Connecting Surface Chemistry and Redox Activity of Iron-Impregnated Mineral Oxides

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Iron-based materials have attracted special interest among environmental researchers owing to their natural abundance, low toxicity, and important roles in mediating catalyic redox transformation of aqueous contaminants. Extensive studies have been conducted to understand reactions catalyzed by single-phase iron oxides; however, the reactivity of surface-anchored iron species on prevalent mineral colloids, such as amorphous or crystalline silica and aluminum oxides, is not well understood. In this study, we sought to understand the fundamental relationship between the surface chemistry of Fe(III)-impregnated silica and alumina surfaces and their catalytic activity in activating environmental oxidants such as dissolved oxygen and hydrogen peroxide. Specifically, we employed surface analysis techniques such as high-resolution X-ray electron spectroscopy (HR-XPS), atomic force microscope (AFM) and diffuse-reflectance UV-Vis spectroscopy to comprehensively characterize the surface coverage, nature of surface precipitation, and molecular structures of Fe(III) anchored on micron and nanometer-scale silica and alumina particles. In conjuction with these surface analyses, we conducted aqueous potentiometric titrations and batch adsorption experiments to characterize surface charge properties of different mineral particles under varying solution conditions. The catalytic activity of these Fe(III)-amended particles was evaluated in batch reactions using phenol or benzoic acid as probe compounds in the presence of H_2O_2. The findings we obtained thus far suggest that the catalytic activity of the particles correlates more strongly with the molecular arrangement and interfacial dispersion of Fe(III) than with the surface mass loadings of Fe(III). These surface chemistry characteristics are influencedly by the nature of the mineral particles as well as the solution conditions during Fe(III) deposition. Results discussed here will generate new insights into contaminant transformation on surfaces of mineral particles in the natural aquatic environemnts or engineering (*e.g.* drinking water treatment) systems.