Mechanistic Insights into Acetaminophen Adsorption on Cashew Nut Shell Biomass-Derived Activated Carbons

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Activated carbons prepared from cashew nut shells by chemical activation with phosphoric acid were tested for the removal of acetaminophen. The activation of shells was achieved by impregnation with phosphoric acid and carbonization at 400 – 700 °C under nitrogen atmosphere. It was found that an increase in carbonization temperature resulted in increased carbon aromaticity, a decrease in the amount of surface functional groups, and an increase in surface area and pore volume of carbons. Potentiometric titration analysis indicates that the majority of surface functional groups on carbons obtained at different temperatures are acidic. Detailed surface analysis of carbons by FT-IR, XPS and thermal analyses, suggest the activity of carboxyl, carbonyl, and phosphorus-containing groups in the removal of acetaminophen, which take place via hydrogen-bonding, π-π interactions, and acid hydrolysis. The highest adsorption capacity was exhibited by the carbon obtained at 600 °C, which has the right amount of acidic groups per m^2, as well as the highest surface area and pore volume. Carbon obtained at 400 °C was found to have the highest density of surface acidic groups, which resulted in dimerization reactions, and prevented adsorption of additional molecules due to repulsive forces and steric phenomena. For this carbon the volume of micropores increased upon adsorption. No linear correlation was observed between the adsorption capacities of carbons and their textural characteristics, suggesting that the removal of acetaminophen by the studied activated carbons is primarily driven by their surface characteristics, provided they possess high surface area accessible via micro/mesopores of appropriate size.

Keywords: acetaminophen, adsorption, biomass-derived activated carbon, cashew nut shells, surface chemistry, porosity, adsorption mechanism

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