THE USE OF A MILLIAMPERE-HOUR METER IN ELECTROPHORESIS

by

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The variations in voltage and frequency of the power supplied to the laboratory at Lindholm were so great that it was difficult to maintain a constant current in the electrophoresis cell. Since current fluctuations were as great as one milliampere, it was considered that the current stabilizers in the AMINCO apparatus** were inadequate. Thereafter, a milliampere-hour (ma–hr) meter*** was incorporated into the high voltage circuit to increase the accuracy of the mobility determinations.

It can be shown that if the total current passing through the cell is measured by an accurate ma–hr meter, it is not necessary to have precise current stabilization. If the electrophoretic mobility and velocity of a given component are designated as u and V, respectively, the cross sectional area of the cell as q, the specific conductivity as k, the current as i, and the time as t, it can be stated that:

$$V\mathrm{d}t = \frac{u}{qk} \cdot i \, \mathrm{d}t \quad \text{or} \quad u = \frac{q \int_{t_1}^{t_2} Vk \, \mathrm{d}t}{\int_{t_1}^{t_2} i \, \mathrm{d}t} \tag{1}$$

If k is constant, the use of a milliampere-hour meter introduces no error since $\int_{t_1}^{t_2} i \, \mathrm{d}t$ can be read directly from the meter. However, if k is not constant, we have:

$$\int_{t_1}^{t_2} Vk \, \mathrm{d}t = \int_{t_1}^{t_2} (V_{av} + \Delta V)(k_1 \Delta k) \, \mathrm{d}t =$$

$$V_{av} k_1 (t_2 - t_1) + V_{av} \int_{t_1}^{t_2} \Delta k \, \mathrm{d}t + k_1 \int_{t_1}^{t_2} \Delta V \, \mathrm{d}t + \int_{t_1}^{t_2} \Delta V \Delta k \, \mathrm{d}t \tag{2}$$

k_1 is the measured value of k and V_{av} is the average value of V during the time $t_2 - t_1$, ΔV and Δk are then functions of t.

The term $V_{av} k_1 (t_2 - t_1)$ is generally used for calculating the mobility instead of $\int_{t_1}^{t_2} \Delta Vk\mathrm{d}t$ so the last three terms of (2) express the error introduced by variations in k. Since Δk is independent of variations in i and $\int_{t_1}^{t_2} \Delta V \, \mathrm{d}t = 0$ (because V_{av} is the average value), variations in i can only influence the last term of (2). However, this last term is small compared to $V_{av} \int_{t_1}^{t_2} \Delta k \, \mathrm{d}t$ and, therefore, variations in i have an insignificant effect on mobility determinations when the ma–hr meter is used.

In addition, to eliminating the need for precise current stabilization, the use of an ma–hr meter makes it unnecessary to have an accurate ma meter. The ma–hr meter currently in use has been tested and shown to have an error of less than 0.5% at a 10 to 30 ma current and less than 1% at a 5 to 10 ma current. The manufacturer recommended that the correction curve should be checked about once a year, or whenever the meter has not been used for a month or more.

The greatest advantage of such a milliampere-hour meter is that current changes or temporary power interruptions do not affect the calculation of electrophoretic mobility.

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** Manufactured by the American Instrument Company, Silver Spring, Maryland.

*** Of the type used commercially to measure current consumption, obtained from Laur. Knudsen Mek. Etab. A/s, København, Denmark, cost approximately $ 40.00.