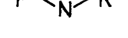
Kinetic *versus* Thermodynamic Control of Products in some Nucleophilic Aromatic Substitution Reactions†

By R. D. CHAMBERS,* R. P. CORBALLY, M. Y. GRIBBLE, and W. K. R. MUSGRAVE

(*Department of Chemistry, University Science Laboratories, South Road, Durham City*)

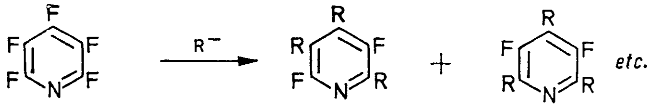
Summary A clear cut variation from kinetic to thermodynamic control of products is observed for polyfluoroalkylation reactions of $CF_3CF_2^-$, $(CF_3)_2CF^-$, and $(CF_3)_3C^-$ with pentafluoropyridine and tetrafluoropyridazine.



$$\mathrm{F^- + CF_2{=}C\!<\; \longrightarrow CF_3\underset{|}{\bar{C}}{-}}$$

[Olefins : $CF_2{=}CF_2$; $CF_2{=}CFCF_3$; $CF_2{=}C(CF_3)_2$]

WE have previously reported that polyfluoroalkylanions, generated by reaction of fluoride ion with fluoro-olefins, will polyfluoroalkylate activated fluoroaromatic systems.[1] It was observed that reaction of $(CF_3)_2CF^-$ with pentafluoropyridine or tetrafluoropyridazine could result in kinetic or thermodynamic control of reaction products, depending on the conditions.[2-4] A comparison of these results with those obtained from corresponding reactions of $CF_3CF_2^-$ and $(CF_3)_3C^-$ provides one of the most striking examples available of the interplay between kinetic and thermodynamic control in aromatic substitution reactions.



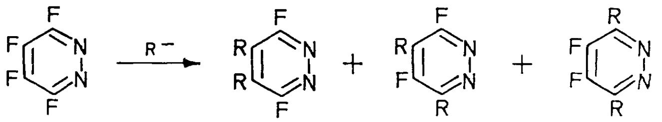
(I)

$R = CF_3CF_2$ (II)

$R = (CF_3)_2CF$ (III) (IV)

$R = (CF_3)_3C$ (V)

Considering *only* the tri-substituted products from pentafluoropyridine (I) at 80°; with $CF_3CF_2^-$, isomer (II) is obtained exclusively, which is not rearranged when heated with fluoride ion even to 190°; with $(CF_3)_2CF^-$, mainly isomer (III) is obtained which is rearranged,[2] on heating with fluoride ion at 160°, to give a mixture of (IV) and side-products; while with $(CF_3)_3C^-$, only (V) is obtained directly. Therefore, across this series there is a complete transition from kinetic control, in reactions with $CF_3CF_2^-$, to thermodynamic control of products with the bulky $(CF_3)_3C^-$.



(VI)

$R = CF_3CF_2$ (VII)

$R = (CF_3)_2CF$ (VIII) (IX)

$R = (CF_3)_3C$ (X)

The situation is even more striking with tetrafluoropyridazine, (VI) here considering only di-substituted derivatives formed at 80°. From $CF_3CF_2^-$, isomer (VII)

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was formed exclusively and was not rearranged by fluoride ion even up to 150°, $(CF_3)_2CF^-$ gave (VIII) which gave a mixture of (VIII) and (IX) on heating with fluoride ion,[3] while $(CF_3)_3C^-$ gave only (X) This is quite distinct from the other products described and clearly steric interactions are minimised with both of the bulky $(CF_3)_3C$ groups adjacent to a ring nitrogen, rather than flanked by fluorine atoms attached to the ring

Other products, not relevant to this discussion, are formed in some of these reactions and these will be described in full publication of these results

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[3] R. D Chambers, Yu A Cheburkov, J A H MacBride, and W K R Musgrave, *J. Chem. Soc* (*C*), 1971, 532.
[4] C J Drayton, W T. Flowers, and R N Haszeldine, *Chem Comm* , 1970, 662