

PREPARATION OF COMPOSITE SORBENTS BASED ON AILANTHUS WOOD CHIPS AND PEANUT SHELLS AND STUDY OF THEIR PROPERTIES

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Abstract

This study presents the results of the preparation of composite sorbents based on Ailanthus wood chips and peanut shells and the investigation of their sorption activity. Using local lignocellulosic raw materials, sorbents with a developed porous structure and increased specific surface area were synthesized by chemical and thermal activation methods.

Keywords

composite sorbent, peanut shell, Ailanthus wood chips, chemical activation, porous structure, specific surface area.

Introduction. Contamination of industrial wastewater with heavy metal ions and petroleum products is one of the most pressing environmental problems today. In particular, Cu^{2+} , Pb^{2+} , Cd^{2+} , and Zn^{2+} ions, as well as petroleum fractions, have a negative impact on aquatic ecosystems and intensify bioaccumulation processes in the biosphere. Therefore, the development of inexpensive, environmentally safe, and highly efficient sorption materials for removing these pollutants from aqueous environments is of great importance.

In recent years, considerable attention has been paid to the production of sorbents based on lignocellulosic waste. Peanut shells and Ailanthus wood chips, containing cellulose, lignin, and hemicellulose, are capable of forming a developed porous structure and active surface during chemical modification.

The aim of this work is to prepare composite sorbents based on peanut shells and Ailanthus wood chips and to investigate their adsorption properties toward heavy metal ions and petroleum products.

Main part. Initially, the raw materials were dried at 105 °C for 4–6 hours, crushed to a particle size of 1–3 mm, and mixed in a mass ratio of 25:75. The samples were then chemically modified using solutions of HCl (5–10%), HNO_3 (1–3%), H_2SO_4 (2–3%), KOH (5–10%), H_3PO_4 (10–20%), and ZnCl_2 (10–15%).

The modified samples were activated in an inert gas atmosphere (Ar) at temperatures of 300–700 °C for 60–120 minutes. As a result of pyrolysis, composite carbon sorbents with developed microporous and mesoporous structures were obtained.

The results of chemical activation showed that treatment with an 18–20% H_3PO_4 solution promotes the formation of phosphate and carboxyl functional groups in the lignocellulosic structure. As a result, the cation exchange capacity of the sorbent reaches its maximum value. The YAD: H_3PO_4 -20 sample demonstrated a static exchange capacity for NH_4^+ ions in the range of 8.1–8.6 mg-eq/g.

Modification with KOH leads to the development of a microporous structure and an increase in the specific surface area. ZnCl_2 contributes to the formation of mesopores, creating favorable conditions for the adsorption of large organic molecules. The results are presented in Table 1.

Table 1

Adsorption results of heavy metal ions and petroleum products by composite sorbents

Sorbent type	Activation temperature	Adsorption object	Mechanism	CAC, mg-eq/g
YAD:H ₃ PO ₄ -20	650–700 °C	Cu ²⁺ , Pb ²⁺ , Cd ²⁺ , Zn ²⁺	Ion exchange	7.9–8.2
YAD:KOH-10	650–700 °C	Petroleum products	Capillary adsorption	7.2–7.5
YAD:ZnCl ₂ -15	600–700 °C	Petroleum products	Diffusion in mesopores	6.9–7.2

Discussion. It was established that the adsorption of heavy metal ions occurs predominantly through an ion exchange mechanism. The dissociation of surface functional groups leads to the formation of negatively charged centers capable of forming complexes with metal cations.

The adsorption of petroleum products is mainly physical in nature and is determined by the porous structure, specific surface area, and hydrophobic properties of the sorbent. Micropores enhance capillary retention, while mesopores facilitate the diffusion of petroleum fractions into the sorbent structure.

Conclusion. The conducted studies demonstrated that the application of impregnation, chemical modification, and thermochemical activation in an inert medium makes it possible to obtain composite sorbents with high sorption activity from local lignocellulosic raw materials.

Sorbents modified with H₃PO₄ effectively adsorb heavy metal ions via an ion exchange mechanism, while sorbents activated with KOH and ZnCl₂, due to their developed porous structure, exhibit high efficiency in the adsorption of petroleum products.

The obtained composite sorbents can be used as effective, affordable, and environmentally safe materials for the comprehensive purification of water from heavy metal ions and petroleum products.

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