DIAMAGNETIC SUSCEPTIBILITY OF SULPHURIC ACID-WATER MIXTURE.

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Received February 5, 1936.
(Communicated by Prof. B. Venkatesachar, M.A., F.Inst.P.)

Introduction.

In this paper a study has been made of the diamagnetic susceptibility of sulphuric acid-water mixture. Farquharson¹ has studied the same mixture with Curie-Cheneveau balance. His concentration susceptibility curve abounds in maxima and minima and deviates a good lot from the additive law. Varadachari² has also studied the same mixture. He infers the presence of definite hydrates in the solution. Till about 87% of the acid, the values of susceptibilities are less than the additive law and above 87% the values are above the additive law. Points of maximum deviation from the additive law are attributed to the formation of hydrates.

The apparatus in this investigation is the one devised by Sibaiya and Venkataramiah.³ "The test system of this apparatus consists of a pyrex-glass cylinder from which the opposite quadrants have been ground off. The grinding operation is done so as to obtain exact symmetry in the test-piece since any slight asymmetry would tilt it when immersed in a liquid. A thin glass stem fused to the test-piece along its axis, carries a plane mirror. The free end of the stem is attached to the lower end of a phosphor-bronze suspension, the upper end of which is attached to a brass rod. The test-system and the suspension are encased in a wide glass tube with an opening for cementing a lens, in front of the plane mirror. The torsion head is attached to the top of the glass tube. The liquid is inserted from a side tube. The tap at the bottom of the tube served to empty it after a completion of a set of readings. When the magnetic field is put on, the couple on the test-piece twists the suspension and the deflection of the image on the scale is noted. In order to obtain high sensitiveness the mirror on the test-piece is adjusted parallel to one of its ground faces, which in its zero position is

¹ Phil. Mag., 1931, 12, 283.
also parallel to the lines of force. The relation between the deflections obtained when the magnetic current is switched off and the volume susceptibility of the liquid is linear, thus rendering the calculation of the volume susceptibility very simple. A density determination enables one to calculate the specific susceptibility.

If the volume susceptibility of the material of the test-piece and the surrounding liquid be $K_0$ and $K$ respectively the couple on the test-piece is $(K_0 - K) \int \frac{1}{2} (\Delta \mathbf{H} \times \mathbf{r}) \, dv$ where $dv$ is the element of volume, whose position vector is $\mathbf{r}$ and $\mathbf{H}$, the field intensity at the point. If $C$ is the couple per unit twist and $\theta$ the angular deflection

$$K_0 - K = - \frac{C\theta}{\int \frac{1}{2} (\Delta \mathbf{H} \times \mathbf{r}) \, dv} = - \lambda \theta$$

whence $K = K_0 + \lambda \theta$

and it is clear that $K$ and $\theta$ are linearly connected and that $K_0$ is obtainable by interpolation.

\begin{table}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
Conc. \ H_2SO_4 & $X$ & Conc. \ H_2SO_4 & $X$ & Conc. \ H_2SO_4 & $X$ \\
\hline
0% & \cdot720 & 41.8 & \cdot562 & 74.9 & \cdot452 \\
10.3 & \cdot680 & 43.0 & \cdot561 & 78.9 & \cdot442 \\
14.1 & \cdot664 & 44.7 & \cdot551 & 78.9 & \cdot442 \\
14.3 & \cdot664 & 48.0 & \cdot539 & 82.7 & \cdot429 \\
16.5 & \cdot657 & 49.1 & \cdot526 & 86.5 & \cdot420 \\
16.7 & \cdot654 & 53.2 & \cdot514 & 91.2 & \cdot410 \\
17.5 & \cdot653 & 56.5 & \cdot507 & 92.8 & \cdot410 \\
20.5 & \cdot641 & 57.2 & \cdot504 & 92.8 & \cdot411 \\
24.4 & \cdot625 & 58.8 & \cdot504 & 93.5 & \cdot407 \\
24.7 & \cdot625 & 59.0 & \cdot514 & 95.0 & \cdot407 \\
28.1 & \cdot611 & 60.5 & \cdot498 & 96.0 & \cdot404 \\
29.2 & \cdot610 & 61.1 & \cdot496 & 96.0 & \cdot405 \\
34.4 & \cdot591 & 62.0 & \cdot492 & 97.3 & \cdot402 \\
35.3 & \cdot585 & 65.1 & \cdot484 & 98.0 & \cdot401 \\
36.5 & \cdot580 & 67.2 & \cdot477 & 99.8 & \cdot400 \\
36.5 & \cdot580 & 70.7 & \cdot465 & 99.8 & \cdot400 \\
37.6 & \cdot579 & 71.0 & \cdot464 & 99.8 & \cdot400 \\
\hline
\end{tabular}
\end{table}
Care is taken to maintain the level of the liquid in the wide tube always the same. The current is adjusted to the same value every time. The deflections were observed by a mirror and scale arrangement. The solutions were prepared in a clean pyrex-glass flask and every time the solution was prepared, it was cooled to the room temperature, before it was poured into the tube. The tube was thoroughly cleaned with the solution before the reading was taken with the solution. The readings tabulated above were obtained in four sets of different concentration. Constantin Salceanu and Dumitru Gheorghiu and Bhatnagar and Nevgi have used the same form of instrument and find this instrument most suitable for working with liquids.

Results.

The sulphuric acid was analytically pure and was taken from freshly opened bottles. The densities were determined using a specific-gravity bottle. From a knowledge of the density, the concentration was found from Landolt and Bornstein Tables.

The graph shows the value of susceptibility plotted against the percentage concentration of sulphuric acid. The susceptibility of water is assumed to be at 25°C: \(720 \times 10^{-6}\).
Discussion.

The graph shows that there is considerable departure from the additive law. The maximum deviation is about 5%. A smooth curve is drawn passing through a maximum number of points and it is seen that most of the points lie on the curve and the points that lie outside the curve differ from the main curve by distances which are within the limits of experimental error. The values are all higher than the additive value, but I find that even above 86% the values are less than the additive value. If the value is taken as \(0.400 \times 10^{-6}\), it will be seen that portion of the curve above 86% also lie below the additive straight line joining 0.720 and 0.400 and at the same time the maximum deviation from additive law also increases.

The smooth line which has been drawn passing through most of the points shows that there is no definite break anywhere in the concentration susceptibility curve. This shows that the magnetic measurements do not support the theory which assumes the presence of definite hydrates in solution. The deviation from the additive value is plotted against the concentration in the second graph and it is seen that \(\text{H}_2\text{SO}_4.3\text{H}_2\text{O}\) is absent.

The maximum deviation is, however, at a concentration corresponding to the compound \(\text{H}_2\text{SO}_4.2\text{H}_2\text{O}\). This has been reported to be the only compound existing from surface tension data.\(^6\) Besides \(\text{H}_2\text{SO}_4.2\text{H}_2\text{O}\) can be obtained in a crystalline form.\(^7\)

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\(^7\) Mellor's Chemistry.
In conclusion, I wish to record my grateful indebtedness to Prof. B. Venkatesachar for valuable guidance and suggestions. My thanks are due to Mr. Sibaiya for useful discussion and criticism. I am highly thankful to the University of Mysore for the award of a stipend which made this work possible.