ALBERTA INNOVATES

CLEAN RESOURCES

BIOINDUSTRIAL MATERIALS

BIOMATERIALS

Electrochemical Detection and Reduction of Hexavalent Chromium using Carbonized Lignin Electrodes

Advanced, carbon-based nanomaterials, produced from fossil hydrocarbons and biomass, have a wide variety of potential uses. Lignin is a woody component of plants and a common pulp mill biproduct which has traditionally been combusted for energy. Treating lignin with pyrolysis (thermal cracking in the absence of oxygen) produces pyrolyzed lignin (or lignochar), a potential high-value nanomaterial. Hexavalent chromium (Cr(VI)) is an industrial residue from metal plating and anti-corrosion treatment, and is toxic to organisms at low concentrations. During water treatment, Cr(VI) is currently detected and removed using "glassy" carbon electrodes containing fossil-based graphene and carbon nanotubes. Pyrolyzed lignin shows potential as a renewable, low-cost alternative nanomaterial. Dr. Daniel Alessi's team conducted a laboratory-scale study, designing and testing electrodes containing pyrolyzed lignin for detecting and removing Cr(VI) in water treatment applications.

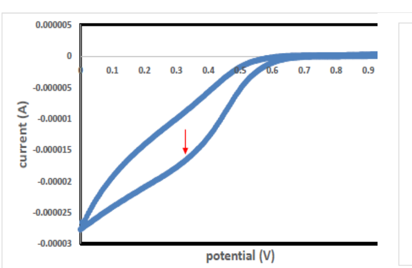

Figure 1 Cyclic voltammetry on a commercially available glassy carbon electrode in 1 mM Cr(VI)

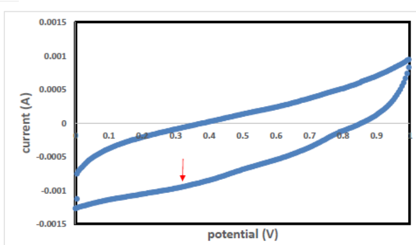

Figure 2 Cyclic voltammetry on lignochar coated carbon foil electrode in 1 mM Cr(VI) at pH 3.

FUNDING DETAILS

RECIPIENT: University of Alberta

PARTNERS: Lignin Enterprises, KBL Environmental

TOTAL BUDGET: $35,500

AI FUNDING: $25,000

PROJECT DATES: JUN 2018 - APR 2019

PROJECT TRL: Start: 2 End: 4

APPLICATION

Pyrolyzed lignin nanomaterials have a wide range of potential applications, including electronics and water treatment. This project focuses on using pyrolyzed lignin to detect and remove toxic substances, specifically Cr(VI), during water treatment. According to previous published research, the graphite-like structure of pyrolyzed lignin gives it high affinity for pollutants such as Cr(VI).

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PROJECT GOALS

- Develop a bench-top process to produce pyrolyzed lignin/iron oxide composites.
- Study the electrochemical detection and recovery of Cr(VI) using pyrolyzed lignin-based electrodes under different physiochemical conditions.
- Outline a simple electrochemical process to sense and remove Cr(VI) in wastewater using pyrolyzed lignin as a working electrode.

BENEFITS TO ALBERTA

- Increase the value of Alberta's abundant lignin supply by developing new, high value products and applications.
- Enhance economic sustainability of Alberta's pulp mills and the rural communities that rely on them for jobs and tax revenues.
- Advance Alberta's bioeconomy, with associated economic and employment benefits.
- Advance development of environmentally sustainable alternatives to fossil fuel-derived materials, particularly in the water treatment sector, within and beyond Alberta.
- Enhance Alberta's reputation in the green economy and related applied research.

2 Students Trained

1-10 Future Jobs

1 Spinoff Company

CURRENT STATUS

APR 2019

The completed project confirmed potential for use of lignin in water treatment electrodes. A bench-top process was developed to sense and remove Cr(VI) using an electrode consisting of pyrolyzed lignin coated on a graphite foil. Under optimized conditions, this electrode met the commercial detection threshold of 100 ppb Cr(VI), comparable to glassy electrodes, and Cr(VI) removal rates of 10 mg g^{-1} h^{-1} at 0.3 V, comparable to a commercial silver/silver chloride (Ag/AgCl) reference electrode.