308f Characterization of Cr(VI) Ion Exchange with Hydrotalcite

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Experiments were performed to characterize the removal of hexavalent chromium from aqueous solution via ion exchange with uncalcined hydrotalcite (HTC), [Mg2Al(OH)6]2CO3, a synthetic clay mineral ion exchange media. First, the effect of pH, Cr(VI) concentration, HTC concentration, and contact time on Cr(VI) removal were determined in a single ion solution. Under optimal conditions, equilibrium data were collected and a Freundlich isotherm and constants were estimated. The kinetics of the process were also estimated using a pseudo-first order reaction rate. Finally, an equilibrium stage process was modeled with sequential batch separations to determine if hydrotalcite ion exchange could reduce Cr(VI) levels to below the U. S. Environmental Protection Agency limit of 0.1 mg/l.

Once single ion removal was established, additional experiments were performed to investigate the competitive effects of first, cations and, then, anions on Cr(VI) removal in multi-ion systems. Because of their prevalence in the metal plating industry, the effect of zinc and cadmium on Cr(VI) removal were measured in a three ion solution. The effect of nitrates and phosphates were also characterized due to their presence in some groundwater sources. Single ion removals of zinc, cadmium, nitrate, and phosphate by HTC were determined prior to multi-ion experiments.

It was shown that the removal of Cr(VI) by HTC is highly pH dependent, only yielding significant removals at pH levels between 2.0 and 2.1. Under optimal conditions, maximum removals exceeding 95% were achieved. Sequential batch experiments performed on initial Cr(VI) solutions ranging from 5 mg/l to 40 mg/l, demonstrated that water could be purified to a level that was not statistically different ($p < 0.05$) than the EPA limit.

Under conditions optimal for Cr(VI) removal, neither zinc nor cadmium was greatly removed by HTC. This was expected because Cr(VI) exists as the chromate anion in aqueous solution and anions are usually removed at different pH conditions than cations in ion exchange. Hence, likely interferences for Cr(VI) removal would be due to the formation of complexes between the anions and cations. At low Cr(VI) levels (1 mg/l), removal is reduced when Zn and Cd concentrations are high relative to Cr (20:1). At a higher Cr(VI) concentration of 20 mg/l, even low levels of Zn and Cd negatively effect removal. Interestingly, Cr(VI) removal is unaffected when the Zn concentration is high relative to Cd (20:1).

Both nitrate and phosphate are removed by HTC under pH conditions optimal for Cr(VI) removal, which was expected since all are anions in solution. In multi-ion solutions, phosphates at even very low levels (0.1 mg/l) reduced removal of Cr(VI). Nitrates, however, did not have a significant effect, even at concentrations comparable to the chromate concentration. This is consistent with expectations because ion exchange tends to favor larger molecules with higher valences.