Removal of naproxen from aqueous matrices by adsorption with activated carbon

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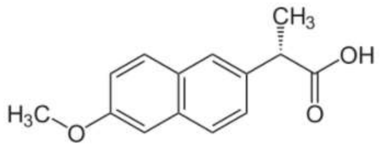
Introduction

Micropollutants are substances which are found in very low concentration (µg/L or ng/L) in water bodies [1]. However, these compounds are only partially filtered by effluent treatment plants (ETEs), which results in water and soil contamination and can become both an environmental and health hazard [2]. One such micropollutant is naproxen, a non-steroidal anti-inflammatory drug (NSAID), prescribed worldwide to the relief of several inflammatory diseases [2,3]. Naproxen's chemical structure is presented in the following Figure [3]:



Objectives

The main objectives of this work involved:

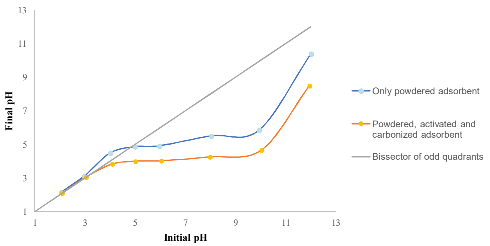
1. Examination of the physical properties of different adsorbents obtained through biomaterials, such as olive stones.
2. Study of the effectiveness of the prepared adsorbents in the removal of naproxen from aqueous matrices.

Methodology

1. Preparation of several types of adsorbents obtained from olive stones:
   - Only powdered, only carbonized and only activated adsorbent;
   - Granulated, activated and carbonized adsorbent.
   - Powdered, activated and carbonized adsorbent.
2. Study of the physical properties of the activated carbons:
   2.1. Point of zero charge;
   2.2. Number of acidic and basic sites;
   2.3. Determination of functional groups by FTIR analysis.
3. Study on the effect of contact time.

Results

Point of zero charge:



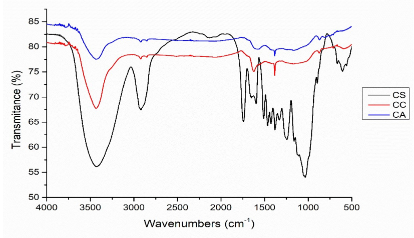
The PZC point for the only powdered adsorbent and for the powdered, activated and carbonized adsorbent was 4.91 and 3.17, respectively. The activation and carbonization processes are responsible for the lowering on the PZC point.

Number of acidic and basic sites:

Type of adsorbent	Acidic sites (µmol H+/ g of adsorbent)	Basic sites (µmol OH-/ g of adsorbent)
Powdered adsorbent	1329.67	45.73
Powdered, activated, and carbonized adsorbent	877.35	44.67
Granulated, activated, and carbonized adsorbent	428.60	111.75

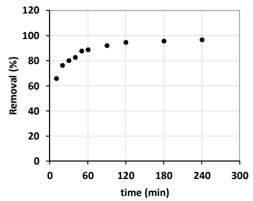
The number of acidic sites decreased with the activation and carbonization processes, but it increased with the grinding process. The number of basic sites remained stable with both the activation and carbonization processes , but it decreased with the grinding process.

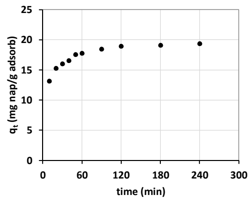
FTIR analysis:



The activation and carbonization treatment greatly decreases the number of functional groups present in the adsorbent, remaining only simpler carbon chains with alcohols and methyl groups. There is, also, an absence of sulfur groups, whereas oxygen groups are present in a high quantity. The destruction of amine groups can also help to explain the decrease in PZC of the adsorbent.

Effect of contact time:





There is a constant increase in removal % of naproxen as time goes on. The equilibrium time was reached after 180 min (3 hours), with the fastest increase verified for the first 60 min (1st hour). The maximum removal of naproxen was 96.8 %, corresponding to 19.4 mg naproxen / g adsorbent at 240 min (4 hours).

Conclusion

The results of this work shows that the grinding, activation and carbonization processes greatly affect the chemistry of the studied adsorbent. Activated carbon obtained with olive stones shows a good potential for the removal of naproxen in aqueous matrices. Further studies are needed on other textural parameters, such as the quantification of ashes, humidity and porosity volume; the comparison with other methods for activation, such as using a strong base; and the evaluation of adsorption for other conditions, such as temperature, pH and amount of adsorbate or adsorbent.

References

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3) Vinayagan, V.; Murugan, S; Kumaresan, R.; Narayanan, M.; Sillanpää, M.; Vo, D; Kushwaha, O.; Jenis, P; Potdar, P.; Gadiya, S. (2022), "Sustainable adsorbents for the removal of pharmaceuticals from wastewater: A review", *Chemosphere*, 300, p.134597.

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