



Surface tension of water and of dilute aqueous solutions

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(2) The use of high potentials so as to drown the polarization E.M.F.

(3) The use of a balancing cell in a Wheatstone bridge as first suggested by Kohlrausch, employed by Tollinger, and greatly improved by Neesen.

The first method is of very limited application. The third method by itself we know to be quite unsatisfactory, but combined with the first it will be fairly satisfactory as Neesen found. The combination of the methods (2) and (3) which we regard as being the distinguishing feature of our method leaves nothing to be desired, and is in our opinion much more convenient and accurate than the alternating current method. Dr. Neesen makes no claim in his paper of 1884 to have devised a method superior to the alternating current method.

The last two paragraphs of Dr. Neesen's letter show how little he appreciates the points of our method, one of the main features of which is the employment of high potentials to drown the residual polarization E.M.F. This necessitates high electrolytic resistance, not high resistance of the two equal arms of the bridge.

I am, Gentlemen,

Your obedient servant,

W. STROUD.

SURFACE TENSION OF WATER AND OF DILUTE AQUEOUS
SOLUTIONS. BY N. ERNEST DORSEY.

During the past year I have been endeavouring to determine the surface-tension of dilute aqueous solutions by means of the method of ripples. All work previously done on the surface-tension of solutions has been on solutions of about one half normal concentration, or greater, and most of the observers have deduced the surface-tension from the measured rise of the solution in capillary tubes.

For at least two reasons the method of capillary tubes is open to serious objections. First, the height a liquid rises in a tube depends upon the angle between the wall of the tube and the surface of the liquid *where it meets the tube*. This contact angle cannot possibly be measured, since the surface of the liquid lies entirely on one side of the point where we wish to know its inclination; and as we can measure the inclination of a finite surface only, every measured value of the contact angle must be too large.

The second objection is that probably the surface-tension of the solution-glass surface, as well as that of the solution-air surface, varies with the concentration of the solution. If such is the case, the surface-tension found will depend upon two changes which cannot be readily separated, and which render the interpretation of the results difficult.

For these reasons I decided to use the method of ripples, which was first successfully used by Lord Rayleigh, although with his arrangement of apparatus individual observations differ by about

2 per cent. After trying many plans one was finally adopted that gives individual results that agree to about $\frac{1}{3}$ per cent.; and the average departure of single observations from the mean of several seldom exceeds $\frac{1}{7}$ per cent.

The waves were generated by a fork whose frequency was often determined, and was always near 62·87 double vibrations per second. The water and solutions were contained in a porcelain tray 1 by 12 by 14 inches. The wave-length was measured by means of a telescope mounted on a dividing-engine, whose screw had a pitch of 1·0328 millim. The waves were invisible under ordinary conditions, but were observed by Foucault's method for rendering visible small vibrations in plane or spherical surfaces.

The water used was especially distilled by Mr. W. T. Mather from chromic acid and alkaline potassium permanganate, and was condensed in a block-tin condenser; it was the kind used by him for his electrolytic work. The salts were obtained from Eimer and Amend, and were said to be chemically pure.

With this apparatus I have determined the surface-tension of water and of solutions of sodium chloride, potassium chloride, sodium carbonate, potassium carbonate, and zinc sulphate, of concentrations varying from 0·05 normal to normal.

The value found for water is $T=75\cdot98$ dynes per centimetre at $0^{\circ}\text{C}.$; while Sentis (*Journ. de Phys.* (3) vi. p. 183, 1897), working by an entirely different method, found $T=76\cdot09$ at $0^{\circ}\text{C}.$, which differs from the other by only 0·14 per cent. These values agree very well with the values given by Lord Rayleigh, Hall, Volkmann, and others, but are much lower than Quincke's value.

It was found that the surface-tensions of dilute aqueous solutions are linear functions of the concentration; so that we may write $T_s = T_w + kC$, where T_s = surface-tension of the solution, T_w = surface-tension of water at the same temperature, k is a constant, C is the concentration in gramme molecules per litre. Below is a table showing the values of k as determined by different observers:—

	Dorsey.	Volkmann.	Quincke.	Rother.
NaCl	1·53	1·59	1·57	1·38
KCl	2·23	1·41	1·57	1·47
$\frac{1}{2}\text{Na}_2\text{CO}_3$	2·00	0·987	1·57	
$\frac{1}{2}\text{K}_2\text{CO}_3$	1·77	1·78	1·57	
ZnSO_4	1·86			

Volkmann found that the curve for Na_2CO_3 at great dilution becomes steeper than the one for K_2CO_3 , which agrees with my results. Quincke's value 1·57 does not agree with his results except for KCl and NaCl. I cannot account for the very high value I found for KCl; but it must be borne in mind that the values given above are not fairly comparable, since my values are for solutions generally less concentrated than $\frac{1}{2}$ normal, while the other are found for solutions of greater concentration.—*Johns Hopkins University Circulars*, June 1897.