The Beckmann Rearrangement of Acetophenone Oximes in Sulphuric Acid

By B. J. GREGORY, R. B. MOODIE, and K. SCHOFIELD*
(*Department of Chemistry, The University, Exeter*)

ONE of the reagents which can effect the Beckmann rearrangement of ketoximes to amides is sulphuric acid. Pearson and his co-workers[1] studied the kinetics of the rearrangement of acetophenone oxime to acetanilide over the range of acidity covered by 80·0—95·8% w/w sulphuric acid. We have extended this acidity range to 60·6—98·2% sulphuric acid, and in the Figure give the rate profile for the dependence of the rate constant for the rearrangement upon acidity.

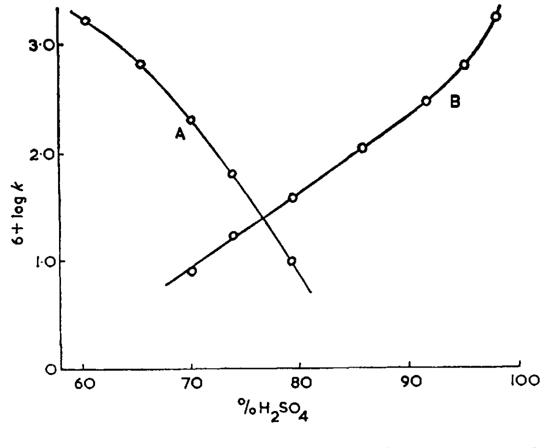


FIGURE. *Variation of rate constant with acidity for the hydrolysis* (*curve A*) *and rearrangement* (*curve B*) *of acetophenone oxime in sulphuric acid at* 80°.

Below 70% sulphuric acid, hydrolysis of the oxime predominates over the rearrangement. The rates of both the hydrolysis and the rearrangement are first order with respect to the oxime. The effects of substituents on the rate of rearrangement in 98·2% sulphuric acid are given in the Table. The logarithms of the rate constants show a rather poor correlation with σ-constants, with $\rho = -1{\cdot}5$ (correlation coefficient 0·963). However, the correlation with σ^+ constants is even worse, an observation which conflicts with an analysis[2] of the findings of Pearson *et al.*, who used a more limited range of substituents. The conclusion of the latter workers[3] that *p*-methoxyacetophenone oxime underwent Beckmann rearrangement under the conditions was mistaken; the principle reaction in 92—98% sulphuric acid is sulphonation of the aromatic nucleus. In contrast to the rearrangement of substituted acetophenone oximes in sulphuric acid, those of the corresponding oxime picryl ethers in 1,4-dichlorobutane show a much greater sensitivity towards substituent effects.[4]

Pearson[5] originally suggested the intermediate formation of an oxime *O*-sulphonic acid (I), but later omitted this step and postulated the formation of a bridged transition state (II) similar to that proposed[4] for the rearrangment of oxime picryl ethers in organic solvents. The lack of a σ^+ correlation, and the low sensitivity to substituent effects reported here, do not support this latter

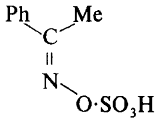
Rate-constants for the rearrangement of substituted acetophenone oximes in 98·2% *sulphuric acid at* 80·0°

Substituent	*p*-MeO	*p*-Me	*m*-Me	H	*p*-F	*p*-Cl	*p*-Br	*m*-Cl	*m*-Br	*m*-F	*m*-NO_2	*p*-NO_2
10^4k(sec.$^{-1}$)	40*	28·2	22·3	16·9	13·8	11·7	11·7	7·2	7·2	6·3	1·08	0·89

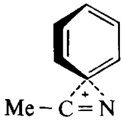
* Value estimated from extrapolation from results at lower acidities.

conclusion for the rearrangement of acetophenone oximes in sulphuric acid.

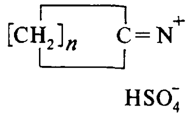
The migration of the oxygen group from nitrogen to carbon during the rearrangement of oxime picryl ethers has been shown to be intermolecular.[6] Experiments involving sulphuric acid enriched with oxygen-18 have now shown that the migration of oxygen during the rearrangement of acetophenone oximes in sulphuric acid is also intermolecular. Acetanilide isolated from the rerranagement of acetophenone oxime in 85—86% sulphuric acid containing approximately 3·8 atom % excess of oxygen-18, after one half-life at 80° was found to have attained the oxygen-18 content of the solution, whilst acetanilide treated in the same way was not significantly enriched. Similar results were obtained with *p*-methoxy- and *m*-fluoro-acetophenone oximes.



(I)



(II)



(III)

In the same experiments, the unrearranged oximes were also isolated and analysed mass-spectrometrically, and found to contain only the normal abundance of oxygen-18. Vinnick *et al.*[7] have postulated the formation, in an equilibrium preceding the rate-determining step, of an ion-pair (III) when alicyclic ketoximes are rearranged in sulphuric acid. Our experiments with isotopic labelling exclude such a mechanism for the rearrangement of acetophenone oximes.

(*Received, August* 19*th*, 1968; *Com.* 1141.)

---

[1] P. J. McNulty and D. E. Pearson, *J. Amer. Chem. Soc.*, 1959, **81**, 612.
[2] J. E. Leffler and E. Grunwald, "Rates and Equilibria of Organic Reactions", J. Wiley, New York, 1963, p. 208.
[3] D. E. Pearson, J. F. Baxter, and J. C. Martin, *J. Org. Chem.*, 1952, **17**, 1511.
[4] R. Huisgen, J. Witte, H. Walz, and W. Jira, *Annalen*, 1957, **604**, 191.
[5] D. E. Pearson and F. Ball, *J. Org. Chem.*, 1949, **14**, 118.
[6] P. A. S. Smith, in "Molecular Rearrangements", ed. P. de Mayo, Part I, p. 491.
[7] M. I. Vinnik and N. G. Zarakhani, *Russ. Chem. Rev.*, 1967, **36**, 62.