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UNIMOLECULAR AND BIMOLECULAR TRANSFER OF N-SUBSTITUENTS FROM PYRIDINIUM CATIONS: EVIDENCE FOR A CLEAR MECHANISTIC CHANGEOVER

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Summary *N*-Substituents in 2, 4, 6-triphenylpyridiniums are transferred to piperidine, morpholine and pyridine by unimolecular and/or bimolecular processes in chlorobenzene solution. These processes are quite distinct and afford no evidence for a mechanism intermediate between S_N1 and S_N2.

1-Benzyl-2, 4, 6-triphenylpyridinium perchlorate reacts with piperidine to give 2, 4, 6-triphenylpyridine and 1-benzylpiperidine.[1] The reaction was studied kinetically in chlorobenzene solution: at 100° it shdwed first order dependence on substrate (over range 3×10^{-5} - 10^{-3} molar) and first order dependence on piperidine (over range 10^{-3} - 2×10^{-1} molar). The second order rate constants $k_2 = 4.94 \times 10^{-3}$ (1 mole^{-1} sec^{-1}) was not affected significantly by ionic strength[2] or by changing the anion from ClO_4^- to BF_4^-. At 100° the rate varied by a factor of *ca.* 50 as the solvent varied from chlorobenzene to dimethyl sulphoxide and n-pentanol.

The reactions of a series of *N*-substituted-2, 4, 6-triphenylpyridiniums with piperidine in chlorobenzene were studied at 100° to determine the kinetic dependence of the rate on piperidine concentration. Some of the results are shown in Figures 1-4. For the benzyl compound (Fig. 1), and also for the methyl, allyl, and *p*-methylbenzyl derivatives, the reaction clearly proceeds almost entirely by a second order process. For the i-propyl and s-butyl derivatives (Figs. 2, 3), while there is a significant second order component, reaction also occurs by a first order process, independent of [piperidine]. This also applies to the 1-*p*-methoxybenzyl analogue which was studied at 40° as the reaction was very fast at higher temperatures. The pattern revealed is that expected: primary alkyl and benzyl react by S_N2, while for secondary alkyl and *p*-methoxybenzyl S_N1 processes are also important.

Table 1. First and second-order rate constants for reactions of 1-substituted 2, 4, 6-triphenylpyridiniums with piperidine in chlorobenzene at 100° [a]

			p-Substituted benzyl				
N-Subst.	Me	$CH_2CH{:}CH_2$	H	Me	MeO	$CHMe_2$	CHMeEt
$k_2 \times 10^3$ (1 mole^{-1}) sec^{-1}	0.60	1.26	4.94	8.52	0.45	0.14	0.10
$k_1 \times 10^5$ (sec^{-1})	<0.1	<0.5	<0.3	<0.3	3.6	0.89	3.20

[a] Measurements refer to 40° for *p*-methoxybenzyl derivative.

First and second order rate constants are recorded in Table 1. As expected the k_2 values increase in the series i-Pr < s-Bu < CH_3 < $CH_2CH{:}CH$ < $PhCH_2$ < *p*-$MeC_6H_4CH_2$ < *p*-$MeOC_6H_4CH_2$. The k_1 values shown for CH_3, allyl, benzyl and *p*-$CH_3C_6H_4CH_2$ are not significantly different from zero.

We next studied the reactions of the benzyl, i-propyl, s-butyl and *p*-methoxybenzyl derivatives with morpholine and pyridine as nucleophiles in place of piperidine. For the benzyl derivative, these nucleophiles also showed only bimolecular reaction; the k_2 values decreased for piperidine > morpholine > pyridine in the expected order of decreasing nucleophilicity (see Fig. 1). However, for i-propyl both unimolecular and bimolecular processes were found for each of the nucleophiles: whereas the k_2 values decreased in the order of the nucleophilicity of the amine used, the k_1 values were constant and independent of nucleophile (Fig. 2). s-Butyl and *p*-methoxybenzyl gave plots of the same form as that found for i-propyl, which strongly supports independent S_N1 and S_N2 reactions without an "intermediate" mechanism.

We have shown separately that high yields of the expected substitution products are produced by reactions of e.g. 1-i-propyl-2,4,6-triphenylpyridinium tetrafluoroborate both with piperidine and with pyridine.[3] These present results show that the bimolecular S_N2 reaction found for all substrates is accompanied by unimolecular ionisation for the i-propyl, s-butyl, and *p*-methoxybenzyl derivatives. We interpret this as evidence for simultaneous S_N1 and S_N2 reactions between the corresponding substrates and the amines studied.

The S_N1 to S_N2 mechanistic changeover has been the subject of considerable controversy; it has been proposed both that substitutions quite generally proceed by initial ionisation[4] and alternatively that solvolyses generally proceed with solvent nucleophilic assistance[5]. We believe that the above data provide in the case of 1-(*p*-methoxybenzyl)-, 1-i-propyl- and 1-s-butyl-2,4,6-triphenylpyridinium particularly clear evidence of a clean S_N1 to S_N2 mechanistic changeover.

Table 2. First and second order rate constants for reaction of 1-substituted 2,4,6-triphenylpyridiniums with morpholine and pyridine in chlorobenzene[a]

Nucleophile		$C_6H_5CH_2$	i-Pr	s-Bu	*p*-$MeOC_6H_4CH_2$
Morpholine	$k_2 \times 10^3$ (l mole^{-1} sec^{-1})	2.37	0.064	0.052	0.20
	$k_1 \times 10^5$ (sec^{-1})	<0.2	0.88	2.9	4.0
Pyridine	$k_2 \times 10^3$ (l mole^{-1} sec^{-1})	0.032	<0.01	<0.01	<0.04
	$k_1 \times 10^5$ (sec^{-1})	<0.1	0.94	3.0	4.0

[a] at 100° except for *p*-methoxybenzyl at 40°.

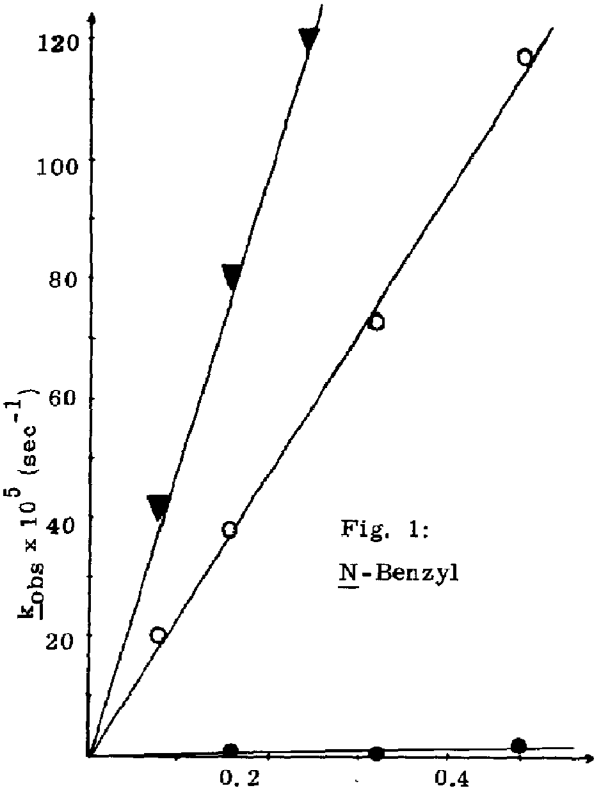

Fig. 1:
N-Benzyl

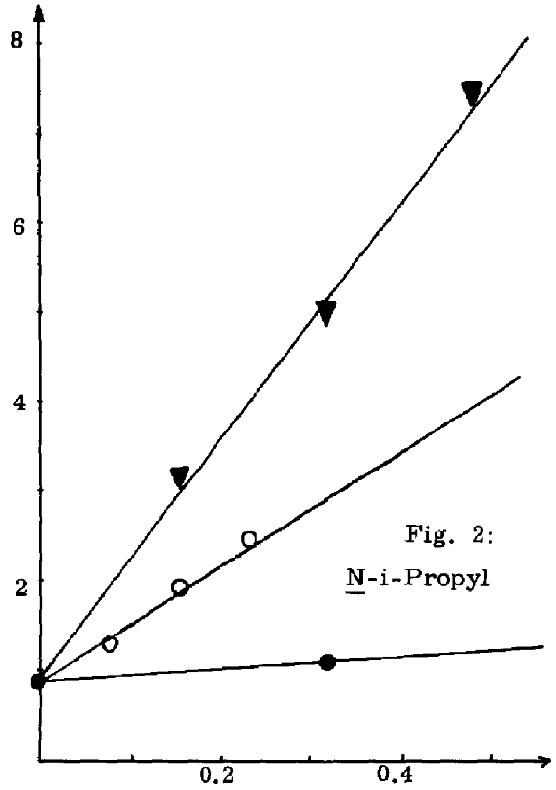

Fig. 2:
N-i-Propyl

CAPTIONS FOR FIGURES

Plots of pseudo first order rate constants (k_{obs}) vs nucleophile concentration for reactions of 1-substituted 2,4,6-triphenylpyridinium tetrafluoroborates in chlorobenzene solution with piperidine (▼), morpholine (○), and pyridine (●).

Fig. 1: 1-benzyl at 100°. Fig. 2: 1-i-propyl at 100°.

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REFERENCES

(1) A. R. Katritzky, J. B. Bapat, R. J. Blade, B. P. Leddy, P.-L. Nie, C. A. Ramsden, and S. S. Thind, J. C. S. Perkin I 418 (1979).

(2) Unlike reactions with anionic nucleophiles for which large salt effects were found as expected.

(3) J. Lloyd and R. C. Patel, unpublished work.

(4) R. A. Sneen, Accounts Chem. Research 6, 46 (1973); cf. D. J. McLennan, Ibid, 9, 281 (1976) and references therein.

(5) T. W. Bentley and P. von R. Schleyer, Adv. Phys. Org. Chem. 14, 15 (1977).

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