Tetrahedron Letters No. 30, pp 2805 - 2808.
©Pergamon Press Ltd. 1979.Printed in Great Britain.
0040-4039/79/0722-2805$02.00/0

DEOXYGENATION OF SUGAR TRIFLUOROMETHANESULFONATES BY SODIUM METAL IN LIQUID AMMONIA AND BY PHOTOLYSIS

Tsutomu Tsuchiya, Fujio Nakamura and Sumio Umezawa

Institute of Bioorganic Chemistry, 1614 Ida, Nakahara-ku, Kawasaki,
211 (Japan)

Summary. Several trifluoromethanesulfonyl(TFMS) derivatives of sugars were prepared and treated with sodium in liquid ammonia or subjected to ultraviolet irradiation. Three 3-O-TFMS derivatives gave the corresponding 3-deoxy compounds, but a 2-O-TFMS derivative gave a branched-chain sugar.

Recently we reported[1)] the preparation of 3-deoxy sugars by treatment of 3-O-(N,N-dimethylsulfamoyl) derivatives with sodium metal in liquid ammonia (Na-NH_3). However, the introduction of N,N-dimethylsulfamoyl group to sugars with N,N-dimethylsulfamoyl chloride generally requires a strongly basic condition, which often induces undesirable side reactions or deprotection of sugar derivatives. We, therefore, searched for other sulfonyl groups which can easily be introduced. This paper deals with a new radical-type deoxygenation (by Na-NH_3 and photolysis) of sugar trifluoromethanesulfonates; the trifluoromethanesulfonyl(TFMS) group is easily introduced under mild conditions and the deoxygenation is successfully performed.

The starting TFMS derivatives prepared are methyl 4,6-O-cyclohexylidene-2-deoxy-2-methoxycarbonylamino-3-O-TFMS-α-D-glucopyranoside (2), 1,2:5,6-di-O-isopropylidene-3-O-TFMS-α-D-glucose[2)] (5), methyl 2-O-acetyl-6-deoxy-6-(p-toluenesulfonylamido)-3-O-TFMS-α-D-glucopyranoside (8) and methyl 6-deoxy-6-(p-toluenesulfonylamido)-2-O-TFMS-α-D-glucopyranoside (11). They were prepared from the corresponding hydroxyl precursors (1, 4, 7 and 10) by treatment with trifluoromethanesulfonic anhydride in pyridine (-10°C → room temperature) in high yields.

These TFMS derivatives were then subjected to reaction with Na-NH_3 in a manner as follows: To sodium metal (~ 100 mg) in liquid ammonia (-50°C, ~ 8 ml), a solution of 2, 5, 8 or 11 (~ 100 mg) in tetrahydrofuran (~ 1.5 ml) was added with stirring and the mixture was maintained at the temperature for 1 h. After addition of methanol (deep-blue color disappeared) followed by evaporation of ammonia, the residue was dissolved in chloroform (in the case of 3 or 6) or the aqueous solution of the residue was charged on a column of Dowex 50W (NH_4^+) resin (in the case of 9 or 13) and the column was washed with 0 → 0.1 M ammonia. The resulting chloroform or desalted aqueous solution was then processed in a usual manner.

On the other hand, photochemical reaction of the above TFMS derivatives was examined. Since the mechanism of photochemical reaction and that of Na-NH_3 are considered to be both radical in character, similar reactions are expected to occur in both types of reactions. Recently Deshayes et al$^{3)}$ have reported photochemical deoxygenation of sugar acetates dissolved in aqueous hexamethylphosphoric triamide(HMPT) (5:95) to occur at the acetoxy position. We utilized, for trial, the above experimental condition for our photolysis. A solution of 2, 5 or 11 dissolved in aqueous-HMPT (5:95) was irradiated by RUL-2537Å lamp (The Southern New England Ultraviolet Co., England) at room temperature and worked up in a usual manner. The results obtained by both Na-NH_3 and photolysis were shown in Table 1.

The 3-O-TFMS-α-D-glucopyranoside (2) was converted to 3-deoxy compound$^{1)}$ (3) in high yield by both Na-NH_3 and photolysis. Another 3-O-TFMS-α-D-glucopyranoside (8) also gave 3-deoxy derivative$^{1)}$ (9) by Na-NH_3 in a moderate yield. A furanoside derivative (5), however, gave, by Na-NH_3, a variety of products including a trace amount of the corresponding 3-deoxy compound (6). On photolysis, however, 5 gave 6 in 64% yield indicating that both processes are not necessarily the same. Horton et al$^{4)}$ reported the photochemical preparation of 6 (17 ~ 23%) from 1,2:5,6-di-O-isopropylidene-3-O-(dimethylthiocarbonyl)-α-D-glucofuranose and from the corresponding 3-deoxy-3-iodo-α-D-glucose derivative. Pete et al$^{5)}$ and Collins and Munasinghe$^{6)}$ prepared 6 photochemically in aqueous HMPT from 3-O-acetyl-1,2:5,6-di-O-isopropylidene-α-D-glucofuranose. Compound 6 was also prepared by Barton and McCombie$^{7)}$ from 3-(S-methyl dithiocarbonate) of 4 by reduction with tributylstannane. The 2-O-TFMS-α-D-glucopyranoside (11), however, gave a peculiar result. On treatment with Na-NH_3, 11 was converted mainly to methyl 5-amino-2,5-dideoxy-2-C-hydroxymethyl-α-D-ribo-pentofuranoside (12) accompanied by methyl 6-amino-3,6-dideoxy-α-D-arabino-hexopyranoside (13) which is produced possibly via 2,3-manno epoxide. The structure of 12 was proved from the PMR spectra of 12, its triacetyl (14) and N-acetyl-O-isopropylidene derivatives (15). A plausible reaction pathway of 11 to 12 is assumed to be as follows:

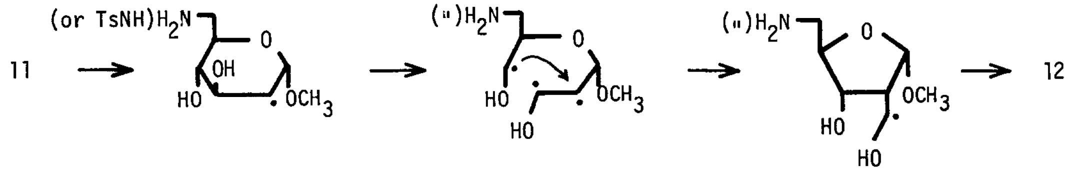
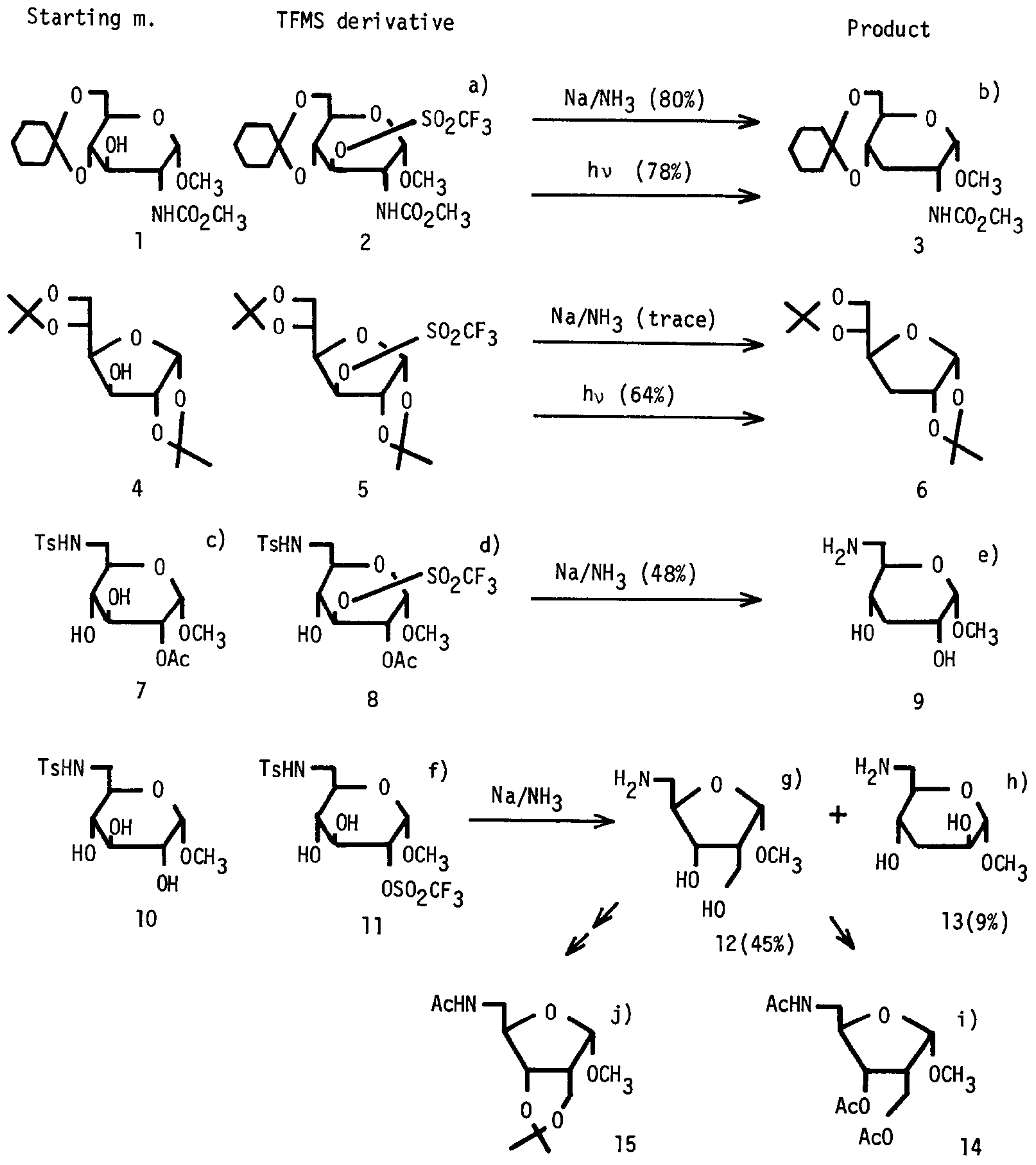


Table 1



a) Mass spectrum: m/e 463 (M^+). b) M.p. 118 - 119°C (alone and on admixture with an authentic sample[1]). c) Selective acetylation of methyl 6-deoxy-6-(p-toluenesulfonylamido)-α-D-glucopyranoside[8] with AcCl/pyridine gave 7 (54% after purification), $[\alpha]_D^{25}$ +97° (c 0.5, chloroform); p.m.r., δ($CDCl_3$): 2.17 (3H s, Ac), 2.47 (3H s, Ts), 4.71 (1H dd, J = 3.5 and 10 Hz, H-2), 4.88 (1H d, J = 3.5 Hz, H-1). d) $[\alpha]_D^{25}$ +88° (c 1, chloroform). The presence of 3-O-TFMS group was proved[8] from the PMR pattern. e) δ(D_2O): 1.68 (1H q, J = 11.5 Hz, H-3_{ax}), 2.22 (1H double t, J = 5, 5 and 11.5 Hz, H-3_{eq}). f) This compound was slightly contaminated with 3-O TFMS derivative. $[\alpha]_D^{25}$ +72° (c 1, $CHCl_3$); δ ($CDCl_3$): 4.77 (1H dd, J = 4 and 9 Hz, H-2), 4.90 (1H d, J = 4 Hz, H-1). g) Free base: syrup, $[\alpha]_D^{25}$ +110° (c 0.5, water); δ (D_2O): 2.40 (1H m, H-2), 2.77 (2H d, $J_{4,5(5')}$ = 5.5 Hz, H-5,5'), 3.40 (3H s, OCH_3), 3.87 (2H d, $J_{2,2'}$ ~ 7 Hz, H-2',2"), 4.0 ~ 4.3 (2H, H-3,4), 5.13 (1H d, $J_{1,2}$ = 4.8 Hz, H-1). h) Syrup, $[\alpha]_D^{25}$ +112° (c 1, water). δ 1.80 (1H septet, $J_{2,3ax}$ = 3.5 Hz, $J_{3eq,3ax}$ = 14 Hz, $J_{3ax,4}$ = 10.5 Hz, H-3_{ax}), 2.08 (1H sextet; $J_{2,3eq}$ = 3.5 Hz, $J_{3eq,4}$ = 5 Hz, H-3_{eq}), 2.5 - 3.2 (2H m, H-5,5'), 3.94 (1H narrow m, H-2), 4.63 (1H slightly broadened s, H-1). Irradiation of H-2 caused the H-1 signal sharpened and the signals of H-3_{ax} and H-3_{eq} to collapse to a quartet, respectively. i) Syrup, $[\alpha]_D^{25}$ +55° (c 0.6, chloroform); δ (pyridine-d_5): 1.93, 1.97 and 2.10 (each 3H s, Ac), 2.85 (1H m, H-2), 3.35 (3H s, OCH_3); 3.76 (1H dd, $J_{4,5}$ = 5.5 Hz, $J_{5,H}$ ~2.5 Hz, H-5) and 3.82 (1H dd, $J_{4,5'}$ = 5.5 Hz, $J_{5',H}$ ~ 2 Hz, H-5') (these signals will be the stronger part of signals of AB q of H-5 and 5'); 4.3 ~ 4.65 (3H m, H-4, 2',2"), 4.75 (1H broadened s, NH), 5.12 (1H d, $J_{1,2}$ = 4.8 Hz, H-1), 5.58 (1H dd, $J_{2,3}$ = 7.5 Hz, $J_{3,4}$ = 2 Hz, H-3). j) Syrup, $[\alpha]_D^{25}$ +105° (c 1, chloroform); δ ($CDCl_3$); 1.35 (6H s, Ip), 1.99 (3H s, Ac), 2.40 (1H octet, $J_{2,3} = J_{2,2'} = J_{2,2''}$ = 7.5 Hz, $J_{1,2}$ = 4.8 Hz, H-2), 3.38 (3H s, OCH_3), 3.88 (2H octet, $J_{2',2''}$ = 11.5 Hz, H-2',2"), 4.95 (1H d, H-1).

In conclusion, it has been found that trifluoromethanesulfonates, which are commonly used in the field of sugar chemistry, can be led to deoxy compounds by radical reactions.

Acknowledgement: We are grateful to Prof. H. Umezawa, Institute of Microbial Chemistry, for his support and encouragement.

References

1. T. Tsuchiya, I. Watanabe, M. Yoshida, F. Nakamura, T. Usui, M. Kitamura and S. Umezawa, Tetrahedron Lett., 3365 (1978).
2. L. D. Hall and D. C. Miller, Carbohyd. Res., 47, 299 (1976).
3. H. Deshayes, J. Pete, C. Portella and D. Scholler, J. Chem. Soc. Chem. Comm., 439 (1975).
4. R. H. Bell, D. Horton, D. W. Williams and E. Winter-Mihaly, Carbohyd. Res., 58, 109 (1977).
5. J. Pete, C. Portella, C. Monneret, J. Florent and Q. Khuong, Huu, Synthesis, 774 (1977).
6. P. M. Collins and V. R. Z. Munasinghe, J. Chem. Soc. Chem. Comm., 927 (1977).
7. D. H. R. Barton and S. W. McCombie, J. Chem. Soc. (Perkin I), 1574 (1975).
8. Details will be reported in near future.

(Received in Japan 25 April 1979)