TITLE: **ELECTROSTATIC SURFACE STRUCTURES OF COAL AND MINERAL PARTICLES**

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ABSTRACT

OBJECTIVE

Electrostatic beneficiation of dry coal has received significant attention in the last two decades. In this process the coal is ground and then charged by triboelectrification (friction charging). When tribocharged against copper, coal and minerals receive opposite polarities of charge and can then be separated in an electric field. The aim of our studies is to develop a comprehensive physical and chemical model for electrostatic charging of coal and mineral particles. Properties of the fundamental constituents of coal are analyzed in relation to bulk coal powders processed with a laboratory scale electrostatic separator. Characterization techniques employed include: quantitative sulfur analyses, single particle charge and mass measurements, petrographic analyses, ultraviolet photoelectron spectroscopy, and diffuse reflectance infrared spectroscopy (DRIFT).

ACCOMPLISHMENTS TO DATE

We have developed a video image analyzer for measuring the size and charge of airborne particles. Particles are illuminated by laser light and subjected to a sinusoidal electric field while images of the trajectories of the particles are captured using a video camera and a frame grabber. Analysis of the particle tracks allows the size and charge of the particles to be determined. The instrument can be used to measure size and charge spectra of charged coal and mineral particles in real time.

A second instrument, an Ultraviolet Photoelectron Spectrometer (UPS) for measuring effective work functions of insulator and semiconductor surfaces in air is under development. Work function data for individual macerals and minerals in a coal matrix will be related to triboelectric charging properties. In this instrumental method, originally developed by Kirhata, the surface of a test sample is bombarded by monochromatic ultraviolet light of known wavelength. At atmospheric pressure, the photo-ejected electrons attach to air molecules forming negative ions. The ions are attracted by an applied electric field into a detector where they are accelerated to sufficient energy that they cause momentary dielectric

breakdown or discharge in the air inside the detector. The rate at which these discharges occur is proportional to the rate at which photoelectrons are generated at the sample surface. From a plot of the discharge rate as a function of photon energy the minimum energy needed to remove an electron can be determined. The mechanical components of our instrument have been completed. A number of electronic circuit difficulties remain to be solved. The counting circuits are able to produce a count rate proportional to the ion concentration generated using a corona gun. However, when the high voltage accelerating potential is applied the circuit oscillates preventing proper operation. Our current focus on this instrument is to attain stability of operation.

In this past year we have performed comprehensive analyses on electrostatically beneficiated Pittsburgh No. 8 coal powders as a function of grind size and processing atmosphere. Both feed and processed powders were measured for moisture, ash, total sulfur, and pyritic sulfur content. Total sulfur was determined both gravimetrically and by titration of sulfur oxides from. Only small differences in beneficiation were observed for freshly ground as compared to ground coal exposed to air for 24 hours prior to electrostatic separation. The most finely ground powders exhibited the greatest degree of beneficiation since entrained pyrites are predominantly submicron sized. For example, finely ground 45-75 μm size classified powders yielded an average total sulfur content of 1.5 wt% and 4.1 wt% in the clean and refuse processed fractions, respectively. Only 17% of the total sulfur in the clean coal was pyritic whereas 92% of the total sulfur in the refuse was pyritic, consistent with the mineral specificity of this cleaning method. Larger dimension powders (e.g. >150 μm) did not acquire sufficient charge to give efficient separation. The composition of the refuse varied as a function of size classification of the feed powders, however, there was remarkable uniformity in analytical values determined for the clean coal fraction regardless of the degree of grinding. Consistent ash and sulfur content in the clean coal powders may be ascribed to a predominance of vitrite maceral in the clean fraction since vitrite is the most chemically and physically uniform of microlithotypes. Thus, a practical limit to beneficiation may be defined by the vitrite fraction in the coal.

Studies have also begun concerning the efficacy of grinding and sieving alone to separate pyrite and other minerals from coal without electrostatic beneficiation. Though pyrite has a small size and high density relative to other coal components, preliminary results indicate that pyritic sulfur is not appreciably enhanced in sieved fines. Pyrite dimensions are so small that electrostatic surface charging effects may predominate. Total sulfur content, however, was found to be higher in fines, which may be attributed to the presence of sulfate minerals such as gypsum.

SIGNIFICANCE TO THE FOSSIL ENERGY PROGRAM

Improved cleaning technology will make lower grade coals available as a US energy source. Dry cleaning methods should generate fewer environmental problems and require less energy than wet washing methods.

PLANS FOR THE COMING YEAR

- Measure size and charge distributions for particles subjected to different charging methods and conditions.
- Develop model for electrostatic beneficiation
- Complete UPS instrument and measure effective work functions for different subclasses of coal from different mines.

ARTICLES, PRESENTATIONS AND STUDENT SUPPORT

M.K. Mazumder, K.B. Tennal, and D.A. Lindquist, "Electrostatic Beneficiation of Coal," Proceedings of the Tenth Annual Coal Preparation, Utilization and Environmental Control Contractors Conference, July 18-21, 1994.

"Electrostatic Beneficiation of Coal" Presented at the Fall Meeting of the Materials Research Society, Boston, MA, November 28 - December 2, 1994.

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N.R. Mason, M.K. Mazumder, D. Lindquist, "Diffuse Reflectance Spectroscopy and Surface Agents on Electrostatically Separated Coal," presented at the 215th American Chemical Society National Meeting, Dallas, TX, March 29 - April 2 1998.

M. K. Mazumder, N. Grable, Y. Tang, S. O'Connor, and R. A. Sims, "Real-time Particle Size and Electrostatic Charge Distribution Analysis and its Applications to Electrostatic Processes," presented at the Institute of Physics Electrostatics 99 Conference, Cambridge, England, March 28-31, 1999.

SUPPORTED AND PARTICIPATING STUDENTS (1997-1998)

Graduate Students
Adam Brown -- MS student in Applied Science
John Joseph -- MS student in Computer Science
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Kathy Farley – High School Physics Teacher summer research participant with STRIVE Project.