Tetrahedron Letters,Vol.29,No.21,pp 2575-2576,1988 0040-4039/88 $3.00 + .00
Printed in Great Britain Pergamon Press plc

DIASTEREOTOPIC SELECTION OF C2 HYDROGENS IN THE REARRANGEMENT OF C1-SUBSTITUTED EPOXIDES: AN EXAMINATION OF STYRENE OXIDE

J.M. Coxon* and D.Q. McDonald

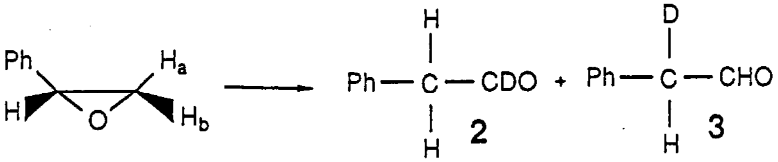
Department of Chemistry, University of Canterbury, Christchurch, New Zealand.

Summary: Rearrangement of styrene oxide with (a) $LiClO_4$ and (b) BF_3 to give phenylethanal exhibits diastereotopic selection with migration of the hydrogen *trans* to the phenyl group being favoured 1.4 and 1.14 times respectively. The rate of rotation about the C1-C2 bond of the intermediate is comparable, but greater than the rate of hydrogen migration.

In the light of continuing interest[1,2,3] in the rearrangement of substituted styrene oxides we have examined the rearrangement of the isomeric (E)- and (Z)-1-deuterostyrene oxides (**1**). We now report the results of this investigation which show that the rearrangement of these styrene oxides occurs with diastereotopic selection[4] of the C2-hydrogen *trans* to the phenyl group, in contrast to a recent report on the rearrangement of p-methoxystyrene oxide.[1]

The rearrangement of the (E)- and (Z)-1-deuterostyrene oxide[5] (1) has been studied under a variety of conditions. With $LiClO_4$ in benzene at 78°, aldehydes (2) and (3) are formed in high yield (total 85%). The ratio of aldehydes (2) and (3), as determined from the integrals of the ^2H NMR spectrum for deuterium at C1 (9.78 ppm) and at C2 (3.65 ppm), was dependent on the structure of the starting epoxide. For epoxide (**1a**) the ratio of C1-H:C1-D migration was 1.42±0.03 while for epoxide (**1b**) the ratio was 2.41±0.07. The reaction was complete in four hours and no isomerisation of the starting epoxides was observed in this period [^2H and ^1H NMR analysis of reaction aliquots withdrawn over the course of the reaction[6]].

1a H_b = D
b H_a = D

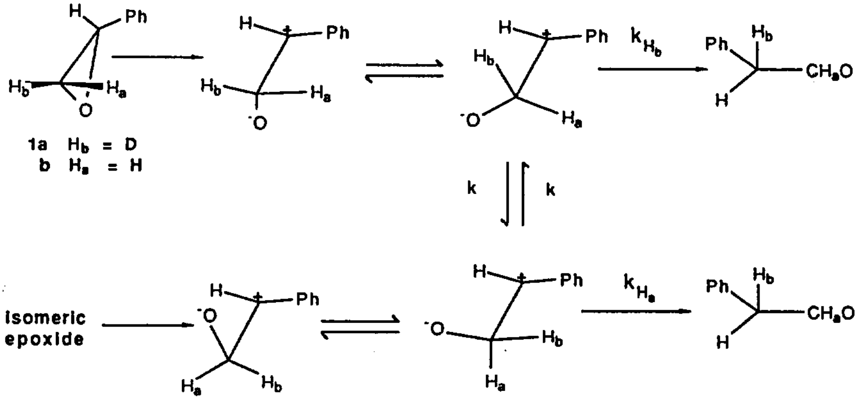


The rearrangement of styrene oxide was also studied with BF_3-diethyletherate and BF_3 gas in a variety of solvents[4]. The highest yield of phenylethanal was obtained when the reaction was carried out at room temperature in dioxan with BF_3-diethyletherate. The ratio of deuterated aldehydes (2) and (3) for reaction of epoxide (1a) was 1.48±0.04 while for epoxide 1b the ratio was 1.83±0.05. This reaction was fast [complete in < 1 min.] and no attempt was made to detect possible epoxide isomerization.

Kinetic isotope effects for hydride to deuteride migration of 2.0 and 1.68 and relative rates of rotation about the C1-C2 bond of the intermediate carbocation of 4.9 and 11.8 (see scheme) were established for the reaction with $LiClO_4$ and BF_3 respectively as catalysts by application of the expression[5,4];

$$H_a \text{ migration} / H_b \text{ migration} = [k_{Ha}/k_{Hb}]\,[1 + k_{Ha}/k]$$

If the rate of rotation (k) about the C1-C2 bond were slow relative to hydrogen migration diastereotopic selection would be at its greatest since after C-O bond cleavage rotation will occur to minimise the interaction of the oxygen with the adjacent aryl group, thereby bringing the hydrogen initially *trans* to the aryl group into a position aligned with the



Isomerisation of styrene oxide (LiClO$_4$ - benzene 78°c or BF$_3$ - dioxan - RT)

Oxygen of intermediate co-ordinated to BF$_3$

vacant orbital of the carbocation. If rotation about C1-C2 of the carbocation intermediate were fast relative to migration then diastereotopic selection would not be observed. When the rate of rotation is comparable with migration, some diastereotopic selection is observed. Diastereotopic selectivity for styrene oxide in the rearrangement with LiClO$_4$ and with BF$_3$ as catalyst is a result of the comparability of the rate of hydride/deuteride migration with the rate of rotation about the C1-C2 bond since the favoured rotation mode allows the hydrogen initially *trans* to the phenyl group the opportunity to migrate before the *cis* hydrogen. The diastereotopic selection of the hydrogen of the styrene oxide *trans* to the phenyl group obtained by application of the above expression is favoured 1.4 times in the reaction with LiClO$_4$ and 1.14 times with BF$_3$ as catalyst. In contrast, *p*-methoxy-*trans*-β-deuterostyrene oxide[7] has been observed to undergo rearrangement without stereoselectivity and with ring closure in competition with rearrangement.[1,3]

References

1. V.C. Ukachukwu and D.L. Whalen, *Tetrahedron Letters*, In Press (1988).
2. J.M. Coxon and M.P. Hartshorn, *Tetrahedron Letters*, 1333, **28** (1987).
3. V.C. Ukachukwu, J.J. Blumenstein, and D.L. Whalen, *J. Am. Chem. Soc.*, **108**, 5039 (1986).
4. (a) J.M. Coxon and C-E Lim, *Aust. J. Chem.*, **30**, 1137 (1977). (b) J.W. Blunt, J.M. Coxon, C-E Lim, and H.A. Schuyt, *Aust. J. Chem.*, **36**, 97 (1983). (c) B.N. Blackett, J.M. Coxon, M.P. Hartshorn, and K.E. Richards, *J. Am. Chem. Soc.*, **92**, 2574 (1970).
5. B.E. Benjamin and C.J. Collins, *J. Am. Chem. Soc.*, **78**, 4329 (1956).
6. (E)-Deuterostyrene (> 97% stereospecifically labelled) was prepared by partial hydrogenation of phenylacetylene with diisobutylaluminium hydride and quenching of the reaction with deuterium oxide. The (Z)-isomer was obtained from deuterophenylacetylene, prepared by replacement of the hydrogen of phenylacetylene by reaction with ethyl magnesium halide and decomposition with D$_2$O (> 97% deuteration) followed by partial reduction with DIBAL. Epoxidations with MCPBA in the presence of NaOAc were stereospecific.
7. While a detailed kinetic study was not attempted the reaction appeared to follow first order kinetics, consistent with previous studies. B. Rickborn and R.M. Gerkin, *J. Am. Chem. Soc.*, **93**, 1693 (1971).
8. The rapid rate of isomerisation of p-methoxystyrene oxide is a matter for further investigation. For this substrate the rate of rotation relative to k$_D$ is faster than that observed for styrene oxide and related studies[4].

(Received in UK 6 April 1988)