Beryllium Interactions with Aerogel-GAC Composites

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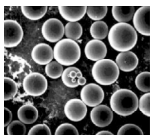
Aerogel

- Silica-based aerogels developed at LLNL have extremely low density and are non-flammable, non-toxic, lightweight and thermally stable upto 650°C.
- LLNL researchers have previously shown adsorbing properties of aerogel/GAC for uranyl and hexavalent chromium ions
- Granular activated charcoal (GAC) added as solid support to increase mass, volume and ease of handling
- BET analysis shows active surface area of aerogel/GAC composite ~ 500m^2/g.

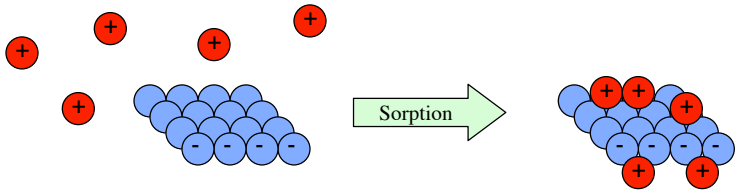


Sorption Theory

- Charged surfaces can arise either from a chemical reaction of ionisable groups at the surface or, from lattice imperfections

$$>S\square O^{\square} \xrightarrow{H^+} >S\square OH \xrightarrow{H^+} >S\square OH_2^+$$

- Chemical sorption ('chemisorption') is a chemical interaction between the solution (solute) and the surface (sorbent)
- Adsorption can be described as a concentration enhancement of one phase at the interface of another

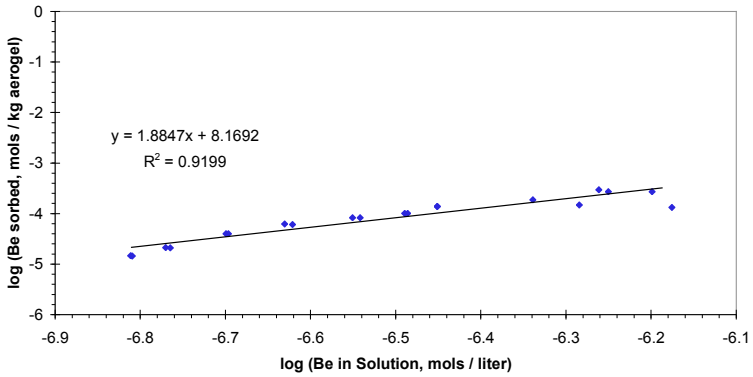


Experimental Details

- Batch sorption experiments using aerogel and ppb quantities of $BeSO_4$
- 5 day equilibration with continuous shaking
- Filter through 0.45□m, followed by 0.2□m syringe filter
- Be analysis by ICP-MS with ^6Li internal standard (EPA method)
- Point of Zero Charge measurement by potentiometric titration
- Surface characterization by BET analysis
- Batch rate and column flow experiments have been performed and are still to be analyzed

Freundlich Sorption Isotherm

- Specific for heterogeneous surface sites

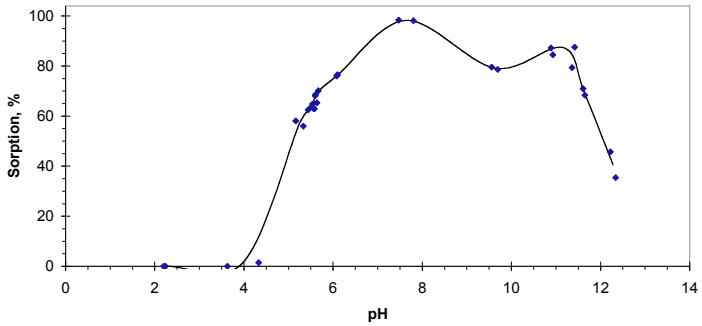


$$[Be]_{aerogel} = K_{adsF} \cdot [Be]^{n_s}_{solution}$$

$K_{adsF} = 1.48 \times 10^{8}$, $n_s = 1.88$

pH Isotherm

- 100mg aerogel/GAC, 1×10^{-6}M $BeSO_4$, HCl/NaOH
- Sorption of beryllium onto aerogel/GAC increases with increasing pH until ~pH 7.5, followed by a plateau and finally decreases with increasing pH after ~pH 11.5



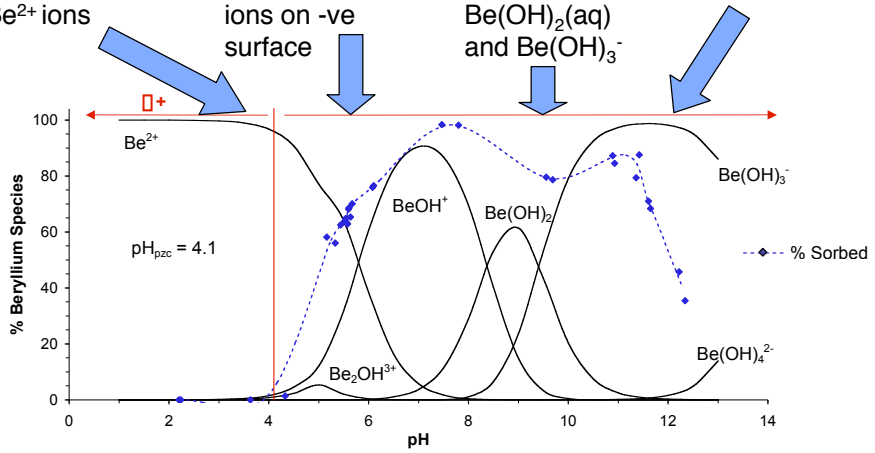
Sorption / Speciation with pH

Poor sorption due to +ve surface and Be^{2+} ions

Sorption increase due to Be^{2+} and $BeOH^{+}$ ions on -ve surface

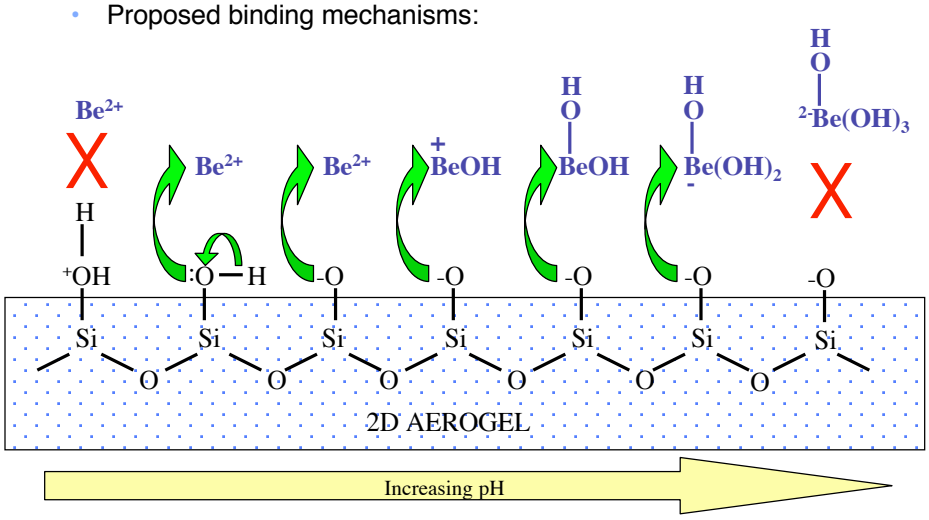
Sorption decrease due to uncharged $Be(OH)_2(aq)$ and $Be(OH)_3^-$

Sorption decrease due to $Be(OH)_4^{2-}$



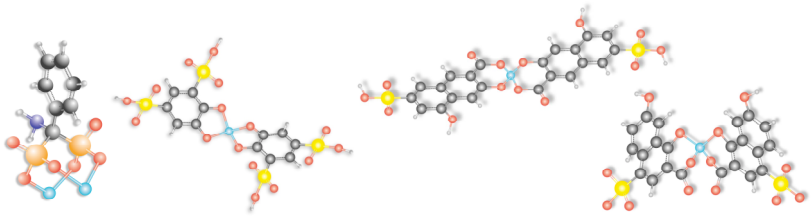
Explaining Beryllium Sorption

- Proposed binding mechanisms:



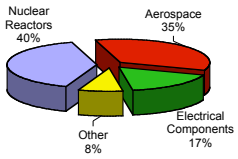
Improving Sorption

- We are working to improve specific beryllium sorption by incorporation of beryllium-specific chelators
- Selective and effective beryllium chelators can be added to the aerogel manufacturing process for specific metal binding



Applications

- Environmental and workplace cleanup of liquid beryllium waste
- Beryllium is used in a variety of industries across the US and the globe
- Scrap yards (especially electronics recycling) are also at risk of Be exposure



- Potential for investigation for environmental / industrial cleanup of other metals
- Improving the understanding of metal-aerogel/GAC interactions.

Summary

- Understanding beryllium chemistry, sorption / desoption with aerogel
- Optimal chemical environments identified
- Solid-support beryllium cleanup method

Acknowledgements

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Column Experiments (addnl. info)