

## STUDIES IN SURFACE TENSION MEASUREMENTS OF SOME COLLOIDAL SOLUTIONS. PART II. GELATIN SOL

By S. N. BANERJI

The effect of concentration, temperature, acid, alkali and various salts on the surface tension of gelatin sols have been studied and the results have been explained from the point of view as given in earlier papers that lyophilic colloids such as gelatin, agar agar etc. have some dissolved material in a true molecular solution under the equilibrium :



It has been shown by some workers (Bottazzi, *Quart. J. Exp. Phys. Suppl.*, 1923, 65; Caro and Laporta, *Rend. Accad. Sci. Fis. Mat. Napoli*, 1929, 85, 171) that gelatin produces a maximum depression of surface tension at the isoelectric point. The effects of concentration, temperature, acid, alkali and various salts on the surface tension of gelatin have been studied in this communication.

### EXPERIMENTAL

The experimental procedure was the same as described in Part I of this series (this *Journal*, 1952, 29, 270).

Purified gelatin (Goldruck, Kahlbaum) containing 0.1% ash was used. The gelatin foils were cut into strips and washed with cold water several times before use. Gelatin sols, prepared under different conditions, gave varying results. These were therefore prepared by dissolving purified gelatin in water on a warm bath kept at 80°. This gave concordant values for the same concentration of gelatin. The concentration of the sol was determined by evaporating a measured volume of it in a platinum crucible on a water-bath ; 1% of the sol, thus prepared, was of  $\eta_{sp}$  value 5.7.

TABLE I

*Effect of concentration on the surface tension of gelatin sol at 30°.*

Surface tension of water at 30° = 71.03 (dynes / cm.).

|                               |     |     |     |       |       |       |       |       |
|-------------------------------|-----|-----|-----|-------|-------|-------|-------|-------|
| Gelatin sol (%)               | ..  | ... | ... | 2.0   | 1.0   | 0.5   | 0.25  | 0.125 |
| Surface tension (dynes / cm.) | ... | ... | ... | 63.24 | 64.21 | 64.72 | 65.20 | 65.80 |

TABLE II

*Effect of temperature on the surface tension of gelatin sols of various concentrations.*

|                   | Surface tension at |       |       |
|-------------------|--------------------|-------|-------|
|                   | 30°.               | 40°.  | 50°.  |
| Water             | 71.03              | 69.54 | 67.80 |
| Gelatin (conc. %) |                    |       |       |
| 0.5               | 64.72              | 61.93 | 60.54 |
| 0.25              | 65.20              | 63.90 | 62.62 |

TABLE III

*Effect of HCl of diff. conc. on the surface tension of gelatin sol at 30°.*

| Sol.                        | Surface tension of gelatin sol. |       |       |
|-----------------------------|---------------------------------|-------|-------|
|                             | 0.5%.                           | 1%.   | 2%.   |
| 40 c.c. sol + 10 c.c. water | 65.19                           | 64.93 | 64.03 |
| 40 " + " N/1.87-HCl         | 63.90                           | 63.54 | 63.14 |
| 40 " + " N/94.5 "           | 65.20                           | 63.90 | 63.00 |
| 40 " + " N/945 "            | 62.45                           | 62.81 | 63.50 |
| 40 " + " N/1890 "           | ---                             | 63.89 | 63.04 |

TABLE IV

*Effect of NaOH of diff. conc. on the surface tension of gelatin sol sat 30°.*

| Sol.                        | Surface tension of gelatin sol. |       |       |
|-----------------------------|---------------------------------|-------|-------|
|                             | 0.5%.                           | 1%.   | 2%.   |
| 40 c.c. sol + 10 c.c. water | 651.9                           | 64.93 | 64.00 |
| 40 " + " N/2.1-NaOH         | 68.50                           | 66.51 | 66.06 |
| 40 " + " N/105 "            | 65.22                           | 65.62 | 64.63 |
| 40 " + " N/1050 "           | 63.90                           | 64.92 | 64.04 |

TABLE V

*Effect of various salt solns. of diff. conc. on the surface tension of 10% gelatin sol at 30°.*

| Sol.                        | Surface tension. | Sol.                                       | Surface tension |
|-----------------------------|------------------|--|-----------------|
| 40 c.c. sol + 10 c.c. water | 63.88            | 40 c.c. sol + 10 c.c. N-NaCl               | 64.66           |
| 40 " + " N-LiCl             | 64.82            | 40 " + " 8.54 N- "                         | 61.73           |
| 40 " + " 23.52 N- "         | 64.28            | 40 " + " 17.08 N- "                        | 60.43           |
| 40 " + " 35.28 N- "         | 64.23            | 40 " + " 25.62 N- "                        | 60.40           |
| 40 c.c. sol + 10 c.c. N-KCl | 64.98            | 40 c.c. sol + 10 c.c. N-NH <sub>4</sub> Cl | 64.70           |
| 40 " + " 6.71 N- "          | 63.12            | 40 " + " 9.53 N- "                         | 64.18           |
| 40 " + " 13.42 N- "         | 61.10            | 40 " + " 19.06 N- "                        | 63.05           |
| 40 " + " 20.13 N- "         | 60.71            | 40 " + " 28.59 N- "                        | 63.02           |

The results confirm the earlier observation (*loc. cit.*) that gelatin produces maximum depression of surface tension at the isoelectric point.

It is seen from the experimental results that the greater the concentration of the gelatin sol, the higher is the lowering of surface tension. This is in accord with the views given in previous papers (Banerji and Ghosh, this *Journal*, 1930, 7, 923; Banerji, *loc. cit.*) that the lyophilic colloids such as gelatin, agar, agar etc. have some dissolved material in true molecular solution under the equilibrium



At higher concentrations of gelatin sols, greater amounts remain dissolved giving rise to greater number of both aggregated and simple molecules and consequently there is a greater lowering of surface tension.

At the isoelectric point, the gelatin is at a maximum degree of aggregation and thus shows a maximum lowering of surface tension. The greater amount of acid may dissolve greater amounts of colloidal material and consequently there will be a greater number of simple molecules with the result that the surface tension values will not be lowered to a greater extent. High concentrations of acids depress dissociation of the aggregated molecules that are formed and the depression of surface tension will again be higher. The results obtained with 0.5%, 1% and 2% sols of gelatin support this conclusion. Ackermann (*Kolloid Z.*, 1934, 69, 87) has observed that the surface tension of a gelatin sol decreases when the sol is boiled but it is raised by hydrolysis with acid. These observations are in line with the views given above.

The effect of alkali is to increase the surface tension continuously with the increasing concentration of alkali and the effect of solutions of different concentrations of monovalent salts in lowering the surface tension follows the order :  $\text{Na} > \text{NH}_4 > \text{Li} > \text{K}$  in the case of gelatin sol.

DEPARTMENT OF CHEMISTRY,  
UNIVERSITY OF SAUGAR,  
SAGAR.

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## STUDIES IN SURFACE TENSION MEASUREMENTS OF SOME COLLOIDAL SOLUTIONS. PART III. TANNIC ACID, VANADIUM PENTOXIDE, ZIRCONIUM HYDROXIDE AND FERRIC HYDROXIDE SOLS

By S. N. BANERJI

The surface tensions of tannic acid and of such hydrated and viscous sols as those of vanadium pentoxide, zirconium hydroxide and ferric hydroxide have been investigated at different concentrations and temperatures, both in presence and absence of electrolytes.

The experimental results indicate that the lowering of surface tension of water in the presence of a colloidal substance originates from the presence of sufficient number of dissolved polaric and aggregated molecules.

In parts I and II of this series of papers (Banerji, this *Journal*, 1952, 29, 270; 1953, 30, 133), the results have been explained from the point of view that the reversible colloids such as gelatin, gum arabic etc. have some dissolved material in molecular condition under the equilibrium : simple molecules  $\rightleftharpoons$  aggregated molecules  $\rightleftharpoons$  colloidal particles.

In this paper, the surface tensions of tannic acid and of such hydrated and viscous sols as those of vanadium pentoxide, zirconium hydroxide and ferric hydroxide have been investigated at different concentrations and temperatures, both in presence and the absence of electrolytes.