Preliminary communication

Solvolytic desulphation of sulphated carbohydrates

A. I. USOV, K. S. ADAMYANTS, L. I. MIROSHNIKOVA, A. A. SHAPOSHNIKOVA, and N. K. KOCHETKOV

N. D. Zelinsky Institute of Organic Chemistry, Academy of Sciences of U.S.S.R., Moscow (U.S.S.R.)

(Received December 14th, 1970; accepted for publication, January 25th, 1971)

Desulphation of sulphated polysaccharides is usually performed by the action of methanolic hydrogen chloride[1]. However, this method often depolymerises polysaccharides and is unsatisfactory, for example, for sulphated galactans of red seaweeds, which contain 3,6-anhydrogalactose residues.

Taking into account the reversibility of sulphation effected by pyridine–sulphur trioxide[2] and the data on solvolysis of sulphated steroids[3,4] and sulpholipids[5,6], it seemed likely that the removal of sulphate groups from carbohydrate derivatives could be brought about by treatment with such solvents as pyridine, *p*-dioxane, *N,N*-dimethylformamide, or methyl sulphoxide. The results in Table I show that this expectation was justified. The reactions were monitored by t.l.c. on silica gel, and the products were isolated by preparative t.l.c. after dilution of the reaction mixtures with water and extraction with chloroform.

The results listed in Table I, together with other data, indicate that the cation and probably the sulphate position and the nature of the neighbouring substituents influence the reaction course. Pyridinium salts react more easily than do those involving inorganic cations. *p*-Dioxane and methyl sulphoxide give better yields of desulphated products than does pyridine.

Table II shows the results obtained when the desulphation procedure was applied to the sulphated galactan from *Laingia pacifica* Yamada[12,13]. The sulphate content was almost unchanged after heating a solution of the sodium salt of the polysaccharide in methyl sulphoxide. However, when the pyridinium salt was heated with *N,N*-dimethylformamide or methyl sulphoxide, followed by dialysis and lyophilization, 75% of the desulphated polymer was obtained. Gel-filtration of this material on Sephadex G-100 showed that a considerable decrease of D.P. had occurred during the reaction. In order to decrease this depolymerisation (*cf.* Ref. 16), methyl sulphoxide containing 2% of pyridine was used as solvent. This modification gave the desulphated polysaccharide in high yield, with a low sulphate content and with decreased degradation. The product was similar to the starting galactan in 3,6-anhydrogalactose content and in the ratio of other monosaccharide constituents. The characteristics of the desulphated polysaccharide obtained[12] by the action of methanolic hydrogen chloride are given for comparison purposes. It is clear that desulphation with methyl sulphoxide–pyridine is more rapid and extensive, gives higher yields, and causes

TABLE I

SOLVOLYTIC DESULPHATION OF MONOSACCHARIDE DERIVATIVES (6 h, 70°)

Starting material	*Solvent*	*Product*[a]	*Yield (%)*
Methyl 2,3,6-tri-*O*-benzoyl-α-D-galactopyranoside 4-sulphate, pyridinium salt[b]	*p*-Dioxane	Methyl 2,3,6-tri-*O*-benzoyl-α-D-galactopyranoside[9]	90
	Pyridine		72
	Me_2SO		97
Methyl 2,3,4-tri-*O*-acetyl-α-D-glucopyranoside 6-sulphate, pyridinium salt[c]	*p*-Dioxane	Methyl 2,3,4-tri-*O*-acetyl-α-D-glucopyranoside[10]	76.5
	Pyridine		68.5
	Me_2SO		70
1,2:3,4-Di-*O*-isopropylidene-α-D-galactopyranose 6-sulphate, barium salt[8]	*p*-Dioxane	1,2:3,4-Di-*O*-isopropylidene-α-D-galactopyranose[11]	74
	Pyridine		27
Pyridinium salt[d] of the above sulphate	*p*-Dioxane		70
	Pyridine		47

[a] The physical constants of the products were in good agreement with the literature data.
[b] The substance was obtained by sulphation[7] of the corresponding, partially acylated glycoside with pyridine–sulphur trioxide. It had $[\alpha]_D$ +113° (*c* 2, methanol), +120° (*c* 1, chloroform).
[c] Prepared as in *b*: $[\alpha]_D$ +81° (*c* 1, methanol). [d] Obtained from the barium salt after treatment with cation-exchange resin followed by neutralisation with pyridine.

TABLE II

DESULPHATION OF *L. pacifica* GALACTAN

Polysaccharide	*Desulphation conditions*	*Yield (%)*	SO_4^{2-} *(%)*[a]	*3,6-Anhydrogalactose (%)*[b]	*Galactose: 2-O-methylgalactose: xylose*[c]
L. pacifica galactan (sodium salt)			12.1	9	5.4:0.6:1
Desulphated polysaccharide	Pyridinium salt, Me_2SO, 100°, 4 h	75	2.9	10.6	5.4:0.6:1
	Pyridinium salt, Me_2SO–pyridine 50:1, 100°, 9 h	90	1.4	10.6	5.4:0.6:1
	Sodium salt, 90mM HCl in MeOH, 20°, 3 x 7 h	40	1.2	3.6	4:0.7:1

[a] Determined according to Ref. 14. [b] Determined according to Ref. 15. [c] G.l.c. of *O*-trimethylsilyl derivatives of alditols obtained after acid hydrolysis and reduction with KBH_4.

less degradation than does use of methanolic hydrogen chloride. When the method was applied to odonthalan[17], a sulphated polysaccharide containing 34% of 3,6-anhydrogalactose residues, the sulphate content was decreased from 15 to 1.5%.

A detailed study of solvolytic desulphation is now in progress.

REFERENCES

1 T. G. Kantor and M. Schubert, *J. Amer. Chem. Soc.*, 79 (1957) 152.
2 M. J. Harris and J. R. Turvey, *Carbohyd. Res.*, 9 (1969) 397.
3 J. McKenna and J. K. Norymberski, *J. Chem. Soc.*, (1957) 3889.
4 S. Burstein and S. Lieberman, *J. Amer. Chem. Soc.*, 80 (1958) 5235.
5 G. L. Mayers, M. Pousada, and T. H. Haines, *Biochemistry*, 8 (1969) 2981.
6 M. B. Goren, *Biochim. Biophys. Acta*, 210 (1970) 116.
7 S. Peat, J. R. Turvey, M. J. Clancy, and T. P. Williams, *J. Chem. Soc.*, (1960) 4761.
8 E. G. V. Percival and T. H. Soutar, *J. Chem. Soc.*, (1940) 1475.
9 E. J. Reist, R. R. Spencer, D. F. Calkins, B. R. Baker, and L. Goodman, *J. Org. Chem.*, 30 (1965) 2312.
10 B. Helferich, W. Klein, and W. Schäfer, *Ber.*, 59 (1926) 79.
11 D. J. Bell, *J. Chem. Soc.*, (1947) 1461.
12 N. K. Kochetkov, A. I. Usov, and L. I. Miroshnikova, *Zh. Obshch. Khim.*, 37 (1967) 792.
13 N. K. Kochetkov, A. I. Usov, and L. I. Miroshnikova, *Zh. Obshch. Khim.*, 40 (1970) 2469, 2473.
14 K. S. Dodgson and R. G. Price, *Biochem. J.*, 84 (1962) 106.
15 W. Yaphe and G. P. Arsenault, *Anal. Biochem.*, 13 (1965) 143.
16 M. H. Fischer, *Carbohyd. Res.*, 8 (1968) 354.
17 A. I. Usov and N. K. Kochetkov, *Zh. Obshch. Khim.*, 38 (1968) 234.