Investigation of ultrafine particulate matter (PM) derived from coal combustion by high resolution transmission electron microscopy (HRTEM)

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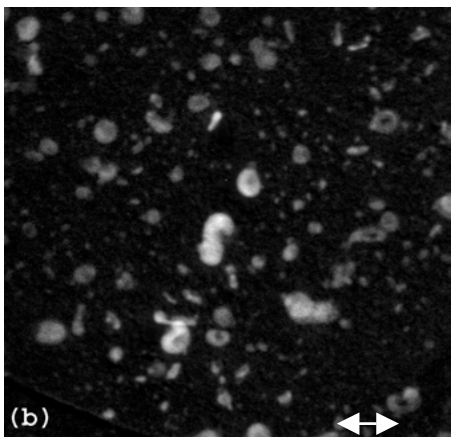
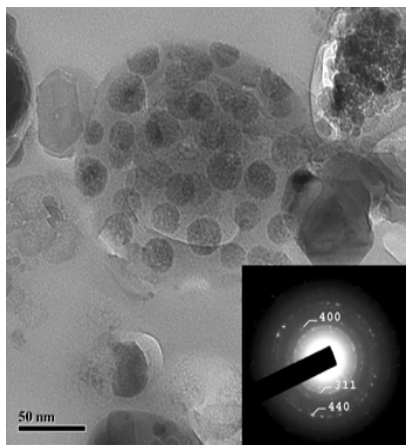
Our previous computer-controlled SEM (CCSEM) studies have demonstrated that the mass of primary $PM_{2.5}$ (PM <2.5 μm in diameter) derived from coal combustion is dominated by aluminosilicate glass particles. For bituminous coals, Fe- and K-aluminosilicates are dominant, while Ca- and Na- aluminosilicates dominate flyash produced by combustion of lignites and subbituminous coals. Recently, we have investigated ultrafine (<100 nm) coal combustion PM from a bituminous coal, a subbituminous coal, and a lignite using several HRTEM techniques. The results suggest that the structure of the ultrafine fraction of coal fly ash (CFA) may be much different from that of the particles ~0.3-2.5 μm in mean size characterized by CCSEM. The ultrafine CFA examined to date consists primarily of: 1. turbostratic carbonaceous soot; 2. iron, titanium, and aluminum oxides; and 3. calcium sulfates and phosphates. Examples of the microstructures of these ultrafine PM species are shown below.

These results are significant because the ultrafine particles are: (1) the particles most likely to escape from plants with good emission control systems; (2) capable of being transported over large distances; (3) easily inhaled into human airways; and (4) capable of penetrating alveolar cell walls. We will soon be collaborating with the Electric Power Research Institute (EPRI) in an investigation of the structure and toxicity of post-environmental control ultrafine PM emissions from several power plants.



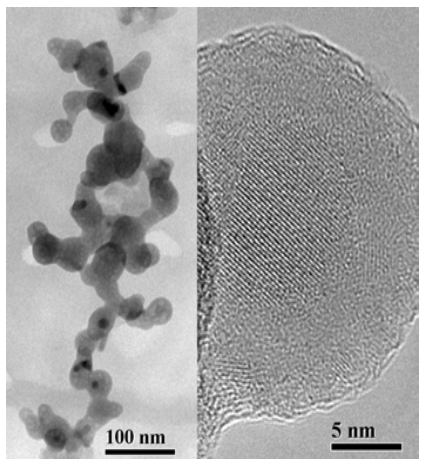
100 nm

Ti-Al oxide particles embedded in char.



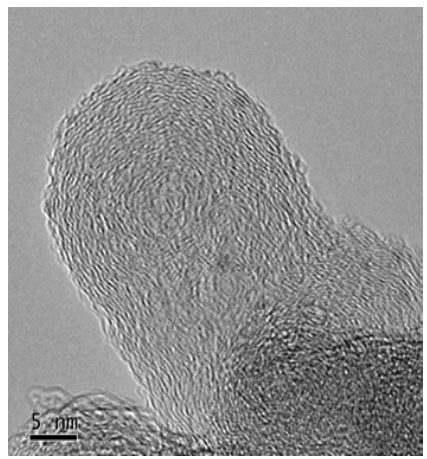
50 nm

Fe-Al oxide ($FeAl_3O_4$) nanoparticles mixed with glass.



100 nm 5 nm

Calcium phosphate.



5 nm

Carbonaceous PM; note the curved graphene walls.