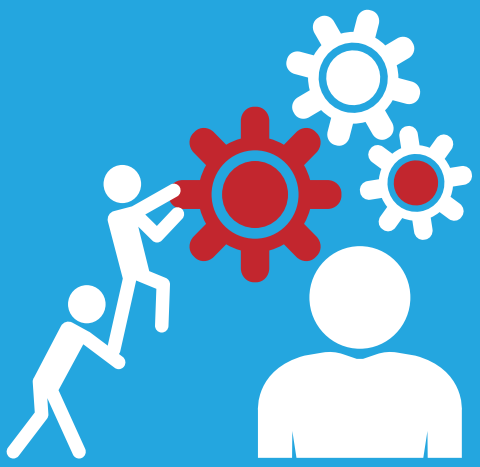
Email:samiariyami@unizwa.edu.om

Ms. Samia graduated from Nizwa University major in chemical and petrochemical engineering (2011). She worked as a research assistant in the chemical engineering department on TRC research projects titled as synthesis and characterization of mesoporous silica fibers (MSF) and the impact of sludge rheology on design and operation of waste water treatment plant. Her current research involves isolation and characterization of natural products from medicinal plants and Boswellia species.



Research team

Chromatography & Mass Spectrometry Unit

Dr. Tanveer Alam

Fragrance Specialist

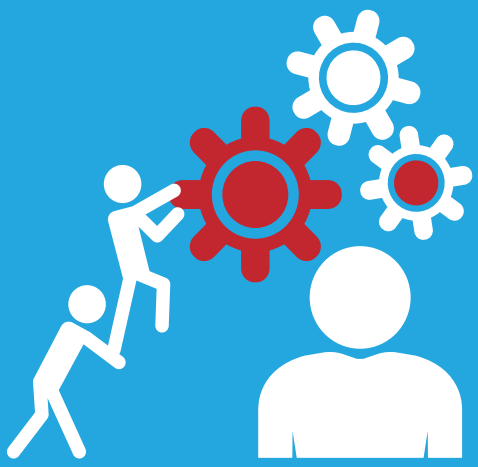
Major: Natural Products Chemistry

ResearchGate: www.researchgate.net/profile/Dr_Tanveer_Alam

Contact: +968 25446841

Email: tanveer@unizwa.edu.om

Dr. Tanveer Alam received his Ph.D. Degree in the field of Natural Product Chemistry from Jamia Hamdard, New Delhi, India in 2001. From Nov. 2000 to Sept. 2001, he was a Research Associate at Jamia Hamdard, New Delhi, India and worked on synthesis of water soluble derivatives of Silymarin. Upon completion of his education, he started his career as an Executive-R&D in a Flavour & Fragrances Company, then worked as a Manager & Head-R&D in different National & Multinational Herbal Industries. Dr. Alam has more than 15 years of R&D experiences in the field of Natural Products. He has been working as Associate Professor in Eritrea Institute of Technology, Eritrea. He is Ph.D. supervisor in JJT, University, Rajasthan, India and Advisor in Natural Food Colors Industry. He is also a Member of Editorial Boards and Referee for more than Eight National & International Journals. Since March 2015, Dr. Alam is working as the Production Unit for commercialization of Omani Medicinal & Aromatic Plants at University of Nizwa, Sultanate of Oman.



Research team

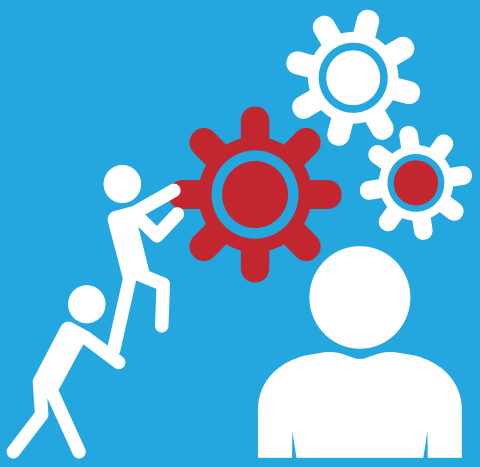
Production Unit

Mr. Syed Farooq

Animal Facility Specialist

Major: Zoology

Contact: +968 25446987
Email: m.farook@unizwa.edu.om



Research team

Animal Facility unit

Mr. Farooq has been working as a Zoological Research Assistant since 1970 to various Wildlife and Scientific Research Projects in Sri Lanka for 11 years along with Scientists, Zoologists, Herpetologists, Entomologists and Botanists from various parts of the world. He joined the Department of Biology, College of Science, Sultan Qaboos University, in 1987 and worked for 12 years as a Biological Technician and was instrumental in setting up a Biology Teaching Museum during that period. He has a vast experience in preparation of Animal & Bird Skeletal material and bones & mounting of skeletons. Permission has been granted by the Ministry of Environment for him to capture snakes when necessary or to conduct educational programs which will help in protecting snakes, especially the rare species, and support in keeping a balance in the biodiversity. He is currently working on establishing an animal facility unit for the Center, containing different species of small animals that are using for research purposes.

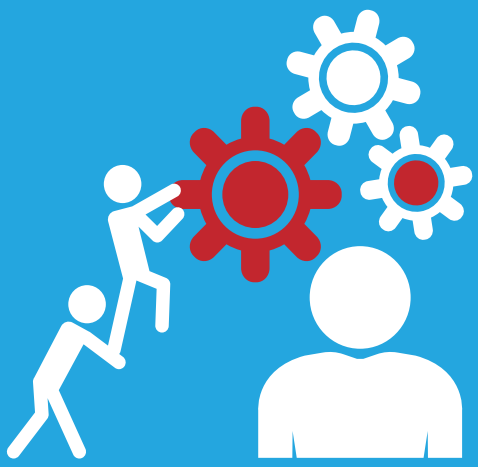
Mr. Ahmed Hamood Al-Busaidi

Animal Facility Specialist

Major: Zoology

Contact: +968 99535139
Email: adventurer.oman@hotmail.com

Ahmed Al-Busaidi is a snake specialist. He is an adventurer with different interests such as diving, hiking, photography and outdoor survival skills. He joined the Center in February 2018 as an animal specialist. He hasa free diving license level two. His highes record in free diving is 31 meters. He covers all of Oman searching for and recording the Omani biodiversity.



Research team

Animal Facility unit

Alumni

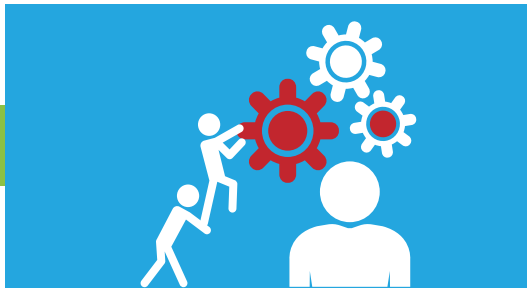
Dr. Hidayat Hussain
Senior Scientist

Dr. Hidayat got M.Sc from Gomal University Dera Ismail Khan, Pakistan. He received his Ph.D under the supervision of Prof. Viqar U Ahmad in 2004 from H.E.J. Research Institute of Chemistry, International Center for Chemical and Biological Sciences, University of Karachi, Pakistan in Synthetic Organic Chemistry and Natural Product Chemistry. His research topic was Asymmetric Robinson annulation via [4+2] heterocycloaddition and design and synthesis of Tin catalyst for [4+2] heterocycloadditions. In December 2008, he rejoined the group of Prof. Karsten Krohn as senior postdoctoral associate until September 2010. His research interests include design and synthesis of antimalarial and antimicrobial compounds, the use of chiral Lewis acids in asymmetric catalysis of the [4+2] heterocycloadditions, and biodiversity and characterization of natural products produced by endophytic microorganisms, plants.

Dr. Thomas Dzeha
Researcher

Dr. Thomas research involves investigating marine cyanobacteria and bacteria for novel pharmaceuticals targeting cancer and nosocomial infections. Dr Dzeha's research brings together expertise in microbiology, molecular biology, bioinformatics and organic chemistry synthesis as a means to tackling important research questions. Recently, he has established that certain bacteria species in the Sultanate of Oman are able to resist UV radiation for prolonged times. Dr Dzeha's other interests include investigating chemical and molecular responses of cyanobacteria cyclodepsipetides towards bacteria – a study that will further aid our current understanding of the relevance of cyclodepsipeptides in cancer therapy.

A. Research team



Dr. Zahid Hassan
Research Assistant Professor

Dr. Zahid was introduced to chemical research at HEJ Research Institute of Chemistry University of Karachi, Pakistan. He worked in the laboratory of Professor Viqar Uddin Ahmad and received M.Phil degree in natural products chemistry. He then moved to Leibniz University Hannover, Germany for a synthetic work on chiral NMR spectroscopy reagents with Prof. Helmut Duddeck (2007-2008). In 2012, Mr. Hassan received his Dr. rer. nat. at the Institute of Organic Chemistry, Leibniz-Institute of Catalysis e. V. at the University of Rostock (LIKAT), Germany in the field of organic catalysis and heterocyclic chemistry under the guidance of Prof. Dr. Peter Langer. His current research program primarily involves metal-catalysis, heterocycles, one-pot cyclizations, domino reactions, arene and heterocyclic chemistry, organohalogen chemistry, natural products and nano-chemistry.

Dr. Liaqat Ali
Research Assistant Professor

Dr. Liaqat Ali, Assistant Professor, Sargodha University, Pakistan. After his graduation from University of the Punjab, Lahore, Dr. Ali did his Master degree in Organic Chemistry from the Federal Urdu University, Karachi and M.Phil and PhD from HEJ Research Institute of Chemistry, ICCBS, University of Karachi, and received (Organic Chemistry). His research work included modified Safety-Catch Linker strategy of Solid-Phase Peptide Synthesis and Phytochemical Investigations of Medicinal Plants. He worked with us as Assistant Professor on Phytochemical Investigations of Medicinal Plants and marine resources from Oman. Currently, he works at the Department of Chemistry, University of Sargodha (Mianwali Campus). His research interests include the isolation and characterization of bioactive secondary metabolites of the terrestrial and marine origins and the endophytic fungi associated with them.

Alumni

Prof. Tee Han

Visiting Professor from Seoul National University College of Medicine, Seoul, Korea 2012-2013

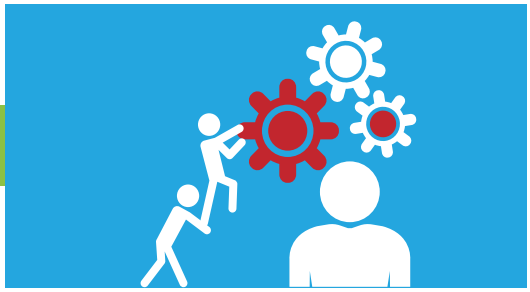
Dr. Tee received his M. D. from Seoul National University College of Medicine, Seoul, Korea in 1983. He completed his Ph. D. from Columbia University, New York, U.S.A, in1995. From 1995 to 1997, he was Assistant Professor at the Seoul National University College of Medicine. From 1997 onwards, he has been a Professor at Sungkyunkwan University School of Medicine. His research interests are: Pathogenesis of myeloid leukemia and Role of TGFβ signaling in cancer progression.

Mr. Abdulaziz Al Dhuhli

Research Assistant

Mr. AbdAluziz obtained his Bachelor of Medicine (Major), Health science (Minor) from College of Medicine and Health Sciences at Sultan Qaboos University, SQU 2009-2015.He is working in the Center as Research Assistant. His current research involves in cancers and stem cell therapies.

A. Research team



Mr. Adil Adrees
NMR Spectroscopist

Mr. Adil Raees was born in Karachi, Pakistan. He did his B.S in Analytical Chemistry in 2010 from Federal Urdu University of Arts, Science & Technology, Karachi, Pakistan. He worked two years in the NMR laboratories of International Centre for Chemical and Biological Sciences (ICCBS), H.E.J. Research Institute of Chemistry, University of Karachi, Karachi, Pakistan. In 2013, He joined the NMR lab in UoN Natural and Medical Science Research Center, University of Nizwa, Sultanate of Oman as NMR Spectroscopist and currently working on 600MHz NMR spectrometer with Cryoprobe Prodigy. His training took place in Fallenden, Zurich, Switzerland.

Mr. Zaid Khalifa Al-Hinai
Technician

Mr. Zaid Al-Hinai, was born in Bahla 1994. Graduated from SQU College of Sciences in 2018 . He has a bachelor in physics as a major and earth science as a minor. He joined the University of Nizwa Natural and Medical Sciences Research Center as a full time supporting staff. He is gaining various experiences in different instruments such as LCMS, XRD, ICP, NMR, SEM and TEM.

Alumni

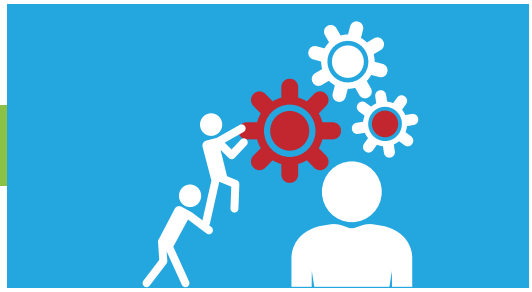
Dr. Husain Yar Khan
Researcher

Dr. Husian received his Ph.D. (Biochemistry) degree from Aligarh Muslim University, Aligarh, India in 2013. In his doctoral work he studied the anticancer mechanisms of plant derived polyphenolic compounds. He proposed and validated a putativecopper-dependent prooxidant DNA breakage mechanism of action of plant polyphenols that better explains their anticancer and chemopreventive properties.The research work has resulted into several important publications in reputed international journals and in a couple of book chapters. During his Ph.D. he was awarded Senior Research Fellowship by the Council of Scientific and Industrial Research, New Delhi. Dr. Husain successfully presented his work in the form of oral talks and poster presentations at various international and national conferences.

Mrs. Noor Mazin Abdulkareem
Research Assistant

Ms. Noor was graduated with B.Pharm (Hons) - highest distinction, University of Nizwa, Nizwa, Oman in 2016. She has been awarded the Chancellor's Fully Funded Scholarship for the Best Academic Performance and nominated on the Chancellor's List for the five years of her undergraduate study. Then, she moved to the United Kingdom and completed her MSc in Pharmacology (with Distinction) from Glasgow Caledonian University, United Kingdom. She has been awarded the best Research Project on the MSc Bio Suite of Programs award for her MSc research project. Her master's research work was focused on investigating the mechanism of action of the opioid drug (Oxycodone) via using variety of organ bath pharmacology and molecular techniques (RNA extraction, RT-PCR, protein extraction and Western blotting) on guinea-pig animal tissues. Her research areas of interest are mainly focused on molecular biology, medicinal plants, and genomics. She is currently working on transcriptomics of date palm and wounded Boswellia sacra.

A. Research team

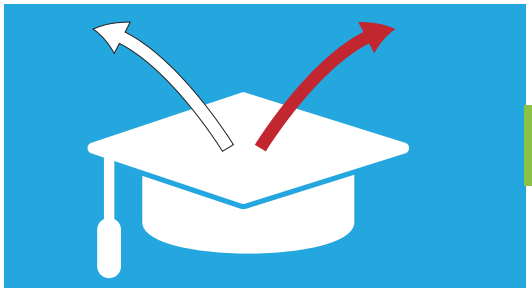


Mr. Omar Salim Al-Sudairy
Research Assistant

Mr. Omar Al-Sudairy has received his M.Sc. degree in Biology from college of science at Sultan Qaboos University (SQU), Sultanate of Oman in 2017. His master degree was about DNA Barcoding of Migratory Shore Birds in Barr Al Hikman. His research is focusing on molecular biology, Sequencing and Bioinformatics. Omar has completed his B.Sc. from the College of Science at SQU in 2015. His major is in Biotechnology with Chemistry as his minor. He has recently joined the Biotechnology and OMICS Lab as a Research assistant.

Mr. Devakannan Gunasekaran
Mass Spectroscopy Expert

Mr. Devakannan received his B.Sc., in General Chemistry from St. Joseph's college of Arts & Science, Thiruvalluvar University, India, in 2009. He started his industrial career as Quality Control Chemist at NATCO Pharma, Chennai, in which he handled various wet lab instruments such as MC analyzer, Titrator & HPLC (Waters, Agilent Technologies) until Dec. 2011. He moved to Sri Ramachandra Medical University, Chennai, as Research Analyst in the Bio Analytical department where he handled the Bruker 400 MHz NMR , HPTLC (Perkin Elmer) & HPLC (Shimadzu) until Feb. 2013. After that, he worked at the Central Veterinary Research Laboratory, Dubai, UAE as Forensic Analyst, handling advanced instruments such as LCMS/MS (Triple Quad, Agilent), LCMS/MS (Orbitrap, Thermo), GCMS (Single Quad, Agilent) and screened various Drugs of Abuse in Equine and Camel race samples. Currently he is working as Mass Spectroscopy Expert in University of Nizwa, Oman, since April 2017, handling Agilent Accurate Mass 6530 Q-TOF LCMS. He is managing the samples from inside and outside the University, analyses and reports them as per scientists' requirements. He is working with a High-Resolution Mass Spectrometer (HRMS) which allows for in depth studies of the unknown molecules.



Post-Graduate Exchange Students

1. Mrs. Farah Jabeen, was born in Quetta, Baluchistan, Pakistan. She received her B.Sc degree from University of Baluchistan and M.Sc degree from University of Peshawar, Khyber Pukhtunkhwa (KPK) Pakistan. She did her research work under the supervision of Professor Dr. Mohammad Rasul Jan and was awarded the degree of Master in Philosphy (M.Phil) in 2006 from Institute of Chemical Sciences, University of Peshawar. Nowadays her PhD research work is in progress under the supervision of Prof. Dr Ikhtiar khan University of Peshawar, Prof. Ahmad Al-Harrasi, Dr Javid Hussain University of Nizwa Oman.

2. Ms. Samina Ali, a PhD student of Kohat University of Science & Technology Kohat-Pakistan, she worked on the extraction, isolation, characterization of natural products from medicinal plantsduring her stay in Oman. Her work also focused on the identification of biologically active (antimicrobial, allelopathic and antidiabetic) metabolites.

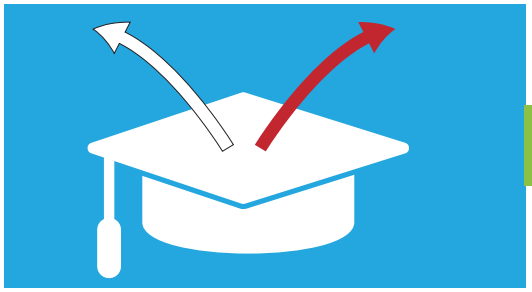
3. Mr. Nisar Ahmed, a PhD student of Quaid e Azam University Islamabad Pakistan, worked on the isolation of biologically active natural products from Nepeta laevigata, Nepeta kurramensis and Rhynchosia reniformis. He performed antimicrobial, xanthine oxidase and antioxidant activities of isolates. He is presently working in Kohat University of Science & Technology Kohat, Pakistan.

4. Mr. Hidayat Ullah, was born in Ahmed Abad, Khyber Pakhtunkhwa, Pakistan. He received his B.Sc and M.Sc degrees from Government Post Graduate College Kohat affiliated with Peshawar University. He enrolled in a M. Phil/Ph.D program in 2012 at Department of Chemistry, Federal Urdu University of Arts, Sciences, and Technology, Karachi-Pakistan. His research topic is on Phytochemical Investigation and Biological Activities of Cleome droserifolia. He is working on the Isolation of Natural Products and Biological activities of Cleome droserifolia. He was appointed as Technical Assistant in the government Sector, Central Drugs Laboratory (CDL), Drugs Regulatory Authority Pakistan (DRAP), Karachi, Pakistan. Currently, he is working as an analytical chemist. He has an excellent academic and research record. In recognition of the quality of his research work, the Director of CDL, DRAP awarded him performance award of Good Laboratory Practice in 2012-13.

5. Mr. Imtiaz Hussain, received his B.Sc degree from the Government Degree College Pararchinar and completed his M.Sc (Organic Chemistry) degree from the Department of chemistry, Kohat University of Science and Technology, Kohat, KPK, Pakistan. He is enrolled in M.Phil/PhD in the Department of Chemistry, Kohat University of Science and Technology, Kohat, KPK, Pakistan. In parallel to academia, Imtiaz Hussain also completed professional educational courses, C.T. and B.Ed. He also got a Diploma in Information Technology (DIT). He has been teaching in various educational institutes of the Parachinar at S.S.C. and H.S.S.C level for about 8 years. Imtiaz Hussain obtained 71 percentile in GAT-Subject and 92 percentile in GAT-General conducted by NTS, Pakistan. His research interests include: isolation of bioactive metabolites from medicinal plants, structural characterization of Natural Products, Green Synthesis of Silver and Gold Nanoparticles from medicinal plants and evaluation of their biological activities.

6. Mr. Sajid Ali, has completed his B.Sc (Hons) from University of Peshawar, Pakistan in the subject of Biotechnology. He then joined Kohat University of Science & Technology, Pakistan to obtain M.Phil degree in Molecular biotechnology while working on "Detection and Genotyping of Hepatitis C virus RNA in Anti-HCV positive individuals in Mardan, Pakistan". He is presently doing his PhD from the Center of Microbiology & Biotechnology, University of Peshawar, Pakistan. He stayed for six months working on the role and diversity of endophytic microbial community of economically important arid plants.

7. Mr. Amjad Khan, received his Doctor of Pharmacy (Pharm-D) degree from the Faculty of Pharmacy, Gomal University securing First-Class-First Position obtaining Gold Medal. He pursued his clinical pharmacy internship at Pakistan Institute of Medical Sciences, Islamabad. Based on his excellent academic scores, Dr. Khan succeeded to get himself registered as research scholar in Quaid-i-Azam University Islamabad-Pakistan. He is working under the supervision of Prof. Dr. Zabta Khan Shinwari and has published and/or submitted several research papers and attended several National as well as International Conferences. He has been awarded a scholarship to pursue his research work at the University of Nizwa under the co-supervision of Dr. Ahmed Al Harrasi and Dr. Javid Hussain, UoN Natural and Medical Science Research Center.



Post-Graduate Exchange Students

8. Mr. Riaz Ahmed was born in District Dir lower, Pakistan. He did his BS in Biotechnology in 2010 from Gomal University. After that he got admission in January 2013 in M.Phil Biotechnology at Qauid-i-azam University; the top ranked University of Pakistan. He is working under the supervision of Dr. Z K Shinwari and co-supervision of Dr. Ahmed Al-Harrasi and Dr. Javid Hussain.He has a great interest in the phytochemistry, Biological Evaluation and Proximate analysis of Medicinal and Aromatic Plants (MAP's).He is working in collaboration with the University of Nizwa, Sultanate of Oman, and some part of his research was conducted in Nizwa.

9. Mr.Aasim obtained the B.Sc degree from Government Degree College for Boys Attock/ Pakistan. Then he joined the Gomal University D.I.Khan /Pakistan for Master. After M.Sc he received the M. Phil degree from Quaid-I-Azam University Islamabad, Pakistan in 2015. Currently he is enrolled as Ph. D Scholar at Quad-i-Azam University Islamabad, Pakistan.

10. Mr. Wajid Hussain did his bachelor degree from the Government boys college Kot Sultan, Master degree from the Islamia University of Bahawalpur, M.Phil from Quaid-e-Azam University in 2015 in Islamabad, Pakistan, and now enrolled as PHD student in Beijing institute of technology, China. Recently, he is working at University of Nizwa, Oman, on the synthetic project "Synthesis of macrocyles". He has expertise in Nano chemistry, catalysis and coordination Chemistry.

11. Mr. Umiar completed his B. Sc degree from GPGC No. 1 Abbottabad, Pakistan and M. Sc degree Quad-i-Azam University Islamabad. Recently he completed his M. Phil from Quad-i-Azam University Islamabad, Pakistan and now enrolled as Ph. D. Recently he continued his research through student exchange program at University of Nizwa Oman. His main expertise is field of organometallics, Materials chemistry, and Catalysis.

12. Mr. Amjad Ali has completed his B.S (Hons) Biotechnology from Government College University Faisalabad, Pakistan, and his M.phil Biotechnology from Quaid-i-Azam University Islamabad Pakistan. His expertise is in plant microbial interaction and plant biotic and abiotic stresses. At the Center, he worked as a Research Assistant in the Biotechnology lab.

13. Mr. Fazal Akber. is a Ph.D scholar, enrolled in the Department of Biotechnology, Faculty of Biological Sciences, Quaid-I-Azam University, Islamabad, Pakistan and has done his Ph.D research project(Assessment of Genetic diversity and Chemodiversity of Boswellia sacra) in UoN Natural and Medical Science Research Center, University of Nizwa, Nizwa, Oman. His area of expertise isPlant genetic diversity and conservation studies, Plant Molecular Biology & Biochemistry, Molecular systematic and applied ethnobotany and Advances in Biotechnology of Medicinal plants.

14. Ms. Asma Bani Orabah, PhD student, obtained her Bachelor in Biotechnology (major) with a minor in Chemistry from college of Science at Sultan Qaboos University, Muscat-Oman, 2006-2011. She obtained her Master Degree in Biology from college of Science (2011-2013). She worked as research assistant in college of Medicine and Health Science at Sultan Qaboos University, Muscat- Oman (Januarys- September 2014). She started her PhD Degree in Biochemistry Department in the same college (October 2014) with Major on Biochemistry and Molecular Biology. Her project in collaboration with Natural and Medical Science Research Center on exploring the anti-tumor activity of the AKBA derivatives on cancer cells.

15. Mr. Arif Khan is M.Phil. scholar at Department of Biotechnology, Faculty of Biological Sciences, Quaid-I- Azam University Islamabad, Pakistan. He is currently working in Molecular Systematic and Applied Ethnobotany Lab, Quaid-I- Azam University Islamabad, Pakistan. His area of expertise is Nanotechnology, Tissue culture, DNA and RNA Extraction, PCR, and Bioinformatics tools. He is currently working in the project of Chloroplast Genome/ Transcriptome sequencing and analysis, at the University of Nizwa, Nizwa, Oman.

16. Mr. Maroof Ali Toori, has received his B.Sc. degree from Kohat University of Science and Technology, Kohat and M.Sc. degree from Quaid-i-Azam University Islamabad, Pakistan. He completed his M.Phil. in Plant Taxonomy and Biodiversity in 2017 from Quaid-i-Azam University, Islamabad Pakistan. Currently, he is doing PhD from Quaid-i-Azam University under the supervision of Prof. Dr. Mushtaq Ahmad. He has expertise on conservation, biodiversity, phytochemistry and taxonomy and ethnobotanical study of medicinal plants, He has published and submitted seven articles in international Journal. He is working at the Center as PhD Exchange Program Researcher for six months.

21. International and National Collaboration

The Center has succeeded to build up a network of active prominent international and national collaborators. This has allowed a two-way flow of personnel between NMSRC and others research institutes. In addition, this has also allowed the transfer of scientific samples under the umprella of signed MTA agreements.

A. The table below shows the list of active international collaborators and their research areas.

No	Name of Collaborator	Country Flag	Institution	Research Area
1	Prof. Simon Gibbons		Schools of Pharmacy, University of London, UK	Phytochemistry & Medicinal Plants
2	Prof. James Paulson		University of Wisconsin Oshkosh, USA	Cell division and apoptosis
3	Prof. Alan Katritzky		University of Florida, USA	Synthesis of Natural Products
4	Prof. Tadhg Begley		University of Texas A&M, USA	Chemical Biology
5	Prof. Gills Gullimen		University of New South Wales, Australia	Cancer Research
6	Prof. Hans Resissig		Free University of Berlin, Germany	Synthesis of Natural Products
7	Dr. John Langley		University of Southampton, UK	Mass Spectroscopy
8	Dr. Eike Reich		CAMAG Laboratory, Switzerland	HPTLC
9	Dr. Doha Al-Waheeb		Kuwait University, Kuwait	Natural Products

10	Dr. Mansoor Ahmad		University of Karachi, Pakistan	Pharmcognosy
11	Dr. Ishfaq Bukhari		King Saud University, KSA	Cardiovascular Research
12	Ms. Fatema Al-Khulaifi		Qatar Foundation	Botany
13	Prof. Dr. In-Jung Lee		Kyungpook National University, South Korea	Plant Physiology
14	Prof. Dr. Jae-Ho Shin		Kyungpook National University, South Korea	Microbial Biotechnology
15	Prof. Dr. Jong-Sang Kim		Kyungpook National University, South Korea	Cancer Biology
16	Prof. Dr. Muhammad Iqbal Choudhary		HEJ, University of Karachi, Pakistan	Phytochemistry
17	Dr. Nessar Ahmed		Manchester Metropolitan University, UK	Clinical Biochemistry
18	Dr. Naoki Matsuda		Nagasaki University, Japan	Cancer Biology
19	Dr.Motohiro Yamauchi		Nagasaki University, Japan	Cancer biology
20	Dr. Hyuk Song		Konkuk University, South Korea	Cancer Biology
21	Prof. Dr. Faik Kantar		Akendiz University, Anatalya, Turkey	Agriculture
22	Dr. Synan Abu Qamar		United Arab Emirates University, UAE	Molecular sciences

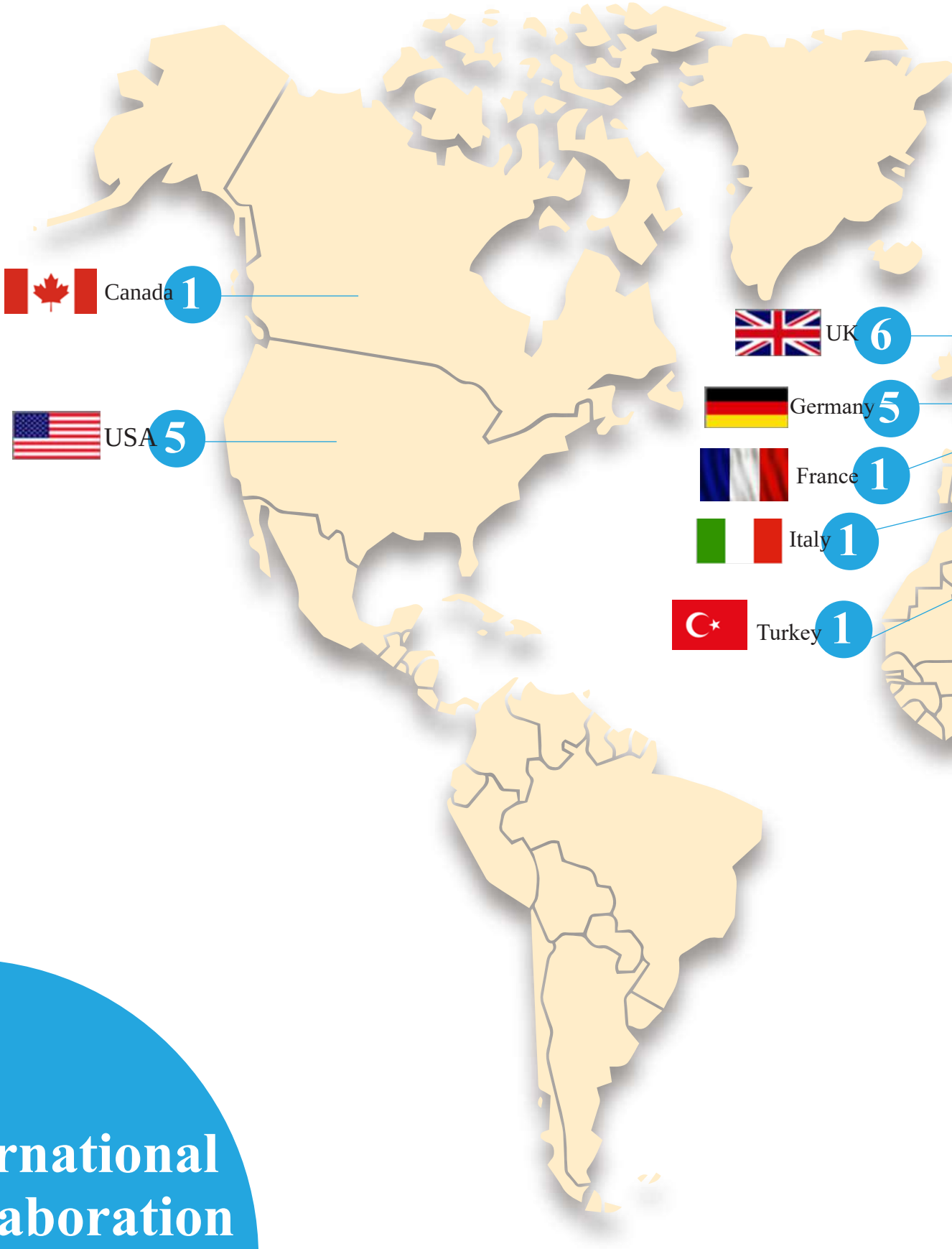
23	Prof. Grant Burgess		University of Newcastle, UK	Chemical Ecology
24	Dr. Mark Evans		University of Leicester, UK	Cancer Research
25	Prof. Andrea Buttner		Fraunhofer-Institut, Munich, Germany	Neuroscience
26	Dr. Farah Mustafa		United Arab Emirates University, UAE	Cancer Reserach
27	Prof. Gilles Dujardin		University of Maine, France	Organic synthesis
28	Prof. Peter Langer		Universität Rostock, Germany	Phytochemistry
39	Prof. Ivan R Green		University of the Western Cape, South Africa	Natural Products Chemistry
30	Prof .Teunis van Ree		University of Venda, South Africa	Natural Products Chemsitry
31	Dr. Zulfiqar Ali		The University of Mississippi, USA	Organic synthesis
32	Prof. Muhammad Shaiq Ali		HEJ, University of Karachi, Pakistan	Marine Natural Products
33	Prof. Dr. Amin Badshah		HEJ, University of Karachi, Pakistan	Organic synthesis
34	Prof. Dr. Muhammad Saleem		Quaid-e-Azam University, Pakistan	Organic synthesis
35	Prof. Ali Reza Ghasanpur		Shaheed Baheshti University, Iran	Phytochemistry

36	Prof. Rene Csuk		Martin-Luther University, Halle, Germany	Boswellic Acids Chemistry
37	Prof. Mohammed Qaiser		University of Karachi, Pakistan	Taxonomy
38	Dr. Lutz Mueller-Kuhrt		AnalytiCon Discovery, Germany	Natural Products
39	Dr. Gennaro Pescitelli		Dipartimento di Chimica, Università di Pisa, Italy	CD/ORD analysis
40	Prof. Jamshed Anwar		Lancaster University, UK	Computational Chemistry
41	Dr. Syed A. A. Rizvi		Nova Southeastern University, USA	Pharmacologist
42	Dr. Syed Aun Muhammad		University Multan, Pakistan	Computational Chemistry
43	Prof. Bernhard Klausgraber & Dr. Dominik Schild		University of Applied Sciences Krems, Austria	Fermentaion Sciences (Bioreactors)
44	Prof. Jeremy Rawson		University of Windsor, Canada	Inorganic Materials
45	Prof. Ringdén		Karolinska Institute, Sweden	Mesenchymal stem cells
46	Dr. Hani		Qatar University, Qatar	Induced pluripotent stem cells
47	Dr. Ahmed beigi		University of Tehran, Iran	CAR-T cells
48	Prof. Daniel Shachtman		University of Nebraska, USA	Microbiome

49	Prof. Jeff Benetzen		University of Georgia	Plant genome
50	Prof. Hoyoun Kim		Korea Institute of Science and Technology, South Korea	Metabolomics
51	Prof. Abbas Zare Dr. Keyvan Tadayon		Razi institute	Vaccine and serum research
52	Dr. Hamid Namavar		Shahroud medical university	Medicinal Plants, Natural Product Research
53	Professor David Sheppard		University of Bristol, UK	Physiology, Pharmacology and Neuroscience
54	Dr. Christopher Schofield		University of Oxford, UK	Chemistry research
55	Alan Forrest		Royal Botanic Garden Edinburgh, UK	Frankincense research
56	Dr. Shahina Ghazanfar		Royal Botanic Gardens Kew, UK	Plant taxonomy
57	Dr. Nicolas Baldovini		Nice Sophia Antipolis University, France	Aromatic and odorants compounds
58	Prof. Robert Harrison		Liverpool School of Tropical Medicine, UK	Venoms research and antivenom production
59	Prof. Frans Bongers		Centre for Ecosystem Studies, Wageningen University, Netherlands	Boswellia ecology

B. The table below shows the list of our active collaborators within Oman and their research areas

No	Name of Collaborator	Institution	Institution's logo	Research Area
1	Dr. Rashid Al-Yahyai	College of Agricultural and Marine Sciences, SQU, Oman		Plants physiology, botany
2	Dr. Abdullah Al-Saadi	College of Agricultural and Marine Sciences, SQU, Oman		Plant Microbe interactions
3	Dr. Fahad Al-Zadjali	College of Medicine and Health Science, SQU, Oman		Cancer research
4	Dr. Raeid Abed	College of Science, SQU, Oman		Microbial ecology and biotechnological applications
5	Dr. Annette Patzelt	Oman Botanic Garden, Diwan of Royal Court, Oman	شؤون البلاط السلطاني ROYAL COURT AFFAIRS	Plan taxonomy
6	Dr. Andrzej Golachowski	Royal Cavalry, Diwan of Royal Court, Oman	شؤون البلاط السلطاني ROYAL COURT AFFAIRS	Bone and tendon injuries
7	Dr. Nadiya Al-Saadi Dr. Ali Al-Lawati	Oman Animal Plant Genetic Resources Center (OAPGRC), Oman	Oman Animal & Plant Genetic Resources Center	Genomic sequence Oman gene bank establishments
8	Dr. Yasin Al- Mulla	Remote Sensing and Geographic Information Systems, SQU		Remote sensing and GIS
9	Dr. Lubna Al-Kharusi	Oman's Centre for Marine Science, MAF		Marine secondary metabolites
10	Dr. Masoud Al-Azri	Animal & Agricultural Research Directorate, MAF		Plant tissue culture research

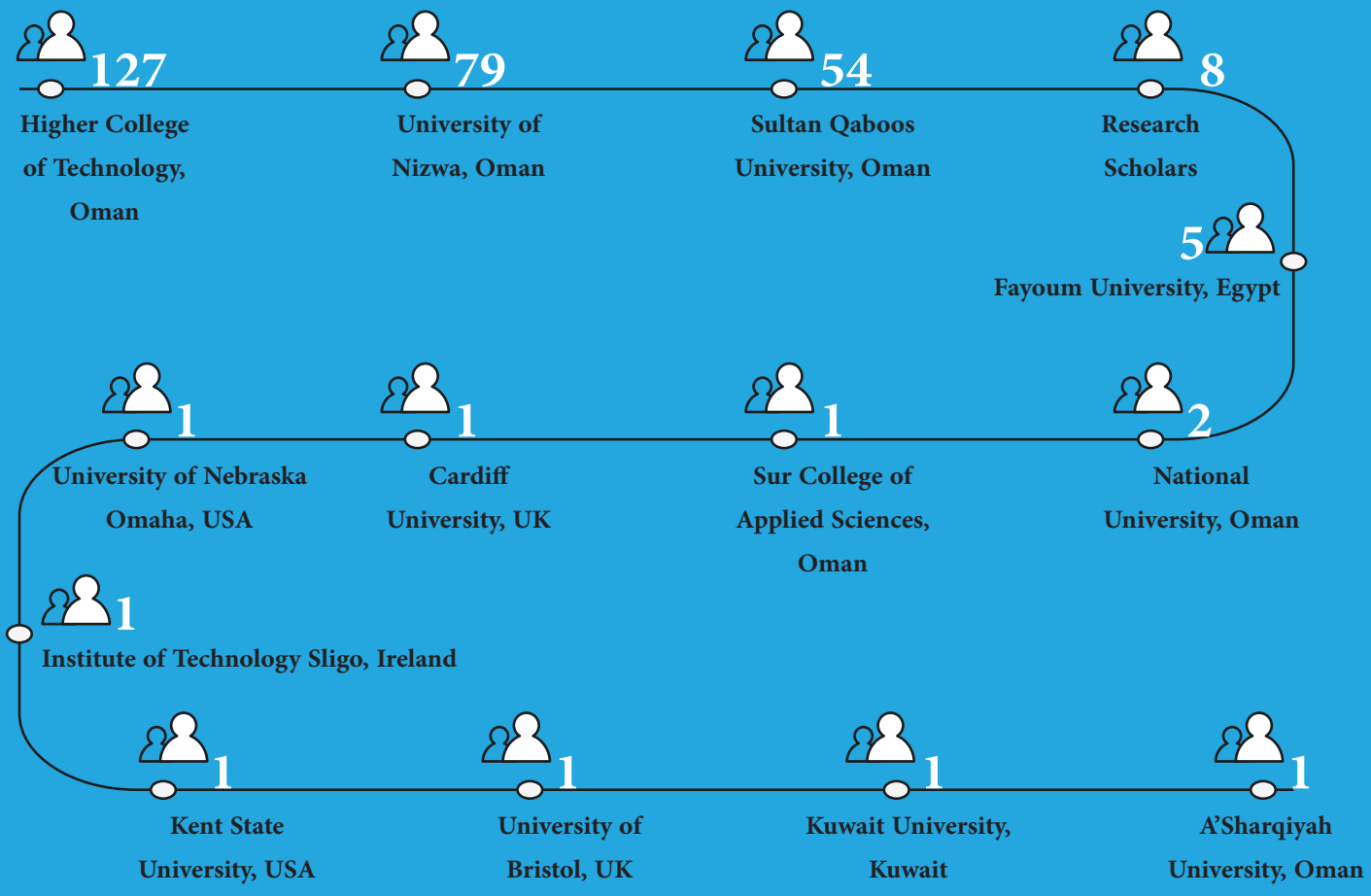


International Collaboration Map


1 Switzerland
Iran 4
1 Sweden
1 Austria
5 South Korea
2 Japan
7 Pakistan
2 UAE
2 Qatar
2 Kuwait
1 KSA
2 South Africa
Australia 1

22. Training

The center serves as ahub for students to conduct their training by involving in ongoing research projects at the laboratories of the center. The following table summarizes the students, the area of training, institute and the duration of training.



= 14
Institutions

= 283
N.O. of Trainees

International Internship for Oxford University Students at NMSRC

6 students

4 weeks (25/08 –19/09 2019)

NMSRC, Uon

The Oxford-Nizwa research students exchange program was held for four weeks at Natural and Medical Ssciences Research Center, University of Nizwa. BA student Karen Yan, MA students Sungmin Cho, Daniel Farooq, Solomon White, Zoe Heighes, and PhD student Leila Hill took part in the programme. The participants have had the opportunity to choose a research project that best applies with his/her major field and performed the designed experiments in the labs of NMSRC, utilizing the available technologies and state of art equipment. The participants were also involved in the weekly research group meetings and discussion.

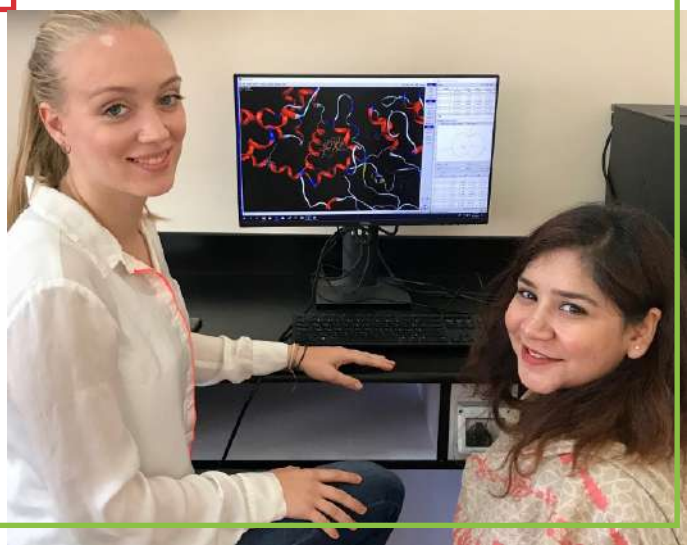
In addition, Arabic language classes were provided for the participants where he/she gained the basic Arabic skills and engaged in Arabic conversations. Classes of the rich Omani culture was also offered where the participant was interacted with the Omani culture and learn more about it. The program was involve field trips and cultural visits to the most famous and historic places in Oman to discover the Omani nature and learn more about the unique Omani environment.

Solomon White, about the Al-Jabal Al-Akhdar said,

“The peace and serenity up on the mountain was a genuine reflective experience, the walks amazing, and the diversity of plant life, absolutely stunning”

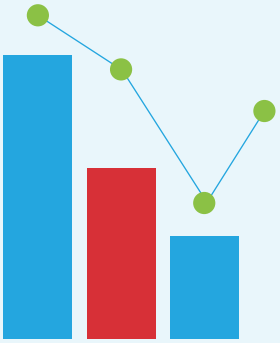
Scientific Collaboration Officer, Ahmed Nasser al Rawahi, said,

“This has been an amazing opportunity for us, to respond to an idea, an initiative, created by Dr Ahmed al Harrasi, the director of the Research Centre, in which we were able to invite applicants from the institution at the pinnacle of global higher education, that probably has more tradition, gravitas and achievement in its alumni than any other in the world”



23. Publications

The Center has published more than 550 research articles in journals of international repute and impact factor. These journals include PlosONE, RSC advances, Chemical Reviews, Tetrahedron, European journal of Medicinal Chemistry, Measurements, Food Chemistry, Plant physiology, Frontiers in Plant Sciences and Frontiers in Microbiology, Environmental Experimental Botany, Journal of Hazardous Material, Critical reviews in Biotechnology, Dalton Trans, Synletters, angewandte chemie, etc. The total impact factor of these publication ranges to 1,515, whereas the average impact factor is 1.98. The total citation of these articles is 11,581, which is increasing every year. The year 2019 is getting more productive with 120 articles either accepted with review or accepted for publication.



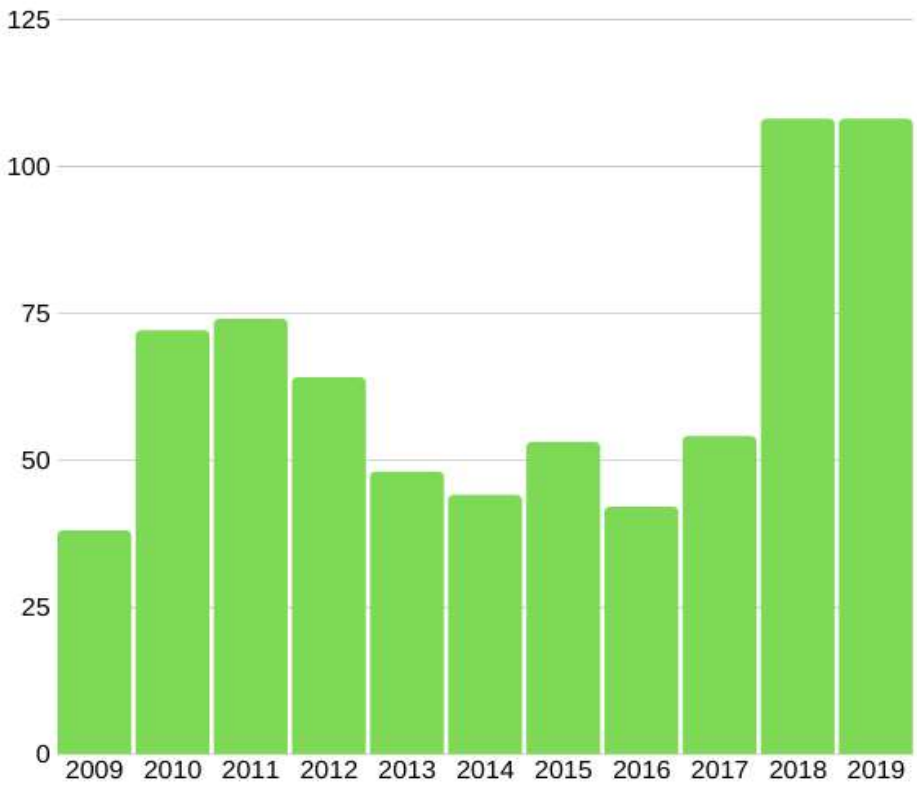
Publications statistics (up to 2019)

Total Publications 717

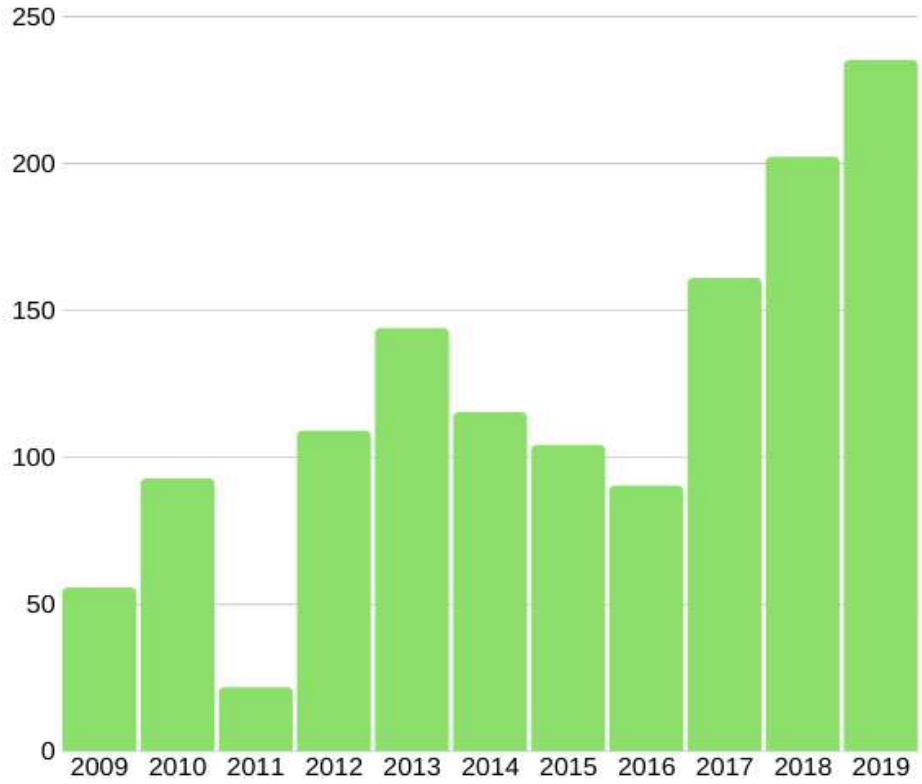
Total impactor factor 1,515

Total citations 11,581

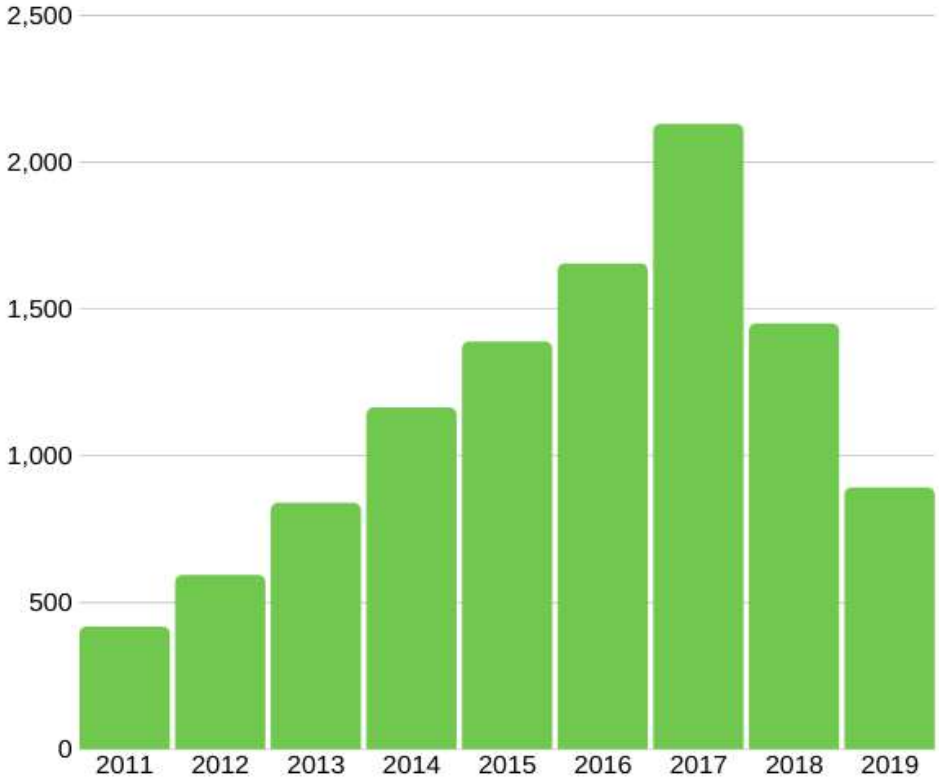
23.1. Number of publications per Year



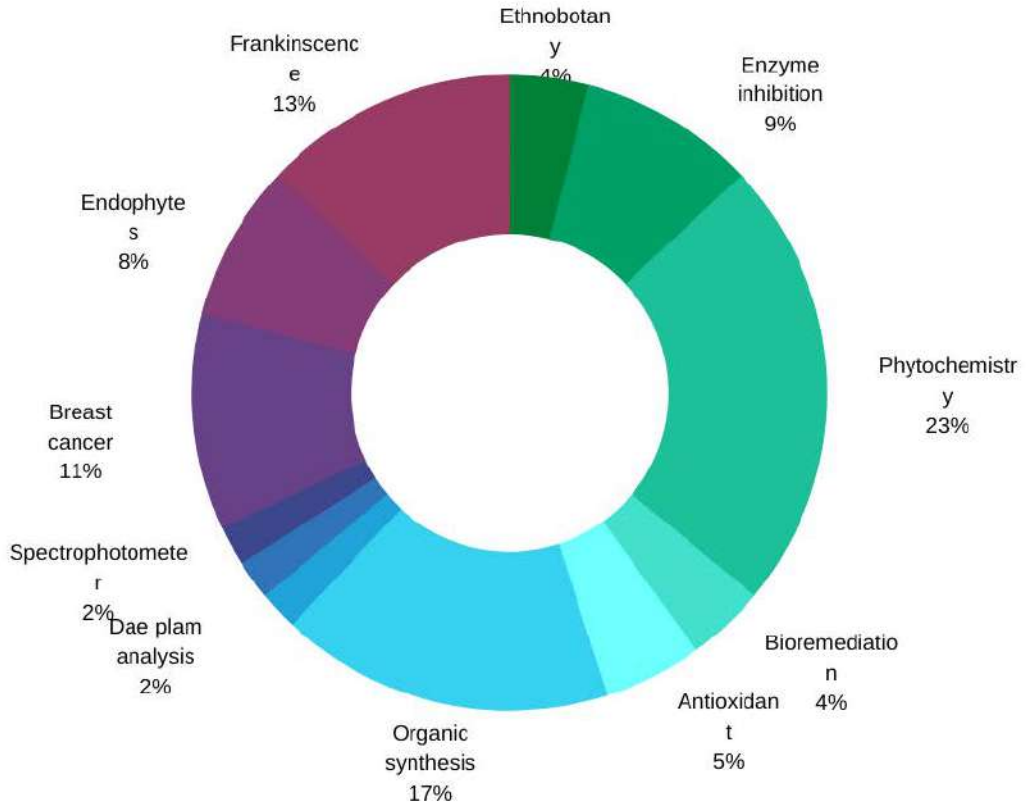
23.2. Impact factor Per Year



23.3. Citations Per Year



23.4. Distribution of Research Topics



23.5. List of Publications

Year 2019

1. Bilal, Saqib, Abdul Latif Khan, Raheem Shahzad, Yoon-Ha Kim, Muhammad Imran, Muhammad Jamil Khan, Ahmed Al-Harrasi, Tae Han Kim, and In-Jung Lee. Mechanisms of Cr (VI) resistance by endophytic Sphingomonas sp. LK11 and its Cr (VI) phytotoxic mitigating effects in soybean (Glycine max L.). Ecotoxicology and environmental safety 164 (2018): 648-658. IF 4.50

2. Akbar, F., Khan, A.L., Gilani, S.A., Al-Harrasi, A., Al-Sadi, A.M. and Shinwari, Z.K., 2019. GENetic Differentiation In Different Endemic Boswellia Sacra (Burseraceae) Populations From Oman. Pakistan Journal Of Botany, 51(1), pp.109-116. IF 1.10

3. Bilal, Saqib, Raheem Shahzad, Abdul Latif Khan, Ahmed Al-Harrassi, Chang Kil Kim, and In-Jung Lee. "Phytohormones enabled endophytic Penicillium funiculosum LHL06 protects Glycine max L. from synergistic toxicity of heavy metals by hormonal and stress-responsive proteins modulation." Journal of Hazardous Materials (2019): 120824. IF 7.30

4. Al-Harrasi, Ahmed, Najeeb Ur Rehman, Abdul Latif Khan, Muhammed Al-Broumi, Issa Al-Amri, Javid Hussain, Hidayat Hussain, and René Csuk. Chemical, molecular and structural studies of Boswellia species: β-Boswellic Aldehyde and 3-epi-11β-Dihydroxy BA as precursors in biosynthesis of boswellic acids. PloS one 13, no. 6 (2018): e0198666. IF 2.80

5. Khan, A.L., Mabood, F., Akber, F., Ali, A., Shahzad, R., Al-Harrasi, A., Al-Rawahi, A., Shinwari, Z.K. and Lee, I.J., 2018. Endogenous phytohormones of frankincense producing Boswellia sacra tree populations. Plosone 13(12), p.e0207910. IF 2.80

6. Kim, Yoonha, Chang-Woo Seo, Abdul Latif Khan, Bong-Gyu Mun, Raheem Shahzad, Jeung-Woo Ko, Byung-Wook Yun, Soon-Ki Park, and In-Jung Lee. Exo-ethylene application mitigates waterlogging stress in soybean (Glycine max L.). BMC plant biology 18, no. 1 (2018): 254. IF 3.50

7. Rehman, Najeeb Ur, Hidayat Hussain, Husain Yar Khan, Ghulam Abbas, Abdul Latif Khan, and Ahmed Al-Harrasi. Desmiflavanoside, a New Bioactive Flavonoid Glycoside Isolated from Desmidorchis flava." Chemistry of Natural Compounds (2018): 1-4. IF 1.50

8. Abdul Latif Khan, Shezad R, Imran M, Yun BW, Al-Harrasi A, Kim YH, Lee IJ. 2018. Regulations of endogenous phytohormones and essential metabolites in preserved and incised endemic Boswellia sacra tree. Acta Physiologiae Plantarum (2018) 40:113. IF 1.90

9. Bilal, S., Shahzad, R., Khan, A.L., Kang, S.M., Imran, Q.M., Al-Harrasi, A., Yun, B.W. and Lee, I.J., 2018. Endophytic microbial consortia of phytohormones-producing fungus Paecilomyces formosus LHL10 and bacteria Sphingomonas sp. LK11 to Glycine max L. regulates physio-hormonal changes to attenuate aluminum and zinc stresses. Frontiers in plant science, 9. IF 3.90

10. Rehman, Najeeb Ur, Raeid MM Abed, Hidayat Hussain, Husain Yar Khan, Ajmal Khan, Abdul Latif Khan, Majid Ali et al. Anti-proliferative potential of cyclotetrapeptides from Bacillus velezensis RA5401 and their molecular docking on G-Protein-Coupled Receptors. Microbial pathogenesis 123 (2018): 419-425. IF 2.58

11. Numan, M., Bashir, S., Mumtaz, R., Tayyab, S., Ullah, I., Khan, A.L., Shinwari, Z.K. and Al-Harrasi, A., 2018. Chemical profile and in-vitro pharmacological activities of yellow pigment extracted from Arthrobacter gandavensis. Process biochemistry, 75, pp.74-82. IF 3.50.

12. Kim, Y., Mun, B.G., Khan, A.L., Waqas, M., Kim, H.H., Shahzad, R., Imran, M., Yun, B.W. and Lee, I.J., 2018. Regulation of reactive oxygen and nitrogen species by salicylic acid in rice plants under salinity stress conditions. PloS one, 13(3), p.e0192650. IF 3.50

13. Jang, S.W., Kim, Y., Khan, A.L., Na, C.I. and Lee, I.J., 2018. Exogenous short-term silicon application regulates macro-nutrients, endogenous phytohormones, and protein expression in Oryza sativa L. BMC plant biology, 18(1), p.4. IF 3.50

14. Akash Tariq, Muhammad Adnan, Anila Iqbal, Sehrish Sadia, Yang Fan, Amina Nazar, Sakina Mussarat, Mushtaq Ahmad, Olusanya Abiodun Olatunji, Shaheen Begum, Paras Mazari, Bibi Ambreen, Shahid Niaz Khan, Riaz Ullah, Abdul Latif Khan: Ethnopharmacology and toxicology of Pakistani medicinal plants used to treat gynecological complaints and sexually transmitted infections. South African Journal of Botany vol 114; Pages 132-149. IF 1.80

15. Tapan Kumar Mohanta, AL Khan, A Hashem, EF Abd_Allah, A Al-Harrasi (2019). Molecular mass and

isoelectric point of plant proteomes. BMC Genomics, 20: 631. IF 3.50

16. Tapan Kumar Mohanta, Yadav D, Khan AL, Hasheem A, Abda_Allah EF, Al-Harrasi A. (2019). Analysis of genomic tRNA reveal presence of novel genomic features in cyanobacterial tRNA. Saudi Journal of Biological Sciences. doi: 10.3389/fgene.2017.00090. IF: 2.82

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20. Tapan Kumar Mohanta, Tufail Bashir, Abeer Hashem, Elsayed Fathi Abd_Allah, Abdul Latif Khan, Ahmed Suleiman Al-Harrasi. (2018). Early events in plant abiotic stress signaling: interplay between calcium, reactive oxygen species and phytohormones. Journal of Plant Growth Regulation., 37(4): 1033-1049. IF: 2.47.

21. Ali A, Tapan Kumar Mohanta, Asaf S, Rehman N, Al-Housni S, Al-Harrasi A, Khan AL, Al-Rawahi A (2019). Biotransformation of benzoin by Sphingomonas sp. LK11 and ameliorative effects on growth of Cucumis sativus. Archives of Microbiology., 201(5): 591-601. IF: 1.64

22. Tapan Kumar Mohanta, Tufail Bashir, Abeer Hashem, EF Abd_Allah, AL Khan, AS Al-Harrasi (2018). Molecular players of auxin transport systems: Advances in genomic and molecular events. J. Plant Interactions., 13: 483-495. IF: 1.83.

23. Pudake RN, Mittal J, Tripathi RM, Tyagi J, Tapan Kumar Mohanta. (2019). Biochemical responses of maize seedlings exposed to SnNPS. Micro & Nano Letters, 14: doi: 10.1049/mnl.2018.5313. IF 0.97

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25. Sajjad Asaf · Abdul Latif Khan · Muhammad Aaqil Khan · Ahmed Al_Harrasi · In_Jung Lee. Complete genome sequencing and analysis of endophytic Sphingomonas sp. LK11 and its potential in plant growth. 3 Biotech ISSN 2190572X, 21905738

26. Muhammad Aaqil Khan, Muhammad Hamayun, Amjad Iqbal, Sumera Afzal Khan, Anwar Hussain, Sajjad Asaf, Abdul Latif Khan, Byung Wook Yun, In-Jung Lee. Gibberellin application ameliorates the adverse impact of short-term flooding on Glycine max L. Biochemical Journal ISSN 14708728, 02646021

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29. Abdul Latif Khan · Sajjad Asaf · In_Jung Lee · Ahmed Al_Harrasi · Ahmed Al_Rawahi.2018. First reported chloroplast genome sequence of Punica granatum (cultivar Helow) from Jabal Al-Akhdar, Oman: phylogenetic comparative assortment with Lagerstroemia. Genetica ISSN 00166707, 15736857.

30. Qari Muhammad Imran, Sang-Uk Lee, Bong-Gyu Mun, Adil Hussain, Sajjad Asaf, In-Jung Lee, and Byung-Wook Yun.WRKYs, the Jack-of-various-Trades, Modulate Dehydration Stress in Populus davidiana—A Transcriptomic Approach. International Journal of Molecular Sciences ISSN: 14220067

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34. Muhammad Aaqil Khan, Ihsan Ullah, Muhammad Waqas, Muhammad Hamayun, Abdul Latif Khan, Sajjad Asaf, Sang-Mo Kang, Kyung-Min Kim, Rahmatullah Jan, In-Jung Lee. Halo-tolerant rhizospheric Arthrobacter woluwensis AK1 mitigates salt stress and induces physio-hormonal changes and expression of GmST1 and GmLAX3 in soybean. Symbiosis ISSN 03345114, 18787665.

35. Raheem Shahzad, Abdul Latif Khan, Muhammad Waqas, Ihsan Ullah, Saqib Bilal, Yoon-Ha Kim, Sajjad Asaf, Sang-Mo Kang, In-Jung Lee. Metabolic and proteomic alteration in phytohormone-producing endophytic Bacillus amyloliquefaciens RWL-1 during methanol utilization. Metabolomics ISSN 15733890, 15733882.

36. Lubna, Sajjad Asaf, Abdul Latif Khan, Muhammad Waqas, Sang-Mo Kang Muhammad Hamayun, In-JungLee, Anwar Hussain.Growth-promoting bioactivities of Bipolaris sp. CSL-1 isolated from Cannabis sativa suggest a distinctive role in modifying host plant phenotypic plasticity and functions. Acta Physiologiae Plantarum ISSN 01375881

37. Arif Khan, Sajjad Asaf, Abdul Latif Khan, Adil Khan, Ahmed Al-Harrasi, Omar Al-Sudairy, Noor Mazin

AbdulKareem, Nadiya Al-Saady, Ahmed Al-Rawahi. Complete chloroplast genomes of medicinally important Teucrium species and comparative analyses with related species from Lamiaceae. PeerJ ISSN 21678359.

38. Muhammad Aaqil Khan, Sajjad Asaf, Abdul Latif Khan, Rahmatullah Jan, Sang-Mo Kang, Kyung-Min Kim, In-Jung Lee. Rhizobacteria AK1 remediates the toxic effects of salinity stress via regulation of endogenous phytohormones and gene expression in soybean. Biochemical Journal ISSN 14708728, 02646021.

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41. Adil Khan, Abdul Latif Khan, Sowbiya Muneer, Yoon-Ha Kim & Ahmed Al-Harrasi. Silicon and salinity: crosstalk in crop mediated stress tolerance mechanisms. Frontier in Plant Sciences. IF 4.3

42. Najeeb Ur. Rehman, Ajmal Khan, Ahmed Al-arrasi, Hidayat Hussain, Abdul Wadood, Muhammad Riaz, Zahra Al-Abri. New α-Glucosidase inhibitors from the resins of Boswellia species with structure–glucosidase activity and molecular docking studies. Bioorganic Chemistry, 79, 2018, 27-33. IF 3.926.

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46. Qamar-un-Nisa Tariq, Sana Malik, Ajmal Khan, Muhammad Moazzam Naseer, Shafi Ullah Khan, Abida Ashraf, Muhammad Ashraf, Muhammad Rafiq, Khalid Mahmood, Muhammad Nawaz Tahir, Zahid Shafiq, Xanthenone-based hydrazones as potent α-glucosidase inhibitors: Synthesis, solid state self-assembly and in silico studies. Bioorganic Chemistry, 2019, 84, 372–383. IF 3.926.

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15. Hussain, H., Rehman, N. U., Abbas, G., Khattak, K. F., Khan, A., & Green, I. R. (2019). Recent Progress of Phenazines as Anticancer Agents. Topics in Anti-Cancer Research: Volume 8, 8, 74.

16. Mohanta, Y. K., Mohanta, T. K., & Nayak, (2019) Recent developments on nanotechnology in agriculture: challenges and prospects In: Nanotechnology in Biology & Medicine: Research Advancements and Future perspectives, 10.1201/9780429259333-6.

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23.7. Conference Proceedings & Posters

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2. Haq. Q.M.I., Jyothsna P., Arif Ali and V.G. Malathi (2010). Deletion and site directed mutation of coat protein (ORF-AV1) gene and changes in viral pathogenecity. Conference on Whitefly and Thrips Transmitted Viruses. August 27-28, University of Delhi - South Campus, New Delhi, India.

3. Jyothsna P, Q.M.I.Haq, Archana Kumari and Malathi VG (2010). Silencing of tomato leaf curl New Delhi virus infection – suppressed by Luffa leaf distortion beta satellite. Conference on Whitefly and Thrips Transmitted Viruses. August 27-28, University of Delhi - South Campus, New Delhi, India.

4. Malathi VG*, Jyothsna P, Q.M.I.Haq, Neha Tiwari, Richa Shukla, VB Singh, Archana Kumari (2010). Investigations on yellow mosaic and leaf curl diseases affecting grain legume and tomato in India. Conference on Whitefly and Thrips Transmitted Viruses. August 27-28, University of Delhi - South Campus, New Delhi.

5. Veer B. Singh, Haq. Q.M.I., Haq. Q.M.R. and V.G. Malathi (2010) . Transformation of soybean with antisense construct targeting Rep gene of mungbean yellow mosaic India virus (MYMIV). Conference on Whitefly and Thrips Transmitted Viruses. August 27-28, University of Delhi - South Campus, New Delhi, India.

6. S. Fadil, P. Jyothsna, Q.M.I. Haq, Neha Tiwari, Richa Shukla, V.B.Singh, Archana K and V.G.Malathi (2010). Universal primers based on conserved region of coat protein for the detection of whitefly transmitted begomoviruses. 13th Congress of the Mediterranean Phytopathological Union, June 20-25, Rome-Italy.

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8. Haq.Q.M.I.,Arif Ali and V.G.Malathi (2009). Infectivity analysis of blackgram isolate of Mungbean yellow mosaic virus (MYMV) by Agroinoculation. 5th International Conference on “Plant Pathology in the Globalized Era” Nov.10-13. Indian Phytopathological Society. Indian Agricultural Research Institute, New Delhi ,India.

9. V.G.Malathi, Jyothsna P, Haq.Q.M.I., Neha Tiwari, Sulaiman K Fadil, Richa Shukla, V. B. Singh and Archana. K.(2009). Universal primers for the detection of Tomato Leaf Curl Begomoviruses. 5th International Conference on “Plant Pathology in the Globalized Era” Nov.10-13. Indian Phytopathological Society. Indian Agricultural Research Institute, New Delhi, India.

10. Richa Shukla, Haq.Q.M.I., Neha Tiwari., V. B.Singh, Jyothsna P., Archana K and V.G.Malathi (2009). RNA silencing suppressors encoded by beta satellite of tomato begomoviruses. The 6th Solanaceae

Genome Workshop, Nov 8-13,2009, Le Meridien, New Delhi, India.

11. Neha Tiwari, V.B.Singh, Haq.Q.M.I., Jyothsna P., Richa S., Archana K and V.G.Malathi (2009). Infectivity of Tomato leaf curl Bangalorevirus. The 6th Solanaceae Genome Workshop, Nov 8-13,2009, Le Meridien, New Delhi, India.

12. V.B.Singh, Neha Tiwari, Haq.Q.M.I., Jyothsna P., Richa S., Archana K and V.G.Malathi (2009). Infectivity of a new begomovirus: Tomato leaf curl Aurangabad virus (ToLCAuV). The 6th Solanaceae Genome Workshop, Nov 8-13,2009, Le Meridien, New Delhi, India.

13. Jyothsna P, Archana K., Haq.Q.M.I., Neha Tiwari, Richa Shukla, V.B.Singh and V.G. Malathi (2009). Real-time PCR for the quantification of Tomato leaf curl virus in tomato plants and its vector Bemisia tabaci. The 6th Solanaceae Genome Workshop, Nov 8-13,2009, Le Meridien, New Delhi, India.

14. Haq.Q.M.I., Rouhibaksh A., Priya J., Periasamy M., Sumiya K.V., Shivalingam P.N. and V.G. Malathi (2007). Association of DNA β with mono and bipartite Begomoviruses: MYMIV, ToLCNDV and ToLCBV. Evidence for enhanced replicative genomic DNA. International Confrence on Emerging and Re-Emerging Viral Diseases of the Tropics and Sub-Tropics. Dec 11 – 14, 2007, Indian Agricultural Research Institute, New Delhi, India.

15. Active principles of bioactive constitute from Aconitum Violaceum. Muhammad Zeeshan, Manzoor Ahmad, M. Liaquat Raza, Humera Perveen, Tania Shamim Rizvi, Huma Javed, Liaqat Ali, Shabana U Simjee and Farzana Shaheen. AFASSA Symposium on Natural Products and Regional Meeting. Organized by HEJ Research Institute of Chemistry, International Center for Chemical and Biological Sceinces, University of Karachi, Karachi-75270. Poster (Abstract), PO-18, p. 33, July 25-27, 2005.

16. Extraction of bioactive constituents from Delphinium nordhagenii. Muhammad Liaquat Raza, Humera Perveen, Muhammad Zeeshan, Liaqat Ali, Manzoor Ahmad, Farzana Shaheen and Shabana U Simjee. 40th IUPAC Congress, Innovation in Chemistry Beijing China. Poster (Abstract), 2-P-076, p. 292, August 14-19, 2005.

17. Anticonvulsant activity of DNS-II acetone fraction of Delphinium nordhagenii. M. Liaquat Raza, H. Perveen, M. Zeeshan, Manzoor Ahmad, Liaqat Ali, Tania Shamim Rizvi, Farzana Shaheen and Shabana U Simjee. AFASSA Symposium on Natural Products and Regional Meeting. Organized by HEJ Research Institute of Chemistry, International Center for Chemical and Biological Sciences, University of Karachi, Karachi-75270. Poster (Abstract), PO-10, p. 25, July 25-27, 2005.

18. An efficient solid phase total synthesis of anticancer cyclic decapeptide phakellistatin 12. Liaqat Ali and Farzana Shaheen. 11th International symposium on Natural Product Chemistry organized by HEJ Research Institute of Chemistry, International Center for Chemical and Biological Sceinces, University of Karachi, Karachi-75270. Poster (Abstract), PO-057, p. 137, October 30 to November 2, 2008.

19. The first phytochemical and pharmacological study on the Omani frankincense (Boswellia sacra). Liaqat Ali, Najeeb Ur Rehman, Ahmed Al-Harrasi, Ahmed Al-Rawahi, Hidayat Hussain, Javid Hussain, and

Fatma Ali Al-Moqbali. 1stInternational conference: Pharmacy in the era of globalization organized by the college of pharmacy and nursing, University of Nizwa, Sultanate of Oman. Poster (Abstract), PO-021, p. 49, January 24-26, 2012.

20. Analgesic, anti-inflammatory, and CNS depressant activities of new constituents of Nepeta clarkei. Javid Hussain, Najeeb Ur Rehman, Liaqat Ali, Hidayat Hussain, and Ahmed Al-Harrasi. 1stInternational conference: Pharmacy in the era of globalization 2012 organized by the college of pharmacy and nursing, University of Nizwa, Sultanate of Oman. Poster (Abstract), PO-020, p. 48, January 24-26, 2012.

21. Physico-chemicals properties and volatile compositions of Omani date palm (Phoenix dactylifera) fruits and seeds at different maturation stages. Najeeb Ur Rehman, Liaqat Ali, Ahmed Al-Harrasi, Ahmed Al-Rawahi, Javid Hussain, and Hidayat Hussain. 1stInternational conference: Pharmacy in the era of globalization 2012 organized by the college of pharmacy and nursing, University of Nizwa, Sultanate of Oman. Poster (Abstract), PO-023, p. 50, January 24-26, 2012.

22. Volatile compositions and proximate analysis of the six grades of Omani olibanum resin and leaves of Boswellia sacra. Rashid Al-Harrasi, Najeeb Ur Rehman, Liaqat Ali, Ahmed Al-Harrasi, Ahmed Al-Rawahi, Javid Hussain, and Hidayat Hussain. 1stInternational conference: Pharmacy in the era of globalization 2012 organized by the college of pharmacy and nursing, University of Nizwa, Sultanate of Oman. Poster (Abstract), PO-022, p. 49, January 24-26, 2012.

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24. Evaluation of Physico-chemical Characteristics and GC-MS Profile of Fruits and Seeds of Omani Date Palm (Phoenix dactylifera L.). Najeeb Ur Rehman, Liaqat Ali, Ahmed Al-Harrasi, Ahmed Al-Rawahi, Rashid Al-Harrasi, Javid Hussain, and Hidayat Hussain. 12th National & 3rd International conference of Botany organized by Pakistan Botanical Society at Quaid-i-Azam University, Islamabad, Pakistan. Poster (Abstract), PPTE-031, p. 222, September 1-3, 2012.

25. Nutritional Assessment and the Composition of Essential Oils Obtained from Different Grades of Omani Frankincense Resin and Leaves from Boswellia sacra. Liaqat Ali, Najeeb Ur Rehman, Ahmed Al-Harrasi, Ahmed Al-Rawahi, Javid Hussain, and Hidayat Hussain. 12th National & 3rd International conference of Botany organized by Pakistan Botanical Society at Quaid-i-Azam University, Islamabad, Pakistan. Poster (Abstract), PPTE-021, p. 219, September 1-3, 2012.

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Ganesan, and Farzana Shaheen. 13th International symposium on Natural product Chemistry organized by HEJ Research Institute of Chemistry, International Center for Chemical and Biological Sceinces, University of Karachi, Karachi-75270. Poster (Abstract), p. 137, September 22-25, 2012.

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29. Zubair H, Khan HY, Ullah MF, Hadi SM. A prooxidant based anticancer mechanism of plant derived polyphenolic nutraceuticals. FASEB J. 2011, 25, 979.1.

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49. Hamayun M, Khan AL, Kim YH, Kang SM, and Lee IJ. 2010. Endophytic fungi isolated from Soybean and their role in plant growth and development. The Korean Society for Horticulture Sciences, Spring Conference, May 28-29, 2010. Korean Journal of Horticulture Sciences and Technology, Vol 28 Supp. 1, P 157

50. Kim YH, Hamayun M, Khan AL, Kang SM, Lee JH, Lee IJ. 2010. Effect of Silicon on Ethylene and salicylic acid contents of Rice after wounding stress. The Korean Society of Crop Science Conference, April 8-9, 2010, Daejon, South Korea. Korean Journal of Crop Science (Vol 55 Supp. 1). P. 25

51. Hamayun M, Kim YH, Khan AL, Kang SM, Lee JH, and Lee IJ. Penicillium sp. MH7 promoted growth attributes of Crown Daisy (Chrysanthemum coronarium). The Korean Society of Crop Science. Chonnan National University, Gwangju, Korea (October, 2009). Korean Journal of Crop Science. 54 (Supp. 2): 76

52. Kim YH, Khan AL, Hamayun M, Kim JT, Lee JH, Kang SM, Hwang IC, Yoon CS, and Lee IJ. Effects of Prohexadion-Calcium on Growth and Gibberellins Contents of Chrysanthemum morifolium R. cv Monalisa White. Conference of the Korean Society for Horticultural Science, 23-24 October, 2009. Soul Korea. Kor. J. Hort. Sci. Technol. 27 (Suppl. II): 118

53. Hamayun M, Khan AL, Na CI, Kang SM, Choi KI, and Lee IJ. 2009. Exogenous kinetin application alleviated the adverse effects of salinity on physio-hormonal attributes of Soybean. The Korean Society of Crop Science-Spring symposium. April 16-17; P 38.

54. Kang SM, Hamayun M, Khan AL, Kim YH, Lee JH, and Lee IJ. 2009. Effect of Burkholderia cepacia SE4 on endogenous Phytohormone and amino acid contents of cucumber. The Korean Society of Crop Science-Spring symposium. April 16-17; P 40.

55. Kim YH, Khan AL, Na CI, Kang SM, Choi KI, and Lee IJ. 2009. Effect of plant growth regulators on plant growth and Phytohormone contents of dandelion (Taraxacum officinale Wigg). The Korean Society of Crop Science-Spring symposium. April 16-17; P 40.

23.8. Patents

1. Kimoon Kim, Gyeongwon Yun, Zahid Hassan, Jiyeong Lee, Jeehong kimTitle: Metal Nanoparticle-decorated CB based Nanocapsules and Their Catalytic Applications in waterPublication Filing Date: 2014, 04, 15Centre for Self-assembly and Complexity (CSC)-Institute for Basic Science Pohang University of Science and Technology POSTECH Campus, Pohang South Korea.
2. Method of Purifying 3-O-acetyl-11-keto-ß-boswellic acid (AKBA), Filled, Australlian Patents.

24. Seminar series

Seminars are organized on a monthly basis in the NMSRC conference room and feature both in house researchers and invited speakers. The main aim of these seminars is to showcase current research done in the labs and to get input and feedback from colleagues and guests in other specialties, insuring a collegial, interactive and innovative research atmosphere within the Center.

#	Title of the seminar	Presenter	External/ Internal	Dept/section
1	Biomimetic microenvironment design strategies for stem cell-based tissue engineering	Saeid Vakilian	Internal	UoN NMSRC
2	Plant Microbe Interaction: an example of BSL10	Khadija Al-Hosni	internal	UoN NMSRC
3	miRNAs and their applications	FATEMEH JAMSHIDI	internal	UoN NMSRC
4	Novel ways to understand natures molecular complexity: Metabolomics in modern drug discovery	Prof. Dr. Ludger	external	Leibniz Institute of Plant Biochemistry (IPB)
5	Assessment of flash-flood trends in Oman with emphases on Nizwa region	Prof. Dr. Nayyer Alam Zaigham	external	Executive Director, GeoEnvo Tech Services (GETS), Karachi, Pakistan
6	Heart Failure	AbdulAziz Sulaiman Al-Dhuhli	internal	UoN NMSRC
7	Biotechnology and omics lab	Dr. Abdul Latif Khan	internal	UoN NMSRC
8	Bone marrow transplantation	Dr. SULAIMAN ALI SAID AL-HASHMI	internal	UoN NMSRC
9	Interdisciplinary Nature of Chair's Research: on the Interface between Chemistry, Biology and Biomedical Sciences of Boswellia Research	Prof. Dr. Ahmed Al-Harrasi	internal	UoN NMSRC
10	Chiral NMR	Anand	internal	UoN NMSRC
11	DNA barcoding of migratory shorebirds in Barr Al Hikman	Omar Al Sudairi	internal	UoN NMSRC
12	Taxidermy	Farukh	internal	UoN NMSRC

13	Current status of in vitro embryo production in farm animals	Dr. Mohammadi-Sangcheshmeh	internal	Department of Animal and Poultry Science, University of Tehran
14	Transformational therapies in cystic fibrosis	Dr. Majid	internal	UoN NMSRC
15	Investigation on Bioactive compounds through synthesis of new derivatives of Incensole and 1H-1,2,3-triazole derivatives as a novel class of α-glucosidase inhibitors	Dr. A. Satya Kumar	internal	UoN NMSRC
16	Principles of Q-TOF Mass spectroscopy	Devakannan Gunasekaran	internal	UoN NMSRC
17	Saffron chemistry and its quality control	Dr. Hassan Rezadoost	external	Medicinal plants and Drugs Research Institute Shahid Beheshti University
18	Efficient approaches for the management of diabetes and diabetic complications	Dr. Ghulam Abbas	internal	UoN NMSRC
19	Cancer Chemoprevention and Dietary Polyphenols	Dr. Husain Yar Khan	internal	UoN NMSRC
20	Chloroplast genome of medicinal plant	Arif Khan	internal	UoN NMSRC
21	Primary sugars composition in eight cultivars of Phoenix dactylifera L. fruit and variation across different developmental stages	Muhammad Numan	internal	UoN NMSRC
22	The snakes of Oman	Ahmed Al-Busaidi	internal	UoN NMSRC
23	chloroplast genome	Dr. Sajjad	internal	UoN NMSRC
24	Synthesis and Studies of Novel P-Stereogenic Diastereomeric Alkoxyphosphonium Salts	Dr. Sulaiman Al Sulaimi	internal	UoN NMSRC
25	Discovery of New Inhibitors for Clinically Important Enzyme: Urease	Mohammad Khaiiat	internal	UoN NMSRC
26	Determination of Binding epitopes of urease inhibitors by STD-NMR and computational Studies	Dr. Ajmal Khan	internal	UoN NMSRC
27	Hydrogen Bonding: From Organic Materials to Catalysis	Dr. Ali Rostami	internal	UoN NMSRC
28	New α-Glucosidase inhibitors from the resins of Boswellia species with SAR study	Dr. Najeeb	internal	UoN NMSRC
29	Development of New Spectroscopy Coupled with Chemometrics & HPLC for KBA Analysis from Boswellia sacra	Mohammed Abdullah Al Broumi	internal	UoN NMSRC
30	Isolation and identification of fungi from resin	Mr. Saif Khalfan Abdullah Al Housni	internal	UoN NMSRC
31	Solid Phase Peptide Synthesis	Dr. Tania Shamim Rizvi	internal	UoN NMSRC
32	Natural Pigments: Stability, Formulations and their Applications	Dr. Tanveer Alam	internal	UoN NMSRC
33	Ionic Polymer Metal Composite as an Artificial Muscle	Saeid Vakilian	internal	UoN NMSRC

34	High Performance Liquid Chromatography (HPLC)	Samia Ahmed Said Al-Riyami	internal	UoN NMSRC
35	quantification of incencole and incensole acetate in different boswellia sp. Using NIR Spectroscopy and HPLC	Sulaiman Nasser Al Shidhani	internal	UoN NMSRC
36	Ionic Polymer Metal Composite as an Artificial Muscle	Saeid Vakilian	internal	UoN NMSRC
37	High Performance Liquid Chromatography (HPLC)	Samia Ahmed Said Al-Riyami	internal	UoN NMSRC
38	The Chronic Effect of Bisphenol A on Growth Hormone Activity	Mohammad Al.Masroori	internal	UoN NMSRC
39	Growing and Mounting Single Crystals for X-Ray Crystallography	Syed reza Hashemi	internal	UoN NMSRC
40	Marine Microbial Biofouling Communities; A Potential Source for the Production of Novel Bioactive Compounds	AHMED NASSER AL RAWAHI	internal	UoN NMSRC
41	Signaling role of ALMT1 transporter that can communicate extreme pH stress and metabolic status in plants	Dr. Mohammad Kamran	internal	UoN NMSRC
42	Reconstruction and Applications of Genome Scale Metabolic Models	Adil AlSiyabi	external	UoN NMSRC
43	DNA barcoding of medicinal plants	Adil Khan	internal	UoN NMSRC
44	Genomic and Evolutionary Aspects of tRNAome	Dr. TAPAN KUMAR MOHANTA	external	UoN NMSRC
45	Wound-induced healing process in Boswellia Sacra	Mohammad Numan	internal	Department of Chemical and Bio Molecular Engineering
46	Regio- & Stereoselective Homologation of 1,2-Bisboronic Esters: Stereocontrolled Synthesis of 1,3-Diols and Sch 725674	Dr. Muhammad Ali	internal	University of Nebraska - Lincoln
47	Natural Biostimulants to induce plant defence against fungi: The experience of wheat and tomato in Tunisia	Prof. Walid Hamada	external	UoN NMSRC
48	Natural a-glucosidase inhibitors from Boswellia Elongata	Mohammed Said Al. Azri	internal	UoN NMSRC
49	Binding prediction of Incensole derivatives in GABAergic Mechanism: An application of Computational Modeling and Molecular Docking	Dr. Sobia	internal	UoN NMSRC
50	Transcriptome of Boswellia Sacra	Dr. Abdul Latif Khan	internal	UoN NMSRC
51	Introducing Venom Derived Peptides (ICD-85) as anticancer agents	Prof. Abbas Zare	external	Razi Research Institute, Karaj, Iran
52	microRNAs, Epigenetics Tools for Cell Manipulation	Dr. Ehsan Arefian	external	Department of Microbiology, University of Tehran, Iran
53	Evaluation of stemness genes expression in umbilical cord blood-derived CD133+hematopoietic stem cells expanded following overexpression of SALL4	Dr. Majid Mossahebi Mohammadi	external	Technical Manager of Hematology, Tehran, Iran

54	Latest Trends and Technologies in Cell Imaging and Screening	Agnieszka Kuriata	external	Thermo Scientific, USA
55	Innovation centers in Sweden: from research to market	Dr. Ali Mushfegh	external	Linköping University
56	AlBusaidi and his personal adventure	Ahmad AlBusaidi	internal	UoN NMSRC
57	Structural Diversity in Genus Boswellia	Prof. Ahmed Al Harrasi	internal	UoN NMSRC
58	Controllable prosthetic limbs	Solomon White	external	Oxford university

25. Conferences and symposia participation

The NMSRC researchers are participating in many national, regional and international events, allowing them to share their research with fellow scientists and to find new possibilities for collaborations. The NMSRC also organizes international symposium, most notably the first International Conference on Frankincense and Medicinal Plants, which took place in 2018 in Oman with many international and national participants.

#	Faculty Name	Conference Details
1	Dr. Tania Shamim Rizvi	6th International symposium on Molecular medicine and Drug research (MMDR-6), December 6 - 9, 2017, University of Karachi, Pakistan.
2	Dr. Satya Kumar Avula	Green and Sustainable Chemistry Conference 13-15 November, 2017 Sultan Qaboos University, Muscat, Oman.
3	Dr. Najeeb Ur Rehman Dr. Abdul Latif Khan Mr. Ahmed Al Rawahi Mr. Omar Al-Sudairy Mrs. Khadijah Al-Hosni	GenoBusiness Forum, 8 – 9 May 2018, Oman Animal & Plants Genetics Resources Center, Muscat, Oman
4	Dr. Majid Al Salmani	Europhysiology 2018, 14 - 16 September 2018, London, UK.
5	Prof. Ahmed Al Harrasi Dr. Tapan Kumar Mohanta Dr. Najee ur Rehman Dr. Ajmal Khan Dr. Abdul Latif Khan Dr. Majid Al Salmani Dr. Ali Rostami Mr. Ahmed Al Rawahi	First International Conference on Frankincense and Medicinal Plants: Recent Advances in Research and Industry 30th October-1st November, 2018, Sultan Qaboos University, Muscat, Sultante of Oman
6	Dr. Majid Al Salmani	The North American Cystic Fibrosis Conference. 18 – 20 October, 2018, Denver, Colorado, United States of America
7	Dr. Ajmal Khan	1st International Confernce on DRUG DISCOVERY AGAINST CANCER AND OTHER DISEASES (DDCD-2019) February 11th- 12th, 2019, University of Swabi, KPK, Pakistan
8	Dr. Sobia Ahsan Halim	Training workshop on Genomics and Bioinformatics Techniques, Feb 17-20, 2019, Natural and Medical Sciences Research Center, University of Nizwa, Sultante of Oman
9	Dr. Abdul Latif Khan	Ecophysiolomics of Frankincense tree American Society for Plant Biologist, USA 2 -7 Aug 2019
10	Dr. Satya Kumar Avula	Indian Institute of Chemical Technology, Hyderabad, India, 5th -8th August 2019.
11	Dr. Majid Al Salmani	16th ECFS Basic Science Conference, Dubrovnik, Croatia, 27-30 March 2019
12	Prof. Ahmed Al Harrasi Dr. Sulaiman Al-Hashmi Dr. Mohammed AlSibani Mr. Aflah Al-Hadhrami Mr. Mohammed Al-Broumi Mr. Ahmed Al Rawahi	The Fourth Middle East International Dermatology & Aesthetic Medicine Conference & Exhibition (MEIDAM), 19th – 21st September, 2019, Dubai, UAE.
13	Prof. Ahmed Al Harrasi Dr. Abdul Latif Khan Mr. Ahmed Al Rawahi	6th World Congress on Medicinal and Aromatic Plants for Human and Animal Welfare (WOCMAP VI), N. Cyprus, Turkey, November 13-17, 2019

26. Workshops organized by the center

Workshops are organized both in the NMSRC Center and outside in the community. They cover a large variety of topics, from current research to hands on demonstration on environmental conservation, industry specific topics and educational outreach. Reaching out to young students and to the Omani public at large is very important to the NMSRC, and our researchers enjoy meeting with the public and sharing their passion for science and the environment.

#	Workshop Title	Speaker Name	Date	Participations	Location
1	Omani medicinal plants	Mr. Mohammed Al-Broumi	July 2016	Summer program students	Imti School (5-9) Izki
2	Laboratory animal workshop	Dr. Sulaiman Al Hashmi	November2016	Students and teachers	High school Muscat
3	Isolation and elucidation of chemical compound from medicinal plans	Mr. Mohammed Al-Broumi	April 2017	Chemistry teachers of high school	Nizwa
4	Applications of organic chemistry	Dr. Suliman Al-Sulimi	April 2017	Chemistry teachers of high school	Nizwa
5	Omani medicinal plants	Mr. Mohammed Al-Broumi	November2017	Students and teachers	Alain School (11-12) Nizwa
6	Preservation of Flora and Fauna of Oman	Dr. Sulaiman Al Hashmi, Mr. Abdulaziz Al-Dhli, Mr. Sayed Farook, Mr. Mohammed Al-Broumi	November2017	Students and teachers	Umm Alfadhl (5-12) Nizwa
7	Preservation of Flora and Fauna of Oman	Dr. Sulaiman Al Hashmi, Mr. Abdulaziz Al-Dhli, Mr. Sayed Farook, Mr. Mohammed Al-Broumi	November2017	Students and teachers	Nizwa School (5-12) Nizwa
8	Handling of Danger-ous Species of Snakes	Dr. Sulaiman Al-Hashmi, Mr. Sayed Farook, Mr. Ahmed Al-Busaidi	April 2018	Almouj Employee (The Wave, Muscat)	Musact
9	Snakes of Oman; diversity and conservation	Dr. Sulaiman Al-Hashmi	September 2018	Students and staff	SQU- Muscat
10	Preservation of Flora and Fauna of Oman	Dr. Sulaiman Al Hashmi, Mr. Hilal Al-Naabi, Mr. Sayed Farook, Mr. Mohammed Al-Broumi	November2018	Students and teachers	Assela Bint Qais School (5-9)-Muscat
11	Snakes of Oman; diversity and conservation	Dr. Sulaiman Al-Hashmi	November2018	Students and staff	Aseelah School Muscat
12	Preservation of Flora and Fauna of Oman, Electronic Microscope, Hazardous of food preservatives	Mr. Hilal Al-Naabi, Mr. Ghanim Awladthani, Mr. Mohammed Al-Broumi, Mr. Sayed Farook, Mr. Khamis Al-Ryami	November2018	Students and teachers	Aljabal Alakhdar
13	Preservation of Flora and Fauna of Oman	Mr. Hilal Al-Naabi, Mr. Sayed Farook, Mr. Mohammed Al-Broumi	November2018	Students and teachers	Mrfaa Daris School (5-10)
14	Laboratory animal workshop	Dr. Sulaiman Al Hashmi Dr. Fatemeh jamshidi Mr. Saeid Vakilian Mr. Mohammad Masroori	January2019	Faculty and students College of Medicine and Health Sciences	Sohar

15	Preservation of Flora and Fauna of Oman	Mr. Ahmed Al-Busaidi, Mr. Hilal Al-Naabi	January2019	Community	Ministry of Environments and Climate Affairs - Nizwa
16	4 days training in Genomics and Bioinformatics	Prof. Danial Schachtman	February 2019	Scientists and researchers specialized in genomics	UoN campus
17	Preservation of Flora and Fauna of Oman	Mr. Hilal Al-Naabi, Mr. Ahmed Al-Busaidi	March 2019	Public attendees	Manah Park, Manah
18	Handling of Dangerous Species of Animal	Dr. Sulaiman Al-Hashmi, Mr. Sayed Farook, Mr. Ahmed Al-Busaidi	July 2019	Khazzan project employee, British Petroleum BP	Khazzan site
19	Medicinal uses of Frankincense; a modern perspective	Mr. Mohammed Al-Broumi	August 2019	Public attendees	Environment society of Oman, Muscat
20	Snakes of Oman; diversity and conservation	Mr. Ahmed Al-Busaidi	September 2019	Staff	General Directorate of Environment & Climate Affairs, Al Dakhiliyah Governorate
21	Diversity of Flora and Fauna in Oman	Mr. Ahmed Al-Busaidi	September 2019	Students and Faculty	Sultan Qaboos College of Arabic language for non-native speakers, Manah
22	Snake of Oman	Mr. Ahmed Al-Busaidi	October 2019	Students and Faculty	Gulf Colleg -Muscat
23	Preservation of Flora and Fauna of Oman	Mr. Ahmed Al-Busaidi, Mr. Hilal Al-Naabi	December 2019	Students and teachers	Umm Alkhair School (10-12)-Izki
24	Ethics of research publication	Dr. Ahmed Al-Shukili	April 2020	Students and Faculty	College of Applied Science -Sohar

27. Photo Gallery

27.1 Signing Agreements and MOUs

Signing MOU with Sultan Qaboos University

Signing MOU with Qatar University

Signing MOU with Diwan of Royal Affairs

Signing MOU with President of INALCO Institute Paris, France

Signing MOU with CEO Explicyte, Paris, France

Signing MOU with Chancellor, Alama Tabtabai University, Tehran, Iran

27.2 Research Collaboration

Research Collaboration with Siemens Oman

Research Collaboration with Chinese Delegates

Meeting with CEO, CNI, Malaysia

Meeting with VC, University of Faisalabad, Pakistan

Meeting with VC Research of Descartes Paris , France

Meeting with CEO AnalytiCon Discovery, Berlin, Germany

Meeting with the Director of Center of Environmental Sciences, Qatar University

Meeting in School of Medicine, Charité, Berlin, Germany

Meeting with Faculty of Science, University of Tehran, Tehran, Iran

Meeting with Director of Medicinal Plants Institute, Shahid Beheshti University, Tehran, Iran

Meeting with University of Kuwait, Kuwait

Research Collaboration with JEOL Company, Japan

Research Collaboration with University of Brunei, Brunei

Research Collaboration with SQUH, Oman

Research Collaboration with PDO, Oman

Research Collaboration with OAPGRC

Research Collaboration with Oman Botanic Garden

Research Collaboration with Krems Institute, Austria and SQU

27.3 Official visits

Visit of Diwan of Royal Affairs

Visit of HE Grand Mufti of the Sultanate

Visit of HE Advisor to His Majesty the Sultan for Cultural Affairs

Visit of HE Minister of Higher Education

Visit of HE Chairman of the Public Authority for Radio and TV

Visit of HE Chair of Shura Council

Visit of HE Secretary General of Oman Research Council

Visit of Founder, Owner and Chairman of the MB Group

Visit of President of Shahid beheshti University, Tehran, Iran

Visit of British Counsil

Visit of PDO Delegates to our X-ray Lab

Visit of Deputy VC Research of SQU

27.4 Weekly seminar series

27.5 TV Interviews

27.6 Group photos

Research Team 2011

Research Team 2012

Research Team 2013

Research Team 2014

Research Team 2015

Research Team 2018

Research Team 2019

28. Media Coverage

الوطن ALWATAN — محليات Local News

SUNDAY 10 November 2013 - NO. (11049) - VOL43

كرسي النباتات الطبية العُمانية ونواتج الأحياء البحرية بجامعة نزوى يحقق إنجازا علميا بإعادة اللبان العماني إلى صدارة الاهتمام العالمي

بهدف اكتشاف أدوية جديدة

مشروعات علمية تبحث عن جهة تتولى إنتاج النموذج الأول «٢»

مجلس البحث العلمي يموّل أكثر من ١٠٠ مشروع بحثي

د. أحمد الحراصي: إذا لم يجد مشروع اللبان الدعم الكامل فحتما سيكمله الآخرون

إنشاء شركة تمويل لتحويل الأفكار المنتجة إلى أعمال تجارية ومجمع ابتكار مسقط يفتتح ٢٠١٥

د. أحمد الرواحي: نحتاج إلى تطوير الأفكار لمشروعات استثمارية

د. سيف الهدابي: الدعم متوفر ونحتاج لصناعة باحثين عالميين

د. عبيد السعيدي: نعد حاليا الاستراتيجية الوطنية للابتكار

اللبان العماني مشروع يراعد لفتح مقبي غير مسبوق خلال بضعة أعوام

بحث «عقار المرجان» ينتظر سرعة التمويل وسط مخاوف من منافسة شركات عالمية !!

د. العرامي: نقل المشروع إلى شركة قيس الآن وإنما في مرحلة التصنيع

نعمل على مشتقات جديدة يمكن زيادة قوة تأثيرها ضد الخلايا السرطانية

الكشف عن مكونات طبيعية مقبلة لسعر اقتصادية وتكاليف دخان اللبان

باحثون عمانيون يتطلعون للأخذ بأيدي المطورين لتحقيق الاستفادة العلمية

11

الرئيسية

بلادنا

اللبان العماني.. تحت الدراسة

مجلس البحث العلمي يمول مشروعا بحثيا حول شجرة اللبان العمانية

تتيح المشروع فرصة لتدريب الدارسين والخريجين العمانيين

د.أحمد الحراصي: الهدف من هذا المشروع البحثي الوطني هو تأهيل جميع أنواع اللبان العماني والتعرف على مواصفاته

نشر من نتائجها ٥ أوراق

دراسة بحثية حول الجانب الدوائي للنباتات العمانية باستخدام التقنيات العلمية المتطورة

أحد النباتات العمانية

صورة علمية لأحد النباتات العمانية

فصل مئات المركبات باستخدام مختلف المذيبات العضوية قاعدة بيانات تبشر بمستقبل واعد في تصنيع الأدوية الطبيعية

جاهد حسين

محمد البروجي

آلية عمل الدراسة

أعضاء الفريق

المشاريع المستقبلية

ملحق إشراقة – العدد 119 –

أخبار ٣

وفد صيني يزور كرسيّ النّباتات الطّبيّة العُمانيّة ونتاج الأحياء البحريّة

أمجد الرواحي.

في سبيل التعاون المستمر بين جامعة نزوى ومختلف المراكز والجمعيات البحثية، استقبل نائب رئيس الجامعة للدراسات العليا والبحث العلمي والعلاقات الخارجية الأستاذ الدكتور أحمد بن سليمان الحراصي وفد صيني من الاتحاد العالمي للجمعيات الطبية، وأعضاء من مركز عمان للموارد الوراثية النباتية والحيوانية برئاسة الدكتورة نادية السعدي المدير التنفيذي للمركز، وبحضور عدد من أساتذة الجامعة وذلك من أجل بحث سبل التعاون المشترك بينهم.

في بداية الاجتماع قدم الأستاذ الدكتور أحمد الحراصي عرضا مرئيا للتعريف بالأبحاث القائمة في العلوم الطبية بجامعة نزوى، تلى ذلك عرضا لأهم مجالات الأبحاث التي يعمل بها الباحثون في الكرسي. من جهتها قدمت منظمة الوفد الزائر عرضا توضح فيه أنشطة الاتحاد العالمي وأهم النتائج الطبية المتعلقة بالسرطان. كما ناقش الاجتماع أوجه التعاون المشترك بين الجانبين في مجالي أبحاث النباتات الطبيّة وأبحاث السرطان بوجه الخصوص، وانتهى النقاش بمقترح إنشاء مركز للنباتات الطبية عن طريق منظمة الأيورا بجامعة نزوى.

في نهاية الزيارة، قام الوفد الضيف بجولة ميدانية في مختبرات الجامعة والاطلاع على أهم الأبحاث التي يعمل عليها الباحثون بكرسي النباتات الطبيّة ونواتج الأحياء البحرية

Frankincense research in France beckons young Omani scientists

TEXT BY RAY PETERSEN
PHOTOS BY M AL BAROUNI

From its reverence during ancient times, to its emergence as an essential perfumery, to becoming a potentially life-saving element in modern organic medical science, the Boswellia sacra, or Frankincense is an example of Omani flora that has the potential for significant economic diversification opportunities according to French scientist, Dr Nicolas Baldovini.

Holding a special place in Oman's culture and traditions, its resin has significant potential for medicinal development, and to this end, the Natural and Medical Sciences Research Centre (NMSRC) of the University of Nizwa, in collaboration with the French Embassy in Oman, organised an internship for three young Omani researchers at the University Cote d'Azur, in Nice, in the South of France. As a result, Mohammed al Barouni, Mohammed al Jassasi and Suloiman al Shidhani have interned in a prestigious throughout October.

Mr Franck Vermeulen, the cultural attaché of the French Embassy, underlining the continued importance of developing and strengthening scientific research collaboration between the two nations and cultures, saying "The French Embassy in Oman is very proud to support collaboration between these two prestigious universities and their researchers."

Youthful Omanis, Mohammed al Barouni, Mohammed al Jassasi and Suloiman al Shidhani have been working under the guidance of Dr Nicolas Baldovini, a global specialist in the field, with the research internship, focused on analysing the differences in volatile compounds found in frankincense sap, harvested from six different Boswellia trees species found throughout the MENA region, in Oman, Somalia, Sudan, Ethiopia, India and Socotra Island. To be the topic of a research publication, co-authored by the entire research team, their synthesis, or combining of specific constituents of the frankincense, is to further facilitate biological testing and evaluation within the current NMSRC programme.

Dr Baldovini, widely recognised as an energetic and passionate advocate for the benefits of frankincense research, has, for some time, worked in collaboration with Professor Ahmed al Harrasi, the chairman of the NMSRC, and presented his initial research findings at the First International Conference on Frankincense and Medicinal Plants, in October 2018, itself a high-profile collaboration between the University of Nizwa and Sultan Qaboos University. Since then, Baldovini and Harrasi have consistently collaborated on research and publications, particularly in respect of some rare and exotic Boswellia species.

The Nice based Dr Baldovini praised the impressive facilities of the NMSRC, and particularly the variety of innovative, active research, in the 'organic and natural' environment of the region's flora and fauna, and even fondly recalls his first 'living' encounter with Frankincense, many years ago in Wadi Dawkah. "I didn't hesitate for a second when I was offered the three young interns, due to their experience in the field and their absolute traditional, cultural and scientific knowledge of this fascinating plant, and what ensued was a mutually rewarding social, scientific and personal experience for us all."

For their part, the tyro scientists thrived in their work environment, with one, Mohammed al Barouni, surprised at "how humble, cooperative and accommodating Dr Baldovini was with us, making us feel like colleagues instead of interns, and valuing our contributions." It would appear that the benefits were obvious as Baldovini commented, "All in all, it was a very fruitful experience and I am looking forward to the next occasion to host them for a longer period, and to come again in Oman to continue our collaborations on this fascinating plant."

Dr Al Harrasi commented, "As the Sultanate continues its drive for sustainable diversification, and knowledge-based intellectual capitalisation, NMSRC research and collaborations on the Boswellia Sacra, and its less common species, unique in the world and found only in the Dhofar Governorate of Oman, demonstrate the promising potential for economic benefits."

Oxford, Nizwa varsities conclude medical research exchange

RAY PETERSEN
NIZWA, SEPT 22

Oxford University and University of Nizwa (UoN) research student exchange, which has taken place during the last four weeks at the Natural and Medical Sciences Research Centre (NMSRC) on the UoN's Birkat Al Mouz campus concluded.

Scientific Collaboration Officer, Ahmed Nasser al Rawahi, said, "This has been an amazing opportunity for us, to respond to an idea, an initiative, created by Dr Ahmed al Harrasi, the Director of the Research Centre, in which we were able to invite applicants from the institution at the pinnacle of global higher education, that probably has more tradition, promise and achievement in its alumni than any other in the world".

BA student Karen Yau, MA students Sungmin Cho, Daniel Inzoug, Solomon White, Zoe Hughes, and PhD student Leila Hill took part in the programme. "The research engaged in on campus at Birkat Al Mouz was first and foremost," said Al Rawahi, "specific to their own specific research requirements, and the task for the selection panel was to ensure that both Oxford and University of Nizwa would also benefit institutionally".

Himself a molecular biologist, Al Rawahi admitted that "in every scientific level, academically and professionally, we are exceeding our initial expectations, and the intention is that the next exchange will find us in our own research students reciprocating, by travelling to Oxford". He continued, "Dr Al Harrasi is always insistent that we need outside influences, more especially from other cultures and societies, to engage with our research, as they have a different way of looking at what challenges us within the research units, especially in the field of medical science which is this centre's priority".

University of Nizwa Liaison Officer, Dr Mila Gabrack was determined that the visitors should "enjoy a wide cultural experience, truly reflective of Oman". She explained that they had arrived with a 'blank canvas' perspective, aware of what they would encounter here, but that "they genuinely embraced Arabic language classes, workshops on the Sultanate's history, religious tolerance, hadeeths, food, traditions and customs. Omani fashions and national dress, and weather! A field trip to Jabal Akhdhar was a highlight. Solomon White said; "The green and serenity up on the mountain was a genuine reflective experience, the walks amazing, and the diversity of plant life, absolutely stunning".

For competitor Zoe Hughes though, "Nothing could beat the camel racing. "It was madness... I've never run sounds outside the crowds, and to see them running like that, with those little robots on top, and the trucks alongside, horns blaring, all dust and noise. I will never forget it".

Andrew Hamilton, a former Vice-Chancellor of Oxford, insisted that, "By the time our students reach their graduation they are able to debate on level footing with their academic masters. That is what Oxford is all about". It could, too, become what University of Nizwa is 'all about'.

البحث العلمي بجامعة نزوى يستهل آفاق التعاون مع أكسفورد البريطانية

حوار: مريم الكعبانية

تحرير: محمد الأسماعيلي

الوطن

شراقة

ملحق شهري

جامعة نزوى
University of Nizwa

العدد 125

اللبان على رأس قائمة النباتات العمانية (طبيا واقتصاديا)

٨ | ملف العدد

شراقة

ملحق إشراقة – العدد 125 –

البحوث الحديثة تعيد اللبان إلى صدارة الاهتمامات الطبية

جامعة نزوى وجامعة السلطان قابوس، بالاشتراك مع مركز عمان للموارد البرائية الحيوانية والنباتية وحديقة القرآن النباتية بقطر، تنظمان المؤتمر الدولي الأول للبان والنباتات الطبية: التطورات الحديثة في البحث العلمي والصناعة

يمثل المؤتمر فرصة سهلة للاطلاع والاستفادة من الخبرات لتطوير الأبحاث والدراسات العلمية والمنتجات الصناعية في مجال اللبان والنباتات الطبية

يأتي اللبان على رأس قائمة النباتات العمانية ذات الأهمية الطبية والاقتصادية

ناقش المؤتمر في نسخته الأولى (٢ بحثا بحضور زهاء ٢٠٠ متخصصة علمية من أكثر من ٢٥ دولة

الاتفاق على ثلاثة مشاريع بحثية جديدة بالتعاون مع علماء من فرنسا والسلكة المتحدة وألمانيا

نائب رئيس جامعة نزوى للبحث العلمي تضم سلطنة عمان أحد أفضل أنواع اللبان من بين ١٥ نوعا لأشجار اللبان المسجلة في العالم

نجاح المؤتمر يدفع اللجنة المنظمة للشروع في إعداد نسخة ثانية خلال عامين

تقرير: أحمد بن ناصر الرواحي

تحت رعاية معالي الشيخ محمد بن عبدالله المعني- مستشار الدولة، نظمت جامعة نزوى بالتعاون مع جامعة السلطان قابوس، المؤتمر الدولي الأول للبان والنباتات الطبية: التطورات الحديثة في البحث العلمي والصناعة، الذي استمر ثلاثة أيام بدءا من يوم الثلاثاء، ١٥ أكتوبر ٢٠١٨م. وسط حضور نخبة من الأكاديميين والمختصين بلغ عددهم زهاء ٤٠٠ باحث من داخل وخارج السلطنة

انطلقت أعمال المؤتمر برعاية المؤتمرات بجامعة السلطان قابوس؛ وذلك بمشاركة عالمية وإقليمية ومحلية واسعة لعلماء وباحثين ومتخصصين في مجال اللبان والنباتات الطبية، ناقشوا ٥٥ بحثا ودراسة وورقة عمل خلال ثماني جلسات، عن الاستخدام التقليدي للبان والنباتات الطبية، وفصائها التصنيف والبيئة والحصاد، وطرق المحافظة على أشجار اللبان والنباتات الطبية، إضافة إلى الجوانب الكيميائية والفيزيولوجية والصحية للبان والنباتات

جامعة نزوى
University of Nizwa

ملحق إشراقة – العدد 102 –

كرسي جامعة نزوى للنباتات الطبية العمانية ونواتج الأحياء البحرية يشارك في مهرجان التمور العمانية الثالث

كتب: أحمد الرواحي

شاركت جامعة نزوى ممثلة في كرسي النباتات الطبية العمانية ونواتج الأحياء البحرية في مهرجان التمور العمانية الثالث، والذي يقام في ولاية نزوى بمحافظة الداخلية بتنظيم من وزارة الزراعة والثروة السمكية بالتعاون مع الهيئة العامة لتنمية المؤسسات الصغيرة والمتوسطة.

وقد أقيم حفل الافتتاح تحت رعاية معالي الشيخ سعود بن سليمان بن حمير النبهاني -مستشار الدولة- وبحضور معالي الدكتور فؤاد بن جعفر الساجواني -وزير الزراعة والثروة السمكية- وعدد كبير من المهتمين بالتمور والصناعات المرتبطة به.

و شارك في المعرض (٦٠) مشاركا من المزارعين وأصحاب المصانع ووحدات التمور يعرضون أنواعا مختلفة من التمور التي تشتهر بها السلطنة، بالإضافة إلى جناح المؤسسات الحكومية والخاصة.

وتأتي مشاركة كرسي جامعة نزوى للنباتات الطبية العمانية ونواتج الأحياء البحرية في مهرجان التمور العمانية الثالث لعرض نتائج بعض أهم الدراسات والبحوث العلمية التي قام بها المركز خلال الفترة الماضية في ثمار النخيل العماني وخصائصه الفيزيوكيميائية.

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