Tetrahedron Letters No.24, pp. 1935-1940, 1965. Pergamon Press Ltd.
Printed in Great Britain.

NUCLEOPHILIC AROMATIC SUBSTITUTION: effect of leaving groups in the methoxy- and thiophenoxy-dehalogenation of 2-halo-benzothiazoles,

A.Ricci, M.Foà, P.E.Todesco and P.Vivarelli

Istituto di Chimica Organica ed Industriale dell'Università
Viale Risorgimento, 4 - Bologna (Italy)

(Received 15 April 1965)

Following our previous research on the factors affecting the nucleophilic reactivity of 2-halo-benzothiazoles and more generally of activated halo-arenes (1), activation energies and entropies for the methoxy- and thiophenoxy -dehalogenation of 2-F-, 2-Cl-, 2-Br- and 2-I-benzothiazoles have been measured (see table 1 and 2).

TABLE 1

Reactions of 2-halo-benzothiazoles with metoxide-ion in methanol

t°	10^3.k (sec^{-1}mol^{-1}l)			
	halogen = F	Cl	Br	I
0°	70.	-	-	-
15°	230.	-	-	0.019
25° (a)	550.	0.55	0.41	0.063
35°	-	1.43 (b)	1.05	0.188
45°	-	3.39 (b)	2.48	-
E	12.4	16.9 (b)	16.2	19.8
log A	8.9	9.2 (b)	8.6	10.4
Δ S	-20.	-19.	-21.	-13.

a) data from reference 1; b) data from P.E.Todesco, P.Vivarelli, Gazz.Chim.Ital. 92, 1221 (1962).

10^3.k (sec^{-1}mol^{-1}l) values ± 3%; $E_{act.}$ (Kcal.mol^{-1}) values ± 0,7 Kcal.mol^{-1}; Δ S(e.u.), values ± 2.6 e.u..

TABLE 2

Reactions of 2-halo-benzothiazoles with thiophenoxide-ion in methanol

t°	10^3k ($sec^{-1}mol^{-1}l$)			
	halogen = F	Cl	Br	I
0°	3.07	0.014	0.040	-
15°	10.4	-	-	-
25° (a)	22.	0.20	0.44	0.14
35°	-	0.50	1.15	0.39
45°	-	-	-	1.05
E	12.4	16.9	16.2	19.8
log A	7.5	8.7	8.6	10.7
Δ S	-26.	-21.	-21.	-11.

a) data from reference 1.

$10^3.k$ ($sec^{-1}mol^{-1}l$) values ± 3%; $E_{act.}$ ($Kcal.mol^{-1}$) values ± 0,7 $Kcal.mol^{-1}$; ΔS (e.u.), values ± 2.6 e.u..

It was shown that the reactions at 25° followed satisfactory the relation I (1)

$$\text{I)} \quad \log k_{PhS^-}/k_{MeO^-} = A + B.\log (R_{C-Alg})_D$$

and it is now found that the same relation holds in the range of temperatures studied (0°-45°). Moreover the values of the energies of activation of the methoxy-dehalogenation do not differ, within the experimental errors, from that of the thiophenoxy- reactions for the same leaving group .

It follows that for the above reactions the relation I is in fact a relation among the entropy factors. This is not a general property because in other reactions, which follow equation I (1) the energies and entropies of activation are different for different reagents (2).

In table 3 the rate coefficients of the reactions of substituted thiophenoxide-ions with the 2-F-, 2-Cl-, 2-Br- and 2-I-benzothiazoles are collected.

TABLE 3

2-Halo-benzothiazoles + X-Ph-S^- in CH_3OH at 25° (10^3.k $sec^{-1} mol^{-1}$ l)

Alg =	X =	p.OCH_3	P.CH_3	H(a)	p.Cl	p.Br	m.Cl
F		76.	41.	22.	15.5	15.5	9.8
Cl		0.65	0.30	0.20	0.162	0.141	0.098
Br		1.38	0.87	0.44	0.44	0.42	0.30
I		0.72	0.275	0.14	0.13	-	0.078
σ^+ (b)		-0.778	-0.311	0.0	0.114	0.150	0.399

a) P.E.Todesco, A.Ricci, P.Vivarelli, Tetrahedron Lett. 3703 (1964).

b) L.M.Stock, H.C.Brown in V.Gold, "Advances in Physical Organic Chemistry" - Academic Press, London 1963, vol. I, pag. 89

For each leaving group the effect of substituent in thiophenoxide may be correlated with an Hammett's type relationship if the appropriate Brown's σ^+ (3) is adopted (see fig. 1). The "rho" values are negative and only minor variations are observes with different leaving groups (-0.72 ± 0.09).

The negative values of "rho" as well as the needing of the σ^+ parameters point out that the sulphur electrons of thiol compound are deeply involved in the transition state (new bond largely formed) while the almost constant value of "rho" suggest that the degrees of bond-forming does not change very much with the various leaving groups (4).

FIG. 1

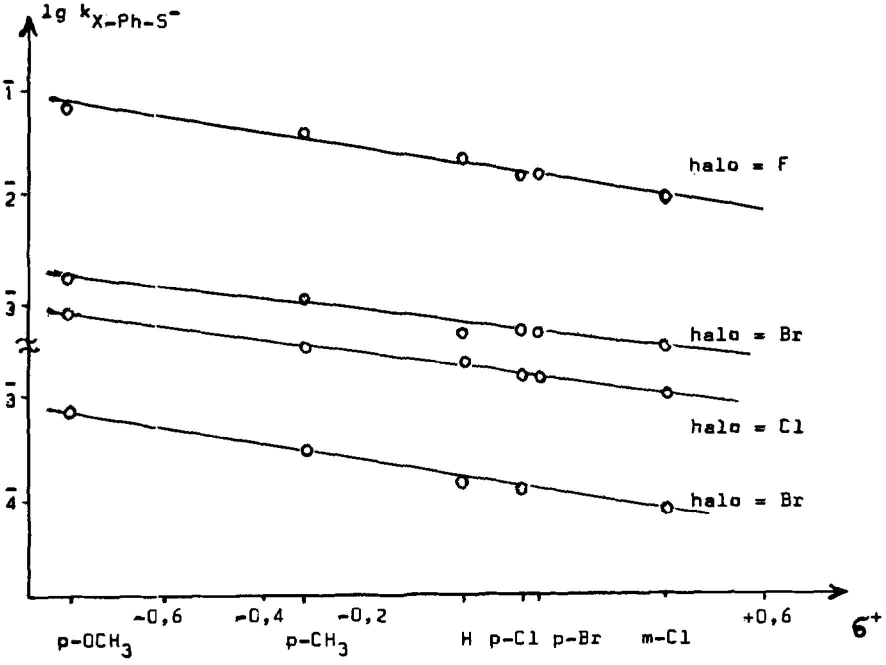

Fig. 1 - Hammett-Brown plot for reaction of substituted thiolates and 2-halo-benzothiazoles in methanol.

The empirical relation I holds also for the reactions with substituted thio-phenoxides (see fig. 2).

FIG. 2

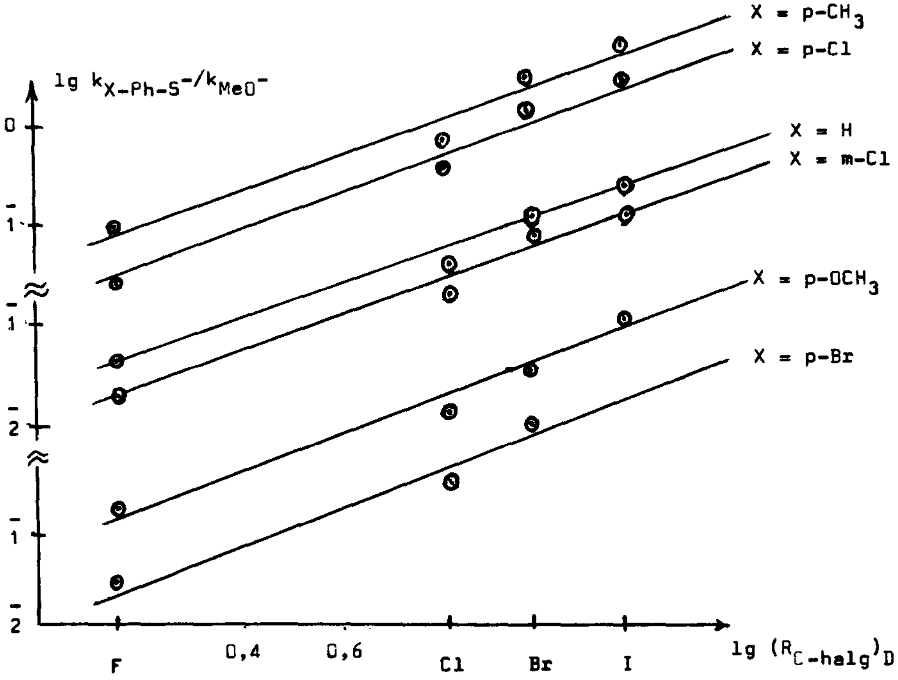

Fig. 2 - Plot of $\log.k_{X-Ph-S^-}/k_{MeO^-}$ versus the polarizabilities of leaving halogens as measured by the logaritms of the refractivity constants $(R)_D$ of the C-halogen bond (5).

The coefficient B of the relation I does not changed significantly varying the ring-substituent in the thiophenoxide-ion; this means that the sensibility of the reactions here studied with respect to the polarisability factors is not greatly affected by a change in the density of charge at the nucleophilic center of reaction as that caused by the different ring-substituents in the thiolate.

-×- -×××- -×-

References

1) A.Ricci, P.E.Todesco, P.Vivarelli, Tetrahedron Lett. 3703 (1964); Gazz.Chim.Ital. 95, 101 (1965).

2) J.F.Bunnett, W.D.Merritt, J.Am.Chem.Soc. 79, 5967 (1957); A.L.Beckwitt, J.Miller, G.D.Leahy, J.Chem.Soc. 1952, 3552.

3) L.M.Stock, H.C.Brown in V.Gold, "Advances in Physical Organic Chemistry", Academic Press, London 1963, vol. I, pag. 35.

4) R.F.Hudson, Chemia 16, 173 (1962); R.F.Hudson, G.Klopman, J.Chem.Soc. 1962, 1066. As matter of fact a slight trend of the rho values F > Cl > Br as espected for a decreasing of bond forming in the transition state could be found: however the "rho" value for the iodo-derivatives is larger than that of the fluoro-derivatives. The little variation observed do not allow a more detailed discussion at this stage of the research.

5) J.Partington, "An Advanced Treatise of Physical Chemistry", Longmans Gree and Co. London 1953, vol. IV, pag. 71.