

## Fragmentation of 2-Methoxyethanol Derivatives

JOHANNES DALE and SIW B. FREDRIKSEN

Kjemisk Institutt, Universitetet i Oslo, Oslo 3, Norway

In an attempt to recover unreacted 2-methoxyethyl tosylate from a reaction with an alkoxide by distillation in vacuum, the distillate was instead found to be pure methyl tosylate. The distillation was repeated on freshly prepared 2-methoxyethyl tosylate, and again only methyl tosylate was obtained. The cold trap did not contain ethylene oxide, but the distillation residue was substantial and consisted presumably of polymerized ethylene oxide.

Similar experiments were performed with 3-methoxypropyl tosylate and with butyl tosylate. In both cases only unchanged starting material distilled, although residues were also formed here. Clearly, a 1,4-relationship between the methoxy group and the tosyl group is required for fragmentation.

Since in the corresponding preparation of iodides no fragmentation was observed during the distillation of the 2-methoxyethyl derivative, a simple electrocyclic mechanism (Fig. 1a) was rejected in favour of a coordination intermediate (Fig. 1b).

In view of the occurrence of bidentate five-ring pentacoordinated species in Si-compounds,<sup>1</sup> it became of interest to investigate the crystal structures of compounds containing the  $\text{TsOCH}_2\text{CH}_2\text{O}$ -group. A tendency towards cyclic coordination might possibly manifest itself already in the choice of conformation in the ground state. 2-Methoxyethyl tosylate is a liquid, but the ditosylates of ethylene glycol, diethylene glycol, and triethylene glycol are crystalline,<sup>2</sup> and their crystal structures were determined by Groth.<sup>3</sup> They revealed that the  $\text{TsOCH}_2\text{CH}_2\text{O}$ -unit had in no case chosen the  $g^+g^+a$  conformation required for a coordination intermediate (Fig. 1b), but had instead the  $aga$  conformation (ethylene and diethylene glycol ditosylate), as generally found for all units in polyethylene glycols,<sup>4</sup> or the  $a g^+g^+$  conformation (triethylene glycol ditosylate), as encountered in some crown ethers and their complexes.<sup>4</sup>

A coordinative mechanism was definitively excluded in favour of a catalytic mechanism (Fig. 1c) by the subsequent finding that the corresponding iodides presented the same picture when traces of NaI were deliberately added before distillation. Thus, when distilled at atmospheric pressure, 2-methoxyethyl iodide gave only methyl iodide, whereas 3-methoxypropyl iodide distilled unchanged, and in both cases the formation of residue was negligible. In the preparation of the tosylates using tosyl chloride in pyridine, the lipophilic salts pyridinium chloride and tosylate are formed, and traces could well have been present in the organic tosylates. (Pyridinium chloride may have produced chloromethane, which would

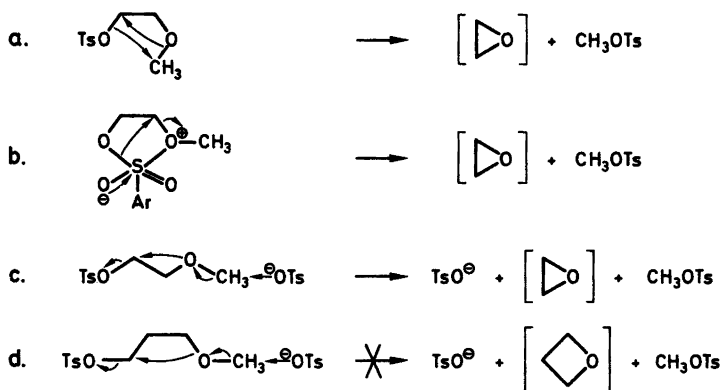


Fig. 1. Fragmentation of tosylates.

not be trapped under these conditions.) The 2-methoxyethyl tosylate was therefore carefully purified by chromatography on alumina and could now in fact be distilled unchanged.

The very much faster cyclization by an  $S_N2$  type reaction to give a three-membered rather than a four-membered ring, has been noted, for example in the cyclization of  $\omega$ -halogenalkylmalonic esters with bases<sup>5</sup> and in the cyclization of  $N$ -phenyl- $\omega$ -halogenoalkylamines.<sup>6</sup> We believe that the strikingly different behaviour of the methoxyethyl as compared with the methoxypropyl derivative has to be considered as a manifestation of the different cyclization tendency to form oxirane and oxetane, respectively. In order to explain this difference, we want to draw attention to the appreciably longer distance between the nucleophile and the carbon carrying the leaving group in the latter case than in the former, when each chain is represented in the particular conformational minimum that brings these atoms closest and correctly positioned for an incipient  $S_N2$  transition state (Fig. 1c and 1d).

**Experimental. 2-Methoxyethyl tosylate.** This was prepared from 2-methoxyethanol and tosyl chloride by a standard procedure<sup>2</sup> in  $\text{CHCl}_3$ -pyridine. The oily product (89 %) was pure by NMR.  $^1\text{H NMR}$  ( $\text{CDCl}_3$ )  $\delta$  2.40 (s, 3H, ar  $\text{CH}_3$ ), 3.23 (s, 3H,  $\text{CH}_3\text{O}$ ), 3.46 (t, 2H,  $\text{CH}_2\text{O}$ ), 4.30 (t, 2H,  $\text{CH}_2\text{OTs}$ ), 7.4 (q, 4H, ar CH).

The tosylate (3.7 g) was distilled directly at 16 mmHg in a simple distillation flask. A liquid (~1.0 g) passed at 176–180 °C, leaving a charred residue (~2.0 g).  $^1\text{H NMR}$  ( $\text{CCl}_4$ )  $\delta$  2.3 (s, 3H, ar  $\text{CH}_3$ ), 3.6 (s, 3H,  $\text{CH}_3\text{O}$ ), 7.3 (q, 4H, ar CH); identical with authentic methyl tosylate.

When the 2-methoxyethyl tosylate was first passed through a neutral alumina column, eluting with ethyl acetate/hexane 1:1, it distilled unchanged at 180–185 °C/8 mmHg.

**3-Methoxypropyl tosylate.** This was prepared from 3-methoxypropanol<sup>7</sup> by the standard method.<sup>2</sup> The oily product (84 %) was pure by NMR.  $^1\text{H NMR}$  ( $\text{CDCl}_3$ )  $\delta$  1.84 (quint, 2H,  $\text{CH}_2$ ), 2.38 (s, 3H, ar  $\text{CH}_3$ ), 3.15 (s, 3H,  $\text{CH}_3\text{O}$ ), 3.30 (t, 2H,  $\text{CH}_2\text{O}$ ), 4.20 (t, 2H,  $\text{CH}_2\text{OTs}$ ), 7.4 (q, 4H, ar CH).

The tosylate was stirred at 120 °C for 8 h and then distilled at 0.01 mmHg in a simple distillation flask. A liquid passed at 108 °C and proved to be unchanged starting material. The distillation flask contained a charred residue.

**1-Butyl tosylate.** This was prepared from 1-butanol by the standard method (84 %).<sup>2</sup> It was heated at 150 °C for 2 h and then distilled unchanged at 171–176 °C/12 mmHg leaving a charred residue.

**2-Methoxyethyl iodide.** This was prepared from 2-methoxyethyl tosylate either with sodium iodide in acetone<sup>8</sup> in a yield of 60 %, b.p. 45 °C/20 mmHg, or with magnesium iodide in diethyl ether<sup>9</sup> in a yield of 69 %, b.p. 49–50 °C/30 mmHg.  $^1\text{H NMR}$  ( $\text{CCl}_4$ )  $\delta$  3.40 (s, 3H,  $\text{CH}_3\text{O}$ ), 3.3–3.8 (m, 4H,  $\text{CH}_2$ ).

The iodide was stirred with traces of NaI and LiCl at 30 °C for 6 h and then distilled at atm. pressure, b.p. 40–46 °C.  $^1\text{H NMR}$  ( $\text{CCl}_4$ )  $\delta$  2.18 (s); identical with methyl iodide.

**3-Methoxypropyl iodide.** This was prepared from 3-methoxypropyl tosylate with magnesium iodide in ether<sup>9</sup> in a yield of 67 %, b.p. 59–60 °C/20 mmHg.  $^1\text{H NMR}$  ( $\text{CDCl}_3$ )  $\delta$  2.20 (quint., 2H,  $\text{CH}_2$ ), 3.20 (t, 2H,  $\text{CH}_2\text{I}$ ), 3.26 (s, 3H,  $\text{CH}_3\text{O}$ ), 3.36 (t,  $\text{CH}_2\text{O}$ ).

The iodide was stirred with traces of NaI and LiCl at 30 °C for 5 h and then distilled at atm. pressure. A liquid passing at 151–152 °C proved to be unchanged starting material.

1. Boer, F.P., Flynn, J.J. and Turley, J.W. *J. Am. Chem. Soc.* 90 (1968) 6973.
2. Dale, J. and Kristiansen, P.O. *Acta Chem. Scand.* 26 (1972) 1471.
3. Groth, P. *Unpublished*.
4. Dale, J. *Tetrahedron* 30 (1974) 1683.
5. Knipe, A.C. and Stirling, C.J.M. *J. Chem. Soc. B* (1968) 67.
6. Bird, R., Knipe, A.C. and Stirling, C.J.M. *J. Chem. Soc. Perkin Trans. 2* (1973) 1215.
7. Searles, S., Butler, C.F. *J. Am. Chem. Soc.* 76 (1954) 56.
8. Finkelstein, H. *Ber. Dtsch. Chem. Ges.* 43 (1910) 1531.
9. Gore, J., Place, P. and Roumestant, M.L. *Chem. Commun* (1973) 821.

Received March 1, 1985.