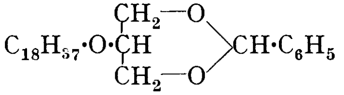
266. *The Unsaponifiable Matter from the Oils of Elasmobranch Fish. Part X. The Structure of Batyl Alcohol and the Synthesis of β-Octadecyl Glyceryl Ether.*

By W. H. Davies, I. M. Heilbron, and W. E. Jones.

It has recently been demonstrated (Davies, Heilbron, and Jones, J., 1933, 165) by degradative methods that batyl alcohol is structurally identical with α-octadecyl glyceryl ether (I). Supplementary evidence of this has now been obtained through the synthesis of the isomeric β-*octadecyl glyceryl ether* (II) by condensing the potassium salt of 1 : 3-benzylideneglycerol with octadecyl iodide, and subsequent hydrolysis of the resulting 1 : 3-*benzylideneglycerol* β-*octadecyl ether* (III).

(I.) $C_{18}H_{37}\cdot O\cdot CH_2\cdot CH(OH)\cdot CH_2\cdot OH$

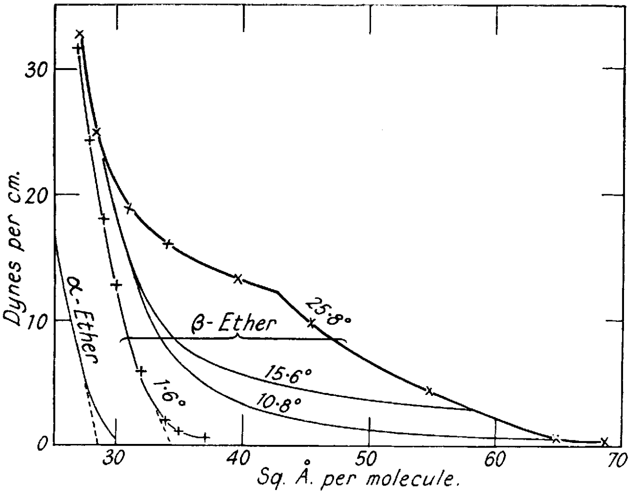
(II.) $C_{18}H_{37}\cdot O\cdot CH(CH_2\cdot OH)_2$

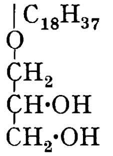


(III.)

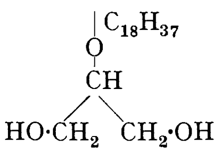
β-Octadecyl glyceryl ether and its *cetyl* homologue have been compared respectively with batyl alcohol and synthetic α-cetyl glyceryl ether (Davies, Heilbron, and Owens, J., 1930, 2542). From the large depressions observed in mixed m. p. both with the alcohols and with their di-phenylcarbamates, it is clear that β-octadecyl glyceryl ether differs markedly from batyl alcohol, a conclusion further confirmed by the results of surface-film measurements kindly carried out by Dr. N. K. Adam and Dr. J. B. Harding of University College, London.

It had been observed by Knight (*Biochem. J.*, 1930, **24**, 257) that a close similarity existed between unimolecular films on water of batyl alcohol and α-monoglycerides, and Adam (J., 1933, 164) found complete identity between the surface films of batyl alcohol and synthetic α-octadecyl glyceryl ether (cf. Davies, Heilbron, and Owens, *loc. cit.*). The examination of the corresponding β-octadecyl glyceryl ether shows that it forms very stable unimolecular films in water, of which the surface pressure curves are given in the fig. At low temperatures the films are condensed and liquid, the limiting area being about 34·5 sq. Å., compared with 27 for the α-ether (Knight, *loc. cit.*; Adam, *loc. cit.*). The condensed films of the β-ether occupy a considerably greater area at all pressures than those of the α-ether, the difference being about 6·5 sq. Å. at 1 dyne per cm., falling to 4·5 sq. Å. at 20 dynes. This difference is unquestionably due to the two hydroxyl groups which anchor the molecules to the water, being side by side in the case of the vertically oriented molecules of the β-ether, but nearly vertically above each other with the α-ether, thus :





α-Ether.



β-Ether.

At higher temperatures, liquid expanded films are formed, closely resembling those of the α-ether, having a limiting area of about 68 sq. Å. The expansion is half completed under 1·4 dynes per cm. pressure at 11·5°, being about 20° lower than with the α-ether. This lower expansion temperature, indicating a smaller lateral adhesion between the molecules in the condensed state, is reasonably accounted for through the vertical arrangement of the hydroxyl groups in the α-ether permitting closer lateral packing of the adhesive hydroxyl groups in adjacent molecules in the film; in the β-ether the packing does not permit such close contact between the hydroxyl groups.

The complete series of values for the two ethers and also for α-monopalmitin is as follows :

	Area at no compression, sq. Å.		Temp. of half expansion at 1·4 dynes/cm.
	Condensed film.	Expanded film.	
Batyl alcohol and α-octadecyl glyceryl ether	27	64	31°
α-Monopalmitin	26·3	70	17·5
β-Octadecyl glyceryl ether	34·5	68	11·5

The 1 : 3-benzylideneglycerol required for this investigation was prepared by condensing glycerol with benzaldehyde in the heat in presence of 40% sulphuric acid (Hill, Whelen, and Hibbert, *J. Amer. Chem. Soc.*, 1928, **50**, 2235). These authors obtained in this way a liquid mixture of 1 : 2- and 1 : 3-isomerides from which the latter, m. p. 83·5°, crystallised on treatment of the distilled oil with cold ligroin and benzene. We have confirmed this result and have observed, moreover, that if the liquid mixture is kept at room temperature, partial crystallisation occurs. After removal of residual oil, the separated solid melts indefinitely between 60° and 70°, and yields the 1 : 3-benzylideneglycerol of Hill, Whelen, and Hibbert on recrystallisation from benzene–ligroin. A large quantity of the crude product was collected in this manner from several preparations and set aside for over two months; the m. p. had then fallen to 52—60°, and repeated crystallisation now gave a product of m. p. 62·5—63°, entirely different in appearance from the compound of m. p. 83·5°. That this substance is actually a geometrical *isomeride* of the higher-melting benzylideneglycerol (cf. also Hibbert and Carter, *J. Amer. Chem. Soc.*, 1928, **50**, 3376) and not the 1 : 2-isomeride described by Irving, Macdonald, and Soutar (J., 1915, **107**, 337), has been proved by the preparation from it of a methyl glyceryl ether, b. p. 119—120°/9 mm., which yields a di-phenylcarbamate and a di-*p*-nitrobenzoate identical with those described by Hibbert, Whelen, and Carter (*J. Amer. Chem. Soc.*, 1929, **51**, 302) from their authentic β-methyl glyceryl ether. Further evidence that this new benzylideneglycerol possesses the 6-membered acetal structure is afforded by the fact that its *benzoate*, m. p. 80—81°, rapidly isomerises on standing into the benzoate, m. p. 103°, of the 1 : 3-benzylideneglycerol of Hill, Whelen, and Hibbert (*loc. cit.*).

Since the isolation of this new benzylideneglycerol, m. p. 63°, all attempts on our part to isolate the higher-melting isomeride, either as described above or by adopting the precise details given by Hill, Whelen, and Hibbert (*loc. cit.*), have failed, and we have therefore employed this isomeride for the synthesis of the β-cetyl and β-octadecyl glyceryl ethers described in this paper.

EXPERIMENTAL.

Isomeric 1 : 3-*Benzylideneglycerols*.—A mixture of 1 : 2- and 1 : 3-benzylideneglycerol, b. p. 155—159°/8 mm., prepared by the method of Hill, Whelen, and Hibbert (*loc. cit.*), partly crystallised when kept at room temperature for 2 days. The solid was filtered off, and the filtrate seeded, whereupon a second crop separated. The process was repeated several times, about 40% of the original mixture finally remaining as an oil which would not crystallise. Two crystallisations of the solid from benzene–ligroin (3 : 5 parts by vol.) yielded soft, feathery needles of 1 : 3-benzylideneglycerol, m. p. 83·5°. The *isomeric* 1 : 3-*benzylideneglycerol*, obtained as described above, crystallises from benzene–ligroin in short, hard needles, m. p. 62·5—63° (Found : C, 66·5; H, 6·7. $C_{10}H_{12}O_3$ requires C, 66·7; H, 6·7%). After prolonged standing, the m. p. rises to 70—80°, seemingly indicating a partial conversion into the higher-melting isomeride.

The *benzoate*, prepared in pyridine, crystallises from ligroin in plates, m. p. 80—81° (Found : C, 71·6; H, 5·9. $C_{17}H_{16}O_4$ requires C, 71·8; H, 5·7%); it is exceedingly labile, passing in the course of a few days into a higher-melting form, which crystallises from ligroin in needles, m. p. 103°, identical with the benzoate prepared by Hill, Whelen, and Hibbert (*loc. cit.*) from the 1 : 3-benzylideneglycerol, m. p. 83·5°.

Methylation of the Benzylideneglycerol, m. p. 62·5—63°.—A solution of the benzylideneglycerol (10 g.) in ether, dry silver oxide (23 g.), and methyl iodide (46 g.) was warmed on a water-bath for 3 hours with rapid mechanical stirring. The solution was filtered, and the residue thoroughly extracted with boiling ether. The viscous oil left after removal of solvent was distilled, and the main fraction, b. p. 145—148°/5 mm., collected. Unlike the 1 : 3-benzylideneglycerol 2-methyl ether, m. p. 52°, described by Hill, Whelen, and Hibbert (*loc. cit.*), this compound failed to crystallise, and was therefore directly hydrolysed by boiling with aqueous-alcoholic hydrochloric acid for 2 hours. Water was then added, and the alcohol removed under reduced pressure. The aqueous solution was extracted with ether to remove benzaldehyde, neutralised with lead carbonate, filtered, and the solvent removed *in vacuo*, leaving a viscous oil which distilled almost wholly between 119° and 120°/9 mm. (b. p. of α-methyl glyceryl ether, 110°/13 mm.; of β-methyl glyceryl ether, 123°/13 mm.; cf. Hibbert, Whelen, and Carter, *loc. cit.*).

For further characterisation, both the di-phenylcarbamate and the di-*p*-nitrobenzoate were prepared, the m. p.'s being respectively 102° (aqueous alcohol) and 155—156° (ethyl acetate). These values are identical with those given by Hibbert, Whelen, and Carter (*loc. cit.*) for β-methyl glyceryl ether, and widely different from those of the isomeric α-methyl ether derivatives (di-phenylcarbamate, m. p. 118—119°; di-*p*-nitrobenzoate, m. p. 108°).

1 : 3-*Benzylideneglycerol* 2-*Octadecyl Ether.*—1 : 3-Benzylideneglycerol (10 g.) was added to a suspension of emulsified potassium (1·9 g.) in dry benzene (150 c.c.) and refluxed until the potassium had completely dissolved. Excess octadecyl iodide (60 g.) was then added, and the solution refluxed for a further 5 hours, cooled, and diluted with ether. After washing with water and drying over potassium carbonate, the solvents were removed, and the excess octadecyl iodide distilled off under reduced pressure (2 mm.). The residual 1 : 3-*benzylideneglycerol* 2-*octadecyl ether* was crystallised several times from aqueous alcohol, being obtained as a waxy solid, m. p. 43—44°; yield, 71% (Found : C, 78·1; H, 10·8. $C_{28}H_{48}O_3$ requires C, 77·7; H, 11·1%).

1 : 3-*Benzylideneglycerol* 2-*cetyl ether*, prepared in an analogous manner, is a colourless solid of similar physical properties, m. p. 34—35° (Found : C, 77·1; H, 10·9. $C_{26}H_{44}O_3$ requires C, 77·2; H, 10·9%).

When these condensations are carried out with equimolecular proportions of alkyl halide and potassium salt, only a 10% yield of a very impure β-alkyl ether is obtained, and with a large excess of potassium salt no condensation product appears to be formed.

β-*Octadecyl Glyceryl Ether.*—1 : 3-Benzylideneglycerol 2-octadecyl ether (2 g.) was refluxed for 70 mins. in 75% alcohol (70 c.c.) containing concentrated hydrochloric acid (2 c.c.). The solid precipitated on dilution with water was repeatedly crystallised from alcohol, from which pure β-*octadecyl glyceryl ether* separated in clusters of small needles, m. p. 62—63°; admixture with batyl alcohol, m. p. 70—71°, caused a depression of over 12° (Found : C, 72·9; H, 12·4. $C_{21}H_{44}O_3$ requires C, 73·2; H, 12·8%).

β-*Octadecyl glyceryl ether di-phenylcarbamate*, prepared by keeping a solution of the alcohol in benzene containing excess phenyl *iso*cyanate at room temperature for 48 hours, separates from benzene–ligroin as a colourless amorphous solid, m. p. 83—84°, depressed to 76—80° on admixture with batyl alcohol di-phenylcarbamate, m. p. 97—98° (Found : C, 72·0; H, 9·0. $C_{35}H_{54}O_5N_2$ requires C, 72·2; H, 9·3%).

β-*Cetyl glyceryl ether*, prepared in a similar manner to the β-octadecyl ether, forms colourless, glistening crystals, m. p. 60—61°. Mixed with synthetic α-cetyl glyceryl ether (m. p. 61—62°; Davies, Heilbron, and Owens, *loc. cit.*), the m. p. falls to 55—56° (Found : C, 72·3; H, 12·6. $C_{19}H_{40}O_3$ requires C, 72·2; H, 12·6%). The *di-phenylcarbamate* prepared as above, has m. p. 82—83°; on admixture with α-cetyl glyceryl ether di-phenylcarbamate, m. p. 91—92°, the m. p. is depressed by over 6° (Found : C, 71·3; H, 8·8. $C_{33}H_{50}O_5N_2$ requires C, 71·5; H, 9·0%).

UNIVERSITY OF LIVERPOOL.

[*Received, June* 1*st*, 1934.