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Redox-active nanocomposites: mechanistic insights on surface-controlled water remediation

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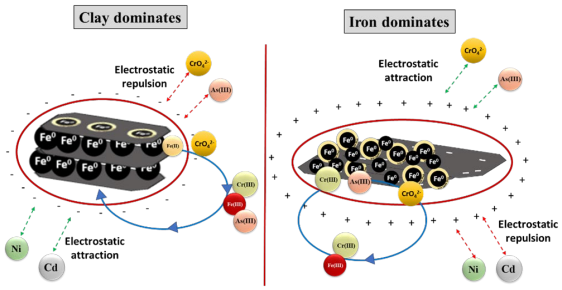

Figure Graphical overview of the work

Increasing global water stress and contamination of water bodies with several life-threatening pollutants are among significant societal and scientific challenges. Nano-enabled water treatment is continuously being explored as an eco-friendly remediation pathway. Redox-active metallic nanoparticles can transfer electrons, leading to reductive co-precipitation of inorganic contaminants and reductive degradation of organic pollutants. However, instant oxidation, agglomeration, and corrosion-assisted secondary contamination are primary applicability-limiting challenges.

We observed that nucleating metallic nanoparticles on eco-friendly natural or synthesized adsorbing surfaces can help preserve the redox state and prevent agglomeration and secondary contamination, enhancing technological efficiency and sustainability. For example- swelling bentonite clay and non-swelling kaolinite clay showed varying growth behavior of redox-active nanoscale zerovalent iron (nZVI) particles. Interlayer growth of particles in bentonite-nZVI composite (B-nZVI) led to negative zeta potential, while surface growth in kaolinite-nZVI (K-nZVI) resulted in the positive zeta potential of composites.

This variation enabled preferentially higher removal of cationic toxic metal species (Ni^{2+}, 36 mg/g and Cd^{2+}, 46 mg/g) with B-nZVI and higher removal of oxyanions (AsO_2^-, 157.3 mg/g and CrO_4^{2-}, 87.5 mg/g) with K-nZVI in different contamination matrices [1]. Similarly, compared to sulfidated-nZVI particles, surface-supported S-nZVI has shown enhanced reductive dehalogenation of organohalides and overcame existing limitations.

Results suggest that a thorough geochemical understanding of probable nZVI-surface interactions and contaminant-composite interactions is required in designing eco-friendly solutions for clean water.

References

1. N. Khandelwal, N. Singh, E. Tiwari, R. Marsac, D. Schild, T. Schäfer and G. Krishna Darbha, *Chem Eng J*, 2023, **461**, 141883.