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Characterization of Particle Charge from Aerosol Generation Process: Impact on Infrared Signatures and Material Reactivity

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Abstract : Aerosols are one of the most important and significant surfaces in the atmosphere. They can influence weather, absorption, and reflection of light, and reactivity of atmospheric constituents. A notable feature of aerosol particles is the presence of a surface charge, a characteristic imparted via the aerosolization process. The existence of charge can complicate the interrogation of aerosol particles, so many researchers remove or neutralize aerosol particles before characterization. However, the charge is present in real-world samples, and likely has an effect on the physical and chemical properties of an aerosolized material. In our studies, we aerosolized different materials in an attempt to characterize the charge imparted via the aerosolization process and determine what impact it has on the aerosolized materials' properties. The metal oxides, TiO_2 and SiO_2, were aerosolized expulsively and then characterized, using several different techniques, in an effort to determine the surface charge imparted upon the particles via the aerosolization process. Particle charge distribution measurements were conducted via the employment of a custom scanning mobility particle sizer. The results of the charge distribution measurements indicated that expulsive generation of 0.2 µm SiO_2 particles produced aerosols with upwards of 30+ charges on the surface of the particle. Determination of the degree of surface charging led to the use of non-traditional techniques to explore the impact of additional surface charge on the overall reactivity of the metal oxides, specifically TiO_2. TiO_2 was aerosolized, again expulsively, onto a gold-coated tungsten mesh, which was then evaluated with transmission infrared spectroscopy in an ultra-high vacuum environment. The TiO_2 aerosols were exposed to O_2, H_2, and CO, respectively. Exposure to O_2 resulted in a decrease in the overall baseline of the aerosol spectrum, suggesting O_2 removed some of the surface charge imparted during aerosolization. Upon exposure to H_2, there was no observable rise in the baseline of the IR spectrum, as is typically seen for TiO_2, due to the population of electrons into the shallow trapped states and subsequent promotion of the electrons into the conduction band. This result suggests that the additional charge imparted via aerosolization fills the trapped states, therefore no rise is seen upon exposure to H_2. Dosing the TiO_2 aerosols with CO showed no adsorption of CO on the surface, even at lower temperatures (~100 K), indicating the additional charge on the aerosol surface prevents the CO molecules from adsorbing to the TiO_2 surface. The results observed during exposure suggest that the additional charge imparted via aerosolization impacts the interaction with each probe gas.

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