64907 "Green" Biopolymers for Improved Decontamination of Metals from Surfaces: Sorptive Characterization and Coating Properties

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RESEARCH OBJECTIVE

The proposed research aims to develop a fundamental understanding of important biological and physical chemical parameters for effective decontamination of metal surfaces using environmentally benign aqueous-based biopolymer solutions. Understanding how heavy metal–chelating biopolymers coat and interact with contaminated surfaces will benefit the development of novel, safe, easy-to-apply decontamination methodologies for removal of radionuclides and heavy metals. The benefits of these methodologies will include the following:

- decreased exposure hazards for workers;
- decreased secondary waste generation;
- increased efficiency of decontamination;
- positive public appeal and development of novel, nature-friendly business opportunities; and
- lower cost of cleanup to the government.

We propose to use aqueous biopolymer solutions to coat a contaminated metal surface (i.e., steel), solubilize the heavy metals (e.g., uranium) from the surface, and bind the heavy metals into the biopolymer. The biopolymer coating (containing the immobilized hazardous metal contaminants) will then be removed as a viscous film, as a dry powder, or by washing. This "apply, wait, and remove" procedure will reduce the amount of worker time spent in decontamination activities.

RESEARCH PROGRESS AND IMPLICATIONS

This report summarizes work after 16 months of a 3-year project. The research aims to develop a fundamental understanding of important parameters for effective decontamination using aqueous biopolymer solutions. The work may be broken down into three parts: (1) selection and generation of biopolymers; (2) characterization of sorbent and material properties; and (3) study of transport properties. Metals used include U, Cu, Cd, and Fe. The latter three of these are model non-radioactive heavy metals that have quickened the pace of laboratory studies in the first and early second year. Critical experiments during the second (and third) year are being performed using depleted uranium.

Screening. We have screened several biopolymers for metals sorption by cultivating a variety of algae (cyanobacteria). Algal strains screened include: *Nostoc* sp. strain GSV39, *Nostoc* sp. strain GSV40, *Nostoc muscorum* (collection of Ukrainian Institute of Hydrobiology), *Anabaena* (*Nostoc*) sp. strain PCC7120, and *Phormidium mucicola* SLR1. These cultures were grown in photobioreactors for 5 days with two different media, then left to mature (maturation leads to accumulation of copious polymer) for 1 month. Biomass was collected and dried. Dry biomass was reconstituted in nitrate buffer and used for metal-binding experiments. The polysaccharides can be partially purified into soluble and insoluble fraction with different rheological properties.

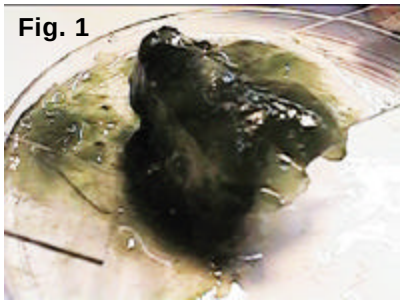
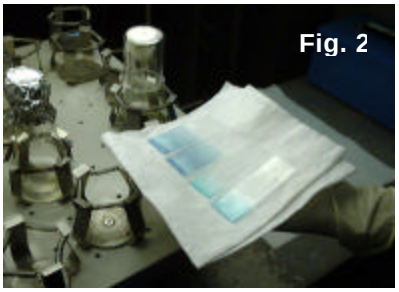


Fig. 1 shows the abundant synthesis of biopolymers by algae (*Nostoc* sp. GSV40).
In **Fig. 2**, a bone-gel biopolymer was used to coat a glass slide and exposed to a solution of copper nitrate. The copper was sorbed from the solution into the gel on the surface – as shown by the blue tint. Algae are growing in shakeflasks in the background.



The soluble excretable biopolymer fraction, which can also serve as a metal chelator was precipitated from media with 2 volumes of cold ethanol. Both components are being analyzed for metal-binding properties.

Selection. The materials/polysaccharides, both soluble and insoluble, isolated from ***Nostoc muscorum Ag*** were chosen for continuation of metal sorption studies after initial screening studies. These materials displayed the strongest binding characteristics for Cd, Fe, Cu, and U (data not shown).

Preparation of Contaminated Steel Coupons. Steel coupons were coated with uranium (UO_2^{+2}) as a means of mimicking actual contamination conditions. Literature protocols for coupon size, shape, cleaning, and heavy metal application were combined and experimentally refined for this project. Techniques for direct measurement of alpha radiation (counts of U^{+6}) on the surface of the coupon, in addition to ICP determinations of U^{+6} in solution and traditional mass balance methods, were developed and verified. This is critical to quantify contaminant removal

PLANNED ACTIVITIES

Quantities of the best metal-sorbing biopolymers will be produced. We will continue tests of heavy metal removal via sorption and adhesion from controlled contaminated steel coupons, primarily with depleted uranium. Radioactive disintegration and inductively coupled plasma spectroscopy (ICP) will be used to quantitate the removal and isotherms. We will test the physical "gel" properties for use as a coating.

Tasks: Green Biopolymers	Year 1				Year 2				Year 3			
Selection/production of biopolymers												
Characterization of metal-chelation properties												
Metal removal from surfaces by biopolymer												
Methods of biopolymer surface application												

INFORMATION ACCESS

"Green Biopolymers for Decontamination" – poster presentation at "Workshop on integration of end user needs with research projects for EMSP: Focus on Deactivation and Decommissioning" at Savannah River Site on Nov. 17-18, 1998.

Presentation, "Green Biopolymer for Decon of Contaminated Surfaces" delivered at *Decontamination, Demolition and Restoration (DD&R) Topical Meeting on Site Restoration of Government and Commercial Facilities*, Sep. 12-16, 1999, Knoxville, TN.