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Case Study

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REMOVAL OF A MODEL NAPHTHENIC ACID – TRANS-4-PENTYLCYCLOHEXANE CARBOXYLIC ACID – USING MESOPOROUS CARBON XEROGEL ADSORBENT

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1 Research Overview

Due to Alberta's zero discharge approach, the oil sands process-affected water (OSPW) is stored in-situ for further treatment before its release to the surrounding environment (Alberta-Government 2014; Brown et al. 2013). OSPW is toxic to aquatic and terrestrial organisms due to the presence of organic matters, such as naphthenic acids (NAs), and non-organic constituents, such as heavy metals (Grewer et al. 2010; Jensen-Fontaine et al. 2014). NAs are a complex mixture of alicyclic and aliphatic carboxylic acids with general formulae of $C_nH_{2n}+ZO_x$, $C_nH_{2n+Z}O_xS$, and $C_nH2_{n+Z+1}O_xN$, where "n" is the carbon number ($7 \le n \le 26$), "Z" is zero or an even negative integer ($0 \le -Z \le 18$) that specifies the hydrogen deficiency resulting from rings or unsaturated bonding formation, and x represents the number of oxygen atoms ($2 \le x \le 6$) in the NA molecules (Grewer et al. 2010). Many recent studies have discussed the OSPW remediation using chemical, biological, physical, and a combination of two or more of these methods.

Adsorption is one of the promising treatment techniques that show a potential in removing the NAs from OSPW. Activated carbon (AC) is usually used as an adsorbent for OSPW treatment. AC shows high removal compared to other adsorbents such as petroleum coke, but the high cost of the AC makes it a less favourable solution for OSPW reclamation process. Carbon xerogel (CX) is a mesoporous carbon based adsorbent that can be used to remove the NAs from the OSPW for the safe discharge of the treated water to the environment.

2 Innovation

In this study, two CX adsorbents (i.e., CX-5.5 and CX-6.9), having different textural properties were prepared by the polycondensation of resorcinol and formaldehyde using two different solution pH values (pH 5.5 and pH 6.9). Trans-4-Pentylcyclohexane (TPCA) model compound was used to evaluate the effectiveness of the two adsorbents in removing the TPCA from aqueous solutions. TPCA stock solution was prepared in pH 8 phosphate buffer to simulate the OSPW water matrix. As a positive control, commercially available granular activated carbon (GAC) was used to assess the removal of TPCA from the water. Characterization result revealed that the GAC has the highest surface area (976 m^2/g) followed by CX-5.5 (573 m^2/g) then CX-6.9 (391 m^2/g). The TPCA isotherm was developed using all of the three adsorbents. Preliminary results show that the CX-5.5 removal percentage was close to that of the GAC for concentrations of TPCA up to 60 mg/L. The results highlight that the mesoporous CX 5.5 can be an alternative to the commercially available GAC in removing the TPCA.

3 Lessons Learned

Results show that the effect of the preparation pH on the CX was significant. This effect was reflected by the surface area and the pore sizes. GAC shows the highest TPCA removal (86%) after 24 hours, while CX-5.5 achieved 63% removal in the same time period. On the other hand, CX-6.9 shows almost no removal after 24 hours. This can be attributed to the adsorbent surface area and the internal pore volume for each adsorbent. The advantage of using the CX5.5 is evident when normalizing the adsorption capacity based on the adsorbent surface area. The CX5.5 removes about 0.11 mg/m^2, while the GAC only 0.08 mg/m^2 this shows the potential of the CX5.5 in removing the NAs model compound. The difference of removal can be explained by the mesoporousity of the CX-5.5. To fully understand the kinetics of the TPCA removal, more experiments need to be performed considering different temperatures; pHs as well as different solution ion strengths.

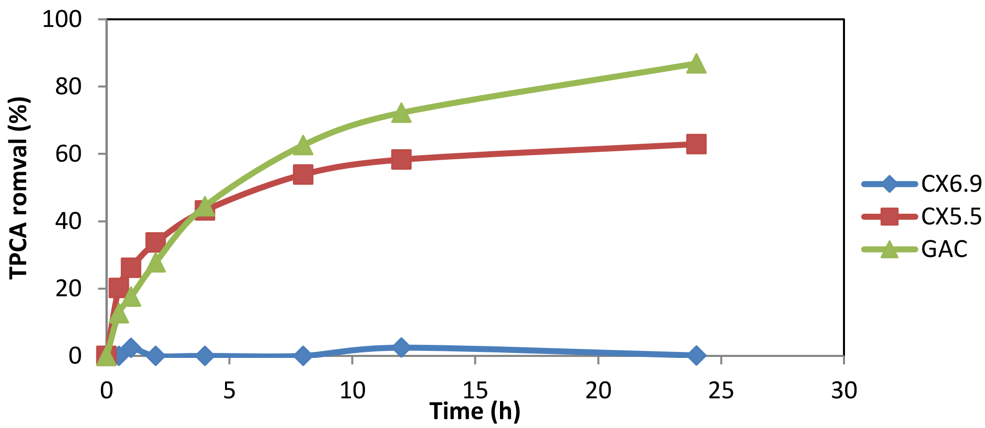

Figure 1: TPCA removal with time for three adsorbents (CX-6.9, CX-5.5, and GAC) at 20 °C.

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