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Continuous Flow Metal Recovery System Using Magnetic Nanocomposites for Contaminated Waters

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CONTINUOUS FLOW METAL RECOVERY SYSTEM USING MAGNETIC NANOCOMPOSITES FOR CONTAMINATED WATERS

Teagan Leitzke, Dr. Jerome Downey, Dr. David Hutchins, Dr. Brian St. Clair

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 of 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 (Fe₃O₄ NPs), silica-coated Fe₃O₄ NPs, and chitosan-coated Fe₃O₄ 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

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.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Initial Concentration (mg Cu/L)</th>
<th>Fe₃O₄ (g)</th>
<th>Loading (mmol Cu/g Fe₃O₄)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Magnetite Nanoparticles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>122.47</td>
<td>0.5020</td>
<td>0.19</td>
</tr>
<tr>
<td>2</td>
<td>30.64</td>
<td>0.5005</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>15.58</td>
<td>0.5061</td>
<td>0.07</td>
</tr>
<tr>
<td>Silica-coated Magnetite Nanoparticles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>46.0154</td>
<td>0.5029</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>30.3376</td>
<td>0.5053</td>
<td>0.23</td>
</tr>
<tr>
<td>6</td>
<td>15.47</td>
<td>0.5055</td>
<td>0.12</td>
</tr>
<tr>
<td>Chitosan-coated Magnetite Nanoparticles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>205.9</td>
<td>0.5095</td>
<td>0.02</td>
</tr>
<tr>
<td>8</td>
<td>112.3</td>
<td>0.5039</td>
<td>0.04</td>
</tr>
<tr>
<td>9</td>
<td>31.7</td>
<td>0.5040</td>
<td>0.10</td>
</tr>
</tbody>
</table>

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

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.