Chromium speciation and transformation in atmospheric aerosol particles

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The EPA estimates that 40,000 to 50,000 deaths occur in the United States annually as a result of inhaled particulate matter. Currently, aerosol particles are regulated based on two size categories PM_{10} (particles < 10 μm) and $PM_{2.5}$ (particles <2.5 μm).

Our size-based understanding of atmospheric particles is relatively crude because it does not account for differences in the chemical composition and reactivity of these particles. Incineration, a common method for the treatment of hazardous wastes, produces metal-containing atmospheric particles. Of the metals potentially released, Cr is of interest because it can exist in two oxidation states with very different toxicities. If atmospheric processes alter the oxidation states of particulate chromium, they should also simultaneously change the Cr-associated toxicity of the particles.

The transformations of Cr in aerosol particles generated in a labortoray incinerator flame were investigated by bulk XANES, while the speciation of Cr in ambient aerosol particles collected in the region around Sacramento California was investigated using micro-XAS. Simulated atmospheric aging caused only minor changes in Cr speciation under most of the conditions studied, although there was a general trend toward Cr reduction. However, under some conditions important changes were in fact observed. The incinerator flame temperature strongly affected Cr(VI) concentrations, with hotter flames containing more Cr(VI). The introduction of Fe into the incinerator flame dramatically reduced the concentration of Cr(VI) in favor of a mixed Cr/Fe phase containing mostly Cr(III) in what appears to be a Chromite like spinel structure.

Micro-XAS analysis of individual Cr containing ambient aerosol particles showed that the majority of these particles, ~75%, appear to be found in the same Cr/Fe Chromite like phase identified in the laboratory. Additional forms of Cr include $Cr(OH)_3$, Cr^0, and Cr carbides. Lastly, Cr(VI) concentrations in ambient aerosols appeared to be significantly increased in samples taken down wind from a Cr plating facility. This seems to indicated that Cr(VI) from anthropogenic sources can be transported relatively long distances, > 5miles, or much longer than currently believed.