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Impact of Swelling on Polymeric Adsorbents

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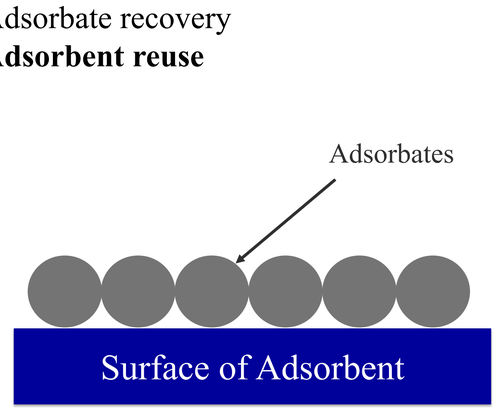
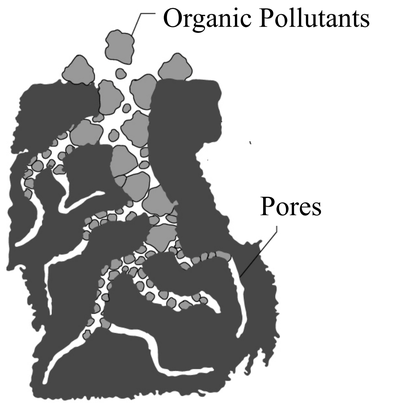
Introduction

- 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**



Adsorption



Pores of adsorbent cdn2.hubspot.net

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

Properties	Activated carbon	Polymers
Specific surface area	> 600 m^2/g	> 1100 m^2/g
Pore volume	0.95 cm^3/g	0.94 cm^3/g
Ash content	2-5 %	< 0.01 %
	sigmaaldrich.com	dowwaterandprocess.com

Motivation

- Unlike activated carbon and other industrial adsorbents, polymers swell when exposed to select solvents. It is important to:

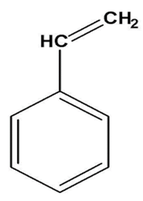
  Identify the impact of swelling on performance of polymeric adsorbents in environmental applications.

  Identify trends associated with multiple swelling/drying cycles, for adsorbent reuse.

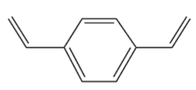
  Quantify the extent of swelling for relevant solvents.

Materials and Methods

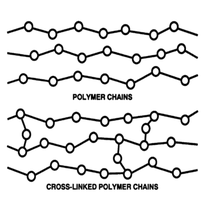
- A commercially available cross-linked polymer bead was immersed in select solvents for 24 h, causing swelling. Beads were then air dried for 24 h to ensure complete drying.



Styrene
marinesciences.uconn.edu



Divinylbenzene
kovats.org



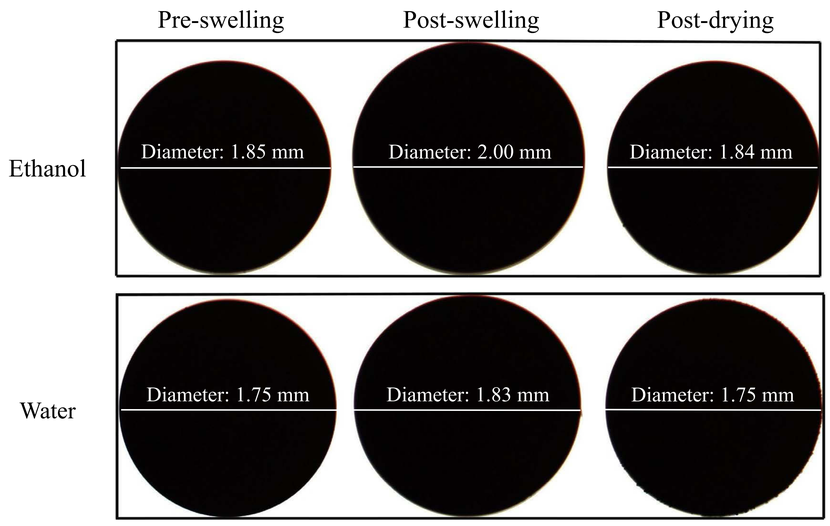
Polymers
revision4gcses.wordpress.com

Polymer beads

- 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.

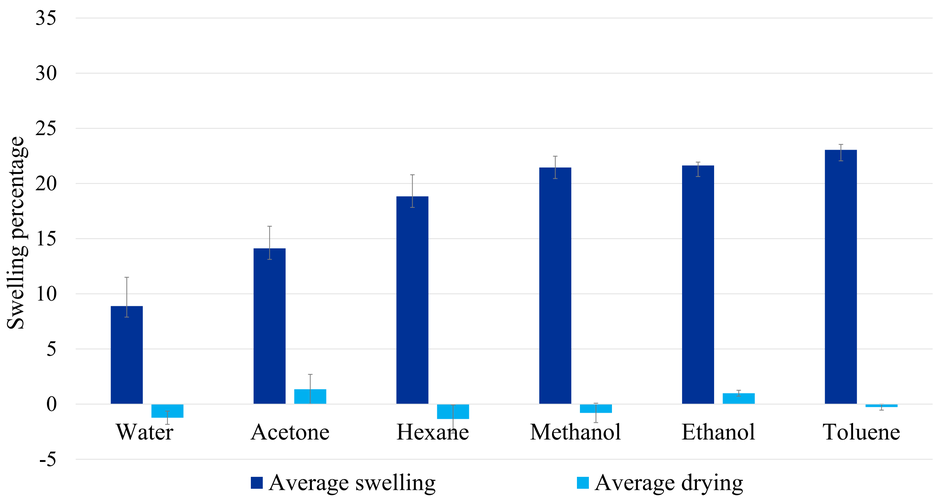
$$\text{Swelling percentage} = \frac{(\text{Final volume} - \text{Initial volume})}{\text{Initial volume}} * 100\%$$

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

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Acknowledgements

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