Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31307

Iron Nitride Nanoparticles for Water Treatment: Advantages, Challenges, and Future Prospects

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Iron nitride (FexN) nanoparticles have emerged as a promising advancement in groundwater remediation, offering enhanced selectivity and reactivity for the degradation of chlorinated ethenes (CEs) while reducing undesired corrosion [1]. This study consolidates experimental and theoretical findings on the synthesis, reactivity, and environmental behavior of FexN-based materials prepared through solid-gas nitridation of commercial nanoscale zero-valent iron (nZVI) particles. As-prepared γ′-Fe_4N and ε-$Fe_{2-3}N$ phases demonstrated superior dechlorination rates for trichloroethylene (TCE), tetrachloroethylene (PCE), and cis-1,2-dichloroethylene (cis-DCE) compared to bare and sulfidated nZVI [2]. Density functional theory calculations indicate that the lower activation energy for C–Cl bond cleavage on γ′-Fe4N(001) contributes to this enhanced performance. Additionally, long-term stability studies reveal that FexN nanoparticles maintain high reactivity even after aging in groundwater-like environments, despite variations in solute composition and corrosion products [3]. Transport experiments further highlight the impact of surface modifications on nZVI mobility, showing that while nitrided particles exhibit distinct migration patterns compared to other derivatives, their reactivity remains almost unchanged [4]. These insights underscore the potential of FexN nanoparticles in environmental remediation and provide a foundation for optimizing their real-world applications in water treatment technologies.

[1] Brumovský, Oborná, Micic, Malina, Kaslik, Tunega, Kolos, Hofmann, Karlicky & Filip (2022), *Environmental Science & Technology* 56, 4425-4436.

[2] Brumovský, Micić, Oborná, Filip, Hofmann, & Tunega (2023), *Journal of Hazardous Materials* 442, 129988.

[3] Křížek Oborná, Brumovský, Micic, Kašlík & Filip (2025), *Journal of Environmental Chemical Engineering* 13, 115431.

[4] Veselská, Magherini, Bianco, Šembera, Parma, Víchová, Sethi & Filip (2024), *Journal of Environmental Management* 370, 122552.