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Continuous Flow Metal Recovery System Using Magnetic Nanocomposites for Contaminated Waters

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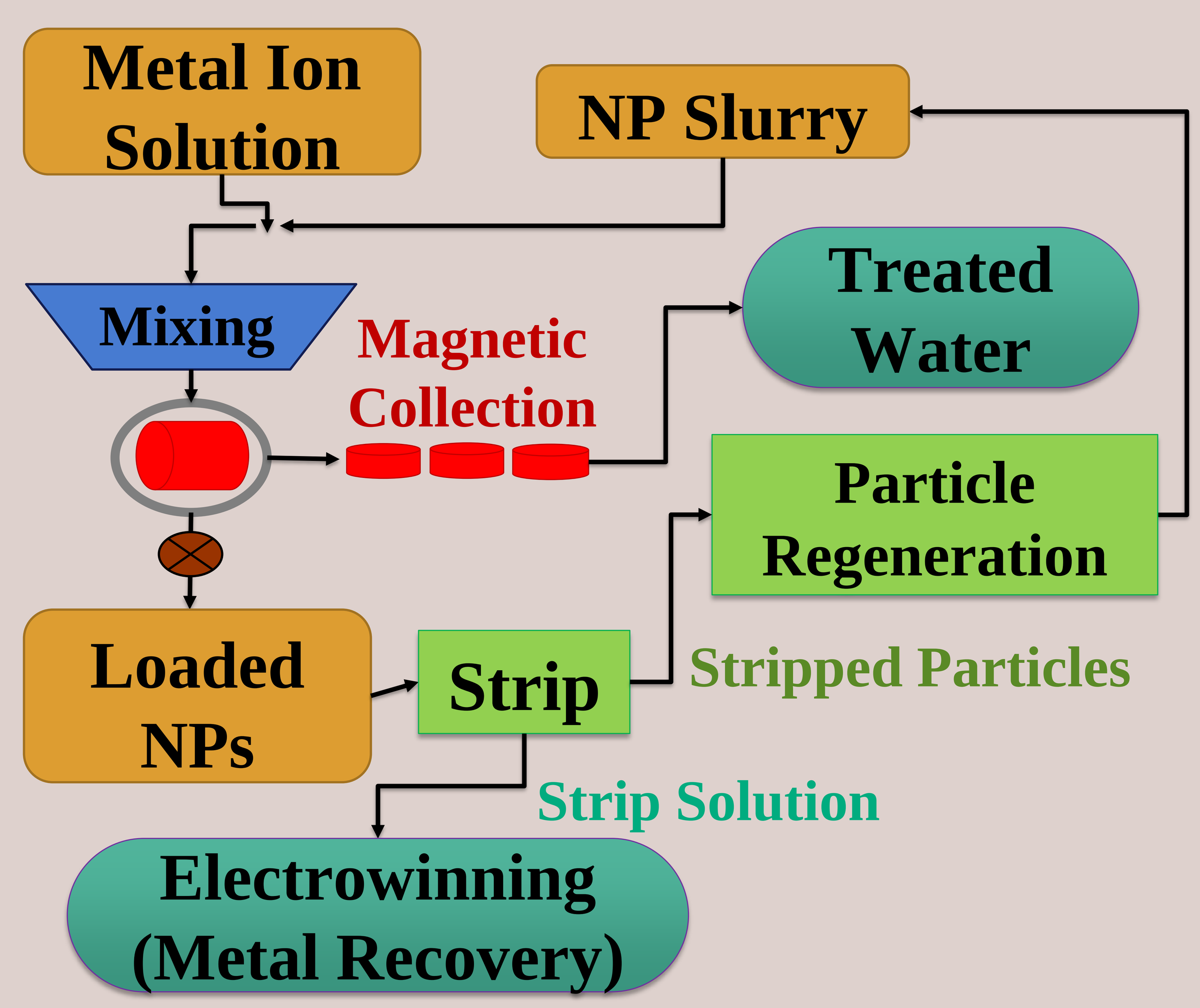
Abstract

Many natural water sources and industrial wastewaters contain low concentrations of metals and other contaminants. Therefore, an effective and economical approach is needed for contaminant removal and recovery. The purpose of the research is to improve and modify a continuous flow metal recovery system, that was originally developed for acid mine drainage treatment, for expansion to a variety of non-industrial applications, including removal metal ions from the Upper Clark Fork River Watershed. The system employs an electromagnet to collect magnetically susceptible nanoscale particles, which in turn adsorb metal ions. Metal ion capture has been examined using natural magnetite nanoparticles (Fe_3O_4 NPs), silica-coated Fe_3O_4 NPs, and chitosan-coated Fe_3O_4 NPs. Current research is focused on particle synthesis and maximizing contaminant capture efficiency. Preliminary results indicate that silica-coated NPs are more effective than magnetite and chitosan-coated NPs for copper recovery from surrogate solutions at low copper concentrations.

Continuous Flow Metal Recovery System



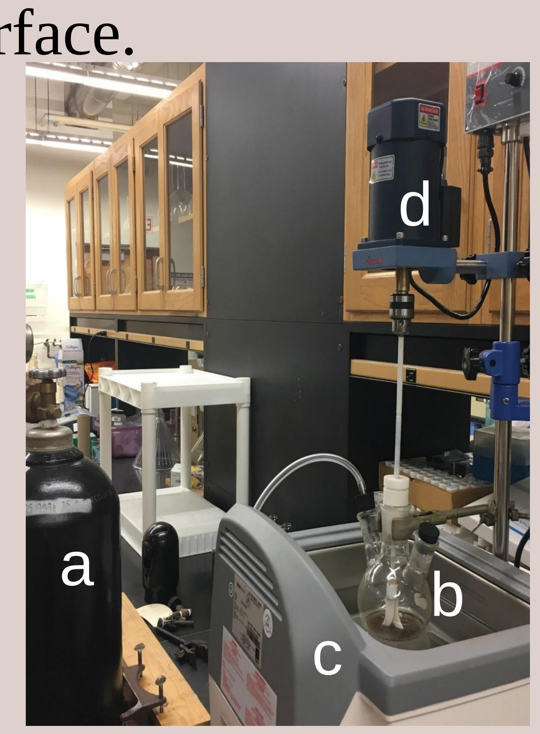
4th generation reactor

Magnetite Nanoparticle Synthesis

Silica-coating Procedure

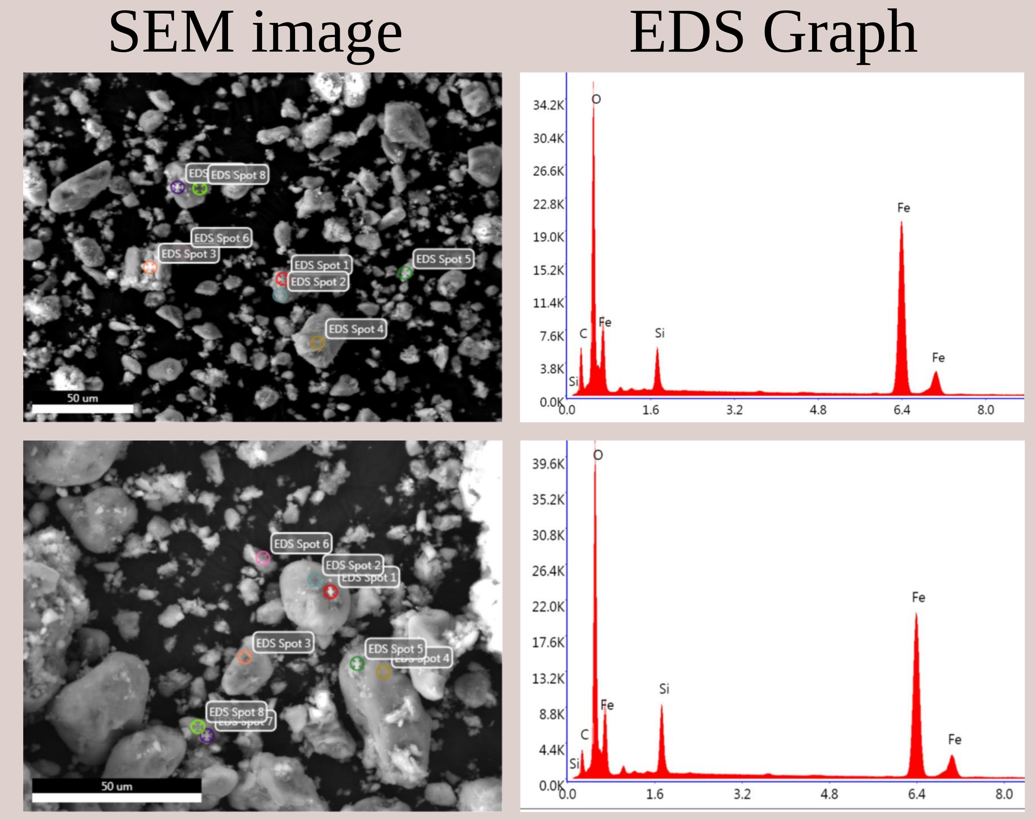
The first step uses TEOS as the source of silica for the coating. Then two functionalization steps are done using MTMS, CPTMS, and PAA. Functionalization adds adsorption sites to the silica surface and encourages metal ions to adsorb to the surface.

Synthesis Setup:
a. Nitrogen tank
b. Glass chemical reactor
c. Sonication bath
d. Mixing arm



Energy Dispersive Spectroscopy Data

SEM image | EDS Graph



EDS graphs verify that silica was coated on the Fe_3O_4 NPs.
Top Row: Tech Batch 1
Bottom Row: Tech Batch 3

Results and Conclusions

The table shows the loading capacity of natural, silica-coated, and chitosan-coated NPs. At low concentrations of copper, the silica-coated NPs tend to have higher loading capacities.

Trial	Initial Concentration $\left(\frac{mg\ Cu}{L}\right)$	Fe_3O_4 (g)	Loading $\left(\frac{mmol\ Cu}{g\ Fe_3O_4}\right)$
Natural Magnetite Nanoparticles			
1	122.47	0.5020	0.19
2	30.64	0.5005	0.05
3	15.58	0.5061	0.07
Silica-coated Magnetite Nanoparticles			
4	46.0154	0.5029	0.25
5	30.3376	0.5053	0.23
6	15.47	0.5055	0.12
Chitosan-coated Magnetite Nanoparticles			
7	205.9	0.5095	0.02
8	112.3	0.5039	0.04
9	31.7	0.5040	0.10

Future Work

- ❑ Optimization based on target contaminants
- ❑ Impact on loading capacities based on additional factors
  - ❑ pH, concentrations of NPs and metal
- ❑ Temperature effects on magnet with electric current and water flow
- ❑ Computer modelling and simulations
- ❑ Automated control system
  - ❑ Valve control
  - ❑ Temperature and pH logging

Acknowledgements

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Student Profile

I am a second year Materials Science Ph.D. student from Wausau, WI. I enjoy doing research and learning, so after graduation I hope to continue doing just that.