A Quickly Made Dielectric Constant Cell

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The usual method of determining the dielectric constant of a fluid is to measure the capacitance of an electrical condenser when its interplate space is filled with the fluid of interest, to measure its capacitance when the interplate space is filled with fluids of known dielectric constants, and from these measurements to calculate the dielectric constant sought. Among the necessary or desirable characteristics of a suitable electrical condenser and container—the cell—are: (1) It must be rigid to the extent that no significant change in spacing of the conductors will occur with use. (2) The magnitude of the cell's electrical capacitance must be compatible with the measuring equipment to be used. (3) The ungrounded electrode should be electrically shielded to prevent capacitance changes resulting from movement of external objects. (4) It should be possible conveniently to thermostat the cell. (5) The cell must not be damageable by fluids to be put into it nor by temperatures within the temperature range over which it is desired to measure dielectric constants. (6) Reproducible filling of the cell should be easy, as should emptying and cleaning. (7) Often it is desirable to minimize the volume of fluid required for filling the cell.

Many embodiments of these characteristics have been worked out. The following description is added to those already in the literature because the cell to be described can be constructed very quickly from readily available parts, and yet it seems to compare favorably in performance, versatility, and ruggedness with cells of considerably more elaborate design.

The cell construction needs little description. Two holes are bored in the metal shell of a 6H6 radio tube (duplex diode), and copper tubes are soldered into the holes. This is the cell (Fig. 1). Fluids of known and unknown dielectric constant are introduced and removed through these tubes, and dielectric constants are calculated in the usual way from measurements of interelectrode capacitances of the 6H6. Since the shell serves as the electrical shield, it is always grounded. The measured capacitance will depend on which of the other electrodes are connected to the shell and which to the ungrounded lead, and the possible variations in these connections considerably extend the range of dielectric constants that can conveniently be measured with a capacitance measuring device of limited range.

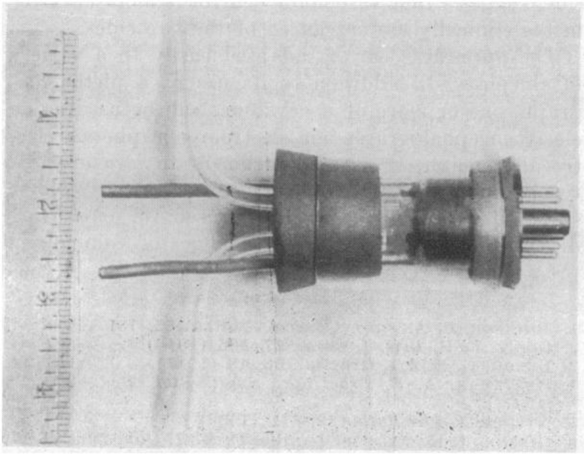

FIG. 1. Dielectric constant measuring cell and enclosure for the thermostating fluid.

A few details are important. One is that the tube should be operated with its axis horizontal, and the copper tubes should be inserted as nearly as possible at the extreme ends of the vertical diameter. Also, since the heaters and plates are perpendicular to the tube axis, the mounting and the inlet and outlet holes should be so oriented that the heaters and the cylindrical plates surrounding them are roughly vertical. These arrangements facilitate completeness of filling and emptying and minimize the probability of entrapping bubbles between the electrodes. This type of tube has a bakelite stud with a ridge on it for orienting the tube in its socket. With the two tube samples investigated it was found that proper orientation of the electrodes was obtained if the guide ridge were directly above or directly below the tube axis.

It is easy to thermostat this cell by enclosing it in a jacket through which thermostated water is pumped. The jacket comprises a glass tube about 2 in. long and of such a diameter as to fit tightly over the tube flange when this flange is covered by a piece of thin-walled rubber tubing of the type used with Gooch filters. The other end of the glass tube is closed by a rubber stopper with 4 holes, 2 for the copper tubes connected to the cell and 2 for tubes opening into the jacket through which the thermostating liquid flows. It was found that unprotected parts of the 6H6 shell rust in the water bath. Suitable paint applied where the original paint and plating are removed should prevent rusting. Certain facts pertinent to the applicability of the cell were obtained from RCA concerning their 6H6. The cathode sleeve is of silicon nickel. The plate and shell are of nickel-plated steel. The heater is made of a commercial molybdenum-tungsten alloy known as "Dowmo." The orientation of the electrode axes with respect to the guide on the tube base is the same for all RCA 6H6s.

In a cell of this type the electrical capacitance varies almost linearly with the dielectric constant of the filling fluid. The following data were obtained at 25° for three of the possible connections. They are expressed in terms of ΔC, the capacitance of the cell when filled with benzene (dielectric constant = 2.27) minus its capacitance when filled with air. (*a*) With all elements of the tube except the shell connected together and capacitance measured between shell and other electrodes, $\Delta C = 3.34$ μμf. (*b*) With all elements including shell but excepting plate 5 connected together and measuring capacitance between plate 5 and the combination, $\Delta C = 2.34$ μμf. (*c*) With plates 3 and 5, and all the other elements, connected together, and the capacitance measured between those two combinations, $\Delta C = 4.53$ μμf.

To determine the constancy of the cell calibration, measurements were made every few days over a period of about a month on the same sample of benzene. Each time a test was made the capacitance of the cell filled with air was first measured. Then the cell was filled with the benzene sample, and the capacitance was measured. Then the cell was emptied, and the residual benzene was evaporated by passing air through the cell. These tests were made with the connection described in (*c*). The values for ΔC obtained in this series of tests were all 4.53 ± 0.01 μμf.

No damage resulted to the cell when steam was passed through the jacket. This suggests that the cell can be used to measure dielectric constants over a considerable range of temperatures.

About 10 ml of liquid is required to fill the cell.

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Effect of Organic Solvents on the Emission Spectra of Sodium and Potassium in Serum and Aqueous Solutions [1, 2]

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A systematic investigation of solvents other than water for the dilution of serum for flame photometric determination of sodium and potassium has been made to discover a solvent which would eliminate some of the disadvantages of aqueous dilutions and possibly increase the range of measurement of small quantities of these elements.

Concentrations of 10–100% of anhydrous, sodium, and potassium free organic solvents in water with 0.3 mEq sodium and 0.01 mEq potassium added, were prepared for the study of the solvents' effect on the flame spectrum of sodium. The same dilutions of organic solvents containing 0.2% normal serum for a comparative study were prepared. Aqueous solutions of the same dilutions of normal serum and of sodium and potassium containing 0.02% Sterox[3] were used to represent 0% solvent. All sodium measurements were made with 0% solvent set at the 5% transmission value on a DU Beckman Spectrophotometer. Slit width was set at 0.05 mm (with sensitivity knob set near 0), oxygen pressure at 7 lbs, and acetylene at 3 lbs. All the above adjustments were kept constant, and the dark current only was adjusted for the slight differences of the flame background of the blanks for the different concentrations of the solvents. No measurable amounts of sodium or potassium were present in these blanks. Serum specimens were centrifuged to remove any precipitate which formed. It was observed (Fig. 1) that all the organic solvents enhanced the emission spectra of sodium progressively, especially above concentrations of 50%, and acetone gave much greater enhancement (seventeenfold) than the other solvents. Increasing amounts of protein were precipitated above 50% acetone, and loss of sodium with the precipitate was observed. Loss of the sodium salt with protein precipitate in 100% acetone removed more than 50% of the sodium from solution. Although serum protein was precipitated by 50% or more methanol, no loss of sodium with the precipitate was evident with this solvent. Of the solvents studied, only methanol exhibited this curious phenomenon. Little enhancement of the sodium spectra by propanol and isopropanol was observed.

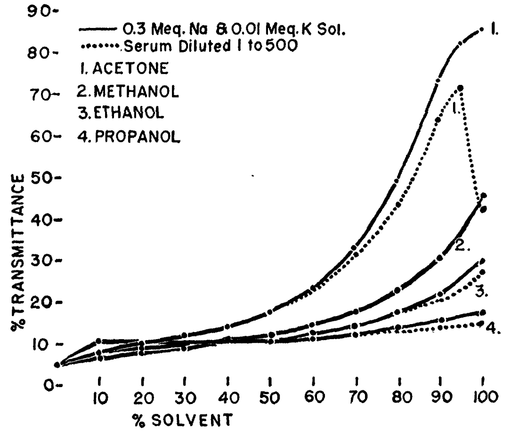

FIG. 1. Comparison of the effect of different concentrations of organic solvents on the flame spectra of sodium at 589.6 μ in diluted serum and in aqueous solutions, as measured with a Beckman Spectrophotometer with flame attachment #9200, acetylene-oxygen-burner assembly. Ordinate, relative light intensity read as % T on instrument's scale.

The solvents were studied (Fig. 2), in the same manner as described for sodium, for their effect on the flame spectrum of potassium, using solutions containing 1.5 mEq sodium with 0.05 mEq potassium and solutions of normal serum diluted 100 times; 0% solvent was set at the 5% transmission value, slit width was fixed at 0.5 mm, oxygen pressure at 7 lbs, and acetylene at 5 lbs. The same relative order of effect of the solvents on intensifying the flame spectrum of potassium was observed as that for sodium. Acetone increased the flame spectrum of potassium thirteenfold. Loss of potassium occurred in all solvents above 50% concurrently with precipitation of serum proteins. Methanol solutions showed loss of potassium with the protein precipitate, although this solvent had shown no loss of sodium with the protein precipitate. Propanol and isopropanol showed little effect on the

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[1] Paper read before the Southern California Section, American Association Clinical Chemists, Feb. 5, 1952, Los Angeles.

[2] Reviewed by the Veterans Administration and published with the approval of the chief medical director. The statements and conclusions of the authors are the result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

[3] Sterox, S. E., Monsanto Chemical Company, St. Louis, Mo.