



The effect of Suwannee River Natural Organic Matter on the Stability and Mobility of Quantum Dot Nanoparticles in Saturated Silica Sand Porous Media and Under Different pH and Electrolytes

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Stability of nanoparticles is a critical parameter governing their fate and transport in the environment, and their bioavailability and toxicity to the public health and ecosystems. In this context, our study investigated the effects that Suwannee River Natural Organic Matter (SRNOM) has on the stability of QDs and their transport in saturated sandy porous media as a function of pH and electrolytes. Selected SRNOM concentration was 10 mg/L. Selected pH values were 1.5, 3.5, 5, 7, and 9. Concentrations of NaCl and CaCl₂ were 0.01 M to 3.5 M and 0.001 M to 0.25 M, respectively. Aggregation, surface charge, and sedimentation kinetics were monitored for these systems over time for 10 minutes using dynamic light scattering, electrophoretic light scattering, and ultraviolet–visible spectroscopy. pH of point of zero charge (pHPZC) of QDs was found to be between pH 1.5 and 3.5. An immediate and significant aggregation of QDs in suspensions whose pH was near pHPZC (i.e. pH=1.5 and pH=3.5) was observed and the average hydrodynamic diameters of QD aggregates were around 500 nm; however, the aggregation was hindered with the increase of pH (i.e. pH=5, 7, and 9) and the QDs were well dispersed in suspensions with average hydrodynamic diameters of about 50 nm. No obvious sedimentation was observed for QDs in all the experimental suspensions. In the absence of electrolytes, SRNOM influenced the stability of QDs through both electrostatic (i.e. charge neutralization) and steric (i.e. steric hindrance and bridging effects) forces. The presence of 10 mg/L SRNOM decreased QD nanoparticles' critical coagulation concentration of CaCl₂ from 10 mM to 5 mM, because of the bridging effect of SRNOM enhancing the coagulation of QDs. QD transport experiments in saturated porous media were performed using ASTM C778 Graded unground silica sand packed in chromatographic columns and under various water chemistry conditions, (i.e. SRNOM, electrolytes, and pH). The mobility of QDs in the saturated column was determined through breakthrough curve analysis. The concentration of QDs was estimated by measuring the concentration of cadmium (Cd²⁺) in the influent (C₀) and effluent (C) using Inductively Coupled Plasma Mass Spectrometry. The normalized QD effluent concentrations increased quickly, reaching a plateau, and decreased after QDs injection stopped. The values of C/C₀ in the plateau region were observed to increase from approximate 0.02 to 1 with the increase of pH value of suspension from 1.5 to 3.5. The retention of QDs was very limited when suspension pH was above 3.5. The mobility of QDs was decreased by the presence of electrolytes (both NaCl and CaCl₂) in neutral pH. The addition of 5 and 50 mg/L SRNOM enhanced the breakthrough of QDs in the presence of 0.5 M NaCl. These findings on the stability and transport of QDs in saturated porous media under various environmental conditions will allow us to develop a model to predict the fate of QDs in the surface and subsurface environments, to assess the risk that QDs may pose to public and environmental health, and therefore to develop guiding policies for their use and disposal.