Comments and Communications

The Exponential Decay Law in Spray De-electrification

THE very interesting experiments of Czyzak and Williams (*1*) demonstrated that the potential of an electrified dielectric plate, against which is directed a uniform spray, decreases according to the relation $V = V_0 e^{-kt}$, where V_0 is the potential at zero time, t is the time, and k is a constant, depending on the material and the spray density.

An attempt was made to explain the data on the basis of discharging, which would occur when oppositely charged "carriers" in the spray deposit out on the plate. As the authors indicated, this leads to difficulties in explaining their results on charcoal sprays, for which the data are the most extensive.

Furthermore, if one assumes that all, or a constant fraction, of oppositely charged particles deposit, and that the spray does not change properties during an experiment, one is led to an expression of the form $V = V_0\ (1 - K't)$, where K' is a constant proportional to the discharge current. This expression, analogous to the zero-order rate law of chemical kinetics, clearly does not fit the data.

Writing the empirical decay law in differential form, $dV/dt = -kV$ and substituting $Q = CV$, where C is the electrical capacity of the charged surface, and Q is the charge, one obtains $(1/C)\ (dQ/dt) = -kV$ or $i = -kCV$, where i is the discharge current. Thus, it is clear that in the experiments the efficiency of the discharge process is linearly proportional to the plate voltage.

This indicates that, if we wish to retain the charged carrier idea, a special assumption is required—namely, that the fraction of charged particles deposited varies linearly with the plate voltage. It appears unlikely that such a special law would be rigidly obeyed over the wide range of experimental conditions reported. For this reason, another mechanism, which requires no special adjustments to give a first-order rate law, is proposed here.

Let us assume that in the experiments which gave decay the initial charging in the spray is of negligible proportions compared to the high charge densities employed on the surface of the plate, and that, as appears plausible, some particles may escape after impinging on the plate. These particles will acquire a surface charge density proportional to the mean charge density, or the potential on the plate, and will carry away some of the charge on the plate. This leads to the equation

$$-\frac{dQ}{dt} = KV,$$

where K is a constant, depending upon the number of particles which strike the surface and carry off charge, and upon the effective surface area of the particles. Integrating this expression and substituting above leads immediately to the exponential decay law, with $k = K/C$.

The emphasis now is upon processes that occur at the surface of the collecting plate. If all particles striking the plate adhere to the surface, a negligible discharge rate will be observed. Such might easily have been the case in the experiments with water, carbon tetrachloride, and glycerin, and with starch on a positive surface. The data for acetone suggest that liquids do not always behave in this manner, and that further work on liquid sprays is required. In addition, the cleanliness of the collecting surfaces becomes a very important factor, and it should be carefully controlled.

The change in discharge rate which occurs when polarity is reversed, but other factors remain constant, presents an interesting problem. Such behavior would be expected if it were known that particles adhered more readily to a charged surface of certain sign, but no such data appear available. However, contact potentials certainly affect adhesion, and it is not difficult to see qualitatively how a surface charge could operate with or against the forces arising from contact surface potentials.

Further experiments are required to establish unequivocally the mechanism involved in this type of experiment, which has an important bearing on problems such as triboelectric charging of airplane surfaces (*2*), and the mechanism involved in the electrostatic particle counter (*3–5*). It is hoped that these suggestions will encourage further work in what has always been a difficult field.

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References

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A Simple Sampling Device for Submerged Cultures

WHEN using a submerged culture fermenter for the small-scale production of antibiotic substances, it is necessary to take frequent samples to follow the progress of their formation. The device described here has been used for small-scale submerged cultures, 6–40 liters, and has been found to be a simple, contamination-proof system for sampling (Fig. 1).

Tube *A* enters the bottle and terminates in a perforated spiral. Air is forced through the opening at *A*, enters the medium through the perforated spiral, and