Biopolymer Sorbents for Tungsten Removal – 2012MA346B

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Problem and Research Objectives:

Since 1999, eighty-eight million "green" tungsten-based bullets have been manufactured to replace the lead-based bullets, which were contaminating Cape Cod's water supplies. Unfortunately, the inertness of tungsten came into question when it was detected in Massachusetts Military Reservation groundwater. Recent studies support that under certain pH conditions, tungsten will dissolve and leach into underlying aquifers. Tungsten has since been declared an emerging contaminant by the Environmental Protection Agency and the Department of Defense. Thus, our research objective is to develop environmentally benign sorbents capable of irreversibly binding and removing tungsten from our water supplies.

Methodology:

1. Three molecular weights of chitosans will be characterized using nuclear magnetic resonance spectroscopy, Fourier transform infrared spectroscopy (FTIR), rheology, and for their processability.
2. Sorbents will be made from the most desirable molecular weight of chitosan (identified from Methodology #1). Novel nanostructures including nanoparticles, gels, and films will be synthesized via a combination of solution chemistry, casting, and/or spin-coating.
3. We will characterize the minimum time/temperature required to crosslink the sorbents using two organic agents. Crosslinking will be confirmed by FTIR, visual inspection, and exposing the sorbents to various pHs.

Principal Findings and Significance:

1. From characterizing the low, medium, and high molecular weight chitosan it was determined that for our applications the low molecular weight was the best source material and yielded the most reproducible results.
2. We developed a processes to fabricate chitosan-based sorbents in numerous modalities: nanoparticles, ultra-thin films, cast-films, nanofiber mats, and hydrogels.
3. Analysis determined the minimum crosslinking time required to create chemically robust sorbents using the organic crosslinking agent, glutaraldehyde. It was determined that cinnamaldehyde is not an efficient crosslinking agent for chitosan films cast from acidic solutions.

From the support provided to us we have established protocols to fabricate a variety of nano- to macro-structured "green" chitosan-based sorbents. From chitosan screening we anticipate these materials to have a high capacity for tungsten removal as will be concluded in future investigations.

Student Support:

Number of students supported by grant or matching funds, the degree they are pursuing, and their major.
1. David P. Gamliel, B.S. 2013, Chemical Engineering
2. Annuli N. Princess Okoye, B.S. 2014 (expected), Double Major: Chemical Engineering & Environmental Science
3. Elena P. Pandres, B.S. 2014 (expected), Chemical Engineering
4. Nathaniel Eagan B.S. 2014 (expected), Chemical Engineering

Notable Achievements and Awards:

From this project, four undergraduates have gained first-hand lab experience that has enabled them to receive impressive fellowships, awards, and acceptance into summer research programs/graduate school. All four students have been accepted to NSF or DOE sponsored summer research experience engineering materials for water purification or energy generation. Posters prepared on data gathered from this grant received 1st and 3rd place in the AIChE Regional Student Conference in April 2013.

Follow-on Funding
UMass Amherst Commonwealth Honors College, Honors Research Assistant Fellowship ($1000 for three undergraduates: Total: $3000)