Elimination and Addition Reactions. Part XIX.[1] Elimination of Phenoxide from β-Substituted Ethyl Phenyl Ethers: the Nature of Activation in 1,2-Elimination

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In an investigation of the nature of activation in elimination reactions, rates of elimination of phenoxide under basic conditions from a series of 17 phenyl ethers of the type $X{-}CH_2{\cdot}CH_2{\cdot}OPh$ have been measured.

Second-order rate constants span a range of 10^{11} according to the nature of X. Good correlation is obtained between log $k_{\text{elimination}}$ and the parameter σ_{R-}, but not with σ or σ^*, indicating that resonance stabilisation of a carbanionic species is an important component of activation in this system.

Relative rates of elimination correlate well with relative rates of addition of oxygen and nitrogen nucleophiles to electrophilic olefins of the type $X{-}CH{:}CH_2$.

THIS is the first of a series of four related papers dealing with the kinetics and mechanisms of elimination reactions in systems of type (I). Effects of β-substituents (X) on elimination of phenoxide from β-substituted ethyl phenyl ethers are described in this paper, and in the following one evidence bearing on the mechanism of this type of reaction is described. Subsequent papers will deal with effects of substituents remote from and between the activating and leaving groups respectively.

Activation in β-Elimination.—Occurrence of 1,2-elimination under basic conditions [equation (1)] is very familiar. Considerable variation in the leaving group Z is possible although it is nearly always of the type also met in nucleophilic substitution.[2,3]

$$B{:} + X{-}\overset{\beta}{C}H_2{\cdot}\overset{\alpha}{C}H_2{-}Z \longrightarrow X{-}CH{:}CH_2 + {:}Z + BH \qquad (1)$$
$$\text{(I)}$$

Little is known of the quantitative effects of the group X on rate or mechanism. Earlier work on mechanisms of 1,2-elimination reactions has focussed mainly on (i) α- and β-alkyl substitution in simple alkyl halides;[2,3] (ii) α- and β-alkyl substitution in 'onium salts ($Z = {}^+MR_x$), chiefly with respect to factors controlling orientation;[4] (iii) the phenethyl system[5] in which much effort has been devoted to estimation of degrees of bond cleavage in transition states; (iv) stereochemistry;[6] (v) the inter-relationship of elimination and substitution and the investigation of merged mechanisms.[7] In certain reactions, elimination of groups not generally regarded as being leaving groups in substitution processes occurs. Base-catalysed dehydration of β-hydroxy-ketones and esters is well known, but in simple systems severe conditions are required for elimination of, for example, phenoxy-[8] or alkoxy-groups.[9,10] Recently more attention has been given to eliminations in which the leaving group is of a type not normally encountered in substitutions. Thus elimination of groups such as alkoxycarbonyl,[11,12] sulphinate,[13] carboxamido,[14] alkoxy,[15] and sulphimate[16] has been found to occur easily in mild conditions when the leaving group is β to a sulphonyl group.

The present work was to examine the nature of activation in β-eliminations. We investigated a system that would allow a very wide differential range of activation to be studied, realised in the β-substituted phenetoles (I; X = activating substituent; Z = phenoxy). Phenoxy is a very poor leaving group and this system has enabled examination of the range of activating substituents, X, shown in Table 1.

Methods and Results.—Reactions of the substrates (Table 1) with ethanolic sodium ethoxide were followed spectrophotometrically. The u.v. spectrum of phenoxide ion differs markedly from that of a phenyl ether rendering this method both convenient and accurate. Second-order rate constants are in Table 1 and unless otherwise stated are mean values derived from 6—12 runs. The large differences in reactivity necessitated somewhat varying procedures for different members of the series. These are explained in the Experimental section.

Products were isolated from each reaction except for those with substrates (Ir) and (Is) for which no elimination of phenol could be detected. In substrates (It) and (In) elimination of phenoxide did not occur; instead,

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TABLE 1

Rate constants and yields of products obtained in reactions of phenyl ethers $X–CH_2\cdot CH_2\cdot OPh$ with ethanolic sodium ethoxide

	X	$k_{elimination}$ [a]	Yield [b] of $X–CH_2\cdot CH_2\cdot OEt$ (%)	Yield [b] of phenol (%)
(Ia)	NO_2	$1\cdot5 \times 10^3$ [c]	99 [d]	91
(Ib)	$^+PPh_3$ [e]	6×10^3 [c]	84	99
(Ic)	$^+SMe_2$ [f]	$1\cdot95 \times 10^2$	85	97
(Id)	CO·Me	$3\cdot15 \times 10$	63, 95 [g]	92
(Ie)	CHO	$2\cdot63 \times 10$	*h*	93 [i]
(If)	SO_2OEt	$7\cdot28 \times 10^{-1}$	*j*	89, 96 [i]
(Ig)	SO_2Ph	$3\cdot49 \times 10^{-1}$	99	91, 100 [i]
(Ih)	SO_2Me	$1\cdot45 \times 10^{-1}$	92	94
(Ii)	CN	$9\cdot44 \times 10^{-2}$	87	95
(Ij)	CO_2Et	$6\cdot05 \times 10^{-2}$	19, 104 [k]	95,[k] 100 [i]
(Ik)	$SO_2N(CH_2Ph)_2$	$1\cdot60 \times 10^{-2}$	99	96, 100 [i]
(Il)	SOPh	$1\cdot19 \times 10^{-3}$	99	85
(Im)	$CONH_2$	$1\cdot13 \times 10^{-3}$	34, 95 [k]	98 [k]
(In)	SOMe	$4\cdot27 \times 10^{-4}$	91	105 [l]
(Io)	$CONEt_2$	$2\cdot56 \times 10^{-4}$	98	97
(Ip)	$^+NMe_3$ [e]	$3\cdot07 \times 10^{-7}$	*m*	88
(Iq)	CO_2^-	$6\cdot97 \times 10^{-8}$ [r]	91 [n]	94, 92 [k]
(Ir)	Ph	*o*	—	0
(Is)	NMe_2	*o*	—	0
(It)	$CH_2\cdot{}^+SMe_2$ [f]	—	*p*	0
(Iu)	$CH_2\cdot{}^+NMe_3$ [e]	—	*q*	0

[a] Elimination rate constant (l. mole^{-1} sec.$^{-1}$). [b] Directly isolated. [c] Value estimated from reactions in $^-OH–H_2O$, following paper. [d] Yield of 2-piperidino-1-nitroethane hydrochloride. [e] Counter ion : bromide. [f] Counter ion : iodide. [g] Yield of 4-piperidinobutan-2-one. [h] Not isolated. [i] Estimated by u.v. spectroscopy. [j] Yield 97% but impure: see Experimental section. [k] Estimated by v.p.c. [l] Contaminated with 2-ethoxyethyl methyl sulphoxide: see Experimental section. [m] See Experimental section for details. [n] As ethyl ester estimated by v.p.c. [o] No detectable phenol. [p] 55% Methyl 3-phenoxypropyl sulphide and 45% allyl phenyl ether. [q] Allyl phenyl ether (69%) isolated. [r] Single determination.

allyl phenyl ether was produced in each case by a Hofmann-type reaction together with dimethyl sulphide and trimethylamine respectively. Some methyl γ-phenoxypropyl sulphide was also obtained from substrate (It). Dealkylation of sulphonium salts in this type of process is faster [17] than that of ammonium salts.

In reactions with the other substrates (Table 1) phenol was either isolated directly or estimated by v.p.c. or u.v. spectrophotometry. In most cases, the complementary product was the β-ethoxyethyl compound which results from nucleophilic addition of ethoxide ion to the electrophilic olefin (II) produced by elimination [reaction (2)]. In certain cases, particularly with the

$$\begin{array}{lll} & \xrightarrow{\text{EtO}^-/\text{EtOH}} \text{X–CH}_2\text{CH}_2\cdot\text{OEt} \quad \text{(III)} & (2) \\ \text{X–CH:CH}_2 & & \\ & \xrightarrow{\text{piperidine}} \text{X–CH}_2\cdot\text{CH}_2\cdot\text{NC}_5\text{H}_{10} \quad \text{(IV)} & (3) \\ \quad\text{(II)} & & \end{array}$$

highly reactive substrates (Ia) and (Id), the β-ethoxy-compound was not readily isolated; this was probably due to the reversibility of ether formation [15,18] and easy polymerisation of nitroethylene [19] and methyl vinyl ketone [20] respectively. In these instances, addition of piperidine traps the olefin as the β-piperidino-adduct [reaction (3)] from which regeneration of the olefin occurs less readily.

In the phosphonium (Ib) and sulphonium (Ic) salts, elimination of the activating group in a Hofmann reaction is possible.[3,4] This pathway is ruled out, however, by the isolation, in each case, of the β-ethoxy-compound and phenol in nearly quantitative yields. For the quaternary ammonium derivative (Ip), attempts to isolate the olefin (neurine) proved futile owing to extensive dealkylation. Neurine bromide and 2-phenoxyethyltrimethylammonium bromide (Ip), however, behaved in a qualitatively similar way.

It was essential to prove that the observed reactions were eliminations; formation of phenol and β-ethoxy-derivative is also consistent with direct substitution. Proof was obtained by use of the procedure previously employed.[13] Two substrates, 2-phenoxyethyl *p*-tolyl sulphone and the nitrile (Ii) whose reactivities (that of the sulphone is in the following paper) lie in the middle of the observed range, were found not to react with piperidine in ethanol. When, however, sodium ethoxide was added, the piperidino-adduct (IV) was produced and it was also shown that piperidine did not react with the β-ethoxy-compound (III) but did so readily with the olefin (II) to give piperidino-compound. Addition of the olefin to a solution of piperidine in ethanolic sodium ethoxide gave only the piperidino-derivative.

Preparation of Materials.—Reaction of 2-phenoxyethyl bromide with silver nitrite gave the nitro-compound (Ia) and with triethylamine, the quaternary salt (Ip). The same bromide with methane- and benzene-thiols under basic conditions gave the respective sulphides which on oxidation gave the sulphoxides (In) and (Il) and the sulphones (Ih) and (Ig). 1-Methylthio-2-phenoxypropane with methyl iodide gave the sulphonium salt (Ic). Similar procedures gave the 'onium salts (It) and (Iu).

2-Phenoxyethyl bromide was converted into 2-phenoxyethanesulphonyl chloride by successive treatment with sodium sulphite and phosphorus pentachloride. Treatment of the chloride with sodium ethoxide [21] gave the ester (If) and with dibenzylamine the dibenzylamide (Ik) of 2-phenoxyethanesulphonic acid.

The nitrile (Ii) was obtained by cyanoethylation of phenol and subsequent ethanolysis gave the ester (Ij). Hydrolysis of the nitrile gave the acid (Iq), which was converted into the amides (Im) and (Io).

Addition of phenol to methyl vinyl ketone gave the ketone (Id); the aldehyde (Ie) was obtained by oxidation of 3-phenoxypropanol by the dimethyl sulphoxide–dicyclohexylcarbodi-imide [22] procedure.

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DISCUSSION

β-Elimination of phenoxide ion had been previously observed in a number of systems. Moderate basic conditions suffice when the activating group is sulphonyl,[15] alkoxycarbonyl,[18] and amido [23] and β-phenoxyethylsulphonium salts [24] are notably unstable to base. An elimination–addition sequence is clearly probable in the closely related reactions involving transcyanoethylation [18] of alcohols, indicating that cyano is a strongly activating substituent. Elimination of phenol from β-phenoxyethylphosphonium salts occurs [25] in the absence of base, indicating a very labile system.

Evidence that the reactions examined in the present work are eliminations has been presented. In only one instance to our knowledge has phenoxide been represented [26] as the leaving group in a nucleophilic displacement at carbon, and this occurs intramolecularly in a structurally very specific system. Further, the great sensitivity of reaction rate to the nature of the β-substituent is consistent with elimination (involving the β-carbon atom) rather than with displacement (at the α-carbon atom) which is much less sensitive [27] to the effects of distant groups.

Activation.—The range of reactivity shown in Table 1, spanning at least 11 orders of magnitude between fastest and slowest reactions, is remarkable. Values of rate constants listed for the nitro- and phosphonium compounds are estimates from reactions carried out in water (following paper) taking into account the effects of this change of solvent on neutral and charged substrates respectively.

In the following paper, evidence which strongly supports the assignment of the pre-equilibrium *E*1c*B* mechanism [28,29] to these reactions is presented. On this basis the high reactivity of the nitro-compound (Ia) matches the relatively high dissociation constant of the adjacent C–H bond.[30] The very much larger rate constants obtained for the phosphonium (Ig) and sulphonium (Ic) salts than for the ammonium salt (Ip) can be understood in terms of the differential resonance stabilisation of the carbanionic intermediate. p_π–d_π-Delocalisation is possible for the second row elements but cannot be significant for the ammonium salt [31,32] in which valency-shell expansion of nitrogen is a process of considerably greater energy. This observation makes an interesting comparison with the widely held view [33] that in the Hofmann elimination, acidification of the C–H bond β to the quaternary group is a significant factor in promoting the reaction.

In this connection, much controversy has been generated [4] over the question of steric *versus* electronic control of orientation of elimination. It was conceivable that the very low reactivity of the ammonium salt was due to an adverse steric effect on removal of the β-proton and the reactivity of the homologue (Iu) was therefore examined. The result of this structural change was that elimination occurred in the opposite direction giving the Hofmann products, trimethylamine and allyl phenyl ether. A corresponding reaction occurs with the sulphonium analogue (It) showing that the rate of elimination of phenoxide is reduced by a factor of about 10^{10}. This emphasises the importance of the resonance contribution to activation by the dimethylsulphonium group. The failure of the amine (Is) to give phenol on long contact with ethanolic sodium ethoxide shows that dealkylation followed by elimination can be ruled out as a pathway for formation of phenol from the quaternary ammonium salt (Ip).

The high reactivity observed for the sulphonium and phosphonium salts relative to the ammonium salt is entirely consistent with data [34] on relative rates of base-catalysed deuterium hydrogen exchange in methyl 'onium salts.

Recently, Oae and Yano [35] have shown that rates of elimination in simple alkyl chlorides are very much more rapid when an arylthio-substituent is situated β to the leaving group than when an aryloxy- or benzyl group is in this position. This phenomenon had been noted qualitatively [36] and is clearly consistent with the present observations.

In accordance with the view that activation in this system is connected with stabilisation of a carbanionic species (whether intermediate or transition state), the phenyl sulphone (Ig) is slightly more reactive than the methyl sulphone (Ih) and these are both more reactive than the sulphonamide (Ik), in which the electronic demands of the sulphonyl group are partially met by the electron-pair on the adjacent nitrogen atom, and the sulphoxides (Il) and (In). Likewise the aldehyde (Ie) and ketone (Id) are more reactive than the ester (Ij) which in turn is much more reactive than the amides (Im) and (Io). The reactivity ratio of these amides shows that the unsubstituted amide (Im) is not substantially ionised since the form with two pairs of unshared electrons on the adjacent nitrogen atom would certainly have a lower reactivity than the diethylamide. This effect is clearly shown in the comparison between the carboxylate (Iq) and the ester (Ij) in which the latter is a million times more reactive than the former.

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The sulphonate (If) is more reactive than the sulphones (Ig) and (Ih). This is in accord with a carbanionic transition state for elimination as it has been shown [37] that α-methylene groups in sulphonates are more acidic than those in sulphones.

The only serious discrepancy between the quantitative data reported here and earlier qualitative data is the report [18] that carboxamido is a better activating group than alkoxycarbonyl in 1,2-elimination under basic conditions.

Correlation of Rate Data.—We have attempted to relate the differential effects of the substituents examined in the present system with the effects of the same substituents in other systems and thereby to draw conclusions as to the nature of activation in this system.

The possibility that the predominant component of activation by a substituent is its inductive capacity may be quickly disposed of. Figure 1 shows the plot of log $k_{\text{elimination}}$ against the Taft parameter [38] σ^*. No correlation exists between the present rate data and the σ^* values of substituents which measure their inductive effects. The highest σ^* value is shown by $^+NMe_3$ which has one of the lowest measured effects on elimination rate.

Hammett σ values [39] give a measure of the combined inductive and mesomeric effects of substituents. Values of σ for *para*-substituents comprise a greater component of the mesomeric effect of the substituent, and in a reaction series in which the reaction site is conjugatively linked with the *para*-substituent, modified values of σ can be used to take account of this situation. As the carbanionic nature of the elimination reaction is clear, correlation of the rate data with values of σ_p^- has been examined (Figure 1). Again an unsatisfactory correlation obtains.

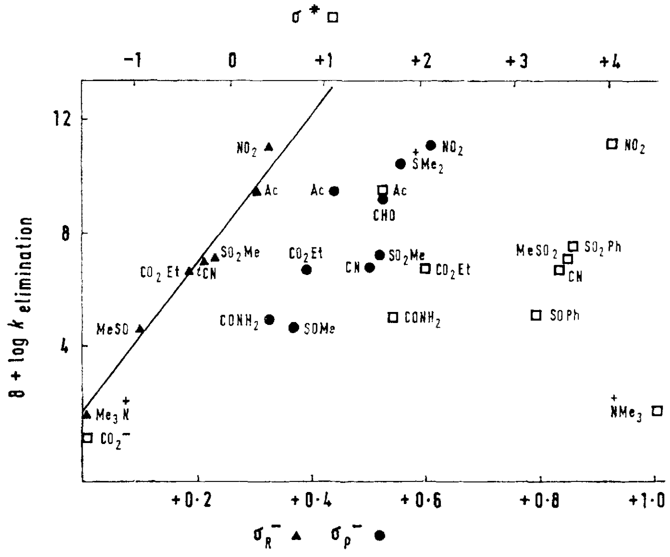

FIGURE 1 Plots of log k_e against σ^* (□), σ_p^- (●), and σ_R^- (▲)

This finding prompted us to inspect correlation with a parameter, σ_R^-,[40] derived from values of σ_p^- by subtraction of the inductive component, σ_I, itself derived from σ^* values. The parameter σ_R^- gives a measure of the 'purely' mesomeric interaction of a substituent with a carbanionic centre. The success of this correlation is clearly shown in Figure 1, and shows that a substituent which powerfully activates elimination in this system is one which is capable of mesomeric stabilisation of a carbanion.

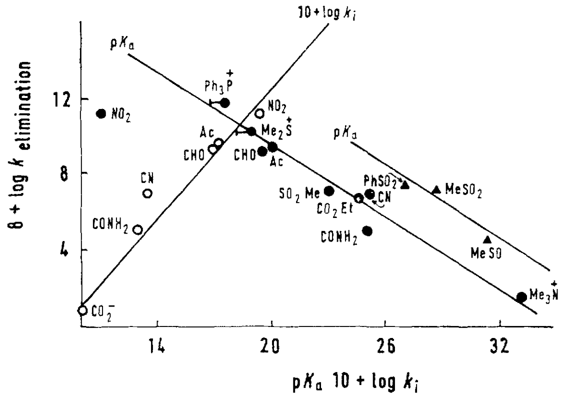

FIGURE 2 Plots of log k_e against pK_a and pk_i of acids, X–CH_3. ▲ pK_a data from measurements in dimethyl sulphoxide [see Table 2 of F. G. Bordwell, R. H. Imes, and E. C. Steiner, *J. Amer. Chem. Soc.*, 1967, **89**, 3905); ● pK_a; ○ 10 + log k_i

Two further correlations have been examined. The carbanionic nature of the elimination suggested that there should be a connection between elimination rate and the acidities (4) of compounds of the type X–CH_3.

$$X\text{–}CH_3 + H_2O \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} X\text{–}CH_2^- + H_3O^+ \quad (4)$$
$$K_a$$

There is a rough rectilinear correlation [41] between log k_i and pK_a for carbon acids in the pK_a range 5—20 although there are some striking exceptions. Plots of log $k_{\text{elimination}}$ against pK_a and log k_i are in Figure 2 (data are in Table 2). The scattered nature of the data being taken into account, the correlations are good and consistent not only with the log k_e–σ_R^- relationship but also with the compelling evidence, presented in the following paper, that elimination occurs in this system by the *E*1c*B* mechanism.

Two sets of quantitative data have recently been reported for reactions which are the reverse of those considered here, namely nucleophilic addition to electrophilic olefins. Ring [42] and his collaborators have studied addition of alkoxides to a series of vinyl com-

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TABLE 2

Kinetic and thermodynamic acidities of CH_3–X compounds

X	k_1 [a,b]	pK_a	Ref.
NO_2	2×10^3	11	*c*
Ph_3P^+	—	17·5 [d]	—
Me_2S^+	—	18·9 [d]	—
MeCO	14·5	20	*c*
CHO	11	19·7	*e*
$PhSO_2$	—	27	*f*
$MeSO_2$	—	28·5 (23)	*f* (*c*)
CN	$2{\cdot}5 \times 10^{-3}$	25	*c*
CO_2Et	—	24·5	*g*
$CONH_2$	1×10^{-3}	25	*g*
MeSO	—	31·3	*h*
Me_3N^+	—	33	*i*
CO_2^-	1×10^{-6}	—	—

[a] Units, min.$^{-1}$. [b] Exchange rate constants for $^-$OD–D_2O: K. F. Bonhoeffer, K. H. Geib, and O. Reitz, *J. Chem. Phys.*, 1939, **7**, 665. [c] A. Streitwieser and J. H. Ammons, 'Progress in Physical Organic Chemistry,' Interscience, New York, 1967, vol. 3, p. 41. [d] G. Aksnes and J. Songstad, *Acta Chem. Scand.*, 1964, **18**, 655 have measured pK_a values (water at 25°) as follows: $Me_3P^+\cdot CH_2\cdot CH_2\cdot COPh = 9{\cdot}2$; $Me_2PhP^+\cdot CH_2\cdot CO\cdot Ph = 8{\cdot}45$, $MePh_2P^+\cdot CH_2\cdot COPh = 7{\cdot}65$, and $Me_2S^+CH_2\cdot COPh = 8{\cdot}25$. Assuming that a third phenyl group on phosphorus lowers the pK_a of the ketone by the same decrement, the pK_a of $Ph_3P^+\cdot CH_2\cdot COPh$ is calculated to be 6·85. The pK_a of acetone is 20 and that of benzoylacetone 9·4 (ref. *c*). These considerations lead to the pK_a values for $Ph_3P^+\cdot Me$ and Me_3S^+ shown. The pK_a data presented in this Table all refer to water whilst the elimination rate constants were measured in ethanol. This means that, to effect a correlation, all pK_a values must be similarly affected on transferring from water to ethanol. Aksnes and Songstad have also presented evidence that this is not the case for phosphonium and sulphonium salts and that, in contrast to the usual rise in pK_a on going to ethanol, the values for these salts are slightly lower (perhaps by 0·75 pK_a unit). Hence the phosphonium and sulphonium points in the pK_a correlation (Figure 2) will be a few units lower down the pK_a scale, relative to the other substrates, than the positions indicated. [e] R. P. Bell, *Trans. Faraday Soc.*, 1943, **39**, 253. [f] F. G. Bordwell, R. H. Imes, and E. C. Steiner, *J. Amer. Chem. Soc.*, 1967, **89**, 3905. [g] R. G. Pearson and R. L. Dillon, *J. Amer. Chem. Soc.*, 1953, **75**, 2439. [h] D. J. Cram, 'Fundamentals of Carbanion Chemistry,' Academic Press, New York, 1965, p. 43. [i] Ref. *h*, p. 56.

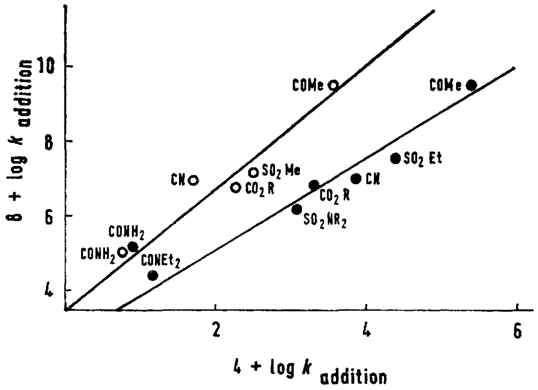

FIGURE 3 Plots of log k_e against log k_{addition} (○, data of Friedman and Wall) (●, data of Ring *et al.*)

pounds, X–CH=CH_2, and Friedman and Wall[43] have measured rates for similar activated ethylenes with amino-acids. Plots of log $k_{\text{elimination}}$ against log k_{addition} for each system are in Figure 3. All comparable data available is included. The good correlation emphasises that similar factors control each reaction and is in accord with elimination and not substitution in the present system. The carbanionic nature of the transition state for the addition of amines to olefins has been pointed out[44] and this provides further evidence for a carbanionic transition state in elimination of phenoxide ion from β-substituted ethyl phenyl ethers.

EXPERIMENTAL

General.—Unless otherwise stated light petroleum had b.p. 40—60°. Extracts were dried over Na_2SO_4. Ethanol was purified by the magnesium–iodine method[45] and contained 320 mg. l.$^{-1}$ of water (Karl Fischer). Solutions of sodium ethoxide were prepared by addition of clean sodium to an appropriate volume of dry ethanol. They were standardised against standard hydrochloric acid at 25°. Extractions were with dichloromethane unless otherwise stated.

Kinetics.—Reactions were followed spectrophotometrically, the difference in the u.v. spectrum of phenoxide ion and a phenyl ether being used. The Unicam SP 800 spectrophotometer fitted with a scale expander, constant wavelength scanner, and an external recorder was used. A Hamilton syringe fitted with a Chaney adapter was used for injection of small volumes of reactants.

The cell-block of the spectrophotometer was thermostatted by circulated water and the temperature (25·40° ± 0·05°) of the cell contents was measured with a calibrated thermistor. Change in intensity of the 291 nm. maximum of the phenoxide ion spectrum was usually used for following reactions but with low substrate concentrations (fast reactions) the 239 nm. band was used because of its greater $\varepsilon_{\max}$.

In all cases, substrate concentrations were *ca.* 10^{-4}—10^{-3}M. For reactions with $t_{\frac{1}{2}} > 30$ min. cells were filled with equal volumes of thermostatted solutions of ethoxide and substrate. For $t_{\frac{1}{2}} < 30$ min. the solution of substrate was allowed to attain equilibrium in the cell and the appropriate small volume of (thermostatted) concentrated ethoxide solution was added. Very slow reactions ($k < 10^{-6}$ l. mole^{-1} sec.$^{-1}$) were followed by measurement of the intensity of the 291 nm. band at intervals of 2—4 weeks.

In all cases the concentration of each reactant was varied independently of the other to establish that the reactions were of the second order (first order in substrate and first order in base). In some cases it was convenient to use a large excess of base; pseudo-unimolecular rate constants thus obtained were then divided by the base concentration used.

1-*Nitro*-2-*phenoxyethane* (Ia).—1-Bromo-2-phenoxyethane[46] (40·2 g.) in anhydrous ether (20 ml.) was added dropwise with stirring during 2 hr. to silver nitrite (0·26 mol.) suspended in anhydrous ether (35 ml.) at 0° in the dark. The mixture was stirred at 0° (24 hr.) and then at 20° (21 days). Filtration and evaporation of the filtrate gave a residue which, on distillation, gave a semi-solid (17·25 g.), b.p. 99°/0·3 mm. Recrystallisation from ethanol–light

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petroleum (b.p. 30—40°) gave the *nitro-compound* (19%), m.p. 41—41·5° (Found: C, 57·5; H, 5·3. $C_8H_9NO_3$ requires 57·5; H, 5·4%).

The nitro-compound (2·505 g.) was added to ethanolic 0·8N-sodium ethoxide (50 ml., 2·7 mol.) containing piperidine (8·5 g., 6·7 mol.). After being kept at 20° for 30 min., the mixture was poured into saturated brine (200 ml.), and excess of piperidine was extracted with dichloromethane. The solution was then acidified (HCl) and extracted. Distillation of the organic extracts gave phenol (91·1%) m.p. and mixed m.p. 39—40°. The aqueous extracts were evaporated to dryness and the residue was extracted with hot ethanol. Evaporation of these extracts gave 1-*nitro*-2-*piperidinoethane hydrochloride* (2·875 g., 98·7%), m.p. 141—142° (decomp.) (from ethanol–ether) (Found: C, 43·2; H, 7·4; Cl, 18·4; N, 14·3. $C_7H_{15}ClN_2O_2$ requires C, 43·2; H, 7·8; Cl, 18·2; N, 14·4%).

2-*Phenoxyethyltriphenylphosphonium Bromide* (Ib).—The salt, prepared from triphenylphosphine and 1-bromo-2-phenoxyethane by Schweizer and Bach's [25] procedure, had m.p. 161—163° (lit.,[25] m.p. 161—163°). It (3·472 g.) was added to ethanolic 0·2N-sodium ethoxide (50 ml., 1·3 mol.) and the mixture, after being set aside for 40 min. at 20° was neutralised with ethanolic hydrogen bromide. The mixture was evaporated at 20°/10 mm. and the residue was washed with anhydrous ether. Evaporation of the washings gave phenol (0·598 g., 98·8%) m.p. and mixed m.p. 36—37°. The residue was then extracted with chloroform and addition of ether to the extracts precipitated 2-ethoxyethyltriphenylphosphonium bromide (83·6%), m.p. 185·5—186·5° (from chloroform–ether) (lit.,[25] m.p. 178—181°), ^{1}H n.m.r. τ 1·4—2·3(m); 5·5—5·8(m); 6·6(q); 9·13(t) with integrals in the ratio 15 : 4 : 2 : 3.

Dimethyl-2-*phenoxyethylsulphonium Iodide* (Ic).—The salt [24] (1·55 g.) was added to ethanolic 0·1N-sodium ethoxide (50 ml., 1 mol.), and after 1 hr. at 20° the solution was neutralised with freshly prepared ethanolic hydrogen iodide. Anhydrous ether (600 ml.) was added and the precipitated salts were filtered off and extracted with chloroform. The chloroform extracts were evaporated and addition of ether to the residue gave dimethyl 2-ethoxyethylsulphonium iodide (85%), m.p. 60—62° (from ethanol-ether) (lit.,[47] m.p. 62°). Distillation of the original ethereal filtrates gave phenol (96·6%), m.p. and mixed m.p. 39—40°.

1-*Phenoxybutan*-3-*one* (Id).—Phenol (70·5 g.), methyl vinyl ketone (1·5 mol.), and pyridine (0·45 ml.) were heated under reflux for 6 hr. Acetic acid (0·35 ml.) was added and the mixture was fractionally distilled. The fraction, b.p. 130—133°/9 mm., n_D^{25} 1·5097 was refractionated to give the ketone (10·5 g.), n_D^{25} 1·5107, ^{1}H n.m.r.: τ 2·5—3·2(m); 5·85(t); 7·25(t); 7·93(s) with integrals in the ratio 5 : 2 : 2 : 3 (lit.,[48] b.p. 123—124°/8 mm., n_D^{20} 1·5165), 2,4-dinitrophenylhydrazone, m.p. 143—144° (from ethanol) (lit.,[48] m.p. 143—144°).

The ketone (2·381 g.) was added to ethanolic 0·5N-sodium ethoxide (80 ml., 2·8 mol.) containing piperidine (7 mol.). The mixture was allowed to stand for 1 hr. at 20° and then poured into 1% aqueous sodium hydroxide saturated with sodium chloride. Extraction with dichloromethane gave 4-piperidinobutan-2-one (63·4%), b.p. 92°/20 mm.; n_D^{24} 1·4630, picrate, m.p. 108—109° (from ethanol) (lit.,[49] b.p. 90°/7 mm., n_D^{25} 1·4628; lit.,[50] m.p. of picrate, 108°).

The aqueous layer was acidified (HCl) and extraction gave phenol 91·8%), m.p. and mixed m.p. 38—40°.

In a second experiment, the dichloromethane extracts of the basic solution were evaporated at 20° and treated with ethanolic hydrogen chloride. Precipitation with ether gave the hydrochloride of 4-piperidinobutan-2-one (98·5%), m.p. 163—165° raised to 167—169° (95%) alone or mixed with an authentic specimen.

An authentic specimen of the piperidino-ketone was obtained by cautious treatment of methyl vinyl ketone at 0° with piperidine (1 mol.). Distillation of the mixture gave the ketone (33%), b.p. 91°/12 mm., n_D^{25} 1·4630, which, on treatment with ethereal hydrogen chloride, gave the hydrochloride (95%), m.p. 172—174° (from ethanol) (lit.,[51] m.p. 167°).

3-*Phenoxypropanal* (Ie).—3-Phenoxypropanol [52] (7·6 g.) was dissolved in a mixture of anhydrous dimethyl sulphoxide (35 ml.) benzene (35 ml.), pyridine (5 ml.), and trifluoroacetic acid (2·5 ml.). Dicyclohexylcarbodi-imide [22] (30·9 g., 3 mol.) was added and, after 16 hr. at 20°, the mixture was treated with dichloromethane (400 ml.) and a solution of oxalic acid (3 mol.) in methanol (75 ml.). When evolution of gas was complete, water (500 ml.) was added and dicyclohexylurea was filtered off. The organic layer was separated and washed with aqueous 5% sodium hydrogen carbonate. Evaporation and distillation gave the crude aldehyde (28%), b.p. 75°/0·1 mm., which was converted into the semicarbazone (51%), m.p. 156·5—157° (from ethanol) (lit.,[53] m.p. 161°). The semicarbazone (2 g.) and aqueous 28% formaldehyde (22 ml.), acidified with 2N-hydrochloric acid (21 ml.), were stirred for 1 hr. Extraction and evaporation of the extracts gave a residue which on distillation and redistillation gave the aldehyde (370 mg.), b.p. 63°/0·3 mm., n_D^{25} 1·5170 (lit.,[53] b.p. 93—95°/1·5 mm., n_D^{25} 1·5238).

Owing to the difficulty of obtaining this substrate, products were not isolated. The yield of phenol was estimated by u.v. spectrophotometry.

Ethyl 2-Phenoxyethanesulphonate (If).—1-Bromo-2-phenoxyethane (100·5 g.) was vigorously stirred under reflux with sodium sulphite (63 g., 1 mol.) in water (230 ml.) for 3·5 hr. The mixture was cooled to 25—30° and the precipitate of sodium 2-phenoxyethanesulphonate (71%) was filtered off, washed with ether, dried, and stirred with phosphorus pentachloride (0·4 mol.) at 100—125° for 34 hr. The cold mixture was poured on crushed ice and filtered. Extraction of the residue with hot light petroleum gave 2-phenoxyethanesulphonyl chloride (64%), m.p. 39—40° (from light petroleum) (lit.,[54] m.p. 39—42°).

The chloride (8·373 g.) in tetrahydrofuran (75 ml.) was treated with ethanolic 0·728N-sodium ethoxide (50 ml., 1 mol.). After being set aside at 20° for 2 hr. the mixture was poured into water and extraction gave the *ester* (72·5%), b.p. 122°/0·2 mm., n_D^{25} 1·5122 (Found: C, 52·0; H, 6·0. $C_{10}H_{14}O_4S$ requires C, 52·1; H, 6·1%).

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The ester (3·98 g.) was added to ethanolic 0·087N-sodium ethoxide (200 ml., 1·01 mol.) at 20° and after 2 hr. the mixture was added to 4% aqueous sodium hydroxide saturated with sodium chloride. Extraction gave a residue which on distillation gave three fractions: (i) 1·15 g., b.p. 120—121°/9 mm., n_D^{24} 1·4380; (ii) (1·42 g.), b.p. 122—123°/9 mm., n_D^{24} 1·4323; (iii) (0·47 g.), b.p. 123°/9 mm., n_D^{24} 1·4398. The total yield, taking the product as pure ethyl 2-ethoxyethanesulphonate, is 97% but the refractive indices suggest that two minor components are present, and the i.r. spectrum of fraction (iii) indicated olefin (arising possibly from thermal elimination). Redistillation of fraction (ii) gave the *ester*, b.p. 122—123°/8 mm., n_D^{25} 1·4317 (Found: C, 40·0; H, 7·3; S, 17·7. $C_6H_{14}O_4S$ requires C, 39·5; H, 7·7; S, 17·7%).

The aqueous phase was acidified (HCl) and extraction gave phenol (89%), m.p. and mixed m.p. 39—40°.

2-*Phenoxyethyl Phenyl Sulphone* (Ig).—Thiophenol (11·02 g.) and 1-bromo-2-phenoxyethane (1 mol.) were added successively to ethanolic N-sodium ethoxide (96 ml.). The mixture was heated under reflux for 1 hr. and poured into brine. Extraction gave 2-phenoxyethyl phenyl sulphide (83%), m.p. 64—66° (from ethanol) (lit.,[55] m.p. 65—67°). Oxidation with hydrogen peroxide in acetic acid gave the sulphone (94%), m.p. 123—124·5° (from ethanol) (lit.,[56] m.p. 120°) (Found: C, 64·0; H, 5·2. Calc. for $C_{14}H_{14}O_3S$: C, 64·1; H, 5·4%).

The sulphone (2·333 g.) was added to ethanolic 0·7N-sodium ethoxide (50 ml., 4 mol.) and the mixture was set aside at 20° for 48 hr. Working up of the mixture as for the previous compound gave 2-*ethoxyethyl phenyl sulphone* (99%), b.p. 110°/0·1 mm., n_D^{20} 1·5219 (Found: C, 56·0; H, 6·8. $C_{10}H_{14}O_3S$ requires C, 56·0; H, 6·6%), and phenol (91·1%), m.p. and mixed m.p. 38—40°.

Methyl 2-Phenoxyethyl Sulphone (Ih).—Oxidation of the sulphide [24] with hydrogen peroxide in acetic acid gave the sulphone (50·5%), m.p. 119—121° (from ethanol) (lit.,[56] m.p. 120—120·5°).

Treatment of the sulphone with ethanolic sodium ethoxide as in the preceding experiment gave 2-*ethoxyethyl methyl sulphone* (91·5%), b.p. 160°/31 mm., n_D^{28} 1·4466 (Found: C, 39·6; H, 8·4. $C_5H_{12}O_3S$ requires C, 39·4; H, 8·0%), and phenol (93·5%), m.p. and mixed m.p. 39—40°.

2-*Phenoxyethyl Cyanide* (Ii).—(*a*) The nitrile, m.p. 57—58° (lit.,[57] m.p. 59°) (3·662 g.) was heated under reflux with ethanolic N-sodium ethoxide (50 ml., 1·5 mol.) for 90 min. Working up as before gave 2-ethoxyethyl cyanide (87%), b.p. 58°/9 mm., n_D^{25} 1·4066) (lit.,[58] b.p. 65°/10 mm.; lit.,[59] n_D^{20} 1·4068) (Found: C, 60·3; H, 9·2. Calc. for C_5H_9NO: C, 60·6; H, 9·2%), and phenol (95%), m.p. and mixed m.p. 39—39·5°.

(*b*) The nitrile (3·24 g.) was treated with piperidine (2·8 mol.) in ethanolic 1·13N-sodium ethoxide (50 ml., 2·7 mol.) at 20°. After 16 hr., working up as before gave 2-piperidinoethyl cyanide (61·4%), b.p. 108°/15 mm., n_D^{25} 1·4673 (lit.,[60] b.p. 105°/11 mm., n_D^{20} 1·4692), methiodide, m.p. 155·5—156° (decomp.) (from ethanol) (lit.,[60] m.p. 158°).

(*c*) Acrylonitrile (1·59 g.) in ethanol (25 ml.) was added to ethanolic 2·32N-sodium ethoxide (25 ml., 19 mol.) containing piperidine (3 mol.). After 16 hr., working up as before gave 2-piperidinoethyl cyanide (87%).

2-Phenoxyethyl cyanide and 2-ethoxyethyl cyanide were recovered (98 and 81·5% respectively) after treatment with ethanolic piperidine.

2-*Phenoxyethyl* p-*Tolyl Sulphone*.—(*a*) The sulphone [13] (2·971 g.) was treated with ethanolic 0·695N-sodium ethoxide (50 ml., 3·3 mol.) and the mixture was heated under reflux for 1 hr. Working up as before gave 2-ethoxyethyl *p*-tolyl sulphone (99%), b.p. 124°/0·1 mm., n_D^{25} 1·5209 (lit.,[13] b.p. 135°/0·05 mm., n_D^{20} 1·5218) (i.r. spectrum identical with that of an authentic specimen [13]), and phenol (92·4%), m.p. and mixed m.p. 38·5—39·5°.

(*b*) The previous experiment was repeated except that piperidine (7 mol.) was added. Extraction of the basic solution as before and evaporation of the extracts gave a residue, which on treatment with ethereal hydrogen chloride gave 2-piperidinoethyl *p*-tolyl sulphone hydrochloride (91·7%), m.p. 218—221° alone or mixed with an authentic specimen.[11]

It has been shown [13] that *p*-tolyl vinyl sulphone, on treatment with equimolecular proportions of piperidine and sodium ethoxide in ethanol, gives 2-piperidinoethyl *p*-tolyl sulphone. 2-Phenoxyethyl *p*-tolyl sulphone was recovered (95%) after treatment with ethanolic piperidine. 2-Ethoxyethyl *p*-tolyl sulphone does not react with piperidine in ethanol.[13]

Ethyl 3-*Phenoxypropionate* (Ij).—(*a*) The ester [61] (3·919 g.) was treated with ethanolic 0·21N-sodium ethoxide (200 ml., 2·1 mol.) at 20° for 30 min. The usual working up gave ethyl 3-ethoxypropionate (19%), b.p. 66°/16 mm., n_D^{23} 1·4066 (lit.,[62] b.p. 67°/17 mm., n_D^{20} 1·4070). Low recovery of ester was due to co-distillation with ethanol; v.p.c. of the mixture showed phenol (95%) and ethoxy-ester (104%).

NN-*Dibenzyl-2-phenoxyethanesulphonamide* (Ik).—2-Phenoxyethanesulphonyl chloride was slowly added to dibenzylamine (2·02 mol.) in anhydrous ether. After the vigorous reaction had subsided, the mixture was set aside at 20° for 30 min. and then poured into brine. Extraction gave the *amide* (22·3%), m.p. 59·5—60° (from ethanol) (Found: C, 68·8; H, 6·1. $C_{22}H_{24}NO_3S$ requires C, 69·2; H, 6·1%).

The sulphonamide (2·138 g.) was added to ethanolic 0·4N-sodium ethoxide (75 ml., 5·4 mol.) at 20° and after 36 hr. the mixture was neutralised with hydrochloric acid, poured into brine, and extracted. Distillation of the extracts first gave phenol (96%), m.p. and mixed m.p. 39—40°, and then *NN*-dibenzyl-2-ethoxyethanesulphonamide (99·3%), b.p. 180°/0·3 mm., n_D^{28} 1·5453 (Found: C, 65·0; H, 6·8. Calc. for $C_{18}H_{23}NO_3S$: C, 64·8; H, 7·0%) (lit.,[14] b.p. 170°/0·1 mm., n_D^{18} 1·5513).

2-*Phenoxyethyl Phenyl Sulphoxide* (Il).—2-Phenoxyethyl phenyl sulphide (5 g.) in acetic acid (20 ml.) at 0° was treated with 30% aqueous hydrogen peroxide (2·9 ml., 1 mol.) dropwise with stirring during 30 min. The mixture was stirred at 0° for 20 hr. and then at 20° for 2 hr. Addition of brine and extraction gave the *sulphoxide* (97%), m.p. 61—63° raised to 66—67° (33%) (from ethanol) (Found: C, 68·4; H, 6·0. $C_{14}H_{14}O_2S$ requires C, 68·2; H, 5·7%).

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The sulphoxide (2·854 g.) was refluxed for 1 hr. with ethanolic 0·696N-sodium ethoxide (50 ml., 3 mol.) as before to give 2-*ethoxyethyl phenyl sulphoxide* (99%), b.p. 110°/0·2 mm., n_D^{25} 1·5417 (Found: C, 60·9; H, 7·35. $C_{10}H_{14}O_2S$ requires C, 60·6; H, 7·1%) and phenol (85%), m.p. and mixed m.p. 38—40°.

Methyl 2-*Phenoxyethyl Sulphoxide* (In).—Methyl 2-phenoxyethyl sulphide was converted as described above into the *sulphoxide* (81%), m.p. 46·5—47·5° (from benzene–light petroleum) (Found: C, 58·6; H, 6·5; S, 17·6. $C_9H_{12}O_2S$ requires C, 58·7; H, 6·6; S, 17·4%). Treatment of the sulphoxide (1·844 g.) with ethanolic 0·6N-sodium ethoxide (50 ml., 3 mol.) (24 hr. at 20°) gave by the usual working up 2-*ethoxyethyl methyl sulphoxide* (90·5%), b.p. 120°/12 mm., $n_D^{24·5}$ 1·4682 (Found: C, 44·0; H, 9·1; S, 23·4. $C_5H_{12}O_2S$ requires C, 44·1; H, 8·9; S, 23·5%) and phenol (105%) contaminated with a small amount of the extremely water-soluble sulphoxide (as shown by i.r. and v.p.c.).

3-*Phenoxypropionamide* (Im).—3-Phenoxypropionic acid [63] was treated with an excess of thionyl chloride and treatment of the crude acid chloride with ethereal ammonia gave the amide (64%), m.p. 116—117° (from ether) (lit.,[23] m.p. 116—117°).

The amide (1·592 g.) was added to ethanolic 0·6N-sodium ethoxide (50 ml., 3 mol.), and after 2 hours heating under reflux the usual isolation procedure gave 3-ethoxypropionamide (34%), b.p. 155°/29 mm., ^1H n.m.r. τ 3·3(broad s); 6·2—6·7(m); 7·55(t); 8·84(t) with integrals in the ratio 2 : 4 : 2 : 3, i.r. identical with an authentic specimen prepared [m.p. 42—46° (sealed tube) (lit.,[64] m.p. 50°)] by treatment of 3-ethoxypropionyl chloride [65] with ethereal ammonia. In conflict with an earlier report [64] that this compound could be recrystallised from water, it was found to be extremely hygroscopic. Direct v.p.c. of the acidified reaction mixture showed the presence of phenol (98·2%) and 3-ethoxypropionamide (95·1%).

NN-*Diethyl*-3-*phenoxypropionamide* (Io).—Treatment of 3-phenoxypropionyl chloride with diethylamine (2 mol.) in ether gave the *amide* (84%), m.p. 50·5—51·5° (from light petroleum) (Found: C, 70·6; H, 8·8; N, 6·1. $C_{13}H_{19}NO_2$ requires C, 70·5; H, 8·7; N, 6·35%).

Treatment of the amide (2·21 g.) with ethanolic N-sodium ethoxide (50 ml., 5 mol.) as before gave NN-*diethyl*-3-*ethoxypropionamide* (97·8%), b.p. 107°/9 mm., n_D^{24} 1·4440 (Found: C, 62·2; H, 11·2; N, 8·1. $C_9H_{19}NO_2$ requires C, 62·4; H, 11·05; N, 8·1%). The i.r. spectrum was identical with that of a specimen, b.p. 108°/9 mm., n_D^{25} 1·4435, prepared in 65% yield by treatment of 3-ethoxypropionyl chloride with diethylamine in ether.

2-*Phenoxyethyltrimethylammonium Bromide* (Ip).—The salt [66] (1·3 g.) was refluxed with ethanolic N-sodium ethoxide (100 ml., 20 mol.) for 3 hr. In the usual procedure, extraction of the basic solution gave only a small amount of a black solid and extraction of the acid solution gave phenol (88%), m.p. and mixed m.p. 39—41°.

In separate experiments, the salt (1·3 g.) and neurine bromide (0·83 g.) were heated under reflux with ethanolic N-sodium ethoxide (50 ml., 33 mol.) while a stream of dry nitrogen was led through the mixtures and into ethereal methyl iodide. Identical colour changes (yellow → brown → black) occurred in each reaction mixture and the changes in the reaction with neurine preceded that in the phenoxy-compound by several minutes. After 4 hr., the crude tetramethylammonium iodide (0·145 g., m.p. 315—322° and 0·208 g., m.p. 307—312° respectively), obtained from each reaction was isolated. The i.r. spectra of the specimens were identical and showed medium-strength bands at 2790 and 1025 cm.$^{-1}$ absent from the spectrum of authentic tetramethylammonium iodide.

Sodium 3-*Phenoxypropionate* (Iq).—3-Phenoxypropionic acid (1·66 g.) was treated with ethanolic 1·335N-sodium ethoxide (60 ml., 8 mol.) containing piperidine (16 mol.). After being heated under reflux for 67 hr., the mixture was added to brine and the excess of piperidine was extracted with dichloromethane. The aqueous phase was acidified (HCl) and extraction gave phenol (94%), m.p. and mixed m.p. 39—40·5°. The aqueous layer was evaporated and the residue was extracted with hot ethanol. Addition of ether to the extracts gave 3-*piperidinopropionic acid hydrochloride* (71·5%), m.p. 209—212°, raised to 213—215° (from ethanol) (Found: C, 49·8; H, 8·55; Cl, 18·2; N, 7·0. $C_8H_{16}ClNO_2$ requires C, 49·6; H, 8·35; Cl, 18·3; N, 7·2%).

In a separate experiment, piperidine was omitted from the reaction mixture which, after reaction was complete, was acidified with hydrogen chloride and set aside for 48 hr. to allow esterification of carboxylic acids. V.p.c. analysis of the mixture showed phenol (92%) and ethyl 3-phenoxypropionate (91%).

Dimethyl 3-*Phenoxypropylsulphonium Iodide* (It).—1-Bromo-3-phenoxypropane [67] (21·5 g.) was added to a solution of methanethiol (1 mol.) in ethanolic 0·97N-sodium ethoxide (100 ml.) and the mixture was refluxed for 1 hr., poured into brine, and extracted. Distillation of the extracts gave the *sulphide* (91%), b.p. 137°/7 mm., n_D^{25} 1·5427 (Found: C, 66·1; H, 7·75. $C_{10}H_{14}OS$ requires C, 65·9; H, 7·75%).

The sulphide (12 g.) and methyl iodide (2 mol.) were set aside in dry ether (50 ml.) for 14 days, at 20°. Filtration gave the *sulphonium salt* (15 g., 68%), m.p. 66—67° (from ethanol–ether) (Found: C, 41·0; H, 5·5. $C_{11}H_{17}IOS$ requires C, 40·8; H, 5·3%).

The salt (3·27 g.) was heated under reflux with ethanolic 0·66N-sodium ethoxide (60 ml., 4 mol.) for 4 hr. while a slow stream of nitrogen was led through the mixture and into ethereal methyl iodide. From the methyl iodide solution was isolated trimethylsulphonium iodide (8%), m.p. and mixed m.p. 202—206°.

The ethanolic solution was treated as before to give a liquid (1·63 g.), n_D^{21} 1·5280. The ^1H n.m.r. spectrum, τ 2·8—3·5(m); 3·9—4·4(m); 4·95(t); 5·85(d); 6·35(t); 7·70(m); 8·29 (s superimposed on m), showed this to be a 55 : 45 mixture of methyl 3-phenoxypropyl sulphide and allyl phenyl ether.

3-*Phenoxypropyltrimethylammonium Bromide* (Iu).—The salt [66] (1·723 g.) was treated with ethanolic 0·84N-sodium ethoxide (60 ml., 5·5 mol.) as in the previous experiment. Tetramethylammonium iodide (56%), m.p. and mixed m.p. 350—354° (decomp.), was collected. The ethanolic solution gave allyl phenyl ether (68·5%), b.p. 74°/13 mm., n_D^{21} 1·5202 (lit.,[68] n_D^{21} 1·5208) (Found: C, 80·4; H, 7·4. Calc.

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for $C_9H_{10}O$: C, 80·5; H, 7·5%), ^1H n.m.r., τ 2·6—3·4(m); 3·6—4·3(m); 4·5—4·95(t) (fine structure); 5·45(d) (fine structure); with integrals in the ratio 5 : 1 : 2 : 2.

Other Compounds.—*2-Phenoxyethylbenzene* (Ir). Phenol and 2-phenylethyl bromide (1 mol.) were heated under reflux in ethanolic N-sodium ethoxide (0·98 mol.) for 1 hr. Dilution with brine and extraction gave the ether (22%), b.p. 93°/0·1 mm., n_D^{24} 1·5667, ^1H n.m.r., τ 2·8—3·4(m); 6·0(t); 7·05(t) with integrals in the ratio 5 : 1 : 1 (lit.,[69] b.p. 162°/14 mm., n_D^{16} 1·5070).

NN-*Dimethyl-2-phenoxyethylamine* (Is). The amine was obtained by treatment of 2-phenoxyethyl bromide with an excess of dimethylamine in benzene.[70]

Neither compound reacted with ethanolic sodium ethoxide to give phenoxide ion.

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