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Use of agar agar stabilized milled zero-valent iron particles for in situ groundwater remediation

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A major obstacle for use of nanoscale zero-valent iron (nZVI) particles as a nontoxic material for effective in situ degradation of chlorinated aliphatic hydrocarbons (CAHs) is the high production cost. For that reason, submicro-scale milled zero-valent iron particles were recently developed (milled ZVI, UVR-FIA, Germany) by grinding macroscopic raw materials of elementary iron as a cheaper alternative to products produced by solid-state reduction. However, milled ZVI particles tend to aggregate and due to the rather large particle size (d50= 11.9 μm) also rapidly sediment. To prevent aggregation and consequently sedimentation of milled ZVI particles and therefore improve the mobility after in situ application, the use of a stabilizer is considered in literature as a most promising option. In this study, milled ZVI particles (1 g L-1 of particle concentration) were stabilized by environmentally friendly polymer agar agar (>0.5 g L-1), which had a positive impact on the milled ZVI stability. Sedimentation rate was significantly decreased by increasing the suspension viscosity. Column transport experiments were performed for bare and agar agar stabilized milled ZVI particles in commercially available fine grained quartz sand (DORSILIT® Nr.8, Gebrüder Dorfner GmbH Co, Germany) and different porous media collected from brownfields. The experiments were carried out under field relevant injection conditions of 100 m d-1. The maximal travel distance (LT) of less than 10 cm was determined for non-stabilized suspension in fine grained quartz sand, while agar agar (1 g L-1) stabilized milled ZVI suspension revealed LT of 12 m. Similar results were observed for porous media from brownfields showing that mobility of agar agar stabilized particle suspensions was significantly improved compared to bare particles. Based on the mobility data, agar agar stabilized milled zero-valent iron particles could be used for in situ application.

Finally, lab-scale batch degradation experiments were performed to determine the impact of agar agar on the reactivity of milled ZVI and investigate the apparent corrosion rate of particles by quantifying the hydrogen gas generated by anaerobic corrosion of milled ZVI. The results indicate that agar agar had a positive impact on the milled ZVI stability and mobility, however adverse impact on the reactivity towards trichloroethene (TCE) was observed compared to the non-stabilized material. On the other hand, this study shows that the apparent corrosion rate of non-stabilized and agar agar stabilized milled ZVI particles is in the same order of magnitude. These data indicate that the dechlorination pathway of TCE by agar agar stabilized milled ZVI particles is possibly impacted by blocking of the reactive sites and not hydrogen revealed during particles corrosion. Finally, calculated longevity of the particles based on the apparent corrosion rate is significantly prolonged compared to the longevity of the nZVI particles reported in previous studies.

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