

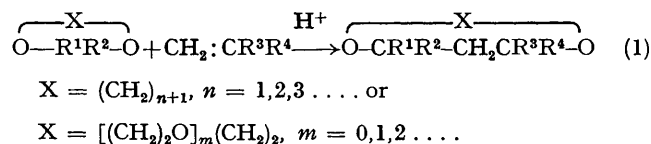
A New Method of making New Crown Ethers

By JOHN COOPER and PETER H. PLESCH*

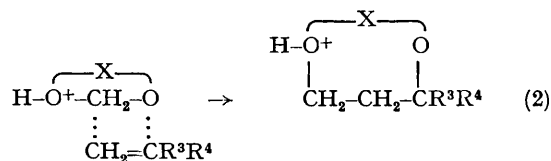
(*Chemistry Department, University of Keele, North Staffordshire ST5 5BG*)

Summary Crown ethers can be synthesised by the acid-catalysed insertion of an olefin into oligomers of 1,3,6-trioxocan and related 1,3-dioxacycloalkanes containing at least 4 oxygen atoms, in a one-step process under mild conditions.

ALTHOUGH the acid-catalysed insertion of olefins into 1,3-dioxo-alkanes, and of keten into 1,3-dioxacycloalkanes, are known the potential and generality of these reactions have previously been unappreciated. The reaction by which hydrolytically unstable 1,3-dioxacycloalkanes are converted into relatively stable cyclic ethers, [Equation (1)] has recently been considered theoretically.¹



The mechanism of the reaction [Equation (2)] may be analogous to that of the ring-expansion polymerisations of 1,3-dioxacycloalkanes.² We are now concerned with its



application to the synthesis of crown ethers,³ compounds whose potential has so far been restricted mainly due to inefficient synthesis.

As the 1,3-dioxo-compound mixtures of cyclic dioxolan oligomers, mixtures of 1,3,6-trioxocan and its cyclic oligomers, and 1,3,6,9-tetraoxa-cycloundecane (the formal of triethyleneglycol) have been used. As the olefin isobutylene, α -methylstyrene, allyl bromide, and allyl chloride have been used. Suitable catalysts are BF₃·Et₂O, various Friedel-Crafts metal halides or preferably a mixture of 72% perchloric acid and acetic anhydride, but a systematic search has not yet been made for the best catalyst. The reaction can be done without solvent, or in halogeno-alkanes or aromatic solvents in normal organic equipment, preferably under 'Grignard dry' conditions. The temperature is not critical, except that addition of an acid catalyst to the 1,3-dioxacycloalkane or to a mixture of its cyclic oligomers may change the size-distribution in the assembly of cycles more rapidly than these are olefinated. To max-

imise the yield of 1:1 adduct the temperature used should be near or above the ceiling temperature⁴ of the 1,3-dioxacycloalkane (50° to 70°) whereas to minimise the proportion of 1:1 adduct in favour of the oligomeric 2:2, 3:3, etc. products, the working temperature should be low, (0° has been found suitable for many reactions). It is advantageous to use an excess of olefin which can be pumped off or distilled out when the olefination is complete.

Reaction mixtures containing crown ethers cannot be neutralised easily with normal reagents such as metal or ammonium hydroxides or carbonates, since these are simply taken into the organic phase. The acid can be removed by means of an alkaline exchange resin, but the reaction is slow and inefficient and some resins seem to release compounds which are taken up by the crown ethers. We now dissolve the reaction product in the minimum volume of water and extract the solution with methylene dichloride or chloroform, leaving the acid in the water.

The reaction products which are mostly pale yellow oils are multicomponent mixtures containing cyclic polyethers of various sizes, each of which (except the 1:1 adduct) can exist in several isomeric forms. Experiments with non-polymerisable 1,3-dioxo-cycloalkanes, such as 2,2-dimethyl-1,3-dioxolan or 1,3-dioxan showed that the insertion goes predominantly in the Markownikoff sense. Also, the main product from 1,3,6-trioxocan and isobutylene was identified as 8,8-dimethyl-1,4,7-trioxacyclodecane, by its n.m.r. spectrum and by degradation with aq. HBr to 2,4-dibromo-2-methylbutane and 1,2-dibromoethane.

The 2:2 compounds are 20-crown-[6]-ethers, and thus belong to one of the most useful categories made by Pedersen and Frensdorf.³ For instance, that made from the dimer of 1,3,6-trioxocan (1,3,6,9,11,14-hexaoxo-cyclohexadecane) and allyl chloride is a mixture of 1,4,7,11,14,17-hexaoxo-10-chloromethylcycloicosanes with the second chloromethyl group either in the 18- or the 20- position.

The reaction and its products are embodied in U.K. Patent Appl. No. 59856/73 assigned to the N.R.D.C. whom we thank for a development grant. We also thank Mrs. P. Browne and Mr. T. Alston for their help.

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¹ P. H. Plesch, IUPAC International Symposium on Macromol. Chem., 1969, Plenary and Main Lectures, Akadémiai Kiadó, Budapest, 1971, p. 213.

² P. H. Plesch and P. H. Westermann, *J. Polymer Sci., Part C, Polymer Symposia*, 1968, **16**, 3837; *Polymer*, 1969, **10**, 105.

³ C. J. Pedersen and H. K. Frensdorf, *Angew. Chem. Internat. Edn.*, 1972, **11**, 16.

⁴ F. S. Dainton and K. J. Ivin, *Nature*, 1948, **162**, 705.