tion (Cairns & Dickson, 1971). It would appear, therefore, that Station 2 was somewhat enriched but not seriously polluted. This assessment is further indicated by the presence of elmid (riffle) beetles and heptageniid mayflies, both of which are sensitive generally to extreme pollution (Cairns & Dickson, 1971). A similar condition apparently was present at Station 7, but it may have been slightly more enriched than 2, since percentage of chironomids was higher, Simuliidae increased in percentage, and hydropsychiids and heptageniids decreased considerably. The effluent from the new wastewater treatment plant seemed to have a pronounced enrichment effect at Station 8, where chironomids dominated the samplers and number of families was lower than at either Station 2 or 7. The sampler at Station 4 collected far fewer organisms than did the samplers at Station 7 or 8, but the number of families at 4 was only one less than that at 7 and chironomids were dominant, which indicates some enrichment. The effluent from the old wastewater treatment plant at Station 5 apparently produced environmental stress, since only three families were present and chironomids made up about 95% of all organisms.

Stations 3 and 6, in pooled areas, were less productive than most riffle stations. Station 3, above the old treatment plant, yielded a lower percentage of chironomids and more diversity and organisms than Station 6, below the old plant. In addition, Station 3 had a high percentage of heptageniid mayflies, but none was present at Station 6. These conditions indicate that Station 6 had not recovered from the effects of the old wastewater treatment plant.

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BEHAVIOR IN AN ELECTRIC FIELD OF ASH PARTICLES SUSPENDED IN A COAL-DERIVED LIQUID

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ABSTRACT

Unfiltered oil from the Solvent Refined Coal process was examined under high magnification to observe the behavior of the particles of ash and unreacted coal when exposed to electric fields in the range of 2000 to 10,000 V/cm. When the particles were exposed to electric fields, it was observed that 1) particles collected on both electrodes, 2) solid filaments formed which eventually bridged the gap between electrodes, and 3) some particles realigned with the electric field without migration.

INTRODUCTION

A problem common to all processes for converting coal to liquid fuels is the separation of ash and unreacted coal from the process liquids. Because the particles are small ($\sim$ 1.0 μm or less) and the liquids are viscous, sedimentation or filtration methods are not attractive unless the solids-bearing liquids are pretreated to agglomerate the solids. To provide guidance for selecting agglomerating additives, Oak Ridge National Laboratory is trying to determine the reasons for the stability of dispersions of these small particles in the process liquids.

Colloidal stability in aqueous media has been attributed traditionally to electrostatic charge on the particles (giving rise to the zeta potential), and agglomeration can be promoted by adding electrolytes to the aqueous medium to lower the zeta potential. There is much less information in the literature about colloidal stability in organic media than about stability in aqueous media. Consequently, the literature provides little guidance for determining if electrical considerations pertain to these coal-derived colloids. Thus, the behavior in an electric field of the particles in the coal-derived liquid was observed to determine if these particles carry a net charge and, if so, of what sign. The observations are reported here.

Similar investigations have been carried out by Reising (1937) for paint pigments and by Hedrick et al. (1941) for pulverized coal particles in gas oil. Hedrick et al. found that in an electric field, coal particles in oil assume a lines-of-force arrangement; it was concluded that both positive and negative charges exist not only on different particles but on different areas of the same particle. They also found that surface-active agents prevent agglomeration. Soyenkoff (1931) concluded that electrostatic charges are unimportant as stability factors in nonaqueous media.

Experimental Apparatus and Procedure

A special microscope slide and slide holder similar to Reising's apparatus was fabricated. A diagram of the slide with the attached electrodes is shown in Fig. 1. A slide holder (not

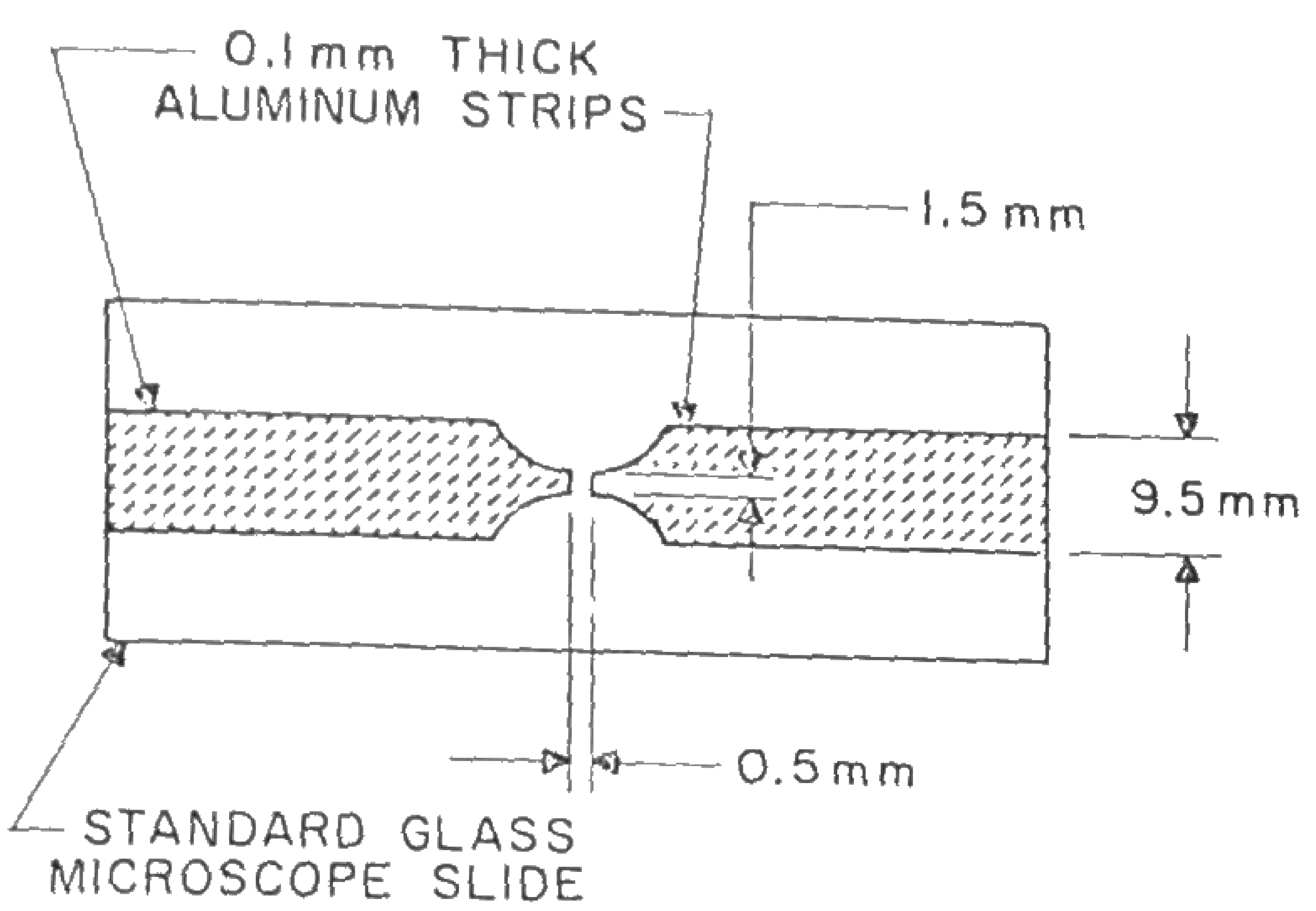

FIG. 1: *Diagram of microscope slide and electrodes for producing electric field.*

shown) was made of nonconductive Bakelite plastic with a recessed area to hold a standard microscope slide and a hole for transmitted light observation. At opposite ends were two binding posts with steel clamps. The dc-power supply (Model D6, Oregon Electronics) was connected to the binding posts, and the steel clamps secured the slide and provided electrical contact with the aluminum electrodes. The holder was clamped to the microscope stand (Microstar 10 Series Microscope) beneath the objective lens. For safety reasons, the cathode was connected directly to ground, the microscope was grounded between the electrodes and the eyepieces, the supply circuit was equipped with a 0.1-A fuse, and the lower part of the microscope was covered with a Plexiglas box (leaving only the eyepieces exposed for viewing). The power supply, high-voltage leads passed through a safety-interlock switch so that no voltage could be applied to the electrodes unless the Plexiglas box was in place.

A drop of oil was placed on the electrode gap and spread to a fairly uniform thickness. After securing the special microscope slide in the holder, the microscope slide was positioned and brought into focus before the Plexiglas cover was put in place. Once the cover was in place, the voltage was applied to the electrodes and the subsequent behavior of the particles was observed (usually at 100X). Unfiltered and filtered oil, which were obtained from the Solvent Refined Coal (SRC) process pilot plant at Wilsonville, Alabama, were used in these studies.

Results

Because the solids concentration in the unfiltered oil was too high for convenient observation, the unfiltered oil was diluted with the filtered oil by a factor 2:1, 4:1, and 8:1. It should be noted that the filtered oil also contained a significant concentration of small particles.

The variable power supply was equipped with both a voltmeter (0 to 600 V) and ammeter (0 to 500 mA). Because of the low conductivity of the nonaqueous media ($\simeq 2 \times 10^{-8}$ mho/cm), the ammeter never indicated a readable current.

The coal-derived oil was quite dark and the oil film had to be spread quite thin on the microscope slide in order to have sufficient light transmitted for observation. In initial experiments no slide cover was used, and oil film depth was uniquely determined by the dimensions of the aluminum electrodes and the surface tension of the oil. Without the cover, the microscope image darkened noticeably when voltage was applied across the electrodes. This darkening is attributed to an increase in oil film depth brought on because of changes in surface tension with the electrolytic heating of the oil. Using a slide cover in subsequent experiments both eliminated the image darkening and cut off the available surface for evaporation.

With the electric field turned off, the particles were relatively stationary, although very slow movement of the liquid was sometimes observed. When the full 500 V was applied to the electrodes in the experiments with no slide cover, very rapid movement of the liquid and the particles was seen. Particles were observed to move toward the anode and toward the cathode. Particles were also observed moving into the gap from surrounding liquid and in the gap normal to the electric field (i.e., not toward either electrode). Time lapse photographs of several seconds showed circular patterns of movement within the electric field.

Over a period of about 25 min, a layer of particles collected on both the cathode and the anode; the layer on the anode was the larger. In addition, short spikes which pointed toward the cathode appeared on the anode. These spikes grew until, after 30 to 45 minutes, they formed filaments that bridged the gap between the anode and cathode.

Small particles moving in both directions parallel to the electric field were observed between the filaments. One large oblong particle (0.3 mm long) revolved 90° to align itself with the electric field when the field was turned on. When the field was turned off, it reverted to its original position.

Some of the observations discussed above are probably due to thermal effects. With the electric fields employed here (500 V per 0.05 cm, assumed to be uniform) and the estimated liquid conductivity of 2×10^{-8} mho/cm, the volumetric heat generation was estimated to be about 2.0 W/cm^3. This heat generation rate is sufficiently high so that strong thermal convection currents could be expected.

The thermal effects were reduced and the problems due to thick liquid films were eliminated by using thin-