Use of X-ray µ-CT to trace the transport behaviour of sulfidised zerovalent iron in porous media

A. SCHIEFLER[1,2*], D. MÜTER[2,3], S. BRUNS[2,3], H. O. SØRENSEN[2,3], N. TUXEN[1], N.D. OVERHEU[1]. D.J. TOBLER[2]

[1]Capital Region of Denmark, Hillerød, Denmark (*adrian.alexander.schiefler@regionh.dk)
[2]Nano-Science Center, Department of Chemistry, University of Copenhagen, Copenhagen, Denmark
[3]Department of Physics, Technical University of Denmark, Kongens Lyngby, Denmark

Sulfidised zerovalent iron (S-ZVI) nanoparticles are promising new reactants that show high reactivity with common groundwater pollutants and have far higher stability in water compared to bare ZVI. While their reactivity has been widely assessed, nothing is known about their transport properties once injected. Understanding the mechanisms (e.g., straining, ripening, clogging) by which S-ZVI get retained inside a pore, as well as the conditions that favour one mechanism over another, is particularly important. This is because these metallic particles easily aggregate due to magnetic interactions, which can potentially lead to pore clogging and micro-fracturing during field scale injection.

We applied synchrotron based X-ray microcomputed tomography (µ-CT) to identify the S-ZVI retention mechanism in porous media, as function of Darcy velocity ($1.6 \cdot 10^{-3}$, 8.0 and $4.0 \cdot 10^{-4}$ m/s), particle concentration (5, 10 and 20 g/L) and total injected particle loading (39, 78 and 127 mg). For this, we injected S-ZVI suspensions (stabilized in 0.5 wt% carboxy-methyl-cellulose) into a fine sand column (4.2 x 62 mm) and performed scans at 3 positions along the column (under no-flow conditions, before and after). The total volume elements was ~0.8 mm^3 with a voxel/pixel size of 0.5 µm. Initial analyses of the CT images showed that the retained particles could be clearly identified in the pore space (figure). We further see that higher particle concentrations led to larger aggregation, as did lower flow velocity. Data evaluation is ongoing but overall, the applied method seems well suited to gain deeper insight into nanoparticle retention mechanisms and the controls thereof.