

# Long-term performance of milled zerovalent iron particles for in situ groundwater remediation

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The nanoscale zerovalent iron (nZVI) particles are widely used with high success in removal/degradation of a variety of environmental contaminants under laboratory conditions. However, high production costs, mobility of nZVI particles limited to a maximum of a few meters due to the rapid aggregation of primary particles, and limited effectiveness of the iron surface to serve as an electron donor for longer period due to fast depletion of nZVI particles after side reaction with groundwater constituents were main technical obstacles for rising the full potential of this technology.

For that reason, submicro-scale milled zerovalent 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. Although the factors and processes affecting milled ZVI particles transport mechanism in porous media were studied in detail, there has to date been no detailed study on milled ZVI particles long-term active performance/corrosion mechanism after *in situ* application. Therefore, lab-scale batch degradation experiments were performed to provide valuable data on the reactivity, life-time and aging mechanism of milled ZVI particles during degradation of trichloroethene (TCE), which are necessary in order to access their potential for groundwater remediation.

The life-time of milled ZVI particles was investigated by measuring the H<sub>2</sub> production as a consequence of ZVI anaerobic corrosion in the presence of aquifer material originating from two contaminated sites and artificially contaminated anaerobic water. The apparent corrosion rate and consequently the life-time of milled ZVI particles are in the same order of magnitude for both geochemical conditions (177-186 mmol kg<sup>-1</sup> d<sup>-1</sup>), indicating a similar fate of milled ZVI particles at both industrial sites. In addition, it was observed that the presence of sulfate can enhance the reactivity of Fe<sup>0</sup> to some extent by possibly removing passivating iron oxides and hydroxides from the Fe<sup>0</sup> surface and consequently increasing the number of reactive sites. In order to fully understand corrosion mechanism, the morphological, structural, and compositional changes of milled ZVI particles were evaluated by using SEM, X-ray diffraction (XRD) and Iron K-edge X-ray absorption spectroscopy (XAS). SEM data show that the magnetite/maghemite are the predominant minerals after 49 days of milled ZVI exposure to two different geochemical conditions. XRD/XAS data show that at the end of experiment 34 ± 8 % of milled ZVI iron was corroded and/or precipitated. This is in accordance with the numerical modeling and consequently simulated magnetite

precipitation (49-54 %). Finally, this study shows that under investigated conditions a similar fate of milled ZVI particles at both field sites can be expected.

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