Removal of naproxen from aqueous matrices by adsorption using activated carbons obtained from olive stones

Vinicíus A. Reis[a,b], Davi Z. Souza[b], Jose L. Diaz de Tuesta[a], Paulo Brito[a], António E. Ribeiro[a], Ana Queiroz[a]

[a]Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal. E-mail: amqueiroz@ipb.pt

[b]Federal Technology University of Paraná (UTFPR), Campus Francisco Beltrão, Paraná, Brazil.

INTRODUCTION

Non-steroidal anti-inflammatory drugs (NSAIDs) are some of the most prescribed drugs worldwide and several studies report their presence in various hydric media including drinking water, surface water, and sewage water. Unfortunately, conventional wastewater treatment plants (WWTPs) are inefficient in the removal of NSAIDs. Of considerable interest is the possibility of using biomass wastes to prepare an effective adsorbent and its use in the removal of NSAIDs.

Adsorption is a treatment process based on accumulation of the adsorbate (pollutant) on the adsorbent surface that has been successful used for the optimization of WWTP. Carbon-based materials (CBMs), such activated carbons have shown incredible efficiency as adsorbents [1]. Traditionally, they are produced from anthracite, coal or peat. However, nowadays biomass residues (*e.g.* walnut shell, olive stones) has become an essential element for their production, due to the lower cost of biomass and its renewable nature [2].

MAIN OBJECTIVE

This work aims to study the removal of naproxen from aqueous solutions using activated carbon obtained from olive stones.

METHODOLOGY

- The quantification of naproxen present in aqueous samples is performed using a Jasco Extrema HPLC-UV system equipped with a Nucleosil C18 column and using a mobile phase of composition of 60%acetonitrile:40%water:0.01%TFA. The UV detector wavelength was fixed at 224 nm and analysis were carried using a flow-rate of 1 mL.min^{-1}.
- The adsorbent used was 0.25 mm olive stone prepared with activation in H_2SO_4 10%, and carbonization at 550 °C for 90 minutes.
- The adsorption studies were performed in a temperature controlled environment varying the following conditions: adsorbent/adsorbate concentration ratio, temperature and contact time.

RESULTS

Naproxen HPLC-UV analysis and calibration curve

Figure 1 shows a typical HPLC-UV chromatogram for naproxen. In Figure 2 is presented the calibration curve from concentrations from 1 and 10 mg.L^{-1} and its linear regression. It is possible to observe a very good agreement between the experimental chromatographic area and naproxen concentration, as the high value of R^2 shows.

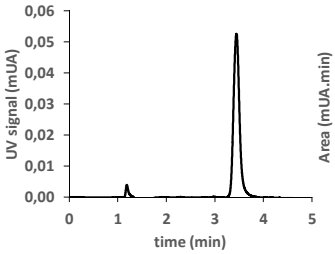

Figure 1 – HPLC analysis of naproxen (2 mg.L^{-1}).

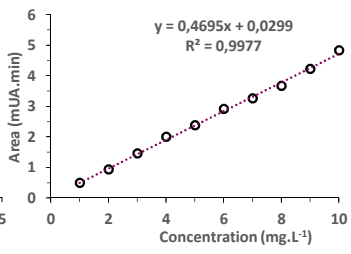

Figure 2 – Naproxen calibration curve.

Contact time needed to reach the adsorption equilibrium

Using the conditions presented in Table 1, a high adsorbent removal efficiency was observed, as presented in Figure 3. It was obtained a value near 90% of naproxen removal from a 16 mg.L^{-1} aqueous solution for 1 h of contact and 95% for 270 min.

Table 1 – Conditions of contact time analyses.

Temperature	25 °C
Speed	150 rpm
Naproxen Concentration	16 mg.L^{-1}
Volume	50 mL
Adsorbent	50 mg

Table 2 – Conditions for equilibrium adsorption runs.

Temperature	25 °C
Speed	150 rpm
Time	1440 min
Volume	50 mL
Adsorbent	10 mg

Contact time to equilibrium

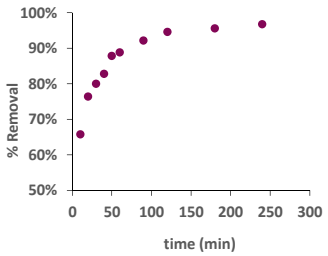

Figure 3 – Percentage of removal of naproxen in relation to time with 50 mg of adsorbent and 50 mL of solution.

Equilibrium adsorption isotherm

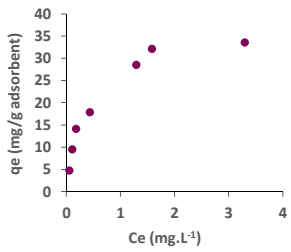

Figure 4 – Equilibrium adsorption isotherm using conditions of Table 2.

The results presented in Figure 4 indicate that the adsorption capacity of naproxen in concentrations above 8 mg.L^{-1} tends to have an activated carbon adsorption capacity close to 35 mg of naproxen per 1 g of adsorbent.

CONCLUSIONS & ONGOING WORK

- Based on the adsorption tests, it is clear that the activated carbon used in this work has high porosity resulting in a great adsorptive power.
- Naproxen demonstrated an optimal adsorption interaction with the adsorbent that presented an high efficiency in naproxen drug removal.
- Other adsorption parameters are under study, such as adsorbate initial concentration, solvent pH, adsorbent/adsorbate concentration ratio and temperature.

REFERENCES

[1] Álvarez-Torrellas et al.; Chem. Eng. J., 2018, 347, 595-606.
[2] Diaz de Tuesta, et al.; J. Environ. Chem. Eng., 2021, 9, 105004 (1-10).
[3] Quesada et al.; Chemosphere, 2019, 222, 766-780.
[4] Lach et al.; J.; E3S Web of Conferences, 2018, 44, 00089.

Acknowledgments

The authors are grateful to the Foundation for Science and Technology (FCT, Portugal) and FEDER under Programme PT2020 for financial support to CIMO (UIDB/0690/2020).