Impact of Swelling on Polymeric Adsorbents
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Introduction
- Organic pollutants, including phenols and volatile organic compounds, are hazardous to humans and the environment.
  - Present in gas and aqueous systems
  - Toxic and carcinogenic
  - Slow biodegradation
  - Bioaccumulating
- Adsorption is widely used to control organic pollutants due to:
  - Low cost
  - High efficiency removal of low concentration pollutants
  - Adsorbate recovery
  - Adsorbent reuse

Motivation
- Activated carbon is the industry standard for adsorption.
- Polymers are emerging adsorbents, providing tailored physical and chemical properties.

Properties
<table>
<thead>
<tr>
<th>Properties</th>
<th>Activated carbon</th>
<th>Polymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific surface area</td>
<td>&gt; 600 m²/g</td>
<td>&gt; 1100 m²/g</td>
</tr>
<tr>
<td>Pore volume</td>
<td>0.95 cm³/g</td>
<td>0.94 cm³/g</td>
</tr>
<tr>
<td>Ash content</td>
<td>2-5 %</td>
<td>&lt; 0.01 %</td>
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Materials and Methods
- A commercially available cross-linked polymer bead was immersed in select solvents for 24 h, causing swelling. Beads were then air dried for 24 h to ensure complete drying.
- An optical microscope was used to quantify the size of beads pre-swelling, post-swelling, and post-drying.
- Post-swelling images were taken 30 sec after removing beads from solvents.
- The swelling/drying procedure was replicated 10 times for each solvent, allowing statistical analysis of results.
- Swelling was quantified in water, hexane, toluene, acetone, methanol, and ethanol.

Swelling percentage = \( \frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}} \times 100\% \)

Results: Optical Microscope Images
- Low swelling in water compared to organic solvent has implications for aqueous phase adsorption applications.
- Independent of solvent and swelling extent, dried beads return to their initial diameter.

Results: Swelling in Select Solvents
- Volumetric swelling in organic solvents is between 14 and 23%.
- Volumetric swelling in water is 8.9%; lower than swelling in organic solvents
- After drying, polymer shrinking (< 2%) may occur; additional testing is required.

Conclusions
- Low swelling in water may indicate that polymer adsorption properties remain stable in aqueous systems.
- Additional testing is needed to identify trends between swelling and solvent properties.
- Shrinking may impact the reuse potential of polymer adsorbents.
- Cyclic swelling/drying experiments needed to simulate reuse.
- Difficulty measuring maximum swelling attributed to solvent evaporation after equilibrium.

Future Work
- Testing adsorption properties to ensure similar performance before and after swelling.
- Identify polymer-solvent combinations that maximize swelling.
- Determine the extent of polymer shrinkage, as well as impacts on adsorption.
- Exploit polymer swelling for adsorption/desorption applications.

References

Acknowledgements