CHEMISTRY LETTERS, pp. 817-820, 1978. Published by the Chemical Society of Japan

REACTION OF ALKYL ARYL SULFOXIDE WITH METHYL PHENYL N-CHLOROSULFOXIMIDE. DIRECT SYNTHESIS OF OPTICALLY ACTIVE α-CHLORO SULFOXIDE WITH OPTICALLY ACTIVE N-CHLOROSULFOXIMIDE

Hiroyuki MORITA, Hideaki ITOH, Naomichi FURUKAWA, and Shigeru OAE

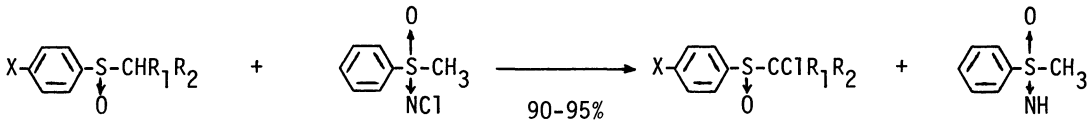
Department of Chemistry, The University of Tsukuba, Niihari-gun, Ibaraki 300-31

Treatment of a few alkyl aryl sulfoxides with methyl phenyl N-chlorosulfoximide resulted in the quantitative formation of α-chloro sulfoxides. When the optically active methyl phenyl N-chlorosulfoximide was used, the α-chloro sulfoxides having optical activity on the sulfinyl sulfur were obtained from the corresponding sulfoxides.

Alkyl sulfoxides are known to be chlorinated readily at the α-position by a number of halogenating reagents, such as, nitrosyl chloride,[1] iodobenzene dichloride,[2] t-butyl hypochlorite,[3] chlorine,[4] sulfuryl chloride,[5] N-chlorosuccinimide,[6] and 1-chlorobenzotriazole,[7] either with or without base.[8] Meanwhile, N-chlorosulfoximides are considered to be used as chlorinating reagents, and indeed are found to be used in the chlorination of aziridine derivatives.[9]

One advantage of N-chlorosulfoximides as chlorinating reagent is that these N-chlorosulfoximides are resolved into optically active enantiomers, and hence could be used as asymmetric chlorinating reagents. Thus, as our first attempt in the asymmetric chlorinations, we have used methyl phenyl N-chlorosulfoximide successfully for α-chlorination of alkyl aryl sulfoxides.

When an equimolar amount of alkyl aryl sulfoxide was treated with methyl phenyl N-chlorosulfoximide at room temperature for 1 day in $CHCl_3$, CH_3CN, benzene or acetone, and the reaction mixture, after concentrated, was directly separated through activated alumina column by eluting with hexane-ethyl acetate(50v/v% mixture), α-chloro sulfoxide and methyl phenyl sulfoximide were obtained quantitatively. These products were identified by comparing IR and NMR spectra with those of authentic samples. When optically active methyl phenyl N-chlorosulfoximide was used in this reaction, the asymmetric induction on the sulfinyl sulfur of the α-chloro sulfoxides was observed (Table I).



1 2 3 4

1a. X=H, R_1=R_2=H, 1b. X=CH_3, R_1= R_2=H, 1c. X=Br, R_1=R_2=H, 1d. X=H, R_1=H, R_2=CH_3, 1e. X=H, R_1=H, R_2=i-Pr, 1f. X=H, R_1=CH_3, R_2=Et.

Table I. Optical Yields of α-Chloromethyl p-Tolyl Sulfoxide

Subst.	Solvent	Temp.(°C)	Subst./2[a]	$[\alpha]_D^{25}$(c)	Optical Yield%[b]
1b	acetone[c]	20	2	+ 2.04(0.49)[d]	1.0
1b	acetone	20	4	+ 2.90(0.56)	1.5
1b	acetone	20	6	+ 2.87(0.97)	1.5
1b	acetone	4	4	+ 2.96(0.65)	1.5
1b	CH_3CN	20	4	+ 3.76(0.70)	1.9
1b	PhH	20	4	+10.22(1.52)	5.1
1f	PhH	20	4	+ 8.14(0.86)	-

a the ratio of substrate vs. N-chlorosulfoximide. the concentration of 2 was 1×10^{-1}M/l. specific rotation of 2 used was $[\alpha]_D^{25}$=+230°(c=1, acetone), of which configuration is S; preparation of optically active 2 has been reported elsewhere.[10]

b calculated values based on $[\alpha]_D^{25}$=+200°(acetone) as 100% purity.[11]

c 2 was almost inert toward acetone at room temperature but optical activity was slowly lost upon keeping for a prolonged time in acetone solution.

d + sign means R-configuration.[12]

The results indicate clearly that the effect of solvent on the asymmetric induction is rather small. However, benzene, the least polar solvent among the solvents used, is most effective, while the asymmetric induction did not change much with the increase of the concentration of the substrate, but attained the highest when the ratio of subst./2 is 4.

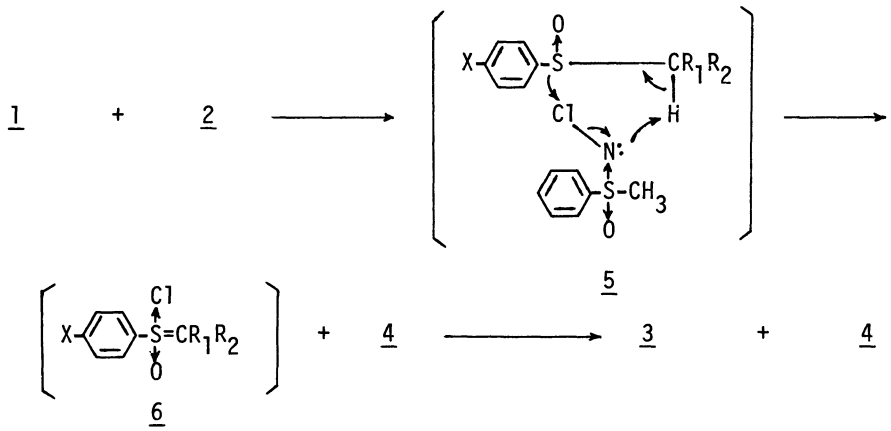
A kinetic study was carried out in order to understand the mechanism of this reaction, and the results are tabulated in Table II. The effect of solvent on the rate was not so remarkable, but the effect of substituents as measured by the Hammett's correlation(ρ=-4.0 against σ value) was quite substantial and somewhat larger than those(ρ=-2.5) observed by Montanari et al.,[8] in the chlorination of the sulfoxide with iodobenzene dichloride in the presence of pyridine.

Table II. Kinetic Results of α-Chlorination of Sulfoxide with Methyl Phenyl N-Chlorosulfoximide

Subst.	Solvent	Temp.(°C)	$k_2(s^{-1}l\ mol^{-1})$	$\Delta H^{\ddagger}$(kcal/mol)	$\Delta S^{\ddagger}$(e.u.)
1a	CH_3CN	30	$8.14\times10^{-2}\pm0.55$[a]	11.9	-24.0
1a	CH_3CN	35	$1.44\times10^{-1}\pm0.14$[a]		
1a	acetone	30	$8.05\times10^{-2}\pm0.43$[a]	8.8	-34.6
1a	benzene	30	$3.58\times10^{-2}\pm0.37$[a]	11.0	-24.3
1b	$CDCl_3$	37	$1.12\times10^{-2}\pm0.04$[b]	-	-
1a	$CDCl_3$	37	$2.80\times10^{-3}\pm0.14$[b]	-	-
1c	$CDCl_3$	37	$2.48\times10^{-4}\pm0.03$[b]	-	-
1a'[c]	CH_3CN	35	$8.16\times10^{-4}\pm0.43$[a]	-	-

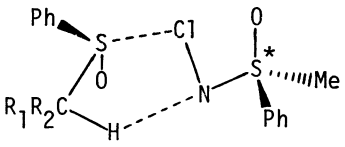
a k_2 was obtained by measuring the loss of the optical activity of 2. b k_2 was obtained by the NMR spectrometrically. c 1a' is $PhSOCD_3$; k_H/k_D is calculated to 1.76.

The large negative value of entropy suggests that the transition state of this reaction is highly rigid. On the basis of these kinetic results, the likely mechanism may be formulated as shown below.



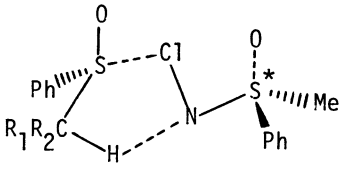
The first step of the reaction is undoubtedly the nucleophilic attack on chlorine atom of the N-chlorosulfoximide by the sulfinyl sulfur of the sulfoxide and conceivably the rate determining in view of the large negative ρ value, since the rate of the reaction with cyanomethyl tolyl sulfoxide was dramatically reduced and the rate could not be determined. The relatively small value of k_H/k_D in comparison with that of Montanari et al., suggests that the proton removal step from α-carbon is a cyclic concerted process as shown by 5, which also explains the asymmetric induction.

The schematic models for 5 could be represented by 7 and 8, which are (R)-(S) and (S)-(S) transition state respectively. Sterically, energetically more preferable arrangement is 7 rather than 8. The subsequent step, 6 to 3, would be quite analogous to the usual Pummerer type migration. The rather low asymmetric induction in the formation of the (R)-enantiomer would be mainly due to the rather long distance from the asymmetric center.



(R) (S)

7



(S) (S)

8

References

1) R. N. Loeppky and D. C. K. Chang, Tetrahedron Lett., 3415 (1968).

2) M. Cinquini and S. Colonna, J. Chem. Soc., Perkin Trans. 1, 1883 (1972).

3) S. Iriuchijima and G. Tsuchihashi, Tetrahedron Lett., 5259 (1972).

4) G. Tsuchihashi and S. Iriuchijima, Bull. Chem. Soc. Jpn., 43, 2271 (1970). D. Martin, A. Berger, and R. Peshel, J. Prakt. Chem., 312, 683 (1970).

5) K. C. Tin and T. Durst, Tetrahedron Lett., 4643 (1970).

6) G. Tsuchihashi and K. Ogura, Bull. Chem. Soc. Jpn., 44, 1726 (1971).

7) M. Cinquini and S. Colonna, Synthesis, 259 (1972).

8) M. Cinquini, S. Colonna, R. Fornasier, and F. Montanari, J. Chem. Soc., Perkin Trans. 1, 1886 (1972). G. Chassaing, R. Lett, and A. Marquet, Tetrahedron Lett., 471 (1978); and the references cited therein.

9) R. Annunziate, R. Fornasier, and F. Montanari, Chem. Commun., 296 (1972).

10) R. Fusco and F. Tericoni, Chem. Ind., (Milan), 47, 61 (1965); Chem. Abstr., 62, 10357h (1965). D. J. Cram, J. Day, D. R. Rayner, D. M. von Schriltz, D. J. Duchamp, and D. C. Garwood, J. Am. Chem. Soc., 92, 7369 (1970).

11) P. Calzavara, M. Cinquini, S. Colona, R. Fornasier, and F. Montanari, J. Am. Chem. Soc., 95, 7431 (1973).

12) C. R. Johnson and C. W. Schreck, J. Am. Chem. Soc., 95, 7418 (1973).

(Received May 3, 1978)