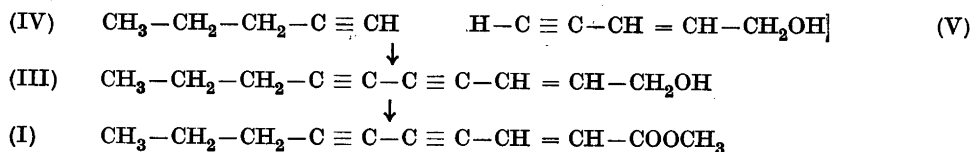


The Synthesis of *trans*-Lachnophyllum Ester

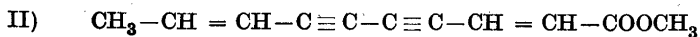
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In 1935 the Russian chemists Wiljams, Smirnow and Goljmov¹ isolated a highly unsaturated aliphatic methyl ester m. p. 32.6—32.8° with the empirical formula C₁₁H₁₂O₂ from the plant *Lachnophyllum gossypinum* Bge, which belongs to the Compositae. On the basis of thorough degradation experiments they gave this compound the constitutional formula (I):



In 1941 Sörensen and Stene² described a still more unsaturated methyl ester, m. p. 37°, containing 2 H less than the empirical formula of (I) (C₁₁H₁₀O₂) and having the same carbon skeleton, from scentless mayweed (*Matricaria inodora* L). On the basis of degradation experiments it was given the constitutional formula (II);



Since Wiljams *et al.*¹ could isolate maleic acid from the alkali decomposition mixture, (I) ought to occur in nature in the *cis* configuration and should be named *cis* lachnophyllum ester. The matricaria ester (II) may exist in four different stereoisomers. The exact configuration of the compound from scentless mayweed is as yet not known. The discoverers of this extremely unsaturated ester realized its transformation into another stereoisomer through the action of U. V. light. This isomeric matricaria ester showed higher molecular refraction and dispersion than the original compound and was named *trans* matricaria ester, a designation of only a preliminary nature.

No further occurrences, of these diacetylenic acids have been noted in literature, so they seem to be rather scarce in nature, at least in large amounts. The first compound of such structure encountered in nature, however, dates back to 1907, when there appeared a small note in the annals of the Ministry of Agriculture of the Dutch East Indies about etherial oils from plants collected in the Tenger Mountains of Java through Dr. Carthaus ³. The oil from a plant which Dr. Carthaus named *Artemisia lavandulaefolia* yielded crystals of m. p. 32.5–33° on cooling. The chemical investigation of this crystalline compound, reported in the same annals for 1910 ⁴, in conjunction with our recent knowledge of the esters (I) and (II), substantiates that the crystals of m. p. 32.5–33° and analysing for C₁₂H₁₄O₂ (misprint C₁₂H₁₄O₃ in Gildemeister, Hoffman) undoubtedly represent the first diacetylenic compound ever found in nature. Unfortunately the same interesting Dutch investigation from 1910, contains the remark that Dr. Carthaus must have been wrong in naming the starting material, since *Artemisia lavandulaefolia* was stated not to occur in the Tenger district.

In a forthcoming communication from this laboratory, however, we are going to demonstrate that at least among the compositae oils the matricaria ester (II) and very interesting relatives may be found in some cases, although mostly in small amounts.

With the intention of definitely establishing the constitutional formula given to the matricaria ester (II) one of us (C. M. H.) in 1942 began attempts to synthesize the all-*trans* compound with the constitution (II). When British periodicals became available after the war we became aware of the great progress in diacetylene syntheses in the laboratory of Sir Ian Heilbron at Imperial College, London. When Professor Heilbron learned about our experiments on the syntheses of (I) and (II) he kindly left the problem to us. Since the independent synthetic work at the Imperial College had developed very close to such compounds, we should like to express our sincere gratitude to him for this gesture.

Oxidative coupling of different 1-acetylenes to symmetrical diacetylenes has been carried out many times since C. Glaser introduced this synthesis in 1870 ⁵. Zal'kind and Aizikovitch ⁶ found that *tert.*acetylenic alcohols could be coupled to diacetylene glycols with good yields using molecular oxygen. *sec.* Acetylenic carbinols, however, gave bad yields ⁷. In 1947 Bowden, Heilbron, Jones and Sargent ⁸ gave experimental conditions for the coupling of *primary* acetylenic carbinols with good yields.

The oxidative coupling of two different 1-acetylenes, first carried out by v. Baeyer ⁹, must give two symmetrical diacetylenes besides one asymmetrical compound. Since many synthetical experiments, *e. g.* the coupling of one Grignardized acetylene with the iodide of the other, failed completely, we tried the asymmetrical oxidative coupling of pentyne-1 (IV) and penten-3-yn-1-ol-5 (V) to decene-2-diyne-4,6-ol-1 (III), *i. e.* the alcohol corresponding to *trans* lachnophyllum acid. The two parts needed for the coupling synthesis have been made readily available through the investigations of Vaughn *et. al.* ¹⁰ and by Haynes *et. al.* ¹¹.

The attempts at coupling the two above mentioned pentynes were begun using the conditions given by Heilbron *et. al.*¹² for the dimerization of penten-3-yn-1-ol-5 (V), but as work progressed, certain changes had to be made. The conditions given in the experimental part of this paper are those which have so far been found to be the best ones, but we do not claim them to be optimal.

Even in the best experiments most (79 %) of the penten-3-yn-1-ol-5 (V) was coupled to decadiene-2,8-diyne-4,6-diol-1,10. Of the pentyne-1 (IV) 23 % was converted to decadiyne-4,6. In the expected boiling range we got quite small amounts (12.7 % of theory) of a beautifully crystallizing carbinol m. p. 39–40° of the expected composition C₁₀H₁₂O.

The constitution of this carbinol (III) was confirmed through hydrogenation to *n*-decanol-1, characterized as the 3,5-dinitrobenzoate. Further, the U. V. spectrum of its hexane solution (Fig. 1, curve A) was in accordance with experience from the spectra of conjugated polyethylenes and related conjugated enynes, *viz.* the long wave absorption being weaker, but falling in the same region, the fine structure spacing, however, corresponding only to the dominant vibration frequency of bisubstituted acetylenes (67.10¹² sec.⁻¹). See ^{13,14}.

$\text{CH}_3\text{CHOH} \cdot \text{CH} = \text{CH} - \text{CH} = \overset{\text{CH}_3}{\underset{ }{\text{C}}} - \text{CH} = \text{CH}_2 \text{ see } 15$	λ_{max} 2 590 ÅU 2 670 » 2 770 »	ϵ_{max} 32 500 40 500 32 500
$\text{CH}_3 - \text{CHOH} - \text{CH} = \text{CH} - \text{CH} = \overset{\text{CH}_3}{\underset{ }{\text{C}}} - \text{C} \equiv \text{CH} \text{ see } 15$	λ_{max} 2 600 ÅU 2 640 » 2 690 »	ϵ_{max} 35 500 32 000 27 500
$\text{CH}_3 - \text{CHOH} - \text{CH} = \text{CH} - \text{CH} = \text{CH} - \text{C} \equiv \text{CH} \text{ see } 16$	λ_{max} 2 470 * 2 600 2 730 *	ϵ_{max} 24 500 34 000 24 500
$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{C} \equiv \text{C} - \text{C} \equiv \text{C} - \text{CH} = \text{CH} - \text{CH}_2\text{OH}$	λ_{max} 2 395 2 520 2 665 2 825	ϵ_{max} 7 300 14 600 21 850 19 440 $\Delta\nu \cdot 10^{-12}$ 62.1 cm ⁻¹ 64.8 » 63.9 »

* = inflections

The oxidation of the carbinol to acid was carried out according to the procedure of Bowden *et. al.*¹⁷, compare ¹². Since the resulting acid, *n*-decene-2-diyne-4,6-oic acid, is very unstable, it was converted to the methyl ester with diazomethane. The ester distilled at 50–55° air bath/0.001 mm as a colourless liquid which

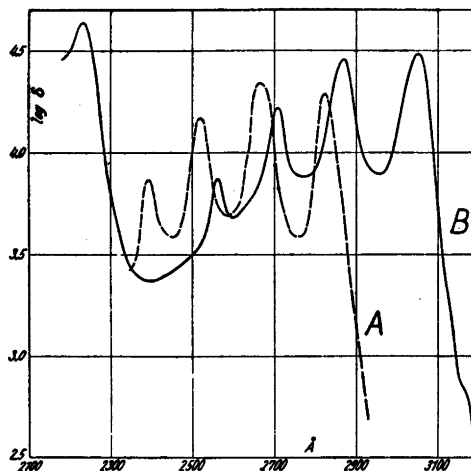


Fig. 1. Ultraviolet absorption of decene-2-diyne-4,6-ol-1 (III), curve A, and trans-lachnophyllum ester (I), curve B in hexan.

$$\left(\epsilon = \frac{\lg I_0/I}{c \cdot d}, c \text{ in mol/l, } d = \text{cm}\right)$$

crystallized at low temperature. It was recrystallized from pentane at -10° , and then formed colourless needles, m. p. $18.5-19^\circ$.

We were rather surprised to find a m. p. definitely lower than that of the naturally occurring *cis* lachnophyllum ester which is reported to be $32.6-32.8^\circ$. As mentioned above the thorough degradation experiments of Wiljams *et. al.*¹ leave no doubt about the constitution of the naturally occurring ester.

However, the hydrogenation of the synthetic *trans* lachnophyllum ester gave methyl caprate with the consumption of exactly 5 moles of hydrogen. The methyl caprate was characterized, after saponification, as the amide, by m. p. and mixed m. p. with capric amide ($94-95^\circ$ and $94-96^\circ$, respectively).

Furthermore the *trans* lachnophyllum ester has a U. V. spectrum in hexane very similar to those of known conjugated diene-diyne. As set forth by Kuhn and Grundmann¹⁸ the carbalkoxy group in conjugation with aliphatic unsaturated systems corresponds to one ethylene bond. The mean values of the long wave maxima for the known 5 conjugated diene diynes are:

λ_{max} , mean value diene diynes	3 102	2 882	2 722	2 581 ÅU
<i>trans</i> lachnophyllum ester	3 053	2 872	2 710	2 568 »

Accordingly, the displacement of the ene diyne spectrum through a conjugated carbomethoxy group seems to be the same as in the polyene series.

EXPERIMENTAL

Pentyne-1 was prepared according to¹¹ and pentene-3-yn-1-ol-5 according to¹².

Decene-2-diyne-4,6-ol-1

Pentyne-1 (3.5 g) and penten-2-yn-1-ol-5 (4.1 g) were shaken with a solution of ammonium chloride (112.4 g), copper(I) chloride and conc. ammonia (2 ml) in water

(286 ml). To the solution was added iron(III) chloride (5.9 g) and air was bubbled through for 6 ½ hours. The reaction product was isolated by repeated extraction with ether. Distillation of the reaction product at 70–80° (air bath)/0.001 mm yielded decadiyne-4,6 (0.8 g) in the trap (–80°), decene-2-diyne-4,6-ol-1 (III) (0.957 g) and decadiene-2,8-diyne-4,6-diol-1,10 (3.2 g) as a residue. The monocarbinol (III) which crystallized immediately, melted at 37.5–38.5°, raised to 39–40° by crystallization from petroleum ether. It formed long, thin needles

	$C_{10}H_{12}O$ (148.2)	Calc.	C 81.04	H 8.16	
		Found	» 80.80	» 8.1	
λ_{max}	2 395 ÅU		2 520 ÅU	2 665 ÅU	2 825 ÅU
ϵ_{max}	7 300 »		14 500 »	22 000 »	19 500 »

The 3,5-dinitrobenzoate of the acetylenic carbinol(III) melted at 105.5–106°, and crystallised in yellow needles from petroleum (b. r. 60–80°).

	$C_{17}H_{14}N_2O_6$ (342.4)	Calc.	C 59.65	H 4.12	
		Found	» 59.8	» 4.0	
λ_{max}	2 538 ÅU		2 691 ÅU		2 860 ÅU
ϵ_{max}	22 500 »		21 000 »		11 500 »

n-Decanol from decene-2-diyne-4,6-ol-1

The hydrogenation of decene-2-diyne-4,6-ol-1 (148 mg) was carried out in ethyl acetate with platinum as a catalyst.

$C_{10}H_{12}O$ (5)	Calc.	112 ml H_2 (0°, 760 mm)
	Found	115 » » (0°, 760 »)

The 3,5-dinitrobenzoate of the hydrogenation product melted at 54–55° when recrystallized from petroleum ether; the mixture with the 3,5-dinitrobenzoate of *n*-decanol-1 (m. p. 56–57°) melted at 55–56.5°.

Methyl-*n*-decene-2-diyne-4,6-oate = *trans* lachnophyllum ester

Decene-2-diyne-4,6-ol-1(III) (2.5 g) in acetone (50 ml) was oxidized with a mixture of chromium trioxide (4.46 g) and sulphuric acid (3.86 ml conc.) in water (17.8 ml). The acetone solution was cooled in ice, and the oxidation mixture was added with stirring at such a rate as to keep the temperature at about 20°. The stirring was continued for 20 min, after all the oxidation mixture was added. At the end of this time, the reaction mixture was poured into much water and the reaction product was extracted with several portions of ether. The combined ether extracts were washed with water and extracted twice with sodium carbonate solution. From the sodium carbonate solutions the extracted acids were liberated with very dilute sulphuric acid and extracted with ether. To the ether solution was added a solution of diazomethane in ether. The ether solution was washed with water and dried with sodium sulphate for a few hours. The residue distilled at 50–55° (air bath)/0.001 mm (410 mg) and crystallized readily below 0°. Recrystallization from pentane at –10°C yielded colourless short needles, m. p. 18.5–19°.

$C_{11}H_{12}O_2$ (176.2)	Calc.	C 74.97	H 6.86
	Found	» 75.1	» 7.0

λ_{\max}	2 235 ÅU	2 568 ÅU	2 710 ÅU	2 872 ÅU	3 053 ÅU
ϵ_{\max}	44 000 »	6 850 »	16 500 »	29 000 »	30 100 »

Methyl caprate from *trans* lachnophyllum ester

trans Lachnophyllum ester (32 mg) was hydrogenated with a 2 % palladium on barium sulphate catalyst.

Calc.	20.4 ml H ₂ (0°, 760 mm)
Found	20.4 » » (0°, 760 »)

The hydrogenation product was saponified with potassium hydroxide and the acid was converted through its acid chloride to the amide, which melted at 94–95° after crystallisation from petroleum (b. r. 60–80°). The mixture of this amide and the amide of capric acid (m. p. 97–98) melted at 94–96°.

SUMMARY

Decene-2-diyne-4,6-ol-1 was synthesized through an asymmetric oxidative coupling of pentyne-1 and penten-3-yn-1-ol-5. Decene-2-diyne-4,6-ol-1 was oxidized with chromium trioxide to the corresponding acid, *trans* lachnophyllum acid. The methyl ester of *trans* lachnophyllum acid has m. p. + 18.5–19°, compared with + 32.6–32.8° given for the methyl ester of *cis* lachnophyllum acid occurring in *Lachnophyllum gossypinum* Bge.

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