

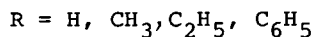
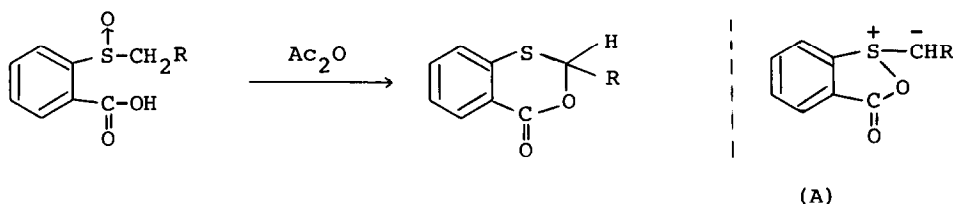
TRANSFER OF CHIRALITY FROM SULFUR TO  $\alpha$ -CARBON  
IN THE PUMMERER REACTION OF  $\alpha$ -CYANOMETHYL ARYL SULFOXIDE

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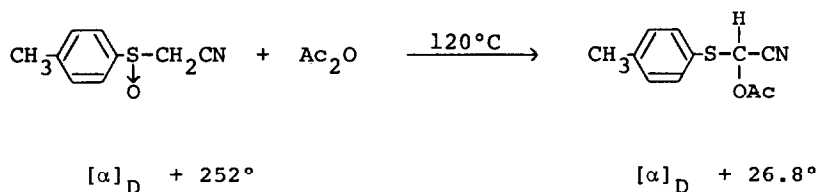
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We reported earlier that treatment of *o*-carboxyphenyl alkyl sulfoxide with acetic anhydride gives a cyclized product, 3,1-benzoxathian-4-one, nearly quantitatively via an intramolecular Pummerer reaction.<sup>1)</sup> Later this cyclization was found by Allenmark et al. to result in a substantial asymmetric induction (e.e., 11.2%) at  $\alpha$ -carbon when an optically active sulfoxide (R=Ph) was used.<sup>2)</sup> The kinetic study indicated that proton-removal to form the intermediate (A) is rapid and irreversible while the subsequent intramolecular 1,2-migration is also quite rapid.<sup>3)</sup> The asymmetric induction is considered



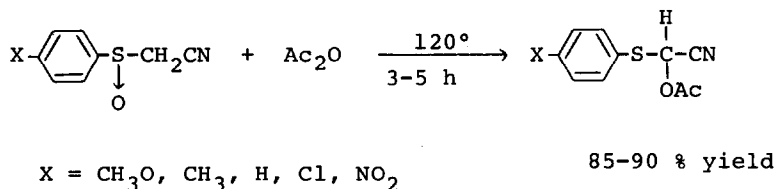
to have resulted due to either the rapid irreversible proton-removal or the intramolecular nature of the reaction or both. However, one can ask further if an asymmetric induction is observed even in an ordinary Pummerer reaction. In order to answer these questions, we have chosen the reaction of  $\alpha$ -cyano-methyl phenyl sulfoxide with acetic anhydride, since the proton-removal is

considered to be fast but reversible while the S-O bond cleavage is likely to be the rate-determining step in this reaction. When optically active  $\alpha$ -cyanomethyl p-tolyl sulfoxide,  $[\alpha]_D +252^\circ$ , was treated with a large excess of acetic anhydride at  $120^\circ\text{C}$  for 3.5 h, the resulted  $\alpha$ -cyano- $\alpha$ -acetoxymethyl p-tolyl sulfide was found to be optically active,  $[\alpha]_D + 26.8^\circ$ , retaining  $29.0 \pm 0.8\%$  of optical activity.<sup>4)</sup>



We now wish to discuss the mode of asymmetric induction in the Pummerer reaction somewhat in detail in the light of  $^{18}\text{O}$ -tracer and kinetic investigations besides the stereochemistry.

A few para-substituted phenyl cyanomethyl sulfoxides (substituent:  $\text{CH}_3\text{O}$ ,  $\text{CH}_3$ ,  $\text{H}$ ,  $\text{Cl}$ ,  $\text{NO}_2$ ) were prepared and allowed to react with a large excess of acetic anhydride at  $120^\circ\text{C}$  for 3-5 h and the corresponding  $\alpha$ -acetoxysulfides were obtained in good yields (85-90%). This Pummerer reaction appears to be generally stereospecific.



Earlier, the 1,2-shift of acetoxy group in the Pummerer reaction of dimethyl sulfoxide<sup>5)</sup> and methyl phenyl sulfoxide<sup>6)</sup> was shown to be intermolecular on the basis of  $^{18}\text{O}$ -tracer experiments. However, when  $^{18}\text{O}$ -labeled cyanomethyl p-chlorophenyl sulfoxide (0.680 excess atom%) was allowed to react with a large excess of  $\text{Ac}_2\text{O}$  until 50% conversion ( $120^\circ\text{C}$ , 1 h), and the original sulfoxide recovered and the Pummerer product separated by column chromato-



The initial acetylation is an equilibrium and the second step of proton-removal is fast and reversible. Then the rate-determining S-O bond cleavage in the sulfonium ylide takes place, followed immediately by the predominantly intramolecular 1,2-acetoxy migration. The S-O bond cleavage and the acetoxy migration via both 5-membered and 3-membered cyclic routes would be quite synchronized by rapid electronic shift within the ylide molecule, like in the anchimerically assisted solvolyses.<sup>7)</sup> However, in view of the relatively low stereospecificity and the size of the Hammett  $\rho$  value ( $\rho = -0.65$ ) for p-substituents in this Pummerer reaction, the intramolecular cyclic transition state would not be so tight but partially dissociated.<sup>8)</sup>

The intramolecular and somewhat synchronized 1,2-acetoxy migration is considered to be mainly responsible for the asymmetric induction.<sup>9)</sup>

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#### References and Notes

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- 4) e.e. Value was determined by the use of the chiral lanthanide shift reagent,  $\text{Eu}(\text{hfc})_3$ , using Varian A-60D nmr.
- 5) S.Oae, T.Kitao and S.Kawamura, *Tetrahedron*, **19**, 1783 (1963).
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- 7) W.J.le Nobel, "Highlights of Organic Chemistry", Ch 20, Marcel Dekker, Inc., New York, 1974.
- 8) In the rigid concerted cyclic transition state such as [2,3]-sigmatropic rearrangement, the rearrangement was proceeded completely stereospecific; for example: over 94% optical induction was observed in the rearrangement of allylic sulfonium ylide. (B.M.Trost and R.F.Hammen, *J. Am. Chem. Soc.*, **95**, 964 (1973)).
- 9) Enantiomeric ratio of the two different enantiomers which results in the asymmetric induction must be due to the energy difference of the two diastereomeric transition states leading to the respective enantiomers, since there should be no energy difference between the two resulted enantiomeric products. Meanwhile, since the carbanion stabilized by cyano group is known to be  $\text{sp}^2$  while the proton-removal is a fast reversible step,<sup>10)</sup> a possibility of stereospecific proton-removal leading to the preferential formation of diastereomeric ylide intermediate with  $\text{sp}^3$  carbanion configuration is ruled out.
- 10) E.Buncel, "Carbanion; Mechanistic and Isotopic Aspects", ch 1, Elsevier, The Netherlands, 1975.