
Modified Clays for the Adsorption of Environmental Toxicants: Binding of Chlorophenols to Pillared, Delaminated, and Hydroxy-Interlayered Smectites

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Abstract: Due to their unique polarity, pore-size distribution, and high surface areas, pillared and delaminated clays are potentially useful materials for the adsorption of environmental toxicants. To determine their properties for adsorption of chlorinated phenols, alumina-pillared montmorillonite (APM), chromia-pillared montmorillonite (CPM), and alumina-delaminated Laponite (ADL) were reacted with aqueous pentachlorophenol (PCP) solutions in batch equilibrium experiments. An hydroxy-Al Laponite (HAL) in which the Na^+ exchange ions were replaced by ions of the type $\text{Al}_{13}\text{O}_4(\text{OH})_{(24+x)}(\text{H}_2\text{O})_{(12-x)}^{(7-x)+}$ was included in the study. With ADL as the adsorbent, the extent of PCP adsorption increased with decreasing pH, and then became constant at $\text{pH} \leq \text{pK}_a$. Thus, the neutral phenol was preferred over the phenolate form. Binding of neutral PCP at pH 4.7 to all adsorbents never reached saturation values, and the loadings achieved were limited by the water solubility of the adsorbate. Among the pillared and delaminated clays investigated, ADL exhibited the largest capacity for physical adsorption of PCP at pH 4.7. Differences in the PCP binding capacities for APM, CPM, and ADL suggested that adsorption was dependent on the pore structure and surface composition of the modified clay adsorbent, not on surface area alone. HAL exhibited quantitative uptake of PCP at the 8 $\mu\text{mole/g}$ level, indicating that a chemi-sorption mechanism may operate for PCP binding to this adsorbent. Adsorption of 3-chlorophenol, 3,5-dichlorophenol, and 3,4,5-trichlorophenol by ADL at pH 7.4 increased as the degree of hydrophobicity and chlorination of the phenol increased; hence, the binding capacity was not limited by the molecular size of the adsorbate. In contrast to the adsorption properties observed for pillared, delaminated, and hydroxy-interlayered clays, Na^+ -montmorillonite and Na^+ -Laponite did not adsorb PCP from aqueous solution.

Key Words: Adsorption • Chlorophenol • Delaminated smectite • Hydroxy-Al • Laponite • Pillared smectite • Smectite • Toxicants

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