INDUSTRIAL APPLICATIONS OF CELLULOSE NANOFIBERS FOR WATER RECLAMATION

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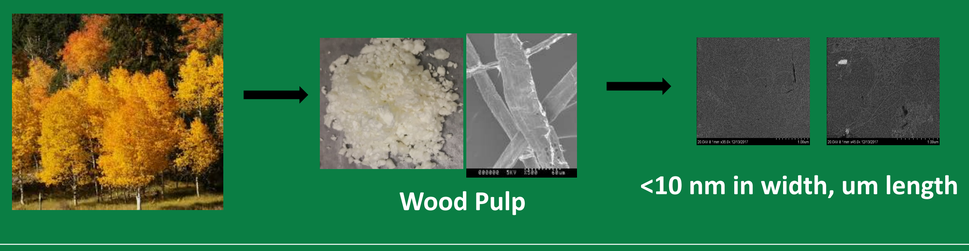
BACKGROUND

- Oil sands process water (OSPW), refers to the water generated from the oil sands mining process. It cannot be discharged directly to the environment due to possible adverse impacts on the receiving environment.
- Some of the inorganics are present at concentrations higher than the established standards in the Canadian Environmental Quality Guidelines, such as copper (II) ions, selenate, selenite, borate, molybdate and so on.
- Nano-cellulose fibrils (CNF) derived from cellulose in nano-size are of interest to be used as adsorbents in water treatment processes in recent years. They feature large surface area, low cost, biodegradability, non-toxicity and readily to be functioned.



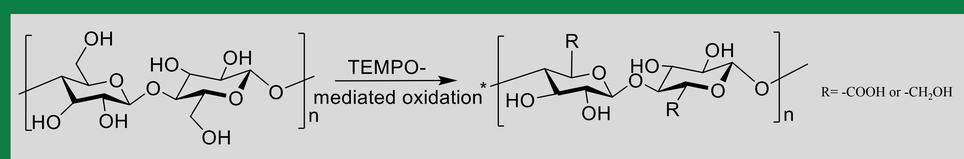
AIMS AND OBJECTIVES

The objectives of the current project include the following:

- To use CNF as it is or modified for inorganics removal from OSPW;
- To evaluate the adsorption performance of the tailored CNF in target pollutant adsorption efficiency and the isolation process;
- To study the interaction between CNF and adsorbate; and
- To understand the removal mechanisms.

RESULTS

- In the present study, TEMPO-oxidation was applied to produce carboxylate group bearing CNF (TEMPO-CNF). The TEMPO-CNF was fully characterized, and the carboxylate groups' content was determined to be 0.7 mM/g.



Scheme 1. TEMPO-mediated oxidation reaction on the surface of CNF.

- The Cu(II) adsorption from synthetic water was tested. The adsorption equilibrium was reached within 2 min and the removal ratio was more than 98% under initial Cu(II) concentration of 2 ppm. (Figure 1 and Figure 2)

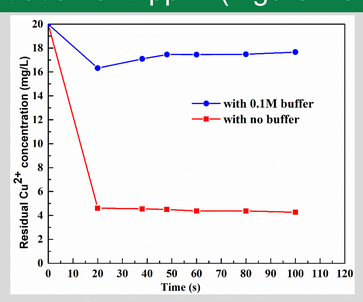


Figure 1. Cu^{2+} adsorption kinetics. Initial Cu^{2+} concentration: 20 mg/L; pH =6; Buffer solution 0.1M Acetic acid-sodium acetate ; 0.5 g/L TEMPO-CNF.

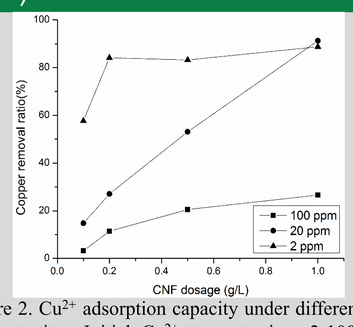


Figure 2. Cu^{2+} adsorption capacity under different initial concentration. Initial Cu^{2+} concentration: 2-100 mg/L; pH =6; 0.5 g/L TEMPO-CNF; Contact time: 3 hours.

- The XPS spectra showed the existence of both Cu(II) and Cu(I) on the used TEMPO-CNF surface, indicating that reduction reaction between copper and CNF might occur. However, further investigation is still needed to draw a robust conclusion.

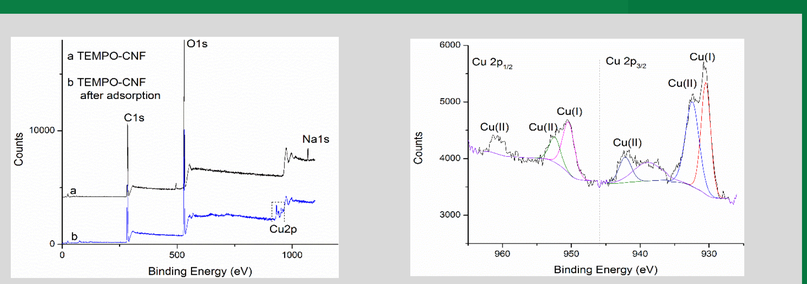


Figure 3 XPS spectra of TEMPO-CNF before and after copper (II) adsorption.

- The Cu(II) adsorption capacity on TEMPO-CNF decreased with the increase of solution ionic strength.
- In 20 mM NaCl solution (with similar ionic strength to OSPW), copper (II) adsorption capacity was 60% of that in copper solution with no other salt added.
- The competitive adsorption result showed that the prevalent cations in OSPW (Mg^{2+}, K^{+}) cannot be adsorbed on TEMPO-CNF, which proved the selectivity of the developed material.

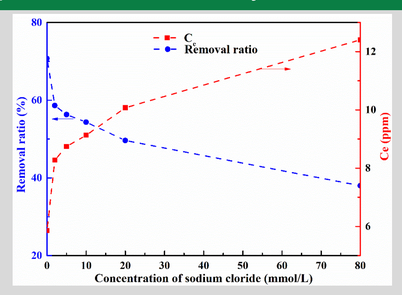


Figure 4 Effect of ionic strength on copper(II) removal.

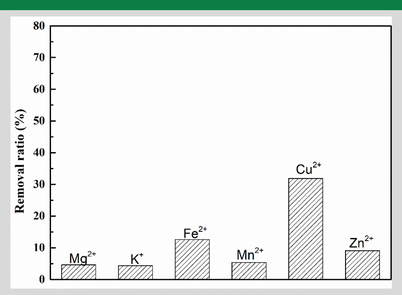


Figure 5 Competitive adsorption over different ions. Initial concentration: 10 ppm of each cations.

FUTURE DIRECTIONS

- The fast adsorption kinetics and high adsorption efficiency benefit the short water retention time and the system design. In the future study, the adsorption of other inorganics of concern will be investigated.
- The non-toxic and biodegradable CNF are with highly potential to be assembled in passive systems (e.g., pipe-line flow-through, river bank, wetland) for OSPW reclamation.

PARTNERS

FES PROJECT OVERVIEW

Resilient Reclaimed Land and Water Systems: Environmental issues associated with energy development, management and supply must be addressed for all energy systems. Regardless of the type, source or transport mode of energy, land and water will be affected. Hence, land and water will be integral components of all future, current and legacy energy systems, addressing land and water use, management, conservation and reclamation. After disturbance from energy focused activities, land and water require reclamation to resilient systems that support desired end land uses. Reclamation success can be achieved if metrics to determine trajectories and final outcomes are robust and science based, with good communication among stakeholders and practitioners. Our theme projects address a systemic approach to energy production and delivery and cross theme benefits.

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