

the reef. As I passed from the bottom layer to the intermediate layer I noticed a discrete horizontal line in the water, somewhat similar to the edge of a piece of glass. I wondered about this line and made a series of dives to investigate it. Diving down the motions of swimming caused so much agitation that the line was not visible, but by returning slowly to the surface through the undisturbed water the demarcation between the layers was visible each time. It could not be seen from more than 2 or 3 in. above or below the interface, and viewed horizontally it seemingly had no thickness but was merely a refractive plane.

Unfortunately in my field gear I had no equipment to measure salinity, temperature, or even depth, so I could not confirm my observations with any measurements. However, there can be only one way to account for the plane that I observed. It is well known that the refractive index of sea water increases with decreasing temperature and increasing salinity [H. U. Sverdrup, M. W. Johnson, and R. H. Fleming, *The Oceans* (Prentice-Hall, New York, 1946), p. 70]. These two masses of clear, still water certainly had different temperatures and probably different salinities. The plane seen was the result of the difference in their refractive indices and marked the location of a very sharp thermocline.

Although I have often seen a sharp demarcation between turbid water and clear water while diving, in my years of skin-diving in the Pacific I have never before seen this phenomenon. I have never heard it remarked upon by other divers, nor have I seen it reported in the literature.

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## Prevention of Evaporation in Horizontal Strip Ionography

In a recent communication concerning electrophoresis in paper stabilized media, [*Science* **120**, 677 (1954)], Samuel Raymond has performed a useful service by focusing attention on the question of whether the current or the voltage ought to be held constant when one is determining mobilities. The answer to this question, which was previously considered in detail by Marbach (1), does not depend, under proper experimental conditions, on whether the paper strip is open to a gaseous atmosphere or is sandwiched between glass or plastic plates.

Raymond states, "When the paper is exposed to an atmosphere, whether saturated or not, evaporation from the paper occurs because of heat generated by the electric current." This statement is not necessarily true and may mislead some persons into thinking that the horizontal paper-strip technique, which is in wide current use, is unsuitable for mobility determinations. As has been pointed out (2), the addition of 5 to 15

percent glycerol, ethylene glycol, or other similar low-molecular-weight substances to the buffer solution, causes the vapor pressure of the solution saturating the paper strips to be lowered below that of the water in the space surrounding the buffer vessels. Since the enclosed air or helium gas space (which is kept minimal by the addition of the maximum allowable water to the chamber) is saturated with respect to pure water, the paper strips saturated with buffer solution containing glycerol can be maintained at a temperature above their surroundings without the occurrence of any net loss of water, owing to evaporation. The strength of the electric current carried by the strips can be varied empirically to a point where the escaping tendency of water molecules from the buffer-saturated strips is just equal to the escaping tendency of water molecules from the pure water in the chamber, and under these conditions, no net loss of water whatever occurs from the paper surface.

It is then possible to maintain a constant current and potential gradient for hours, and with such an arrangement the field strength is calculated directly by dividing the applied voltage by the length of paper measured between the surfaces of the buffer solution in the end vessels. Other things being equal, the lower the molecular weight of the addition compound, the greater the vapor pressure lowering achieved at a given weight concentration. The additives should not of course, in general, alter to any appreciable extent the electrochemical characteristics of the buffer solution, such as its conductivity, pH, ionic strength, dielectric constant, and so forth, and should not form complexes with either the migrant or the buffer. Other methods for determining meaningful mobilities using the horizontal paper-strip technique are considered in greater detail in a forthcoming monograph (3).

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## References

1. E. P. Marbach, Ph.D. dissertation, Loyola University (1954).
2. H. J. McDonald, *J. Chem. Educ.* **29**, 428 (1952).
3. ——— et al., *Ionography; Electrophoresis in Stabilized Media* (Year Book Pub., Chicago, in press).

1 December 1954.

Aside from its effects on viscosity, dielectric strength, and other factors that affect the electrophoretic mobility, the chief effect of glycerol in the buffer solution is to increase the temperature difference between the buffer and pure water at vapor equilibrium. A tenth-molar buffer is at vapor equilibrium with pure water when its temperature is approximately 0.1°C above the water temperature. This is increased 0.4°C in a 10-percent glycerol solution. If vapor equilibrium is maintained, this small temperature difference must account for all the cooling of the paper in hanging-strip apparatus. The permissible power dissipation in the paper is thereby severely limited.

Although measurements are complicated by concentration changes in the paper resulting from evaporation, condensation, or electroosmosis while equilibrium is being reached, preliminary experiments indicate that a power level of less than  $0.001 \text{ w/cm}^2$  is permissible. This corresponds to a field strength of less than  $3 \text{ v/cm}$ . In practice it is difficult to determine the exact power level for equilibrium; and unless accurately standardized conditions and low voltages are used, the glycerol concentration will change during the run. At normal levels of operation in hanging-strip apparatus, most of the heat generated in the paper is carried away by evaporation, as I have stated; the addition of glycerol increases slightly the proportion of heat removed by other routes—that is, conduction, convection, and radiation.

These complications are completely avoided in the pressure-plate type of apparatus, where the vapor space is entirely eliminated and the paper is in good thermal contact with thermostatted cooling plates. For good results a constant pressure must be maintained on the paper; apparatus for doing this will be described in a separate publication.

Most workers in this field recognize that specific identifying tests applied to the completely separated fractions obtainable in paper electrophoresis make "absolute" mobility determinations unnecessary. Useful mobilities can be obtained by applying various empirical corrections.

I hope my note did not mislead anyone into thinking that horizontal paper-strip apparatus is unsuitable for electrophoresis work. Indeed, as the designer of such an apparatus, I prefer it to other types. I must add, however, that in my opinion the pressure plate is an essential element of the design.

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## Lattice Constants of Pure and Fluoride-Contaminated Ice

X-ray measurements have been performed to obtain precise values for the unit cell dimensions of pure and fluoride-contaminated ice. A new  $c/a$  ratio is calculated for pure ice, and in the case of fluoride-contaminated ice evidence is found that this impurity enters into the ice structure substitutionally. The latter finding is important in connection with the mechanism of electric conductivity in fluoride-contaminated ice, since it has been shown that presence of traces of

fluoride ions almost completely determines the electric conductivity (1, 2).

The lattice constants of pure and fluoride-contaminated ice were determined by the use of a symmetrical back-reflection focusing camera designed specifically for use on ice. The diameter of the camera was  $17 \text{ cm}$ , and the area of the irradiated sample was  $24 \text{ mm}^2$ . Copper  $K_\alpha$  radiation was used with an exposure time of  $12 \text{ hr}$  at  $17 \text{ ma}$  and  $40 \text{ kv}$ . The sample temperature during the time of exposure was  $-46.0 \pm 0.7^\circ\text{C}$ . The Miller indexes of the back-reflection lines were determined by the graphical method of Bjurström (3), and the procedures of calculation followed Jette and Foote (4).

The lattice constants of pure ice (prepared from water having a specific conductivity of  $2.5 \times 10^{-7} \text{ mho/cm}$  at  $20^\circ\text{C}$ ) were measured at  $-46^\circ\text{C}$  giving the values:  $a = 4.507_1 \pm 0.000_5 \text{ \AA}$  and  $c = 7.332_7 \pm 0.000_9 \text{ \AA}$ . In the case of fluoride-contaminated ice (frozen from  $4.5 \times 10^{-4} M \text{ CsF}$ ), the dimension of the cell base was found to be the same as that for pure ice, but the cell height was  $0.033 \pm 0.025$  percent shorter. Since only the fluoride ion is incorporated (1) and considering the properties of this ion, one would expect a slight shortening of the lattice if the impurity enters substitutionally. On the other hand, the amount of fluoride used would be expected to produce a detectable expansion of the lattice if it were incorporated interstitially. The fact that the fluoride impurity did not increase the unit cell dimensions gives evidence that this impurity enters into the ice structure substitutionally rather than interstitially.

The afore-mentioned values for the lattice constants of pure ice agree fairly well with the values obtained by H. D. Megaw (5). The slight difference that does exist between Megaw's values and the values stated here for pure ice leads to a new value for the  $c/a$  ratio of  $1.627$  at  $-46^\circ\text{C}$  as opposed to the ideal value of  $1.633$ . The present determination of the  $c/a$  ratio for pure ice further substantiates Bjerrum's argument concerning preferred dipole orientation (6).

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## References

1. E. J. Workman and S. E. Reynolds, *Phys. Rev.* **78**, 254 (1950).
2. E. J. Workman, F. K. Truby, and W. Drost-Hansen, *ibid.* **94**, 1073 (1954).
3. T. Bjurström, *Z. Physik.* **69**, 346 (1931).
4. E. R. Jette and F. Foote, *J. Chem. Phys.* **3**, 605 (1935).
5. H. D. Megaw, *Nature* **194**, 900 (1934).
6. N. Bjerrum, *Science* **115**, 385 (1952).

4 January 1955.

*Think like a man of action and act like a man of thought.*—HENRI BERGSON.