NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | School of Materials Science and Engineering
College of Engineering

MSE Seminar:
Radioactive and Hazardous Waste Immobilization by Crystallochemical Incorporation

Professor Tim White

Abstract
Materials for the containment of inorganic industrial wastes arising have become progressively more sophisticated both to reduce anthropogenic loads in the biosphere and increase the range of stabilised and recycled products. As the design of contemporary methods for immobilising pollutants is underpinned by crystal chemical and mineralogical principles, the selection of a suitable ceramic or synthetic mineral as an immobilisation matrix is governed by well-prescribed considerations. First, toxic metals should be incorporated in their least toxic chemical states. For example, substances that eschew As^{3+} and Cr^{6+} in preference to less dangerous As^{5+} and Cr^{3+} are favoured. Second, for complex waste streams it is sometimes necessary to simultaneously accommodate oxidized and reduced species of different metals in a suite of mutually-compatible materials. Third, crystal structures are preferred that have multiple cation and/or anion acceptor sites as this minimizes the number of phases required to crystallise simultaneously, and allows greater flexibility to respond to variations in waste stream composition. Finally, phases with a selection of cation acceptor sites are advantageous opening the opportunity for higher waste-loadings and less ‘bulking’ of the waste product through the introduction of inert additives.

Within these constraints a subset of structural families – perovskite, spinel, apatite, tridymite-related compounds, zirconolite, zeolites, clays - form the basis of many synthetic mineral immobilisation technologies. In detail, the crystallochemical properties of these waste forms can be complex and remain the subject wide investigation. In particular, final products are usually far from thermodynamic equilibrium as they may crystallise rapidly from solution or be quenched from high temperatures. This can lead to a range of interesting, complex and decisive crystal chemical features including nanometric domains, polytypism and miscibility gaps. Such features require investigation using a combination of crystallographic methods – neutron, X-ray, electron - that can probe the waste forms at different scales to give a complete understanding of the distribution and chemical state of waste metals that in turn contributes to predicting the long term stability of waste form after disposal or reuse. In this seminar, these crystallochemical considerations will be illustrated by reference to the zirconolites, already used for nuclear waste treatment, and the apatites that are potential materials for the fixation of hazardous waste and Fukushima nuclear waste.

Biography
Tim White is the President’s Chair in Materials Science & Engineering and Vice President (International Engagement) at the Nanyang Technological University, Singapore. He has 40 years research experience at national laboratories and universities in Australia, USA, Japan, Germany and Singapore in materials science and engineering, minerals processing, nuclear waste treatment and environmental management. These appointments included group leader at The Australian Atomic Energy Commission and Multiplex Professor of Environmental Technology.

Tim joined NSTB (the predecessor of A*STAR) in 1995 as a scientist in the Environmental Technology Institute (1995-2004). Subsequently, he moved to NTU and served as the Head of the Division for Materials Science (2006-2009), Director of the Facility for Analysis, Characterization, Testing and Simulation (FACTS) (2005-2009), Associate Chair (Research) (2013-2018) in the School of Materials Science and Engineering, and Associate Vice President (Infrastructure and Programs) (2019-2021). Tim has also served as Director of the Centre for Advanced Microscopy at the Australian National University (2009-2012) and President of The Australian Microscopy and Microanalysis Society (2010-2013). He is presently President of the Materials Research Society of Singapore (since 2020). He is a pioneer of massive open online courses (MOOCs) and for several years delivered one of the few such courses in the world that awards full academic credit. His current teaching is in partnership with Ludwig-Maximilians-Universität München for the joint-development and deployment of the Adaptive Learning and Teaching System ATLAS on-line platform to serve the needs the Skills Future learners, as well as catering for graduate students.

Wednesday, 29 March 2023 ll Time: 2 pm – 3 pm ll
ABN Seminar Room 1-1 (ABN-01a-CF2)
Please register here.
Hosted by: Professor Raju V Ramanujan

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