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Micro- and nanochemistry of fly ash from a coal-fired power plant

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ABSTRACT

Fly ash from a coal-fired power plant was investigated to obtain detailed information on its physical and chemical properties, and to gain an understanding of potential environmental and health impacts associated with its disposal in landfills. The studied material was produced through combustion of Illinois Basin coal and trapped within the power plant by an electrostatic precipitator. It is a fine-grained, low-Ca fly ash containing primarily SiO_2, Al_2O_3, and Fe_2O_3, and is enriched in many toxic elements (e.g., Be, Zn, As, Cd, Tl, Pb, and U) by a factor of up to 30 relative to coal. The ash consists of mainly hematite, magnetite, mullite, quartz, and amorphous material. These constituents occur mostly as spherical particles with diameters of less than 13 μm. We examined the physical, chemical, and structural characteristics of individual fly ash particles by scanning and transmission electron microscopy and electron probe microanalysis. The results demonstrate that, with the exception of complex plerospheres, individual particles are chemically fairly homogeneous, but a pronounced compositional variation exists among particles with similar physical and structural attributes. Electron microprobe data document that several trace elements, including U, are partitioned into the Fe-rich particles. Transmission electron microscopy revealed that various types of small (<1 μm) crystalline Ca-rich phases, including lime, are attached to the glass spheres, particularly the non-magnetic glass. These crystals may contain substantial amounts of S. Even though only a few of these crystals were analyzed quantitatively, our data indicate that the Ca-rich and S-rich phases may be important hosts for trace elements such as V and Zn. The observed element partitioning and the existence of surface-attached crystals enriched in certain trace elements suggest that fly ash from coal-fired power plants might have a more deleterious environmental impact than is inferred from bulk analytical data.