Static Electrification of Solid Particles by Spraying

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The known basic mechanisms of electrification have been classified into five or perhaps six groups (*1*), and it is believed that more than one of the mechanisms may operate during the process. Spray electrification of liquids has been studied by several investigators (*2–7*).

A commercial-type spray gun modified to produce a fine spray of variable density was used in this experiment. The spray was deposited on an insulator consisting of five sheets of polyethylene (4″ × 5″) bound to an aluminum backing plate (4″ × 5″ × 1/16″). Before the spray was deposited, the insulator was positively or negatively charged to the desired potential by means of corona wires. By running a series of preliminary tests, it was observed that for optimum condition the distance of the nozzle from the insulator and the pressure of spraying were 15 cm and 10 psi, respectively. At lower pressures reproducible data could not be obtained because a uniform spray could not be maintained. At higher pressures and at 15-cm distance or more, a circular area free from particle deposit was produced, indicating that the blast effect of the spray had not been eliminated before reaching the plate; the density of spray was increased or decreased by varying the length of the needle valve stem. For these tests, three arbitrary settings on the needle valve stem were made so that a light, medium, or heavy spray density was obtained. The density was not evaluated quantitatively. After depositing the spray on the insulator for a specified length of time, the change in potential was measured by means of a sensitive electrometer. Any variation in the potential after the spray cloud was deposited on the charged plate indicated the polarity and magnitude of the

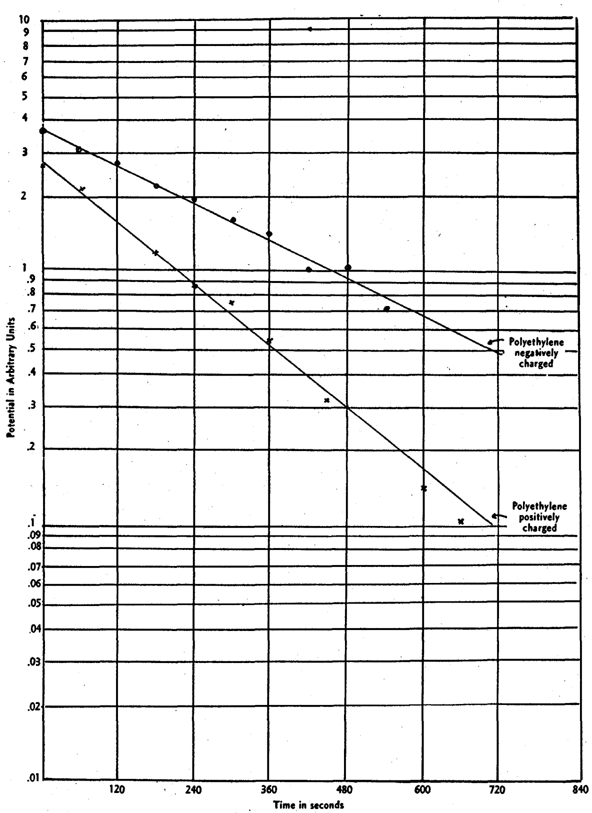

FIG. 1. Acetone spray on polyethylene.

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TABLE 1

HALF-TIME DECAY DATA

Cloud density	Polarity of polyethylene plate	Low (sec)	Medium (sec)	Heavy (sec)
Acetone	+	156		
	−	260		
Starch	+	Negligible		
	−	290		
Charcoal	+	464	27	13
	−	202	24	15
50/50 Charcoal starch mixture	+	110		
	−	22		

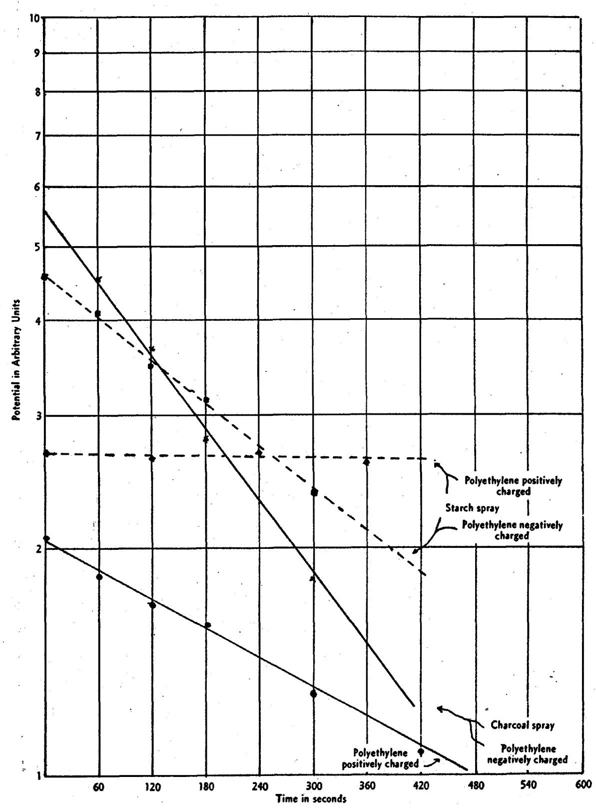

FIG. 2. Starch and charcoal spray on polyethylene.

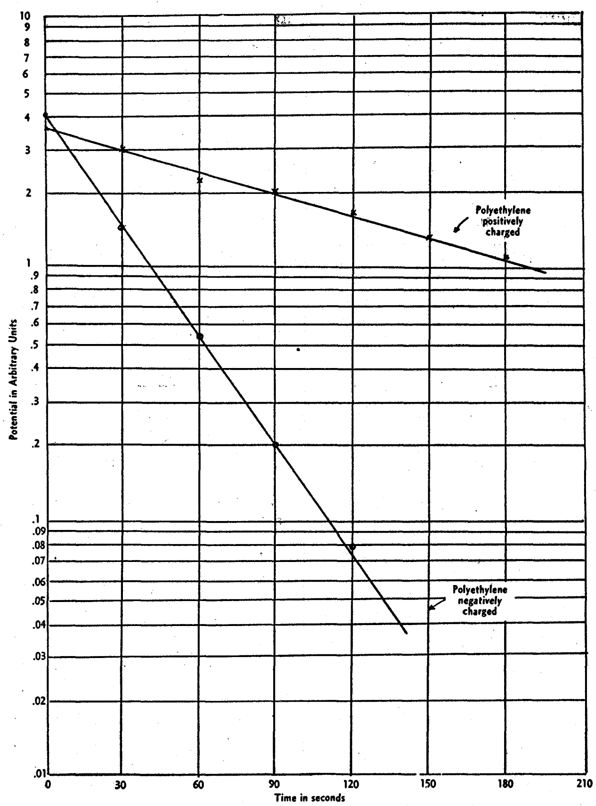

FIG. 3. 1 : 1 mixture of starch and charcoal spray on polyethylene.

cloud charge. By repeating the operation several times on the same plate, the rate at which the charge on the plate was "decaying" was determined.

A series of experiments was conducted on several insulators—Kodapak, mica, pliofilm, and polyethylene—to determine which would be most satisfactory. The various insulators attached to an aluminum backing plate were charged, positively and negatively, by means of corona wires. The different dielectrics behaved quite differently when charged. Polyethylene accepted a high and uniform charge repeatedly, regardless of the polarity. The other dielectrics varied considerably. For this reason polyethylene was chosen for the spray experiments (*8*).

Spray experiments using water, carbon tetrachloride, acetone, and glycerine were first tried to test the experimental method and sensitivity of the apparatus. Other investigators (*2–5, 7, 9*) have used some of these liquids to study spray electrification. In the case of dry sprays, charcoal and starch were used to study the electrification of solid particles. Powders were vacuum-dried before using.

In the case of water, carbon tetrachloride, and glycerine sprays for low-, medium-, or high-density spray clouds, no change in potential was observed on the polyethylene plate regardless of the polarity of the plate. Chapman (*3, 4*) observed in the case of water sprays that particles of positive and negative charges of small magnitude existed in the sprays in approximately equal amounts, and Dodd (*10*) found this also existed in the case of poorly conducting liquids. This would indicate the same condition exists in the case of carbon tetrachloride and glycerine. However, for acetone spray an exponential-type decay was obtained on the polyethylene plate (Fig. 1). The half-time decay values for a low-density spray cloud were 156 sec and 260 sec for droplets deposited on a positively charged and negatively charged polyethylene plate, respectively. Thus it appears that the acetone spray contained more negative than positive carriers. Repeated tests gave results reproducible to within 10%.

For low-density spraying of powdered charcoal, starch, and a 1 : 1 mixture of charcoal and starch, an exponential-type decay was also obtained. The half-time decays obtained are shown in Table 1 and Figs. 2 and 3. The mixture had a considerably faster half-time decay than either of the pure powder sprays, varying anywhere from a factor of 5 to more than an order of magnitude, depending upon the material and polarity. In the case of starch the half-time decay for a spray depositing on a positively charged plate was negligible, whereas on a negatively charged plate it was 290 sec, thus indicating that the starch spray cloud had a great preponderance of positively charged particles. The charcoal spray gave half-time values of 464 sec and 202 sec for positively and negatively charged plates, respectively. Medium- and high-den-

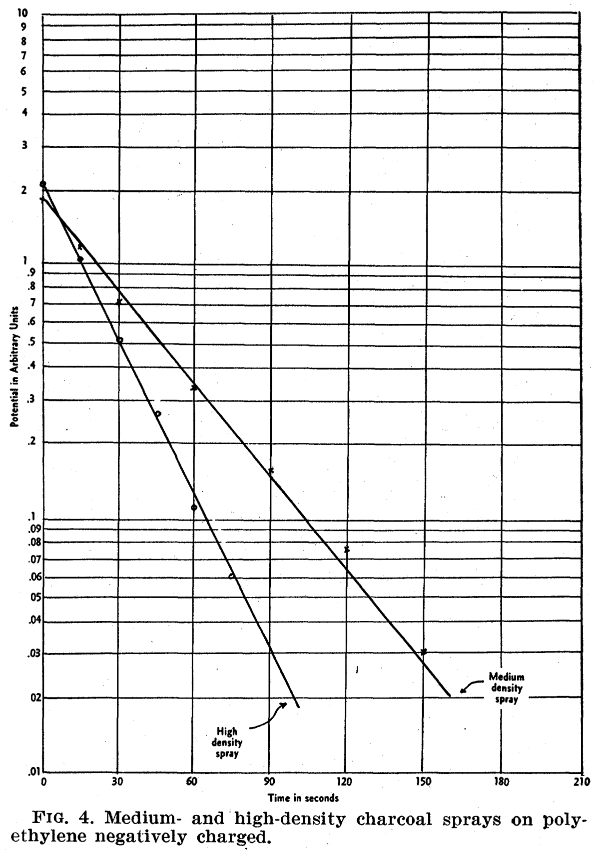

FIG. 4. Medium- and high-density charcoal sprays on polyethylene negatively charged.

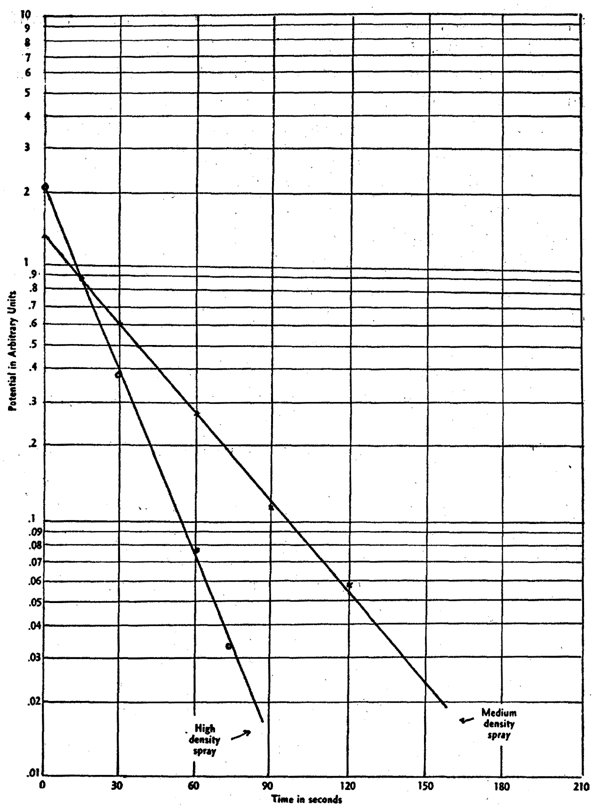

FIG. 5. Medium- and high-density charcoal sprays on polyethylene positively charged.

sity spray experiments were done using charcoal, and again the exponential type decay was obtained; however, the half-time decays were of an order of magnitude faster than in the case of the low-density spray clouds, and are shown in Table 1 and Figs. 4 and 5. Repeated tests with powders gave results reproducible to within 10%.

In both liquid and solid sprays an exponential-type decay of the charge on the polyethylene plate is obtained, and its rate of decay is dependent upon the density of spray and material used. This serves to indicate the net polarity and the magnitude of the spray cloud. In the case of the spray deposit of 1:1 charcoal-starch mixture, it is found that it produces a considerably faster half-time decay on the charged polyethylene plate than in the case of the individual powders. If the charging of the solid particles is assumed to be caused by triboelectric phenomenon—i.e., contact of particles with metal—then it would appear that the phenomenon operates at greater efficiency in the case of the mixture. Since, after spraying has begun, some of the particles adhere to the nozzle, the available contact surface is decreased, thereby decreasing the opportunity for the triboelectric phenomenon to operate. In the case of a mixture, however, both types of particles would adhere to the nozzle, permitting the triboelectric phenomenon to operate more efficiently. It would seem that the data qualitatively verify this. No satisfactory explanation seems available for the change in the ratio of positive to negative carriers for charcoal sprays when the density is increased.

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Prevalence of *Escherichia coli* Strains Exhibiting Genetic Recombination

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The first bacterium to be tested by an efficient selective method for the occurrence of genetic recombination was strain K-12 of *Escherichia coli.* Experiments with auxotroph mutants of this strain promptly gave conclusive, positive evidence of genetic exchanges between different mutant cells in mixed cultures (*1, 2*). However, subsequent attempts to obtain comparable results with a number of other strains used for genetic work were fruitless.

Cavalli and Heslot (*3*) examined a number of auxotroph strains from the National Type Culture Collection (England) and found one that could be crossed with K-12. Unfortunately, this isolate has a complex nutrition, so far unanalyzed, which greatly hinders further work. In other characteristics it closely resembles K-12.

It would be surprising if K-12, the first *E. coli* strain examined, should prove to be uniquely suitable for crossing experiments. Unfortunately, the method for testing fertility involved a good deal of work: it was necessary to prepare at least two nonoverlapping, double nutritional mutants from each strain. Despite improved techniques (*4*), such a procedure is almost prohibitive for routine survey of new strains. The following procedure was therefore put into effect for preliminary screening.

A multiple marker strain, W-1177 (= 677-sr in [*5*]) has been developed from K-12 by a long sequence of mutational steps. This strain differs from the wild-type strain K-12 in these markers: polyauxotrophy for threonine, leucine, thiamin; resistance to streptomycin and to bacteriophage T1; failure to ferment lactose, maltose, mannitol, xylose, galactose, or L-arabinose. These may be symbolized as: $T - L - B_1 - S^r$ $V_1{}^r$ $Lac - Mal -$ etc. Typical wild-type *E. coli* strains are $T + L + B_1 + S^s$. These four markers are useful in detecting recombination between W-1177 and new strains to be screened. Heavy inocula of W-1177 and

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