The Methoxydechlorination of Phenanthridine Derivatives

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IN aromatic systems rendered nonplanar by molecular overcrowding, a semiquantitative relationship has been postulated to exist between chemical reactivity and the degree of enforced nonplanarity.[1] The effects of overcrowding on a number of physicochemical characteristics have been established,[2] notably by Newman and his coworkers,[3,4] but authentic instances of significant differences in chemical reactivity at sites remote from direct steric intervention are rare, and may in fact be limited to the differences in "methyl affinities" observed by Levy, Newman, and Szwarc.[5]

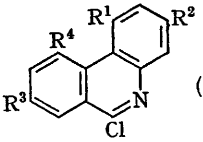
The kinetic data reported here appear to constitute an example of such a difference. The methoxydechlorination of 6-chlorophenanthridine (I) proved, as expected, to be a straightforward second-order process, with activation parameters

TABLE

Compound	k_2 (l.mole^{-1} sec.$^{-1}$)[a]	E_A (kcal.mole^{-1})[b]	$\Delta S\ddagger$(e.u.)
(I)	$5{\cdot}18 \times 10^{-5}$	18·8	−18·7
(II)[c]	$1{\cdot}73 \times 10^{-5}$	19·0	−18·6
(III)[c]	$6{\cdot}79 \times 10^{-4}$	15·9	−22·6

[a] Methoxydechlorination with methanolic sodium methoxide at 25°.
[b] From rate constants in the range 13—60°.
[c] The preparation of these compounds will be described elsewhere.

(Table) roughly comparable with those of 9-chloroacridine.[6] The substitution of methyl groups at the 3- and 8-positions produced an approximately threefold rate decrease, consistent with the inductive effect of the substituents, but, in contrast, the rate of methoxydechlorination of the isomeric 6-chloro-1,10-dimethylphenanthridine (III) was more than ten times that of the parent compound.



(I) $R^1 = R^2 = R^3 = R^4 = H$
(II) $R^1 = R^4 = H$; $R^2 = R^3 = Me$
(III) $R^1 = R^4 = Me$; $R^2 = R^3 = H$

This rate increase, and the accompanying decrease in the energy of activation, clearly cannot be explained on the basis of the electronic effects of the substituents (and in this connection it should be noted that 3,8- and 1,10-dimethylphenanthridine have closely similar pK_a-values, 5·00 [7] and 4·96 [8] respectively). It seems probable, therefore, that the explanation is steric; the rate-determining stage of the usual bimolecular S_NAr process involves rehybridisation (to sp^3) of the attacked carbon atom, and in an overcrowded system this process may well become energetically more favourable due to the release of the intramolecular strain known to be present in such systems.[3] Under these circumstances a decrease in the energy of activation would not be unexpected. Appreciable acceleration of an aromatic nucleophilic substitution appears, however, to be without precedent. The lower entropy of activation in the methoxydechlorination of (III), relative to (I) and (II), is significant and probably reflects the restriction imposed on rotation about the biphenyl link in the corresponding transition state by the interfering methyl substituents. Full details of these and related results will be published shortly.

(*Received, January 17th,* 1966; *Com.* 054.)

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