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ADSORPTION OF QUINACRINE DIHYDROCHLORIDE ON LOCALLY PRODUCED LIGNOCELLULOSIC ACTIVATED CARBONS: EFFECTS OF POROSITY, pH, AND TEMPERATURE

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Introduction

The increasing environmental pollution has become a major threat to water quality and ecosystems, turning into a vital issue for society. The growing prevalence of emerging pollutants in aquatic environments significantly degrades water quality, with adverse consequences for both aquatic ecosystems and human health. In this context, research focused on developing and validating efficient contaminant removal methods is both urgent and timely. The use of activated carbon, obtained from plant-based materials, represents one of the most effective and practical methods for removing pollutants from water. This study aimed to evaluate the adsorption behavior of quinacrine dihydrochloride ($C_{23}H_{30}ClN_3O \cdot 2HCl$) on locally produced activated carbons derived from renewable plant sources: AC-MR (apple wood) and AC-C (apricot stones).

Materials and methods

The adsorbents were obtained by steam activation in a vertical reactor and characterized by nitrogen adsorption–desorption isotherms, using the BET method to determine specific surface area and density functional theory (DFT) for pore size distribution. The total pore volume (V_{total}) was determined from the amount of nitrogen gas adsorbed at a relative pressure of 0.99. The micropore volume (V_{micro}) was obtained using the t-plot method, and the mesopore volume (V_{meso}) was calculated as the difference between the total and micropore volumes. The adsorption of quinacrine dihydrochloride was investigated under static conditions at different temperatures (25 °C, 35 °C, and 45 °C) and pH values (2.0, 4.5, and 7.0). The equilibrium time was established from adsorption kinetic curves, obtained by contacting a fixed amount of adsorbent with a predetermined concentration of quinacrine dihydrochloride over time intervals ranging from 15 to 300 minutes. The residual concentrations were determined spectrophotometrically using a UV–VIS spectrophotometer (JENWAY 6505) at a wavelength of 280 nm. The determined adsorption isotherms data were fitted to the mathematical models using the Langmuir and Freundlich equations.

Results and conclusions

The porous structure parameters of the locally produced activated carbons AC-MR and AC-C were determined from the nitrogen adsorption-desorption isotherms and pore volume distribution curves. For the investigated activated carbons, the specific surface area ranged from 1385 to 1820 $m^2 \cdot g^{-1}$, the total pore volume from 0.943 to 1.605 $cm^3 \cdot g^{-1}$, with mesopores accounting for ~64% of total pore volume in AC-C and nearly 74% in AC-MR. Batch adsorption experiments were performed over an initial concentration range of 200–500 $mg \cdot L^{-1}$ at three values of temperature and three pH values. The time required to reach adsorption equilibrium of quinacrine on the investigated adsorbents was determined from the adsorption kinetic curves, measured for three initial concentration values (200, 350 and 500 mg/L) over a time interval of 15–300 minutes. The obtained results showed that the initial concentration value significantly influences both the amount of adsorbate retained per unit mass of adsorbent and the duration of contact/stirring necessary to reach the equilibrium of the adsorption process, decreasing this parameter from 300 min in the case of Co=500 mg/l to 60 min for Co=200 mg/l. The results revealed rapid adsorption dependent on the adsorbate's initial concentration, with removal of ~62% at C_0 = 500 $mg \cdot L^{-1}$ and >97% at C_0 = 200 $mg \cdot L^{-1}$ within the first 30 min of contact under agitation (Table 1). Subsequently, the adsorption process becomes slower, and 5 hours of contact are sufficient to establish the equilibrium of the adsorption process.

Table1. The degree of immobilization of Quinacrine on samples AC-MR and AC-C

Sample	C, mg/L	15	30	60	90	120	180	240	300
AC-MR	200	96,4	97,1	98,8	99,5	99,8	99,8	99,9	99,9
	350	67,7	73,6	78,8	84,1	85,4	88,9	91,4	92,3
	500	60,6	62,6	66,3	76,9	79,7	84,3	85,6	86,1
AC-C	200	95,4	97,9	99,2	99,6	99,5	99,8	99,9	99,9
	350	74,9	86,4	88,4	88,9	91,3	92,9	92,8	92,9
	500	53,9	59,9	66,6	72,9	73,6	77,4	82,1	82,4

The influence of temperature and pH value on the capacity of locally produced carbon adsorbents to immobilize quinacrine were investigated. Increasing temperature had a slightly favorable effect, confirming the endothermic nature of the process, while raising pH from 2 to 7 increased quinacrine immobilization by more than 40%. The analysis of experimental data using the Langmuir and Freundlich equations shows a stronger correlation with the Langmuir model, indicating that the adsorption process is more consistent with monolayer coverage on a homogeneous surface than multilayer adsorption. Given their efficiency and low cost, this locally sourced carbon materials are promising adsorbents for immobilizing quinacrine-type pollutants from water.

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