Kinetics of Nucleophilic Substitution of α-Halogeno-sulphoxides

By M. CINQUINI, D. LANDINI,* and (MISS) A. MAIA

(C.N.R. Centro di studio sulla sintesi e stereochimica di speciali sistemi organici, Istituto di Chimica Industriale della Universita', Via Saldini 50, 20133 Milano-Italy)

Summary α-Halogenomethyl sulphoxides react with Pr^nO^- and EtS^- in Pr^nOH *via* S_N2 substitution; α-halogenoethyl and isopropyl derivatives react more slowly: S_N2 reactions are greatly retarded by steric effects and S_N1 reactions by the effect of the SO group.

ALTHOUGH syntheses of α-halogeno-sulphoxides have been reported,[1] the behaviour of this class of compound is largely unknown. The Finkelstein reaction of chlorosulphoxides has been investigated,[2,3] and a study[4] of nucleophilic substitution has appeared, but no kinetic data were reported in the latter case. The reactivity of α-halogeno-sulphoxides towards nucleophilic substitution was thought to be low.[3,5] This is in contrast[2] with the well known reactivity of phenacyl halides. We now report on the kinetics of the nucleophilic substitution of α-chloro- and α-bromo-methyl aryl sulphoxides by $NaOPr^n$ and EtSNa in Pr^nOH.

$$\underset{\text{(I)}}{X{\cdot}C_6H_4{\cdot}SO{\cdot}CH_2{\cdot}Hal} + Nu^- \rightarrow \underset{\text{(II)}}{X{\cdot}C_6H_4SO{\cdot}CH_2{\cdot}Nu} + Hal^-$$

(Ia) X=*p*-Me, Hal=Cl
(Ib) X=*p*-Cl, Hal=Cl
(Ic) X=*m*-Cl, Hal=Cl
(Id) X=*p*-Me, Hal=Br
(Ie) X=*p*-Cl, Hal=Br

In the reaction with EtS^-, the corresponding α-ethylthiomethyl aryl sulphoxides (II) were obtained in ⩾90% yield. In the reaction with Pr^nO^-, together with α-propoxymethyl aryl sulphoxides (II), the corresponding thiosulphinates (III) were obtained, *i.e.*, the products of thermal rearrangements of ethers (II). T.l.c. analysis showed that only for conversion ⩾60% were noticeable quantities of thiosulphinate formed, the amount increasing with time.

Ethers (II) are converted into thiosulphinates (III) under the conditions of the reaction in the absence of nucleophiles. A similar transformation has been observed in the case of α-methoxymethyl aryl sulphoxides.[6]

Reaction of (I) with EtS^- and Pr^nO^- follows second-order kinetics up to at least 80% conversion. Rate constants and activation parameters are given in the Table.

The ratios k(Br)/k(Cl), *ca.* 12 and 33 for Pr^nO^- and EtS^-, respectively, the ratios $k(EtS^-)/k(Pr^nO^-)$, *ca.* 8×10^2 and 3×10^3 in the case of α-chloro- and α-bromo-sulphoxides, respectively, and the activation parameters (see Table) all support an S_N2 mechanism.[7] The reaction is favoured by electron-withdrawing groups, as in the Finkelstein reactions of α-halogenosulphones.[2]

The reactivity of (I) is comparable with that of 1-bromo-3-phenylpropane (see Table),† probably resulting from a

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† A direct comparison with the reactivity of the corresponding α-halogenomethyl sulphones was not possible since under the conditions of the reaction reduction to methyl sulphones occurs instead of nucleophilic substitution.[8]

Rate constants for the reaction of (I) *with* Pr^nO^- *and* EtS^- *in* Pr^nOH

Substrate	Nucleophile	Temp./°C	10^3k/l mol^{-1} s^{-1}	E_a/kcal mol^{-1}	ΔS^*/e.u.
(Ia)	Pr^nO^-	80	0·23		
(Ib)	"	80	0·70		
(Ic)	"	80	0·79		
(Id)	"	80	2·75	20·3[a]	−15[b]
(Ie)	"	80	7·61		
$PhCH_2CH_2CH_2Br$	"	80	3·3		
(Ia)	EtS^-	50	21·8	16·1[a]	−18·7[b]
(Ib)	"	50	54·6		
(Ic)	"	50	61·4		
(Id)	"	40	346	15·1[c]	−14·8[b]
(Ie)	"	40	864		
(Id)	"	30	148		
$PhCH_2CH_2CH_2Br$	"	30	49		

[a] From measurements at 80°, 70°, and 60°. [b] At 60°. [c] From measurements at 60°, 50°, 40°, 30°.

balance between the electron-withdrawing effect of the SO group, which should promote nucleophilic attack,[2] and a field and steric effect which should retard S_N2 displacement, as found in α-halogenosulphones.[2] α-Halogenoethyl and α-halogenoisopropyl sulphoxides react with alkoxides and thiols only after longer reaction times to give the products of β-substitution, *via* elimination–addition.[6,9] This illustrates the important role played by steric effects in S_N2 displacements. In contrast, the formation of carbocations is likely to be greatly hindered by the presence of the SO group.

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