Evidence for Differences in Interpretation of Mechanism of Acid-catalysed Hydrolysis of Aliphatic and Aromatic Amides

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Summary The rate constants of acid hydrolysis of aliphatic, but not aromatic, amides give linear Bunnett *w* and Bunnett-Olsen l.f.e.r. plots; aromatic amides follow an empirical two-term rate law.

It has been widely accepted[1–3] that a Bunnett *w* plot[4] of $\log_{10}k_\psi$ (corrected for degree of protonation of the substrate) *vs*. $\log_{10}a_W$ for acid-catalysed hydrolysis of an amide will be curved. An attempt to explain this curvature by postulating the competition of two mechanisms, involving protonation on oxygen and nitrogen, respectively, has been proposed.[2] Moodie[1] has criticised this mechanism, and recently[5] reiterated that there is no reason to invoke the idea of competing mechanisms involving different sites for protonation of amides, since Bunnett *w* plots for hydrolysis data on some completely protonated substrates, whose hydrolysis does not therefore involve complications arising from protonations, are still curved.

We have recently carried out an extensive survey of all acid-catalysed amide hydrolyses reported which have been studied over a sufficiently wide range of acidities to justify kinetic analysis. Most literature reports of K_{BH^+} for these amides have been based on the value of H_0 at half protonation and have therefore been reassessed on the H_A scale, in order to calculate more accurately the fraction of *O*-protonated substrate, before carrying out the analysis.

When these more valid values of K_{BH^+} were used, we found, that contrary to expectation, aliphatic amides,[1,6] and pseudo-aliphatic amides, *i.e.* acetanilide[7] and substituted acetanilides,[8,9] and substituted formanilides[10] all gave excellent correlation coefficients ($>0{\cdot}99$) with Bunnett w[4] and Bunnett–Olsen l.f.e.r.[11] relationships. The exceptions within this classification are for hydrolysis of acetamide,[12] butyramide,[1] and acetanilide[9] in perchloric acid, suggesting that there may be a term involving either specific anion or general acid catalysis in this medium.

All available data for acid-catalysed hydrolysis of aromatic amides, *i.e.* for benzamide, *N*-methylbenzamide, and *NN*-dimethylbenzamide[2,13] carried out over an extensive range of temperatures and in a variety of mineral acids gave poor correlations with the Bunnett w criterion of mechanism. Correlation with the Bunnett–Olsen l.f.e.r criterion was often reasonable, but correlation with the proposed empirical two-term mechanism[2] was invariably excellent. This suggests that the mechanism for the acid-catalysed hydrolysis of aromatic amides involves complications which may not be present in the hydrolysis of aliphatic amides, and this aspect is being investigated further.

Data[14] for the cyclic amide ϵ-caprolactam do not fit any of the above criteria well.

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[1] V. C. Armstrong, D. W. Farlow, and R. B. Moodie, *J. Chem. Soc.* (*B*), 1968, 1099.

[2] C. A. Bunton, C. J. O'Connor, and T. A. Turney, *Chem. and Ind.*, 1967, 1835.

[3] R. B. Moodie, P. D. Wale, and T. J. Whaite, *J. Chem. Soc.*, 1963, 4273; K. Yates and J. C. Riordan, *Canad. J. Chem.*, 1965, **43**, 2328.

[4] J. F. Bunnett, *J. Amer. Chem. Soc.*, 1961, **83**, 4956; 4968, 4973; 4978.

[5] R. B. Moodie and R. Towill, *J. C. S. Perkin II*, 1972, 184.

[6] J. T. Edward, H. P. Hutchinson, and S. C. R. Meacock, *J. Chem. Soc.*, 1955, 2520; V. K. Krieble and K. A. Holst, *J. Amer. Chem. Soc.*, 1938, **60**, 2976; B. S. Rabinovitch and C. A. Winkler, *Canad. J. Res.*, 1942, **20B**, 73.

[7] J. W. Barnett and C. J. O'Connor, *J. C. S. Perkin II*, 1972

[8] M. I. Vinnik, I. M. Medvetskaya, L. R. Andreeva, and A. E. Tiger, *Russ. J. Phys. Chem.*, 1967, **41**, 128; M. I. Vinnik and I. M. Medvetskaya, *ibid.*, p. 947; I. M. Medvetskaya, M. I. Vinnik, and L. R. Andreeva, *ibid.*, 1969, **43**, 1283.

[9] J. W. Barnett and C. J. O'Connor, *J. C. S. Perkin II*, 1972.

[10] I. M. Medvetskaya and M. I. Vinnik, *Russ. J. Phys. Chem.*, 1969, **43**, 345, 1157; N. G. Zarakhani, V. M. Promyslov, M. I. Vinnik and L. G. Yudin, *ibid.*, p. 348; 1970, **44**, 29.

[11] J. F. Bunnett and F. Olsen, *Canad. J. Chem.*, 1966, **44**, 1899; 1917.

[12] M. M. Mhala and M. H. Jagdale, *Indian J. Chem.*, 1970, **8**, 147.

[13] C. R. Smith and K. Yates, *J. Amer. Chem. Soc.*, 1971, **93**, 6578; C. A. Bunton, S. J. Farber, A. J. G. Milbank, C. J. O'Connor and T. A. Turney, *J. C. S. Perkin II*, 1972.

[14] S. J. Farber and J. A. Brieux, *Chem. and Ind.*, 1966, 599; M. M. Mhala and M. H. Jagdale, *Indian J. Chem.*, 1968, **6**, 711.