

# Application of Stabilized Gold Nanoparticles in the Investigation of Transport in Natural Barriers

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**Abstract:** Understanding of the migration behavior of colloids in subsurface geomechanics is important because it may facilitate the transport of radionuclides from radioactive waste disposal sites. Column experiments were conducted to investigate the transport behavior of two polymeric ligands stabilized nanometer-sized gold particles (AuNPs) through quartz-sand medium.

**Keywords:** transport, gold nanoparticles, natural and engineered barrier, porous medium, column experiment

## 1. Introduction

Understanding the transport of colloids in natural and engineered porous media is a key for the safety assessment of radioactive waste repositories. Application of ligand-stabilized and functionalized gold nanoparticles (AuNPs), which exhibit tunable physical, optical and electronic properties, may be useful not only for the understanding of colloidal transport, but also for investigating the porespace physical and chemical environment in porous media. In this work, column experiments were conducted using 10 nm and 100 nm methyl-terminated polyethylene glycol (PEG) functionalized AuNPs to study the parameters controlling their transport.

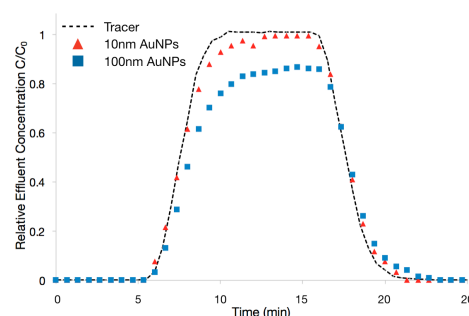
## 2. Experimental

Transport experiments were performed using glass columns ( $\phi=20$  mm) packed with the quartz sand. The columns were fully saturated and received deionized water (DI) at a flow rate of 1.5 mL/min for 2h. Then the suspension of the nanometer-sized (10 and 100nm) PEG-modified AuNPs were injected for 10 min at the same flow rate, followed by DI until no AuNPs were detected in the effluent. The collected effluent samples were analyzed by UV-vis spectrophotometry (UV-vis) and Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Prior and after the AuNPs experiments, tracer breakthrough curves (BTC) of tritiated water (HTO) were obtained to examine significant changes in the porous media transport characteristics. In addition, the stability over time of AuNPs particles in the presence and absence of quartz sand was evaluated using time-resolved UV-vis spectra.

## 3. Results and Discussion

The BTCs of the tracer HTO and the 10 nm and 100nm AuNPs in the quartz sand are shown in Fig. 1. An obvious difference was observed between the BTCs of the tracer and the two-different sized AuNPs. Instead of a flat plateau, a sloping plateau was observed for both 10 nm and 100 nm

AuNPs where the effluent concentration continued to increase gradually as less and less AuNPs were being deposited onto the collector quartz sand surfaces. The higher affinity for the collector was more significant for the 100 nm than for the 10 nm AuNPs. Furthermore, AuNPs aggregation within the column porespace was observed in terms of their UV-vis spectra evolution, where the UV-vis spectra of the 100 nm AuNPs effluent presented blueshifts in its absorption maxima from ~565 nm to ~563 nm in addition to band broadenings. The causes for the BTC discrepancies were studied in terms of the particle and collector surface chemistry and interactions between AuNPs and quartz sand.



**Figure 1.** Breakthrough curves (BTCs) for two AuNPs in quartz-sand at a flow rate of 1.5 mL/min at room temperature at the ionic strength of deionized water. The data is displayed as normalized effluent particle concentration ( $C/C_0$ ) as a function of time.