Reactivity of Iron Oxides in Complex Groundwater Systems

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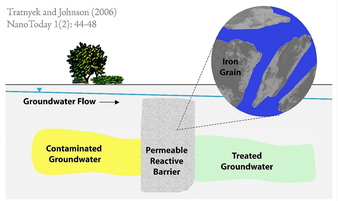
Motivation

- Over 80 million gallons of water are withdrawn from groundwater sources per day (USGS)[2]
- Pesticide application, industry waste, urban runoff, etc. threaten groundwater as a clean water resource
- The need for efficient and low-impact groundwater remediation methods is rapidly increasing



A potential method of remediating contaminated groundwater. Image taken from (1).

Research Overview

- Application of affordable and environmentally friendly iron oxide nanoparticles and Fe(II) ions to a polluted groundwater system can degrade contaminants to less hazardous byproducts[3,4]
- Reactive characteristics of iron oxides in complex groundwater systems (i.e., those containing clay or varying Fe(II) concentration) must be understood on a fundamental level to predict remediation efficiency
- Research focus: to determine the influence, along with the mechanism and magnitude, of clay particles and Fe(II) concentration on the reactivity of several classes of iron oxides

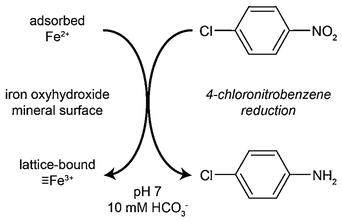
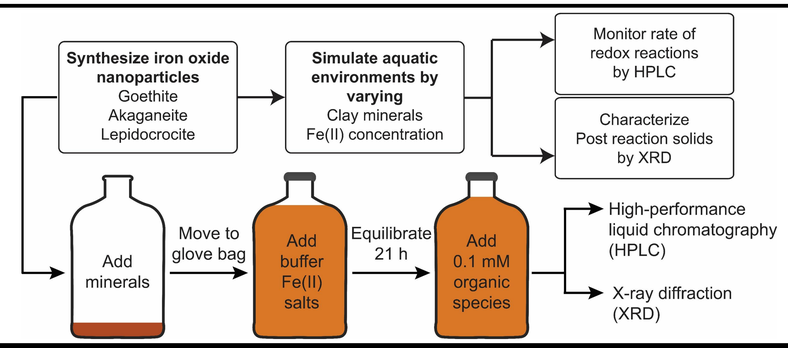


Illustration of the redox chemistry behind contaminant degradation by iron oxides. 4-chloronitrobenzene (4ClNB) is a model contaminant.

Experimental

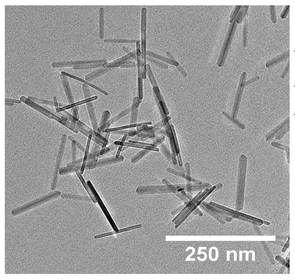


Synthesis Confirmation

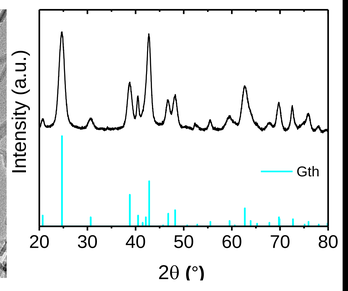
Goethite (α-FeOOH):

Synthesized by Jennifer H. Strehlau

TEM:

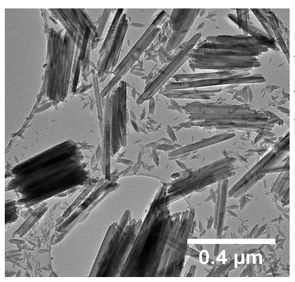


XRD:

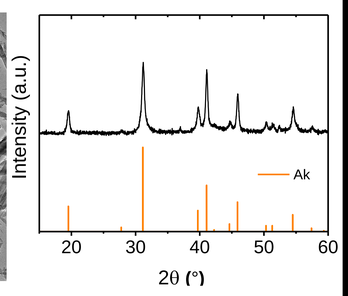


Akaganeite (β-FeOOH):

TEM:

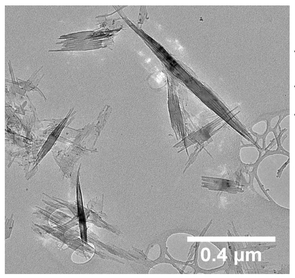


XRD:

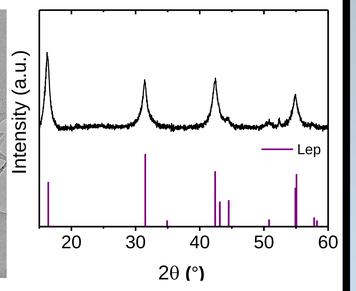


Lepidocrocite (γ-FeOOH):

TEM:

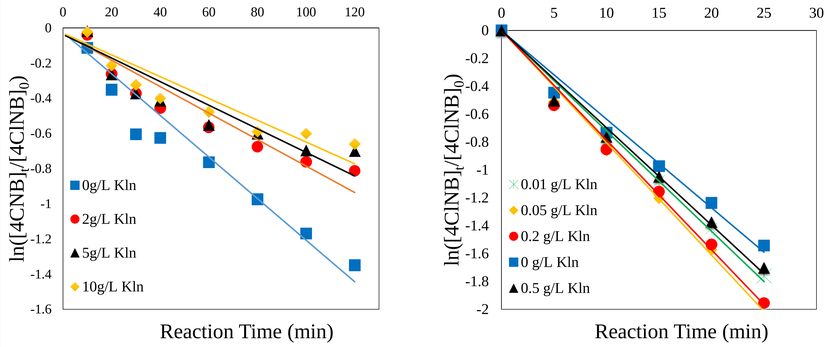


XRD:



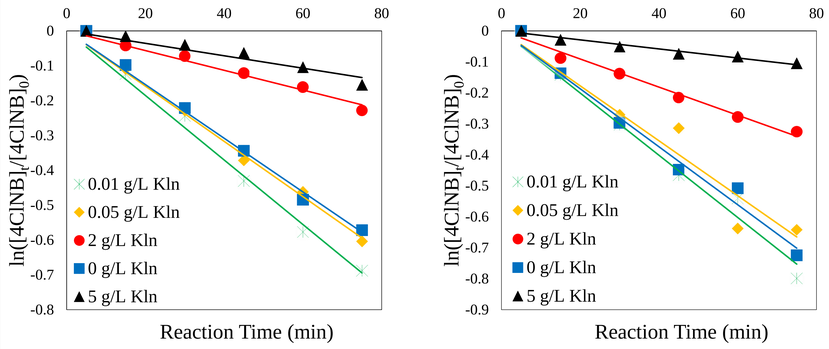
Influence of Clay Particles

Goethite:



- High mass loadings of clay particles led to decreased rate of contaminant degradation by goethite, a trend caused either by heteroaggregation which decreases accessible reactive surface area or competitive Fe(II) adsorption
- Low mass loadings of clay particles were observed to increase the rate of reaction

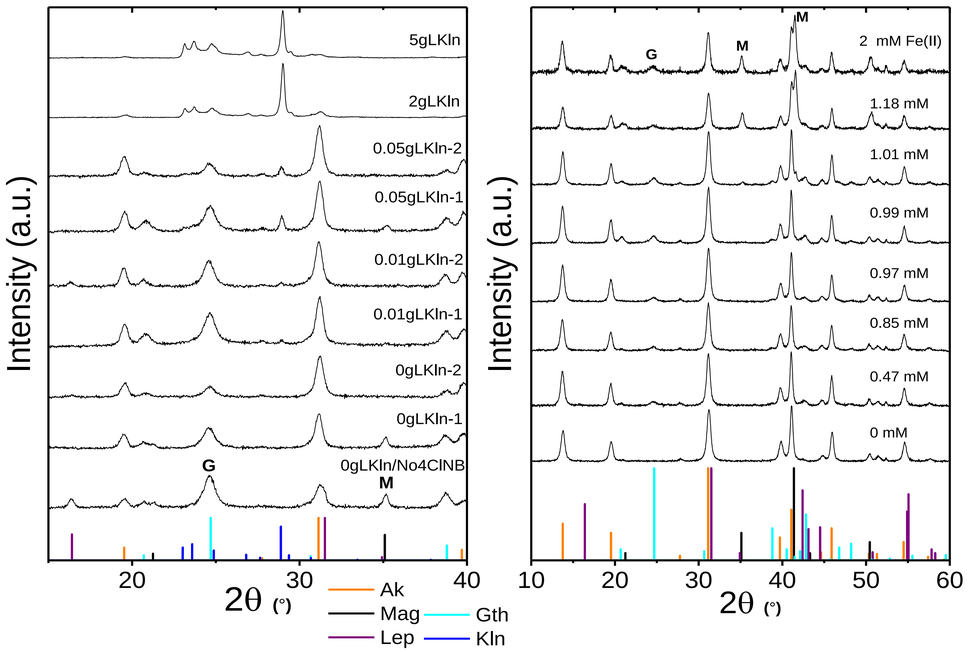
Akaganeite:



- High mass loadings of clay particles were correlated to a decrease in contaminant degradation by akaganeite
- Low clay mass loadings were shown to increase the reactivity of akaganeite with the model contaminant

Influence of Fe(II) Concentration

Akaganeite XRD Patterns Post Reaction:



- Reactors initially containing akaganeite experienced transformation to various other iron oxides
- Transformation was shown to be resultant of addition of Fe(II) ions and unrelated to reaction with a model contaminant
- Magnitude of transformation was inconsistent across reactors of identical composition
- Increasing Fe(II) concentration was shown to result in a larger magnitude of akaganeite transformation, particularly to magnetite and goethite

Future Research

- Determine influence of clay particles on lepidocrocite reactivity
- Assess Fe(II) concentration on lepidocrocite transformation
- Explore increased reaction rates in low clay mass loadings
- Evaluate the reactivity of systems that have experienced transformation
- Apply experiments to other natural clays and silts

Acknowledgements

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References

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