THE UTILIZATION OF OXIDIZED BIOCHAR OBTAINED OF PALM TREE FIBERS FOR CAFFEINE REMOVAL

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INTRODUCTION

Efficient recovery of caffeine from large quantities of processing solutions and industrial wastewaters is of particular importance to protect the environment. [1, 2] Oxidized carbons and biochars are excellent adsorbents for the removal of various toxic substances because of their large surface aera, and the high affinity of their surface-active groups for pollutants. In addition, they are economical and environmentally friendly. [3]

The present study deals with the adsorption of caffeine (CAF) by oxidized biochar prepared from palm tree fibers (OPT). Carbonization and following oxidation of these fibers, leads to a very stable tubular/porous material with increased surface area and number of active sites, which negatively charged for pH > 3 resulting in an increased affinity for the positively charged caffeine molecule in the near neutral pH region. [4]

EXPERIMENTAL

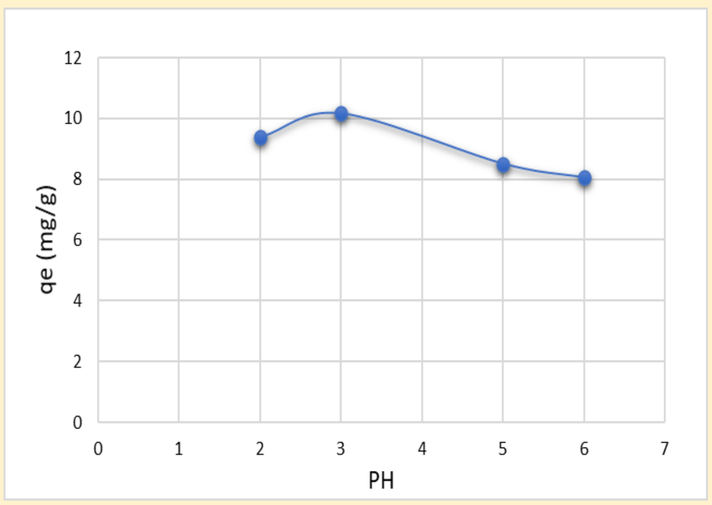
Oxidized activated biochar used in this study as adsorbent material was obtained of palm tree fibers.

All experiments were performed at pH 4 in aqueous solutions, at room temperature (22 ± 3 ºC) under ambient atmospheric conditions. The pH in the test solutions was adjusted by addition of $HClO_4$ or NaOH.

The caffeine adsorption was examined at various conditions e.g. pH, contact time, temperature, and ionic strength. The pH was varied between 2 and 6, the amount of adsorbent was 0.1 g, the ionic strength between 0.2 M and 1 M, and the temperature between 25 and 50 ºC. The measurement of the caffeine concentration in solution was performed using ultraviolet spectrophotometry. Characterization of activated biocarbon after CAF adsorption was performed by FTIR spectroscopy.

RESULTS AND DISCUSSION

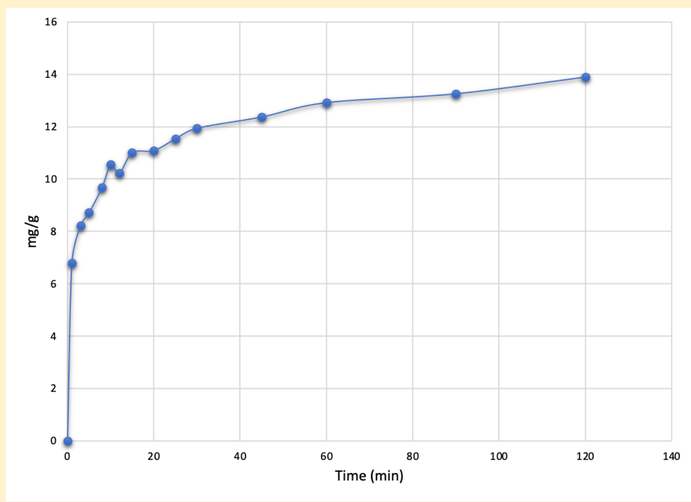
❖ Effect of pH



Effect of pH on adsorption onto oxidized palm tree under normal atmospheric condition and T (m = 0.1 g, V = 30 mL, t = 24h)

- The pH did not greatly affect adsorption.
- Maximum adsorption efficiency at pH 3 (10.55 mg/g)

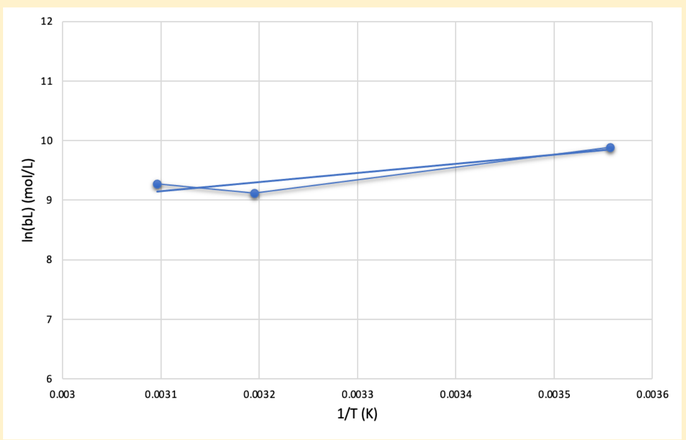
❖ Effect of contact time



Effect of contact time onto adsorption onto oxidized palm tree under normal atmospheric condition and T at pH = 4 (m = 0.1 g, V = 30 mL, t = 24h)

- Increasing of contact time → Increasing of adsorption
- 120 min: the equilibrium was achieved (qt = 27.81 mg/g)

❖ Effect of temperature



Effect of temperature on adsorption onto oxidized palm tree under normal atmosphere at pH 4 (m = 0.1 g, V = 30 mL, t = 24h)

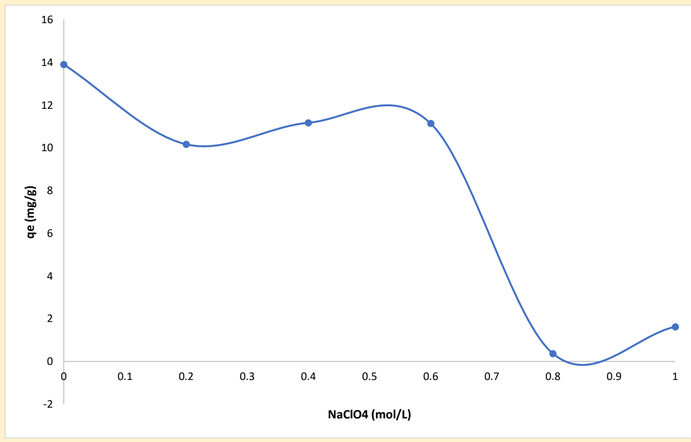
- Temperature did not significantly affect adsorption

$$\Delta G^0 = -RT\ln b_L$$

$$\ln K_d = \frac{\Delta S^o}{2.303 \cdot R} - \frac{\Delta H^o}{2.303 \cdot R \cdot T}$$

- ΔHº = -21 kJ/mol, ΔSº = 12 J/mol → Exothermic process

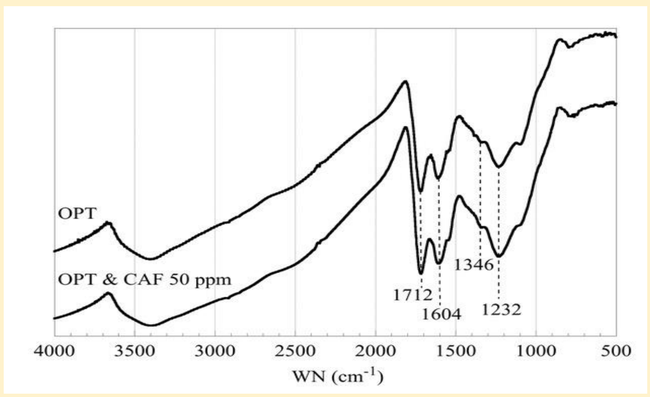
❖ Effect of ionic strength



Effect of temperature onto adsorption onto oxidized palm tree under normal atmosphere at pH 4 (m = 0.1 g, V = 30 mL, t = 24h)

- Increasing of ionic strength above 1M → Decreasing of adsorption

❖ FTIR Characterization



IR spectra of oxidized palm tree (OPT) and OPT adsorbed caffeine (OPT & CAF)

- No remarkable changes in the FTIR spectrum observed
- Adsorption through pure electrostatic interactions

CONCLUSION

- The results of the present study confirmed the ability of oxidized biochar fibers from palm tree to act as efficient adsorbents for the removal of caffeine from waters.
- At pH 3 the adsorption efficiency reached a maximum value (q_{max} = 10.2 mg/g)) and the temperature increase had a negative effect indicating on a exothermic process.
- The adsorption follows rather the pseudo-second-order kinetic model and the equilibrium data were well fitted by both, the Langmuir and Freundlich adsorption isotherm models.
- The formation of the outer-sphere complexes on the biochar surface is indicated by FTIR spectroscopic measurements.
- The combination with other adsorbents could improve the adsorption capacity.

LITERATURES

[1] Z. Rodriguez del Rey, E. F. Granek, B. A. Buckley. Expression of HSP70 in Mytilus californianus following exposure to caffeine. Ecotoxicology, 20, 855, 2011.
[2] G. v. Aguirre-Martinez, S. Buratti, E. Fabbri, A. T. DelValls, M. L. Martin-Diaz. Using lysosomal membrane stability of haemocytes in Ruditapes philippinarum as a biomarker of cellular stress to assess contamination by caffeine, ibuprofen, carbamazepine and novobiocin. Journal of Environmental Sciences, 25, 7, 2013, 1408-1418.
[3] Y. Dai, N. Zhang, C., Xing, Q. Cui, Q. Sun. The adsorption, regeneration, and engineering applications of biochar for removal organic pollutants: A review. Chemosphere, 223, 2019, 12-27.
[4] Mangun, C. L.; Kelly, R. B.; Daley, M. A.; Economy, J. Oxidation of Activated Carbon Fibers: Effect on Pore Size, Surface Chemistry, and Adsorption Properties. Chem. Mater. 1999, 11, 3476-3483.

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