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Towards Coated Nano-Gold Particles as Non-Reactive Tracers in Coated nZVI for In-Situ Remediation

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Background/Objectives. Chlorinated solvent (e.g. trichloroethene and tetrachloroethene) source zones in the subsurface pose a continuous threat to groundwater quality at many sites worldwide. Remediation of these contaminated sites is especially challenging in the presence of Dense Non-Aqueous Phase Liquids (DNAPLs) and the development of innovative remediation technologies is still needed. It has been proved, in laboratory scale as well as in field tests, that nanoparticles of zero-valent iron (nZVI) are efficient in degrading chlorinated solvents in aqueous solution, due to their large surface area and reducing ability. Stability of nZVI in aqueous emulsions and mobility of nZVI in the subsurface has been obtained through coatings. However, lack of knowledge of the fate of nZVI once they are released to the environment, including their transport, reactivity, mobility, and affinity towards various environmental phases, hinders the implementation of an effective environmental remediation process. Also, from a risk assessment perspective, it is of great interest to know the dispersion of such reactive nanoparticles in the environment. A possibility is the introduction of non-reactive tracer particles with the same mobility and partitioning properties as the reactive particles. In this study, the use of gold nanoparticles (nAu) mixed in tracer amounts to track the fate of nanoparticles in porous media is investigated, initially at the lab scale.

Approach/Activities. Colloidal nAu have been of great interest for centuries due to their vibrant colors produced by the interaction with visible light. These unique optical – electronics properties along with their very low natural abundance, high chemical stability and relative low toxicity have made them useful in such tracing applications. In this project, 30 nm sized citrate stabilized nAu were and coated with amphiphilic block copolymers such as PVP-VA and PVA-COOH. The coated nAu were found to be stable in water and in a number of organic solvents as well. The partitioning of the nAu from an aqueous solution (5 mg/L) into two different DNAPLs (tri- and tetrachloroethene) was tested. The nAu mobility was investigated in sand packed columns and the breakthrough was monitored using spectrophotometry on the effluent.

Results/Lessons Learned. The results showed nanoparticles with great mobility and a significant affinity for the DNAPL. The breakthrough curve from the mobility study showed that only minimal retardation and tailing occurred at both the front and back of the nAu plume. These results obtained by conducting model experiments (lab scale aerobic) using nAu coated with amphiphilic block copolymers like PVP-VA and PVA-COOH, hold great promise for the co-injection and DNAPL affinity of both reactive (nZVI) and tracer nanoparticles. DNAPL affinity of the coated nZVI is expected to target treatment of DNAPL source zones.