

MODIFICATION OF THE NORTHROP-KUNITZ MICROCATAPHORESIS CELL.

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A modification of the microcataphoresis cell described by Northrop and Kunitz has been used by the author for the study of many different types of suspensions and of different aspects of electrokinetic phenomena. (For a summary and literature review see Abramson: Colloid chemistry symposium monograph, No. VI, New York, 1928.) The essential differences in construction and use of the apparatus as used by the author are briefly described in the following and in Figs. 1 and 2.

1. The cell is not only made entirely of glass, as described by Northrop and Kunitz, but is so blown that the electrode vessels are fused to the cell itself.*

This is of advantage in that:

(a) The apparatus is smaller, lighter, more readily handled and is filled with no difficulty.

(b) It can be placed directly on the sliding stage of the microscope and can be held in position by two brass extensions which move with the stage.

(c) It is easily cleaned with cleaning mixture between measurements with no other manipulation than sliding the entire apparatus out of its support.

(d) If it be desired to resuspend particles which have fallen out, the apparatus is simply turned upside down.

2. Instead of Zn-ZnSO₄ reversible electrodes it has been found con-

* Two types of glass cells are available: (1) a cell of soft glass of uniform cross-section; (2) a cell of Pyrex or Jena glass drawn out sideways, but not of uniform cross-section. See article in Bibliography for further information.

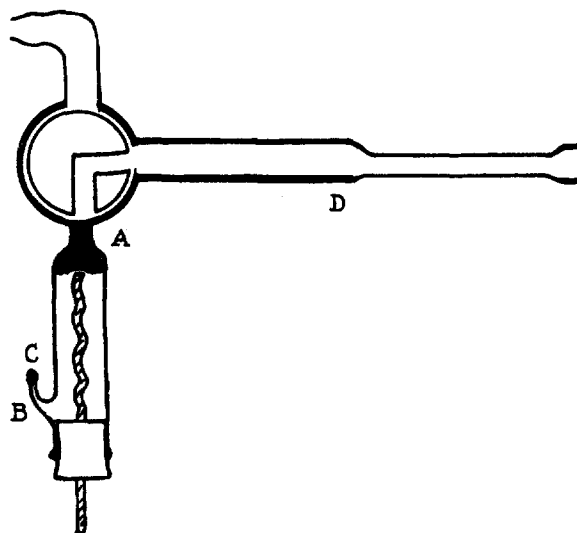


FIG. 1. Schema in longitudinal section of apparatus. At *A* is the agar plug *B* is the outlet, sealed off at *C*. The cell itself is fused to the electrode arm at *D*. By reference to previous publications, and Fig. 2, other details can be obtained

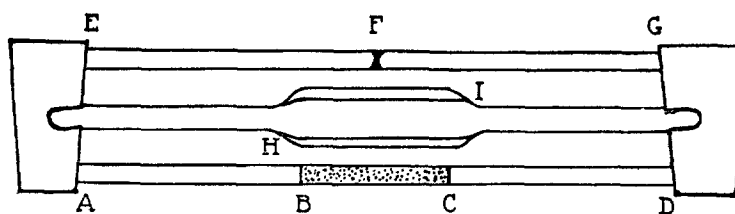


FIG. 2. Schematic view from above. The bars *ABCD* and *EFG* are solid glass supporting rods. Part of the bar *BC* (stippled) is curved so that dark-field illumination from the side is possible. Shaded *F* of the rear supporting rod is a break in *EFG* which is sealed with a suitable cement. By cementing glass plates above and below at the sides *H*, *I* of the cell itself, surfaces are obtained for both manual and mechanical manipulation.

venient to use the following systems, depending on the type of experiment to be made:

- (a) Cu-CuSO_4 —electrolyte-free agar

(b) Cu-CuSO₄—agar in isotonic saline solutions

(c) Cu-CuSO₄—agar in saturated salt solutions like Na₂SO₄ and KCl.

The use of agar prevents streaming of the liquid from the electrode chamber into the system to be measured. In the case of suspensions in systems with high protein concentrations, as in serum, streaming occurs incidental to the heavy protein precipitate. This streaming, which makes measurement impossible, can be prevented by an agar plug. If the agar plug is electrolyte-free, it is best to allow freshly prepared electrodes to stand overnight before use. Otherwise the applied electrical force may move the agar, slightly, but sufficiently to cause turbulence. Saturated KCl agar has also been used. In the presence of the chloride ion Cu⁺⁺ is apparently reduced by the copper electrode to Cu⁺. Although the saturated KCl-agar electrode works excellently as a Cu ⇌ Cu⁺ electrode, a precipitate on the copper may occasionally cause disturbance. Instead of the side arm stop-cocks with a ZnSO₄ reservoir as devised by Northrop and Kunitz, the capillary outlets in the diagram are situated as indicated. These facilitate filling the electrode chamber with CuSO₄ solution. They are sealed off with a suitable cement after stoppers are in place. A suitable diameter for the electrode vessels is 1 cm. The reproducibility of measurements is considerably enhanced by making consecutive experiments at the same point in the cell. Hairs are crossed and cemented to the top of the cell with Canada balsam. By using the point of crossing of the hairs as a reference mark, it is simple to return to the same point.

3. The calculations of the drop in potential may be accomplished as Northrop and Kunitz suggested. It has been found more convenient to use the following scheme. It follows from Ohm's law that E , the drop in potential per cm. in the cataphoresis cell is

$$E = \frac{IR}{q}, \quad (1)$$

where I is the current, R the specific resistance of the suspension and q the cross-section of the cell at the point of measurement. Since measurement of current prevents errors possible through accidental resistances, it is advisable to use the method of calculation as expressed in equation (1) when possible.

The movements of the water and particle within the cell follow the theory of von Smoluchowski in the case of small E.M.F.'s. If there is a very high electroendosmotic streaming of the medium, the curve of particle velocity may deviate from the well known parabolic form. This deviation is in the nature of a diminished return flow in the mid-regions of the cell, due perhaps to turbulence phenomena in other parts of the system rather than in the cell itself. Except for these anomalous and mostly avoidable cases, the curve is parabolic. In making measurements one should therefore use the lowest E.M.F. possible for the degree of accuracy required. When the curve of particle velocity at different levels is parabolic, the curve of velocity as plotted against level is the same near the fused ends of the cell itself (within 1.5 mm.) as in the middle. The stream lines of the liquid throughout the cell are therefore uniform. A most useful magnification is that obtained with a Zeiss 28 × ocular and 40 × water immersion objective. The working distance with this objective is 1.6 mm.

SUMMARY.

A modification of the Northrop-Kunitz microcataphoresis cell is described. Although the theory of von Smoluchowski relating to such systems is in general followed, certain deviations may be encountered which are easily avoided.

Addendum.—When the cell is used frequently, it may occur that the current passing through the system gradually falls. This indicates that there is a resistance at some point in the circuit. It can easily be shown that this resistance is at the junction of the agar plug and the solution in the cell itself. I have found that if the agar plug remains in contact with a saturated KCl solution for about 20 minutes, the constancy of the current flow is restored. It seems likely that a thin semi-insulating film of stop-cock grease on the agar surface may be responsible for such erratic behavior of the electrodes.

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BIBLIOGRAPHY.

1. Northrop, J. H., and Kunitz, M., *J. Gen. Physiol.*, 1925, vii, 729.