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Removal of Ibuprofen from Wastewaters by Aluminum Modified Hybrid Porous Activated Carbon Derived From Coconut Shells

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Extended Abstract

Pharmaceuticals are continuously introduced into the influent of municipal wastewater treatment plants (WWTP) from pollutants arising in both hospital and domestic wastewater. The World Health Organization (WHO) [1] emphasizes the importance of implementing an appropriate process for the effective removal of pharmaceuticals from wastewater, due to their widespread use by humans and their persistent presence, since the biological treatment methods used in WWTPs cannot effectively deconstruct them.

Analgesics and anti-inflammatories are among the most commonly used pharmaceuticals, and they are frequently found in wastewater and water samples. Ibuprofen (IBP) is a nonsteroidal anti-inflammatory drug (NSAID), and thus is the third most popular, prescribed and available pharmaceutical in the world, and as such, the toxicity and concentration of ibuprofen in wastewater treatment plants is constantly increasing. NSAIDs usage is basically in treating inflammation or musculoskeletal pain and they can be delivered in aquatic systems through several ways, such as hospitals, health centres or pharmaceutical plants [2]. They are detected at low concentrations, ranging from l g/L to ng/L. Even though that these concentrations are very low and are difficult to detect, they have adverse impact on human health and environmental.

Numerous technologies and methods have been investigated for the removal of pharmaceuticals from water and wastewater, such as ion exchange, filtration, reverse osmosis, Fenton method, etc. The main disadvantage of these technologies is their cost and the need for additional use of hazardous chemical reagents that are not environmentally friendly [3]. Among the available technologies for pharmaceutical removal, adsorption is preferred due to its ease application, its simplicity and the fact that it is one of the most economical technologies. A wide range of adsorbent materials are available and are being considered for their application to pharmaceutical compounds. According to literature, carbon-based adsorbents are among the best adsorbents for the uptake of IBP exhibiting a highest reported adsorption capacity.

In this study, a new composite material consisted of activated carbon and aluminum (abbreviated hereafter AC-Al) was prepared for the removal of IBP. Coconut shells were used to produce raw activated carbon, which was then modified with $AlCl_3$. To the best of our knowledge, there are no recent studies in the literature using a similar material to remove this type of pharmaceuticals. Factors affecting the adsorption, such as adsorbent dosage, pH solution, initial concentration of IBP, contact time, and temperature, were investigated. According to the results obtained, it was found that at pH 3.0 ± 0.1 by applying 0.5 g/L of AC-Al in 100 mg/L of IBU, more than 90% was removed, reaching 100% by adding 1.0 g/L of the adsorbent. This study indicates that the aluminum modified hybrid porous activated carbon derived from coconut shells could be used as an efficient low-cost adsorbent. Kinetic data of IBP followed the pseudo-second-order kinetic model. Langmuir and Freundlich equations were used to describe the adsorption. The maximum adsorption capacity (Q_{max}) according to Langmuir model was found to be very high, as 2720 mg/g. The positive values of $\Delta H°$ (42.92 kJ/mol) confirm the endothermic nature of the adsorption. The increasing values of $\Delta G°$ with temperature indicate a spontaneous adsorption of IBP on the aluminum-modified activated carbon.

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