CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Aurnov Chattopadhyay

Project Number

S1109

Project Title

Efficient Removal of Pb2+, Cd2+, and UO2+ from Water through Sustainable Nanocellulose Coagulants Derived from Biomass

Abstract

Objectives/Goals

Heavy metal pollution is a pressing global environmental threat and public health concern, responsible for several hundred thousand deaths annually. However, current methods to remove heavy metals are inefficient, too expensive for impacted regions, and produce harmful byproducts. This research sought to identify the application of one step modification, a new process to synthesized anionic cellulose nanofibers, to address the global demand for heavy metal remediation.

Methods/Materials

Raw biomass, jute fibers and spinifex grass, were treated with HNO2 and NaNO3 through a one-step modification to inexpensively and directly produce oxidized nanocellulose. The adsorption capacity of the nanofibers was analyzed through batch remediation studies measured using UV - visible Spectroscopy and ICP # ms (Inductively Coupled Plasma Mass Spectroscopy). Characterization of nanofiber mediated removal of metals was analyzed using FITR (Fourier Transform Infrared Spectroscopy) and SEM (Scanning Electron Microscopy).

Results

The anionic nanofibers coordinated with cationic metals form visible flocs which can be removed using a simple 1.0-micron filter. SEM characterization of the flocs confirmed the coordination of metals on the nanofiber surface indicating the precipitation of heavy metals following nucleation. FTIR characterization of the flocs indicated shifts in chemical groups corresponding to metal cations binding to carboxyl groups. Batch removal experiments, measured with ICP # MS and analyzed using Langmuir isotherm models, assess jute nanofiber#s Pb2+ removal capacity as 2,270 mg/g and spinifex nanofiber#s Cd2+ removal capacity as 2,550 mg/g.

Conclusions/Discussion

The nanofibers are the most effective adsorbent of Cd2+ and Pb2+ reported to date, 15% more efficient than the most effective Pb adsorbent and 70% more efficient than the most effect Cd adsorbent. The nanofibers perform optimally at neutral pH, are recyclable, and cost effective enabling widespread use in impacted regions of developing countries.

Based on this work, I am coauthoring three papers for publication in scientific journals. My research has also been incorporated into a patent. Further studies based on my work are being conducted by graduate students, and the Hsiao Lab hopes to translate this research towards commercialization in several years.

Summary Statement

I identified the novel heavy metal remediation application of inexpensive, efficient, and green carboxy cellulose coagulants by characterizing and quantifying the agent's capacity to promptly remove lead, cadmium, and uranium from water.

Help Received

I designed, performed, and analyzed most of the research independently, receiving technical assistance with advanced characterization techniques and guidance in organization of my research plans.