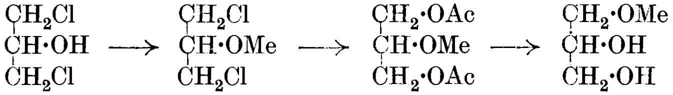
CCLXXXVI.—*The Partial Esterification of Polyhydric Alcohols. Part IX. The Discovery of the First True β-Ether of Glycerol.*

By ARTHUR FAIRBOURNE.

CONSIDERABLE importance, regarding the possibilities of migrations of radicals in polyhydric compounds, attaches to the following series of reactions, by which Gilchrist and Purves (J., 1925, **127**, 2735) prepared glycerol " α "-monomethyl ether.



$$\begin{array}{ccccccc} \mathrm{CH_2Cl} & & \mathrm{CH_2Cl} & & \mathrm{CH_2{\cdot}OAc} & & \mathrm{CH_2{\cdot}OMe} \\ \mathrm{CH{\cdot}OH} & \longrightarrow & \mathrm{CH{\cdot}OMe} & \longrightarrow & \mathrm{CH{\cdot}OMe} & \longrightarrow & \mathrm{CH{\cdot}OH} \\ \mathrm{CH_2Cl} & & \mathrm{CH_2Cl} & & \mathrm{CH_2{\cdot}OAc} & & \mathrm{CH_2{\cdot}OH} \\ \mathrm{(I.)} & & \mathrm{(II.)} & & \mathrm{(III.)} & & \mathrm{(IV.)} \end{array}$$

As mentioned in Part VIII (this vol., p. 1151), the preparation has been repeated, particularly with a view to confirm or disprove the supposed " α " structure of (IV).

Gilchrist and Purves found (*loc. cit.*) that sodium methoxide reacted with (I) to produce glycerol " αβ "-dimethyl ether, and suggested that the sample of (I) which they were using might be " interchangeable with " its αβ-isomeride. Recent work, however, has shown that this was not the case (Part VII, this vol., p. 129), and, moreover, that the structure of the " αβ "-dimethyl ether itself is unproven (Part VIII, *loc. cit.*).

The only other evidence that these authors put forward in favour of the supposed " α "-structure of (IV) is its similarity in boiling point at reduced pressure, and in its refractive index, to the α-methyl ether isolated by Irvine, Macdonald, and Soutar (J., 1915, **107**, 337); this evidence is perhaps strengthened by the recent determination of the corresponding constants (Hill, Whelen, and Hibbert, *J. Amer. Chem. Soc.*, 1928, **50**, 2235; Hibbert, Whelen, and Carter, *ibid.*, 1929, **51**, 302) for the β-isomeride :

	B. p.	n_D.
α-Monomethyl ether	110—111°/13 mm.	1·4463; 1·4461
Monomethyl ether of Gilchrist and Purves	110—112°/11 mm.	1·4462
β-Monomethyl ether	122—123°/13 mm.	1·4505

On the other hand, there are two theoretical reasons, of general importance in connexion with the trustworthiness of accepted constitutions of polyhydric compounds, for believing that the α-ether is a very unlikely product. None of the explanations for the migrations of radicals in glycerol derivatives which are reviewed in Part VII (*loc. cit.*) is applicable to the formation of an α-methoxy-group in (IV), whereas each of the other cases of migration may be conveniently accounted for by one or other of two similar explanations considered in that paper: either by the formation of an intermediate αβ-oxide or by that of an intermediate αβ-oxidic ring. Even the preparations, mentioned in the paper, of allyl alcohol and of allyl acetate from (I) can be explained in these ways, since epichlorohydrin has been shown (Hübner and Müller, *Z. Chem.*, 1870, **6**, 480; Claus and Stein, *Ber.*, 1877, **10**, 556; Kischner, *J. Russ. Phys. Chem. Soc.*, 1892, **24**, 31) to yield allyl alcohol under similar conditions.

The second reason for believing (IV) to possess the β-structure is that Hibbert, Whelen, and Carter (*loc. cit.*), in extending the suggestions of Irvine, Macdonald, and Soutar (*loc. cit.*) and of Peacock (J., 1915, **107**, 815) towards the adoption of *ethers* as the standards of reference in work on the constitution of glycerol compounds, have drawn the conclusion that there is no case on record of the migration of an alkyl group from the β- to the α-position. In the reactions now under consideration, however, since (II) retains both chlorine atoms, contains no iodine atom, and is produced from (I) in the presence of silver hydroxide and methyl iodide in excess, it is clear that no intermediate αβ-oxide (involving the elimination and absorption of hydrogen chloride or methyl chloride) could occur, and that (II) must therefore have the structure assigned to it, a conclusion confirmed by its exhibiting different properties from those of the α-methoxy-isomeride (see p. 2234). Hence, either Gilchrist and Purves are wrong in assigning the α-structure to (IV), or else a case of the migration of a methoxy-group of the type which Hibbert, Whelen, and Carter have been unable to discover is clearly established in a series of reactions which they quote.

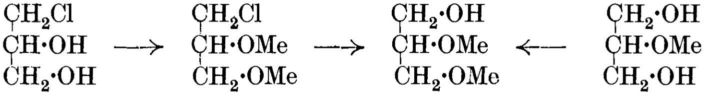
The experimental results now recorded confirm decisively that (IV) has the β-structure, and the following facts therefore emerge from this discovery :

(1) The recent isolation by Hill, Whelen, and Hibbert of the first true β-ether of glycerol has been anticipated by Gilchrist and Purves, who synthesised the same β-methyl ether three years earlier (by a process, moreover, which is free from the difficulty of fractionating similar isomerides), but mistakenly recorded their experiment as a failure instead of as a success.

(2) The conclusion of Hibbert, Whelen, and Carter, that Irvine, Macdonald, and Soutar were correct in supposing that methoxy-groups would not migrate in glycerol molecules, is confirmed by the satisfactory disposal of the only case discovered in the literature in which such migration would have had to be admitted.

(3) All the remaining cases of migrations of radicals reviewed in Part VII (*loc. cit.*) may now be accounted for by a combination of two of the explanations discussed in that paper.

(4) Chlorohydrins, instead of being unsuitable initial materials for the syntheses of glycerol ethers (Gilchrist and Purves, *loc. cit.*; Hill, Whelen, and Hibbert, *loc. cit.*), can now be made to yield either α- or β-ethers at will. In this connexion, the corresponding hydrolysis of methylated α-monochlorohydrin (Blanchard, *Bull. Soc. chim.*, 1927, **41**, 824) has been investigated with the three-fold object (i) of isolating the true glycerol αβ-dimethyl ether; (ii) of proving the identity of the latter with the product obtainable by the further methylation of the β-monomethyl ether :



$$\begin{array}{ccccccc} CH_2Cl & & CH_2Cl & & CH_2{\cdot}OH & & CH_2{\cdot}OH \\ CH{\cdot}OH & \longrightarrow & CH{\cdot}OMe & \longrightarrow & CH{\cdot}OMe & \longleftarrow & CH{\cdot}OMe \\ CH_2{\cdot}OH & & CH_2{\cdot}OMe & & CH_2{\cdot}OMe & & CH_2{\cdot}OH \end{array}$$

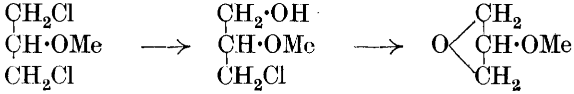
and (iii) of thus discovering the standard of reference for work on the configuration of glycerol derivatives, shown in Part VIII (*loc. cit.*) to be still unknown. There is also evidence that ethers of the unknown type can occur as by-products in preparations from sodium glyceroxide by the method previously described (J., 1921, **119**, 1035; 1925, **127**, 2759). A further communication on this subject will be made later.

EXPERIMENTAL.

βγ-Dichloro-α-methoxypropane, $CH_2Cl{\cdot}CHCl{\cdot}CH_2{\cdot}OMe$.—Chlorine was gradually passed, at laboratory temperature, into a dilute ethereal solution of methyl allyl ether, prepared by the method of Henry (*Ber.*, 1872, **5**, 449), the resulting *βγ-dichloro-α-methoxypropane* being isolated by washing with water, drying with calcium chloride, and fractionating at 56°/27 mm.; b. p. 158°, *d* 1·162, *n* 1·443 (Found: Cl, 49·5. $C_4H_8OCl_2$ requires Cl, 49·65%). The structure of this ether is established by its difference from the following isomeride.

αγ-Dichloro-β-methoxypropane, $CH_2Cl{\cdot}CH(OMe){\cdot}CH_2Cl$.—The sample of this ether used in the investigation was prepared by the method of Gilchrist and Purves, but, as already explained, these authors were *presumably of opinion that the product would be found identical with the ether described above.* Its properties were satisfactorily in accordance with those recorded by Hess and Fink (*Ber.*, 1915, **48**, 1986) and Blanchard (*loc. cit.*), whose products, however, are also dependent upon the doubt expressed by Gilchrist and Purves: b. p. 160°, *d* 1·21, *n* 1·453. That the ether is a definite compound, differing from the α-methoxy-isomeride, is now made clear, and is decisively confirmed by its hydrolysis to glycerol β-monomethyl ether, as described below.

Glycerol β-Monomethyl Ether, $CH_2(OH){\cdot}CH(OMe){\cdot}CH_2{\cdot}OH$.—Attempts to obtain the supposed "α"-monomethyl ether of Gilchrist and Purves by direct hydrolysis of αγ-dichloro-β-methoxypropane with aqueous sodium hydroxide were unsuccessful, although analysis showed that the chlorine was slowly eliminated. Darkening and a loss of organic material occurred. It is suspected that the trouble may be due to an escape of the volatile αγ-glycide, since no intermediate formation of epichlorohydrin is possible:



Gilchrist and Purves do not state the proportion of alcohol they employed in their indirect hydrolysis. With 25%, two layers persisted after many hours' heating, and in no conditions yet tried has anything more than a very small yield been obtained.

This supposed "α"-ether has, however, definitely been shown to be the β-ether by converting it into its di-*p*-nitrobenzoate, as described by Hibbert, Whelen, and Carter (*loc. cit.*), m. p., alone or mixed with an authentic specimen prepared from the true β-ether, 155°. A specimen prepared from the true α-ether for comparison melted at about 108°.

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