Anomalous Water

Pethica, Thompson and Pike¹ have attributed the properties of anomalous water to impurities. First, we wish to comment on their statement that the NMR study by Willis *et al.*² gave no positive result. The expected resonance frequency shift has since been found in a study by Petsko³, who used a very sensitive method, so either the sensitivity of the apparatus used by Willis *et al.* was much lower, or they did not succeed in producing a sufficient amount of the anomalous component (water II). Petsko's results were confirmed by Page⁴ of the Battelle Institute of Columbus.

Pethica *et al.*¹ name silica gel as one of the possible impurities. But Rousseau and Porto⁵, cited by Pethica *et al.*, say that even with the very sensitive electron probe method no silicon atoms were detected in water samples produced by the prolonged exposure of fused quartz capillaries to water vapour. This result agrees with Page's analysis for silicon (reported at the Forty-fourth Colloid Symposium⁶). Thus there is no point in suggesting a scheme for the formation of silica gel during vapour condensation. Besides, because such sols or gels contain water, they could not show the refractive index of 1.49 of water II, as the application of the Lorentz-Lorenz equation shows.

Further, for at least one Si atom to be present in the molecule of the anomalous component (of molecular weight approximately 180) (ref. 7: the same value was obtained from our measurements on a sample kindly given to us by Dr Pethica in 1968, and by Brummer (private communication)), the weight percentage of the Si present in a low molecular form would not be less than 25, and this is not realized.

The assumption that the properties of anomalous water are due to contamination is at odds with the facts⁸. We have found that the introduction of liquid water into many hundreds of fused silica capillaries, their exposure for many days (even at elevated temperatures), followed by evaporation, has produced water columns that even in the last stages of evaporation show no similarities to columns of anomalous water. So only the condensation of vapour leads to the formation of anomalous water.

Finally, Pethica *et al.* write: "Derjaguin and Lippincott claim that anomalous water can be distilled and thus freed from involatile impurities" (our italics). By attributing to us statements which we never made, Pethica *et al.* show that they did not realize the significance of our experiments on the distillation of anomalous water vapours. We found no loss of anomaly in distillation through a moderately high heat barrier (~500° C), but loss of anomaly occurred on distillation through a high barrier (~700–800° C) (see also ref. 9). The first observation shows that molecules of water II exist in the vapour phase; the latter means that the former observation cannot be explained by the distillation of contaminants.

The distillation experiment has been established unambiguously and, what is more, it has become routine practice to collect the anomalous condensate from many capillaries at one point so as to obtain and analyse larger samples (for example, in our laboratory and at the Lowell laboratory in the work of Bela Fabuss). This would be impossible if the polymeric molecules of water II (their average molecular weight in solution in water I is about 180) dissociated upon vaporization to monomeric H₂O. This assumption also contradicts the thermodynamic equilibrium that we have observed between liquid water II and its vapour (the measured density of the latter depending only on temperature¹⁰), in conjunction with the impossibility of a similar equilibrium between liquid water II and water I vapour. If the mass spectrometric method used by Willis *et al.*² gave no evidence of polymeric molecules, the reason must certainly be sought in the method itself.

We cannot indicate the exact reasons for the findings of Pethica, Thompson and Pike although one possibility may be

the dissociation of the polymeric molecules of water II which are held probably by a kind of cooperative bond under the action of electron impacts. Pethica, Thompson and Pike give no quantitative data or experimental details, but there is no doubt that such a reason exists.

To sum up, we believe that the criticism of our work by Pethica, Thompson and Pike is due chiefly to incomplete understanding of and inexact quoting from the literature^{7–11}.

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