NAWI National Alliance for Water Innovation

Tailored Reductants for Selenium Removal in Iron Electrocoagulation

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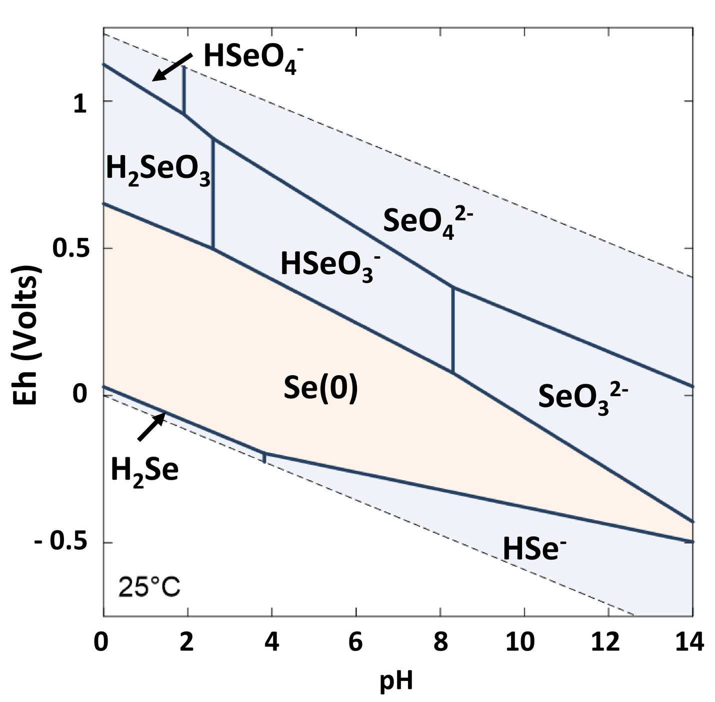
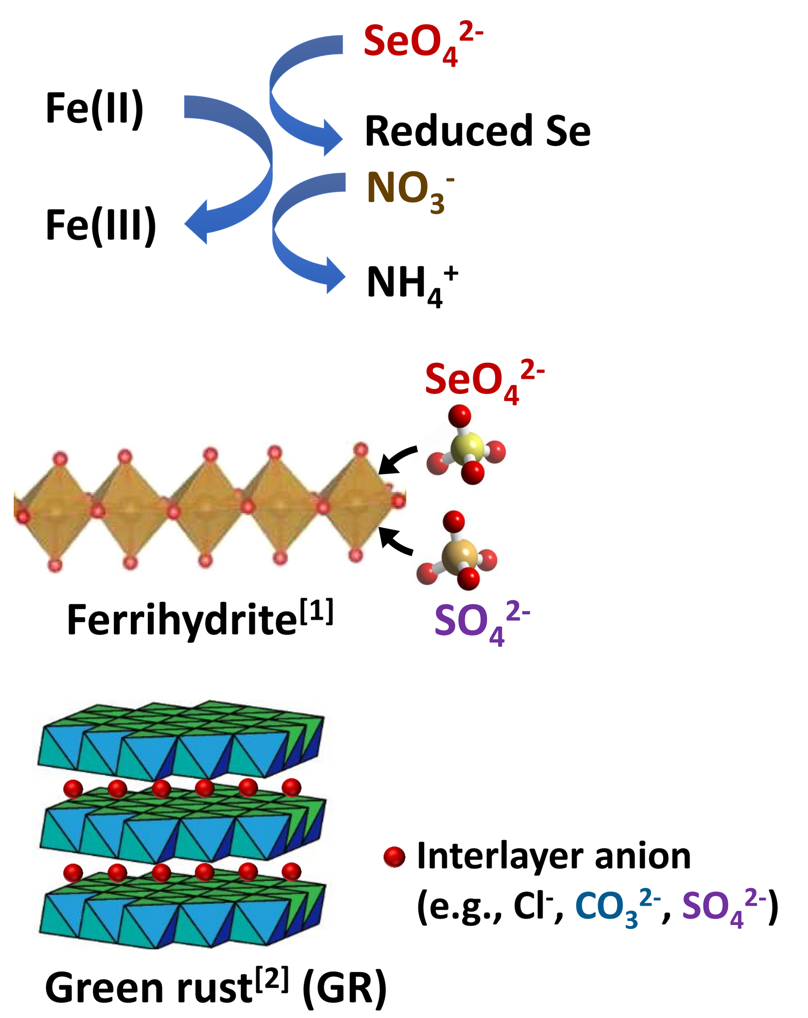
INTRODUCTION

Selenium (Se)



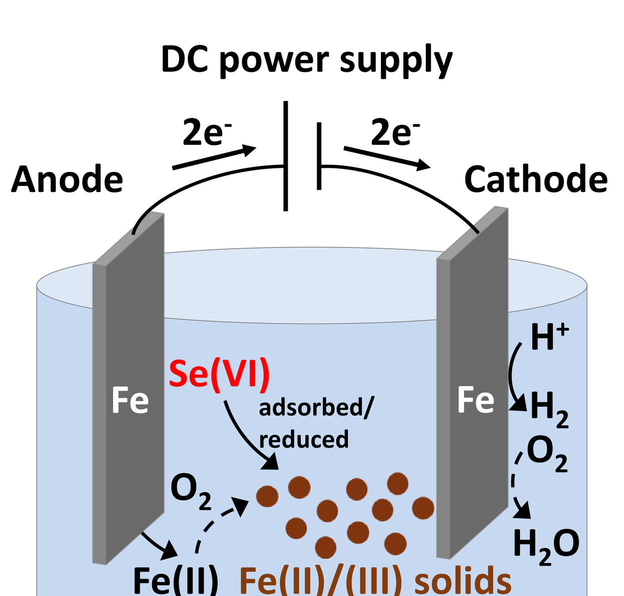
- Se is an essential trace element but is toxic at elevated concentrations.
- Se exists in four oxidation states (+VI, +IV, 0, and -II) in the environment.

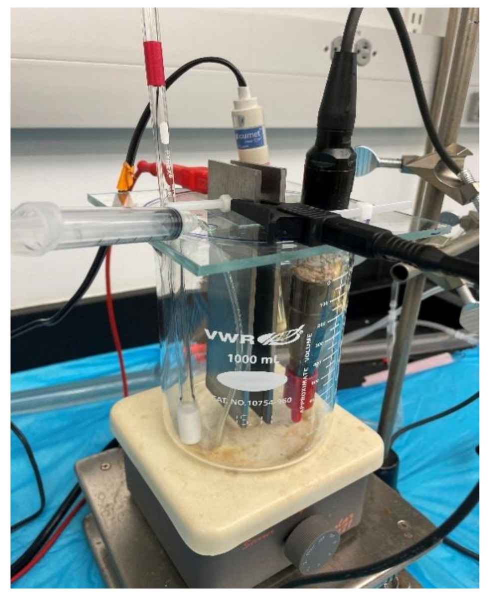
Possible Pathways of Common Anions



GR can be written as $Fe^{II}_{(1-x)}Fe^{III}_{x}(OH)_2]^{x+}\cdot[(x/n)A^{n-}\cdot(m/n)H_2O]^{x-}$, where A^{n-} are anions (e.g., Cl^-, CO_3^{2-} and SO_4^{2-}).

APPROACH





Water Chemistry Conditions

- pH and dissolved oxygen (DO)
  - pH 4, oxic
  - pH 7, anoxic
  - pH 8, anoxic
- Electrolyte – 10 mM NaCl
- Initial Se(VI) concentration – 1000 µg/L
- Nitrate concentration – 0, 50 mg/L
- Sulfate concentration – 0, 50, 500 mg/L

Operating Conditions

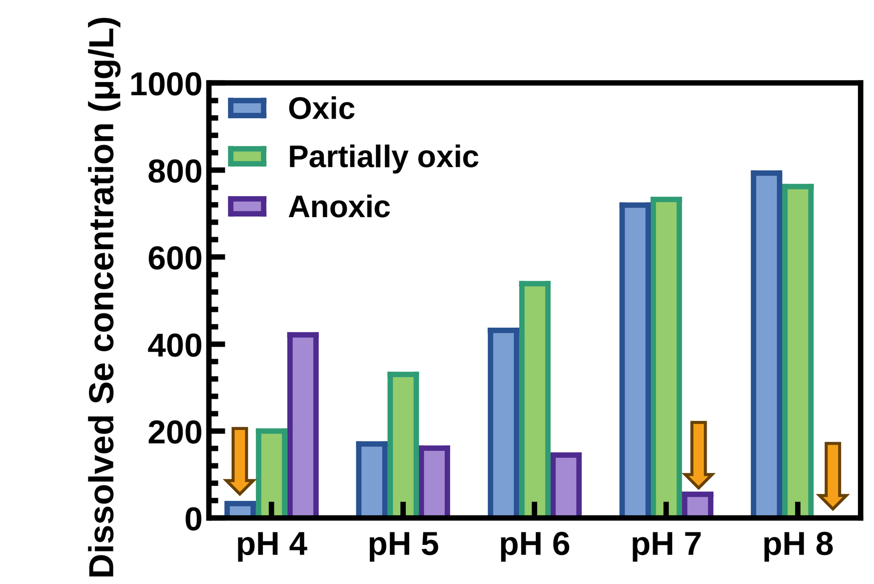
- Current density – 2.55 mA/cm^2
- Charge loading rate – 13.44 C/(L·min)
- Iron dose rate – 3.88 mg Fe/(L·min)

Measurements

- Real-time monitoring of pH and DO
- Dissolved and total Se and Fe
- Solid characterization

RESULTS

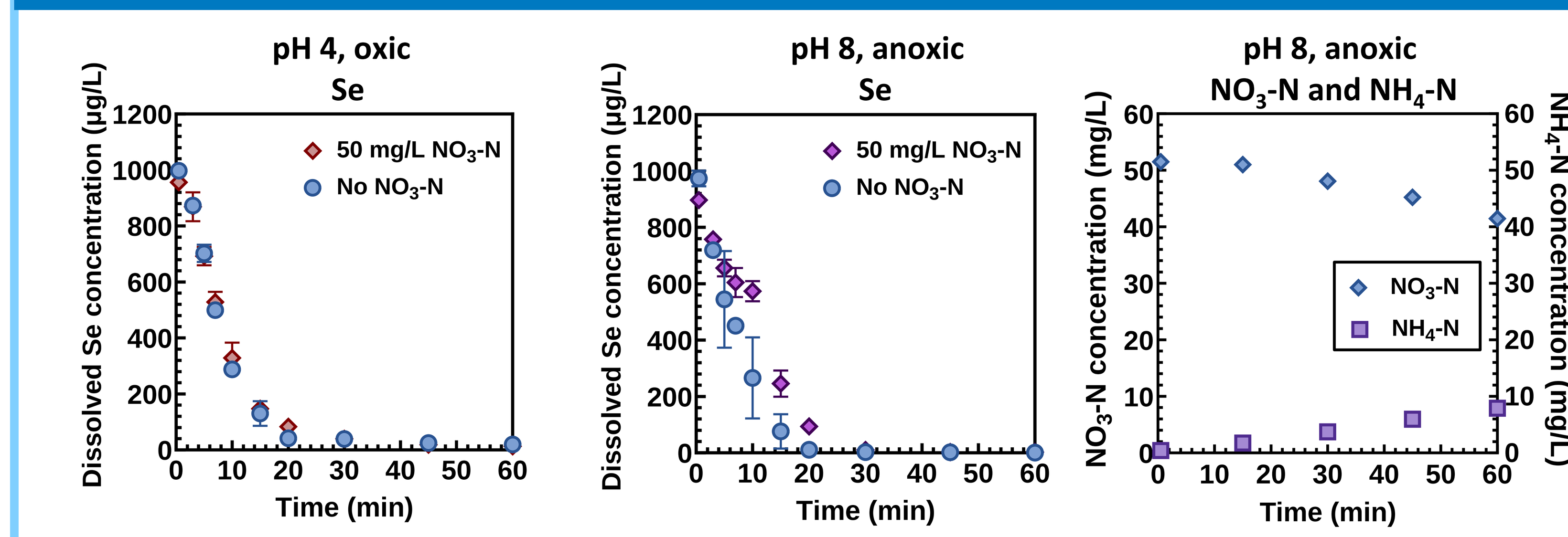
Effects of pH and DO



The highest Se(VI) removal extents were achieved at three conditions:

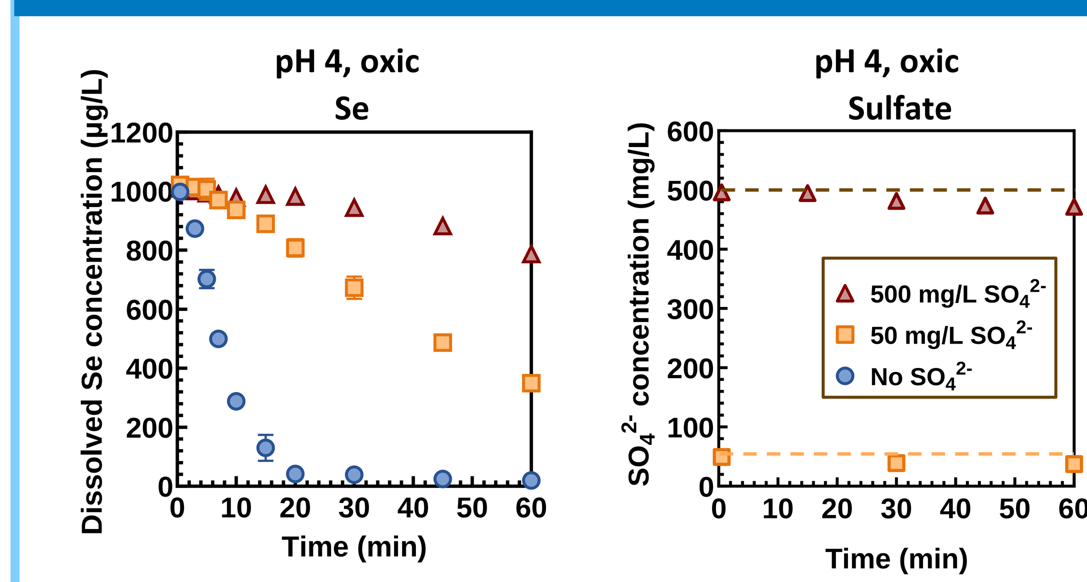
- pH 4 and oxic by adsorption
- pH 7 & 8 and anoxic by reduction

Effects of Nitrate

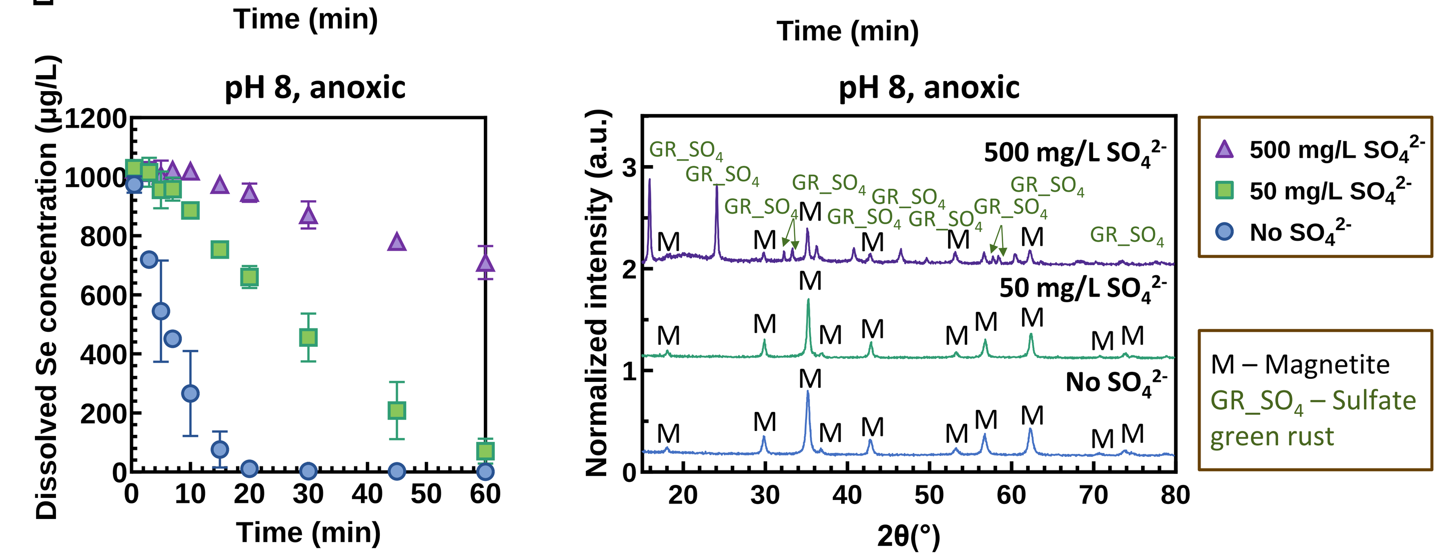


- NO_3^- did not affect Se(VI) removal under oxic conditions.
- Under anoxic conditions, NO_3^- slightly inhibited Se(VI) reduction by acting as a competitive electron acceptor.

Effects of Sulfate



- Under oxic conditions, SO_4^{2-} decreased Se(VI) removal due to competition for adsorption sites.



- Under anoxic conditions, the formation of GR(SO_4^{2-}) lowered the Se(VI) removal rate and extent.

NAWI CONNECTIONS

Period of Performance: February 2022 – April 2025
Challenge Area: Electrified, Modular, Precision
Topic Area: Process Innovation and Intensification
NAWI Leverage:

This project involves collaboration with two other NAWI projects (5.14 and 5.15). The techno-economic analysis (TEA) component are using tools developed by NAWI. The identification of composition of challenge waters was aided by the involvement of EPRI and input from the project support group. Flow-through electrocoagulation reactors were designed and fabricated by industry partner WaterTectonics.

KEY FINDINGS AND CONCLUSIONS

Key Findings:

- NO_3^- inhibited Se(VI) reduction by acting as a competitive electron acceptor.
- Under oxic conditions, SO_4^{2-} decreased Se(VI) removal due to competition for adsorption sites of Fe(III) oxyhydroxides.
- Under anoxic conditions, the formation of GR(SO_4^{2-}) lowered the Se(VI) removal rate and extent.

Conclusions:

Common anions such as nitrate and sulfate may affect iron EC performance for Se(VI) removal. Process optimization and potential pretreatment strategies, such as sulfate removal, are needed to enhance the performance of iron EC for Se(VI) removal.

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[2] Wander, M. C., Rosso, K. M.,and Schoonen, M. A. (2007). Structure and charge hopping dynamics in green rust. *The Journal of Physical Chemistry C*, 111(30), 11414-11423.

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