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Characterization of modified nanoscale zero-valent iron particles transport through sandstones by nuclear magnetic resonance

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With the increasing application of nanomaterials for environmental remediation, modified nanoscale zero-valent iron (nZVI) particles have been extensively examined in terms of their enhanced mobility in porous media as compared to bare nZVI particles. However, the monitoring of nZVI particle transport processes in low permeability media is still a challenge. To quantify the particle transport behavior, low-field nuclear magnetic resonance (LF-NMR) was employed to image the modified nZVI particles through tight artificial sandstones, which is preferable in the laboratory research of fluids in rock with the limited influence of internal gradients compared to high-field NMR. The spin-echo single point imaging (SE-SPI) sequence of NMR was applied to monitor the fluid flow processes in porous media in terms of the changing site-specific transverse relaxation time (T2), which was available to capture the transient effects at a time scale of seconds. More importantly, the SE-SPI sequence allows the high resolution detecting of nanoparticle transports through nanoscale porous materials. Quantitative concentration profiles converted from T2 distribution mapping profiles were analyzed by CXTFIT software to estimate the transport parameters. A comparison of the parameters calculated by various points along the length of the sandstone at different time intervals indicated that the dispersion coefficients, deposition rate constant, and collision efficiency decreased with time, whereas the fast deposition rate constant and average particle velocity increased with time. Meanwhile, the three-dimensional structure of sandstone, which was built using ORS Visual software with micro computed tomography (micro-CT) images, indicated the possibility of observing nanoparticles clogging in the pore throats. Accordingly, the modified nZVI particles exhibited better migration through porous media, which may result in their widespread commercial applications in the environment remediation.

References

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