Summary

1. While the acidity of bog waters of the Puget sound region may be due to carbonic acid, it is not the dominating cause of the acidity.

2. The maximum acidity that could be produced by carbonic acid is much less than that actually observed.

3. Colorimetric and electrometric methods for the measurement of acidity gave different results.

4. The acidity as measured electrometrically is not appreciably altered by evaporation of the waters and their dilution to the original volume.

5. There appears to be rather an indefinite relationship between color intensity and acidity.

6. The stage of succession of the bogs is directly proportional to the acidity.

7. "Dry" bogs show a greater acidity than "wet" bogs.

8. The per cent. of organic matter in the four bogs studied is a logarithmic function of the acidity. The amount of the organic matter present thus appears to be the controlling factor of acidity.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF WASHINGTON]

A MICRO METHOD FOR THE DETERMINATION OF SURFACE TENSION AND DENSITY

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Although several micro methods for the determination of surface tension[1] and density[2] are known, none of the apparatus employed in these is applicable to both determinations. The purpose of this article is the description of an exceedingly simple apparatus by which surface tension and density can be determined on amounts of liquid as low as one-tenth of a cubic centimeter, with a theoretical accuracy of from one part in 100 to one part in 300, depending on the liquid.

Apparatus.—A ten centimeter portion of 5 mm. soft glass tubing was heated to softness in a Bunsen burner with wing top attachment and quickly pulled to arm's length. By running a three centimeter column of water up and down the resulting capillary, an eight centimeter portion that had practically uniform bore was found, and a ten centimeter length was cut out so that the eight centimeter portion was on one end. This

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[1] (a) Du Noüy, *J. Gen. Physiol.*, **1**, 521–524 (1919); (b) Kiplinger, THIS JOURNAL, **42**, 472–476 (1920); (c) Sugden, *J. Chem. Soc.*, **119**, 1483–1492 (1921); (d) Ferguson, *Proc. Phys. Soc. London*, **36**, 37–44 (1923); (e) Richards, Speyers and Carver, THIS JOURNAL, **46**, 1196–1207 (1924).

[2] (a) Wartenberg, *Ber.*, **42**, 1126–1131 (1909); (b) Wiedbrauck, *Z. anorg. allgem. Chem.*, **122**, 167–170 (1922); (c) Detre, *Deut. med. Wochschr.*, **49**, 985 (1923).

end was filed flat and the other end notched, so the correct end could be used in all determinations. The radius was determined in the usual way with mercury and was found to be .01650 cm. A larger capillary was pulled, with a bore such that the small tube slipped in snugly, without sticking. This tube, used as a jacket, was made seven centimeters long and sealed at one end. A third tube, five centimeters long and sealed at one end was next made, being large enough to fit loosely over the jacket. This was the holding tube, used in the determination of density, to prevent the hands from touching the rest of the apparatus.

Determination of Surface Tension.—The jacket and holding tube were not used in the determination of surface tension. A small tube, with a capacity of about one-half of a cubic centimeter and 0.7 cm. in diameter, was used to hold the sample. This tube was put in a small thermostat and the liquid kept just at room temperature. The capillary tube (held close to the top by the fingers to prevent transfer of heat to the liquid) was lowered as nearly vertical as possible, so that the end just made contact with the liquid, in this way approaching the maximum rise from below. When the liquid had stopped rising, the capillary was pulled up, laid horizontally on a millimeter rule and measured by the eye to 0.1 mm. Now the end of the tube was dipped far into the liquid and after it had stopped rising was brought to the surface, thus approaching the maximum rise from above. To come from below again, a little of the liquid was shaken out of the tube and the first procedure repeated. Eight or ten readings were taken and the average recorded.

Determination of Density.—An assay balance weighing to 0.00001 g. was used. The weight of the capillary tube plus the jacket was first determined. Then the capillary tube was dipped in the liquid and the length of the column was determined as before, except that the capillary was held by forceps instead of the fingers. As soon as the length of the column was determined, a stop watch was started, the time of weighing being taken into account in order to correct for evaporation. The capillary was put into the jacket, great care being taken that none of the liquid ran out as it was being inserted, and the apparatus was weighed again. In all these operations the hands were kept off the apparatus, although a little practice was necessary to do this successfully. As soon as the second weighing was made, the time that the stop watch had been running was observed. The apparatus was left right on the balance, and at the end of another equal period of time a third weighing was made. The difference between the second and third weights was added to the first determined weight of the liquid, the assumption being made that the same weight of liquid would evaporate during each period of time. Since radius was known, as well as the length of the liquid column, the density was readily determined.

Experimental Results

TABLE I

SURFACE TENSION MEASUREMENTS

Subs.	Temp., °C.	Surface tension, dynes/cm.	Interpolated values of other observers for same temp.	Observer
H_2O	21	72.4	72.6	Accepted
C_6H_6	18.5	29.5	29.2	Accepted
CCl_4	23	25.7	25.3	Ramsay and Shields
			25.9	Jaeger
			26.4	Richards and Carver
$(C_2H_5)_2O$	22	16.8	16.5	Jaeger
			16.6	Brunner
			16.8	Richards and Carver
$C_6H_5CH_3$	23	28.4	27.6	Volkmann
			28.4	Jaeger
			28.1	Richards and Carver
$C_6H_5NO_2$	20	42.4	41.9	Ramsay and Shields
			43.2	Morgen (corrected)
			42.4	Jaeger
$C_6H_5NH_2$	19	43.9	43.1	Jaeger
			43.6	Renard and Guye
			43.9	Volkmann

TABLE II

DENSITY MEASUREMENTS (R = 0.01650 cm.)

Subs.	Temp., °C.	Observed density	Correct density
H_2O	22.5	1.002	0.998
$C_6H_5N(CH_3)_2$	23	0.950	.952
$C_6H_5CH_3$	23	.857	.864
CCl_4	25	1.592	1.584
$C_6H_5NO_2$	26	1.188	1.198

Discussion of Results.—No correction for meniscus was applied, since due to the small bore of the capillary (.01650 cm.) the error introduced was negligible compared to the accuracy of the method as a whole.

Blowing into the tube, to force the liquid out in getting checks on the maximum rise, was found to introduce a large error. Results were also inconsistent when the tube was not wet with the liquid before determining maximum rise.

No readings were taken at other than room temperature, since with the present technique it is difficult to regulate the temperature of the liquid in the capillary.

In preparing the jacket for the capillary in determining density it was found essential to have one that fitted snugly. Otherwise, liquids like benzene and carbon tetrachloride were found to evaporate too rapidly to weigh accurately, in spite of the correction.

Liquids having a higher vapor pressure than 100 millimeters at 20°, such as ether and carbon disulfide, did not give satisfactory results in the determination of density.

Summary

A micro method for the determination of surface tension and density has been described which requires not over one-tenth of a cubic centimeter of sample for both determinations, which uses the same apparatus (with the addition of a jacket) for the determination of density as for the determination of surface tension and has an accuracy of from one part in 100 to one part in 300, depending on the liquid.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF WASHINGTON]

IMPROVED APPARATUS FOR THE REMOVAL OF DISSOLVED GASES FROM WATER[1]

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Many different forms of apparatus for the removal of dissolved gases have been described in the literature. In general they consist of three types: those employing vacuum only,[2] which include numerous modifications of the Van Slyke apparatus,[3] those employing heat only,[4] and those employing both heat and vacuum.[5]

Those of the latter type will remove gases from water more completely than the first two, and so an apparatus was designed which combines the good features of the Van Slyke type with those of the apparatus described by Treadwell-Hall. This improved apparatus has been used by the authors with excellent success for the removal of gases dissolved in natural waters. It is adaptable to any size of system or amount of gas, provides means of making a sharp separation of water from gas, employs the minimum number of joints consistent with ease of manipulation and also provides a seal for each joint.

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[1] Read before the Chemical Section of the Pacific Coast Division of the American Association for the Advancement of Science.

[2] (a) Frankland, *J. Chem. Soc.*, **6**, 109 (1854); (b) Lothar Meyer, *Z. anal. Chem.*, **2**, 237 (1863); (c) Jones, Yant and Buxton, Bureau of Mines Reports of Investigations, No. 2553, December, **1923**.

[3] (a) McClendon, *J. Biol. Chem.*, **30**, 259 (1917); (b) Van Slyke, *ibid.*, **30**, 347 (1917); (c) Van Slyke and Stadie, *ibid.*, **49**, 3, 44 (1921); (d) Austin and others, *ibid.*, **54**, 129 (1922); (e) Hall, *ibid.*, **55**, 751 (1923).

[4] (a) Bunsen, "Gasometrischen Methoden," 1st ed., **1857**, p. 18; (b) Reichardt, *Z. anal. Chem.*, **11**, 271 (1872); (c) Jacobsen, *Ann.*, **167**, 12 (1873); (d) Buchanan and Dittmar, "Physics and Chemistry, Report on the Scientific Results of the Voyage of H. M. S. *Challenger*," Longmans and Co., or Macmillan Co., **1884**, I, p. 141; (e) Petterson, *Ber.*, **22**, 1434 (1889); (f) Treadwell-Hall, "Analytical Chemistry," John Wiley and Sons, Inc., New York, **1924**, 5th ed., Vol. II, p. 634, Fig. 128.

[5] (a) McLeod, *J. Chem. Soc.*, **7**, 313 (1855); (b) Hamberg, *J. prakt. Chem.*, **141**, 433 (1885); (c) Hoppe-Seyler, *Z. anal. Chem.*, **31**, 367 (1892); (d) Richardson, *J. Soc. Chem. Ind.*, **29**, 198T (1910); (e) *ibid.*, **38**, 32T (1919); (f) Ref. 4 f, p. 631, Fig. 127.