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Note

Detection of crown ethers by means of Dragendorff's reagent

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Many crown ethers with different structures have been synthesized after the first publication by Pedersen[1]. Their thin-layer chromatographic (TLC) detection has, however, not previously been published and no selective and specific methods are available for their colour staining on a chromatographic plate. The generally applied development with iodine does not produce a stable colour and it is not selective.

The detection of the intermediates and end-products of the different crown ether syntheses, including different fused constituents, could be made possible if a selective development method was elaborated for reaction with the compounds separated on a chromatographic thin layer. Dragendorff's reagent could be applied for this purpose.

Farnsworth and co-workers[2,3] observed that the Dragendorff colour reaction occurred with certain compounds containing oxygen atoms in their molecules. Based on an investigation of 65 compounds, they concluded that a carbonyl group in a conjugated arrangement or a lactone ring (*e.g.*, α-pyrones) in the molecule is necessary for a positive Dragendorff reaction. No nitrogen-containing compounds of vegetable origin, such as sterols or triterpenes, were detected with Dragendorff's reagent by Anderson *et al.*[4].

Ossicini[5] obtained orange and yellow spots on paper chromatogram with Dragendorff's reagent for Rh(III)–amine complexes; thus red and yellow spots can be expected with large inorganic and organic cations, provided they form insoluble iodobismuthates.

Based on the previous results, it was assumed that the more oxygen atoms in the ring of the crown ether molecules, the more likely is their complexation with Dragendorff's reagent. Good separation and specific colour reactions were achieved with Dragendorff's reagent in our experiments with crown ethers. The specificity of the colour reaction proved to be dependent on the structure of the fused constituent.

EXPERIMENTAL

Dragendorff's reagent was prepared according to Vágujfalvi[6,7]. Basic bismuth carbonate (2.6 g) and sodium iodide (7 g) are boiled in 25 cm^3 of glacial acetic acid for a few minutes and precipitated crystalline sodium acetate is filtered off after 12 h. A 20-cm^3 volume of the transparent reddish brown solution is then mixed with 80

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TABLE I

COLOUR REACTIONS OF CROWN ETHERS AND OF ALKYLATED L-LYSINE DERIVATIVES WITH DRAGENDORFF'S REAGENT AND THEIR R_F VALUES

Compound	*Colour*	$R_F \cdot 100$	
		*A**	*B***
12-Crown-4	Red	27	47
15-Crown-5	Red	24	50
18-Crown-6	Red	21	52
Dibenzo-18-crown-6	Violet	27	80
Dicyclohexyl-18-crown-6	Orange	37	78
1a	Dark blue	51	76
1b	Dark blue	58	–
2a + 2b	Dark blue	15;10	86;81
3a + 3b	Orange	28;20	–
N^{ε}-Trimethyl-L-lysine	Red	–	1.6
N^{ε}-Dimethyl-L-lysine	Red	–	20
N^{ε}-Monomethyl-L-lysine	Red	–	6.6
N^{ε}-Trimethylene oxide-L-lysine	Red	–	40
N^{ε}-Formyl-L-lysine	Yellow	–	53

* A = benzene–methanol (9:1).
** B = chloroform–methanol–25% ammonia solution (4:4:1).

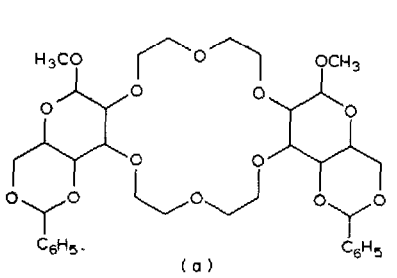
cm^3 of ethyl acetate and 0.5 cm^3 water, and the solution is kept in a brown, stoppered flask. A 10-cm^3 volume of the solution, diluted with 100 cm^3 of glacial acetic acid and 240 cm^3 of ethyl acetate, is sprayed on to the chromatographic thin layer. The thin layer, dried in open air, is kept in a drying oven at 60°C for 20 min. All TLC was carried out on 200-μm silica gel plates (Merck DC-Fertig Platten, Kieselgel 60) and developed, in the presence of amines with chloroform–methanol–25% ammonia solution (4:4:1) and in the absence of amines with benzene–methanol (9:1).

RESULTS AND DISCUSSION

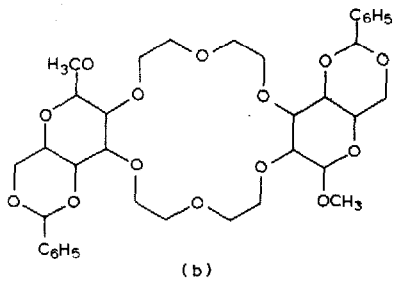
Table I lists the colour reactions of the tested compounds (crown ethers and alkylated lysine derivatives). The definite dependence of the colour reaction on the fused constituent could be demonstrated, *e.g.*, unsubstituted 18-crown-6 produced a different colour to that produced by dibenzo-18-crown-6 or dicyclohexyl-18-crown-6.

The reagent could be used successfully for the detection of 18- or 24-member-containing crown ethers composed of two different monosaccharides, the methyl-4,6-O-benzylidene-α-D-glucopyranoside and the methyl-4,6-O-benzylidene-α-D-galactopyranoside[8–11]. The generation of crown ethers could be detected, because the developed colour was completely different from those of the starting compounds and the by-products.

While the colour reaction of the benzylidene-containing crown ether 1b was dark blue, that of the tetrahydroxy-4 derivative, obtained after elimination of the benzylidene groups, was yellow[8,10].



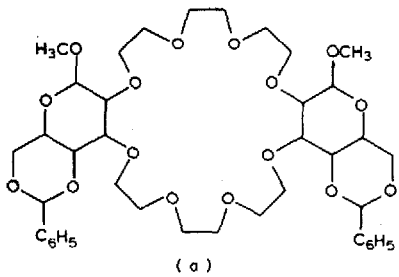
(a)



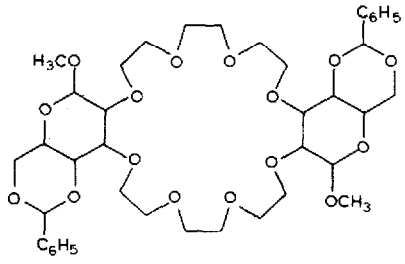
(b)

(1,2)

Compound	Starting sugar derivative
1	Methyl-4,6-O-benzylidene-α-D-glucopyranoside
2	Methyl-4,6-O-benzylidene-α-D-galactopyranoside

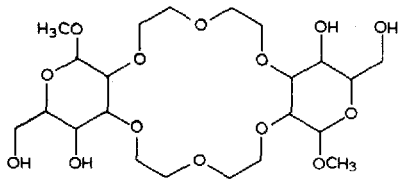


(a)



(b)

(3)



(4)

The characteristics of 18-crown-6 are different from those of 24-crown-8 (compound 3)[11], which may be the reason for the colour difference. The colour reaction with compound 1 is blue, whereas that with compound 3 is orange.

It is possible that the colour reaction of a crown ether and that of a reaction product obtained in the presence of the crown ether may be similar. As reported earlier[12], spontaneous N^{ε}-methylation occurs in the reaction of L-lysine with formaldehyde. N^{ε}-mono, -di- and -trimethyl derivatives are the reaction products. All three derivatives are Dragendorff-positive, leading to a red colour reaction. The colour reaction of a by-product (N^{ε}-formyl-L-lysine) is yellow. Crown ethers have been applied as catalysts for the acceleration of a more selective reaction; 18-Crown-6 proved to be most appropriate[13]. The colour reaction of the applied crown ether was red, similar to that of the quaternary N^{ε}-trimethyl-L-lysine derivative.

The R_F values of compounds giving similar colour reactions were nearly iden-

tical. This difficulty could be overcome by the application of the yellow colour reaction yielding crown ether 4 instead of 1b.

It can be concluded from the above examples that selective development of crown ethers is possible, even in reaction mixtures, by means of the Dragendorff reaction.

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