Effect of Certain Dissolved Salts Upon the Cohesion of Water.

By Edwin Morrison.

Cohesion is defined as "that force which holds molecules of the same kind together." This force is very manifest in all solids, giving rise to such properties as hardness, brittleness, malleability, ductility, tensile strength, etc. Although not so apparent, all liquids manifest the same kind of an attractive force between molecules. Surface tension and the phenomenon of capillarity are due in a measure to cohesion of the molecules. That molecules of water are held together by means of cohesion can be demonstrated by bringing a clean, horizontal disk of glass in contact with the surface of water and then adding sufficient force to pull the disk away from the water. In case the surface of the disk is wet when it comes away from the water we know that the force applied has separated two films of water, each equal in area to that of the disk.

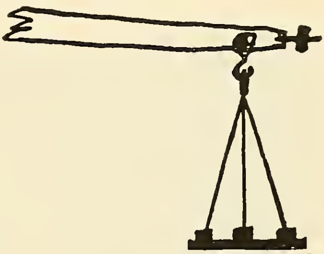

Fig. 1.

Probably Gay-Lussac first experimented upon this force and established the commonly accepted data of 526.875 dynes per square cm. Gay-Lussac used a glass disk supported by three guy cords as shown in Fig. 1.

The author designed and constructed a piece of apparatus for measuring cohesion of water and other liquids and reported the same to the Iowa Academy of Science in 1904. This apparatus consists of a round glass disk 10.6898 cm. in diameter mounted upon an accurately constructed cone 10.5 cm. high, with an eyelet in the apex for suspending the cone from the hook of a specific gravity balance. A cut of this apparatus is shown in Fig. 2.

In 1905 the author carefully worked out and reported to the Iowa Academy of Science the value of the cohesion of water as follows:

Data.—Diameter of the glass disk.

1 Measurement	10.662 cm.
2 Measurement	10.698 cm.
3 Measurement	10.727 cm.
4 Measurement	10.694 cm.
5 Measurement	10.645 cm.
6 Measurement	10.674 cm.
7 Measurement	10.702 cm.
Average	10.6898 cm.

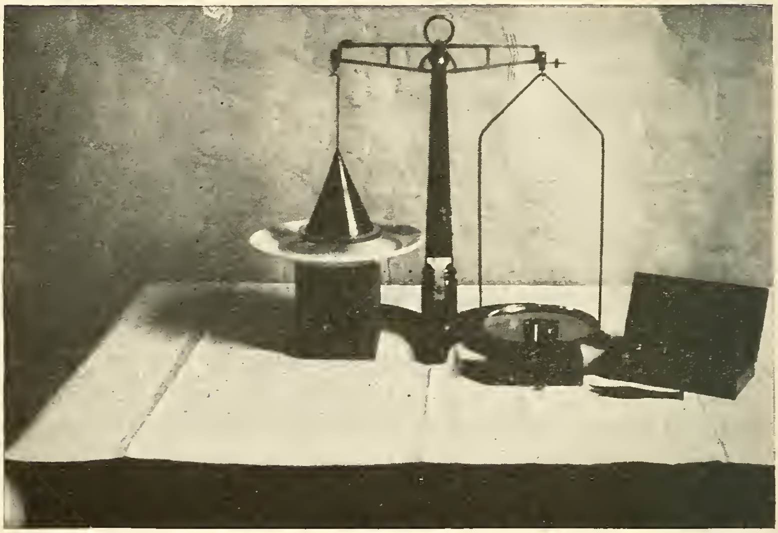

Fig. 2.

Test No. 1.—The number of grams to separate the disk from water at 4° C.

Trial 1	48.725
Trial 2	48.730
Trial 3	48.725
Trial 4	48.733
Average	48.728

Test No. 2.—The number of grams to separate the disk from water at 7° C.

Trial 1	48.710
Trial 2	48.715
Trial 3	48.725
Trial 4	48.730
Average	48.720

Test No. 3.—The number of grams to separate the disk from water at 7° C.

Trial 1	48.630
Trial 2	48.640
Trial 3	48.655
Trial 4	48.675
Average	48.650

The diameter of the disk being 10.6898 cm., the radius being 5.3449 cm., the area is 89.7200 square cm. In the first test given above it required 0.5431 g. to separate one square cm. of water. In the second 0.5430 g. and in the third 0.5421 g. The average of the three tests is 0.5427 g. per square cm., which is equal to 531.846 dynes per square cm.

In comparing these results with those of Gay-Lussac we find that he used a disk which was 11.86 cm. in diameter, and that it required 49.40 g. to separate the disk from water, or 526.875 dynes per square cm.

At this point it may be well to state the precautions taken in the experiment. First, in order to insure that the water used was chemically pure, ordinary laboratory distilled water was redistilled in Jena glass vessels in the presence of sulphuric acid and potassium dichromate. Second, the disk was thoroughly cleansed by washing in a solution of potassium dichromate and sulphuric acid; then in alcohol; then the disk was dried in a current of air and washed again in redistilled water. Third, a delicate laboratory balance with a rider weight was used in the experiment.

At the time the above data on the cohesion of water was worked out it was suggested that certain dissolved salts have a marked effect upon the cohesion of water. It is the purpose now to note some of these effects.

A number of solutions of certain salts in distilled water have been tested by means of the same glass disk as used in the cohesion of water experiment. The first solution tested was that of sodium chloride. Six solutions were prepared by dissolving each of the following number of grams of salt in 200 cc. of distilled water: 7.82 g., 15.64 g., 31.28 g., 46.92 g., 62.56 g., 72 g. (saturated solution).

Six solutions each of copper sulphate and sugar were prepared in the same way as in the case of sodium chloride, and each solution was tested for the number of grams to separate the liquid films.

The results for the eighteen different solutions are tabulated as follows:

First.—The number of grams to separate the disk from the solutions when 7.82 g. of each of the three materials were dissolved in 200 cc. of water.

Trial.	Sodium Chloride.	Copper Sulphate.	Sugar.
1	42.45	48.40	48.50
2	42.50	48.45	48.52
3	42.50	48.47	48.48
Mean.	42.48	48.44	48.50

Second.—The number of grams to separate the disk from the solution when 15.64 g. of each of the three materials were dissolved in 200 cc. of water.

Trial.	Sodium Chloride.	Copper Sulphate.	Sugar.
1	42.15	49.20	50.50
2	42.00	49.30	50.52
3	41.95	49.35	50.51
Mean.	42.03	49.28	50.51

Third.—The number of grams to separate the disk from the solutions when 31.28 g. of each of the three materials were dissolved in 200 cc. of water.

Trial.	Sodium Chloride.	Copper Sulphate.	Sugar.
1	46.39	50.35	51.50
2	46.30	50.37	57.49
3	....	50.35	51.51
Mean.	46.345	50.356	51.50

Fourth.—The number of grams to separate the disk from the solutions when 46.92 g. of each of the three materials were dissolved in 200 cc. of water.

Trial.	Sodium Chloride.	Copper Sulphate.	Sugar.
1	50.00	51.00	53.10
2	50.02	51.05	53.10
3	50.01	51.07	53.50
Mean.	50.01	51.06	53.26

Fifth.—The number of grams to separate the disk from the solutions when 62.56 g. of each of the three materials were dissolved in 200 cc. of water.

Trial.	Sodium Chloride.	Copper Sulphate.	Sugar.
1	50.90	51.50	55.70
2	50.85	51.45	55.80
3	51.05	51.25	55.75
Mean.	50.90	51.46	55.75

NOTE. The copper sulphate solution was a saturated solution.

Sixth.—The number of grams to separate the disk from the solutions when each of the three materials were saturated solutions at the normal temperature.

Trial.	Sodium Chloride.	Copper Sulphate.	Sugar.
1	50.92	....	57.00
2	51.05	....	56.95
3	50.90	....	57.10
Mean.	50.96	51.46	56.99

These results for each of the three dissolved salts may be plotted graphically by using the number of grams concentration as abscissas and grams to separate the disk as ordinates.

CONCLUSIONS.—First, the above data seem to indicate that within certain limits the cohesion of water with dissolved salts in it is a function of the concentration.

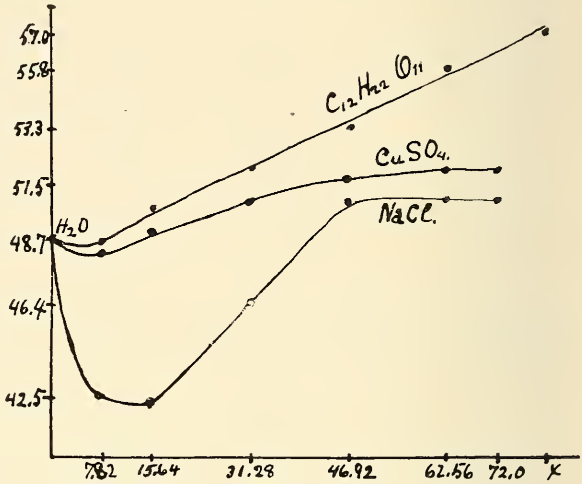

Fig. 3.

Second, as far as tested all dilute solutions of salts in water render the cohesion of the solution less than that of pure water.

Third, so far as tested the dilute strongly basic salts produce a greater decrease in the cohesion of the solution from that of pure water than the nonbasic salts.

Fourth, it is also noted that before the point of saturation is reached in the strongly basic solutions, increased concentration does not produce increased cohesion.

Tests are in progress with various other salts than the ones referred to above. Also tests are in progress in which other solvents than water are being used.

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