USE OF CARBON XEROGEL FOR ADSORPTION OF ORGANIC MATERIAL IN OIL SANDS PROCESS WATER

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BACKGROUND

- The Alberta oil sands are composed mostly of mineral solids (85%) which makes it necessary to extract the bitumen from the oil sands by the Clark caustic hot water method.
- Water that has come into contact with oil sands is called oil sands process water (OSPW) and is a complex mixture that contains sand, silt, clay, dissolved salts, heavy metals and organic compounds (naphthenic acids (NAs) and polyaromatic hydrocarbons). Studies have shown that NAs are one of the responsible for the acute and chronic toxicity of OSPW.
- Adsorbents used for NAs removal studies include activated carbon (AC), petroleum coke, biochar, and chitosan hydrogels. AC is a well-known adsorbent used for organics removal due to its high surface area, however, with larger sized adsorbates, some of the microporous volume may not be accessible. Carbon xerogels (CX) are polymer derived mesoporous materials that can be customized to accommodate larger sized adsorbates. CX can have high surface area (400-1200 m^2/g), controllable pore size, and high adsorption capacity.

AIMS AND OBJECTIVES

In this work, the use of CX is evaluated an adsorbent for removal of acid-extractable fraction (AEF) of OSPW. AEF contains NAs and other organics.

The objectives of the study were to:

- Determine the equilibrium time needed for adsorption of AEF by CX;
- Gain an understanding of the effect of adsorbent dose;
- Gain an understanding of the kinetics for the removal of AEF by CX;
- Gain an understanding of the types of diffusion governing the adsorption of AEF by the CX using diffusion modeling; and
- Determine the adsorption capacity of CX.

RESULTS

Effect of Adsorbent Dose

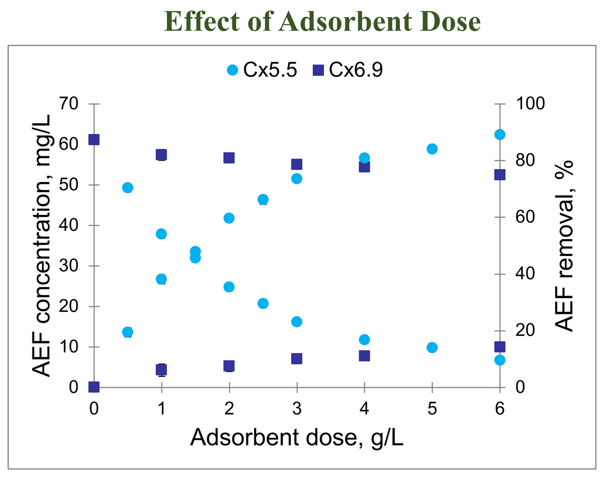

Fig. 1. AEF concentration and removal in OSPW after 24 hour adsorption with CX5.5 and CX6.9.

Equilibrium time & Kinetics

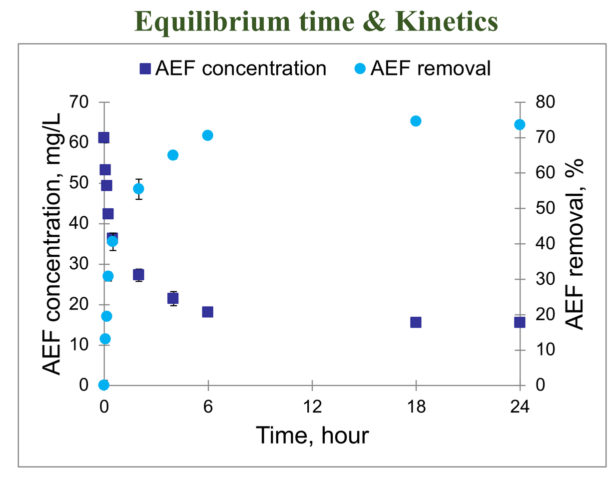

Fig. 2. AEF concentration and removal in OSPW after adsorption with 3 g/L dose of CX5.5 for different time.

Adsorption Capacity of CX

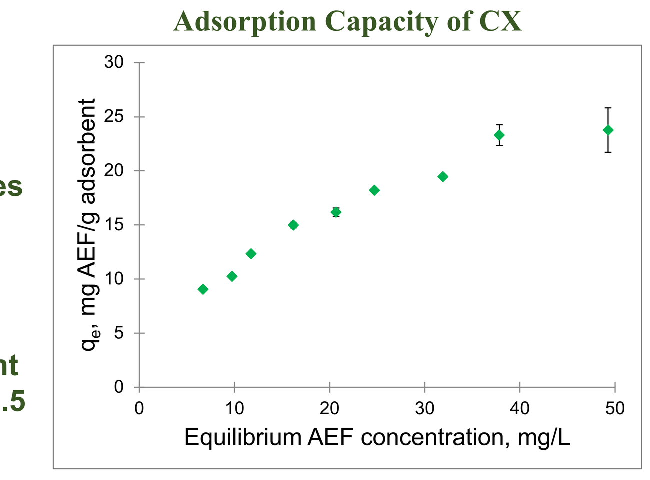

Fig. 3. Equilibrium adsorbent capacities for CX5.5 as a function of AEF equilibrium concentration in OSPW for adsorbent load from 6 g/L to 0.5 g/L.

Modeling the Kinetics of Adsorption

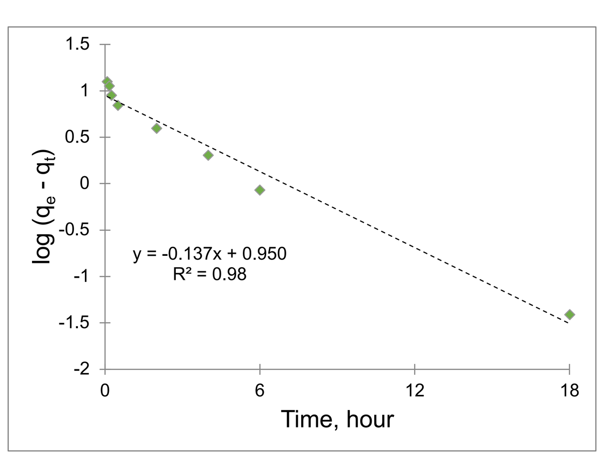

Fig. 4. Pseudo-first order kinetic model for adsorption of AEF onto CX5.5, 3 g/L dose.

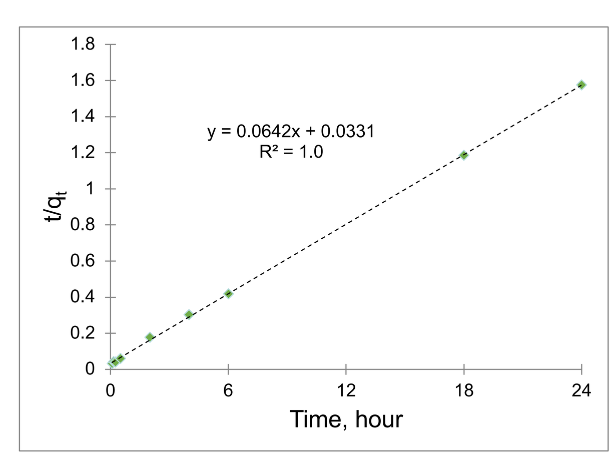

Fig. 5. Pseudo-second order kinetic model for adsorption of AEF onto CX5.5, 3 g/L dose.

Diffusion Modeling

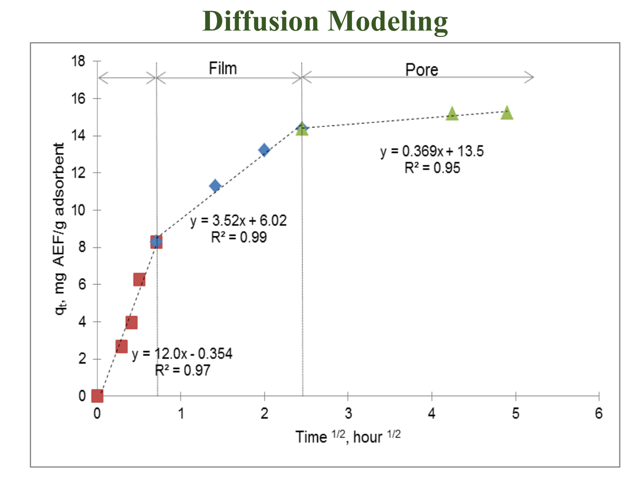

Fig. 6. Intraparticle diffusion model for the adsorption of AEF onto CX5.5, 3 g/L dose.

CONCLUSIONS & FUTURE DIRECTIONS

CONCLUSIONS

- This research demonstrated that a mesoporous carbonaceous material (carbon xerogel) can successfully be used to adsorb persistent organic contaminants from OSPW.
- By 18 hours, adsorption of AEF by CX has reached equilibrium.
- Removal of AEF by adsorption on CX5.5 is much higher than CX6.9 for all adsorbent doses tested due to higher BET surface area and greater mesoporous volumes found in CX5.5.
- Adsorption of AEF follows pseudo-second order kinetics.
- Diffusion through the pores of the carbon xerogel is the rate limiting step during adsorption.
- Equilibrium adsorption capacity for 3 g/L CX5.5 is ~15 mg AEF/g CX5.5.

FUTURE WORK

- Identify other carbonaceous mesoporous material that can successfully adsorb AEF in OSPW.
- Use of CX in a column can be investigated for treatment of OSPW.
- Investigate use of mesoporous carbonaceous material in semi-passive treatment methods such as pit lakes for the removal of organic constituents from OSPW.

PARTNERS

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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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UNIVERSITY OF ALBERTA FUTURE ENERGY SYSTEMS

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