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Transport and Retention of CdSe/ZnS Quantum Dots in Saturated Sand: Effects of Organic Ligands, pH and Ionic Strength

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The presence of nanomaterials in soil, water, and air systems following their life cycle or accidents and their effects on the environment and public health are inevitable. Ability to forecast the public health and ecological impacts of these nanomaterials encountered in the environment is limited. Therefore, it is critical to be able to predict the fate and transport on nanomaterials in the environment, in particular the subsurface, in order to conduct risk assessments. To assess the transport and retention of nanomaterials in the subsurface environment, we selected quantum dots (QDs). QDs are metal and semiconductor based nanomaterials that are essential to nanoscience and nanotechnology. Understanding the parameters that effect the transport and retention of QDs in the soil water environment is critical. Natural organic ligands are commonly found in soils and impact the soil physico-chemical processes through multifaceted reactions with metal ions present in soil solution and ligand exchange reactions on soil surfaces. Therefore, ligands may modify the surface properties of QDs and effect their stability, transport and retention in the subsurface environment. In this research, size, surface charge, and stability of CdSe/ZnS QDs in water solutions are monitored in batch experiments. The influence of organic ligands (acetate, oxalate, and citrate) on the stability of QDs at different pHs (1.5, 3.5, 5, 7 and 9) and ionic strengths (0.05 and 0.1 M) conditions were examined. The stability and aggregation phenomena of QDs were studied using UV-vis and DLS methods. Parameters from batch studies were selected to establish chemical conditions to be used in transport experiments to produce breakthrough curves and retention profiles in order to characterize the fate and transport of QDs in saturated sand. These transport experiments are essential to understand the mobility and retention processes in porous media where QD interactions with surfaces of heterogeneous chemistry and changing soil-water chemistry are naturally occurring.