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Use of Waste Plant Materials for Adsorption of Methylene Blue

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ANNOTATION: A comparative study of the sorption properties of plant lignocellulosic materials - peanut shells and pine cones, in relation to the cationic dye methylene blue (MB) was carried out. Experimental data on MB adsorption from aqueous solutions described by the Dubinin-Radushkevich model.

KEYWORDS: adsorption, peanut shell, pine cone, methylene blue, adsorption capacity.

In recent years, due to the booming dye-related industry, a huge amount of wastewater from dyes is constantly being dumped into the water, which poses a huge threat to the environment and human health. Methylene blue (MB) is a widely used cationic dye that can form a stable solution with water at room temperature. It is hazardous to human health above a certain concentration due to its strong toxicity. In addition, almost all dyes are poorly biodegradable and have some resistance to environmental conditions, making wastewater treatment an urgent task. Therefore, it is especially important to develop effective and inexpensive materials for the removal of MG and other dyes from wastewater and environmental renewal.

Currently, methods of physical, chemical and biological treatment are widely used to remove dyes from wastewater. However, these methods have the disadvantages of high energy consumption, high cost and a large amount of toxic by-products. Therefore, most researchers have paid attention to the adsorption method due to its simple workflow, low cost, large amount of adsorbent materials, easy processing, and high efficiency.
In order to assess the possibility of using cheap natural adsorbents for industrial wastewater treatment, the adsorption of methylene blue on sawdust, cereal straw and husks, and algae was studied.
In this work, the methylene blue surface determination method was used to compare the adsorption properties of waste plant materials, such as peanut shells and pine cones.
The study shows that the adsorbent materials for the adsorption of methylene blue have a high adsorption capacity. High adsorption capacity depends on several parameters that affect the material, the concentration of the adsorbate (methylene blue), the concentration of the adsorbent, the temperature and time of contact of the adsorbate with the adsorbent.

The purpose of this study was to determine the adsorption efficiency. Adsorption tests were carried out in a batch method using a shaker. Then the adsorbent was analyzed using a KFK-3M photoelectric calorimeter.
Experimental part. Samples of activated carbon from peanut shells and pine cones without pretreatment were used as adsorbents. The water content in air-dry materials was determined gravimetrically and was 3–5%. Raw materials, peanut shells, and pine cones were subjected to pre-heat treatment without air access in a pyrolysis unit, heated to 600°C and 8000°C, respectively, at a rate of 10°C/min and kept at this temperature for 1 h.
The adsorbate was the cationic dye methylene blue MG (N,N,N',N'-tetramethylthionine chloride trihydrate) C16H18CIN3S · 3H2O, Mr = 319.9 g/mol.
Adsorption was carried out from aqueous solutions at room temperature. The weight of the adsorbent was 2.5 g, the volume of the solution was 50 ml, the concentration of the working solutions of MG: 1, 2, 5, 10, 20 mg/l, the adsorption time was 30 min. The concentration of MG in the solution was determined by optical absorption at a wavelength of λ = 609 nm using a spectrophotometer of a KFK-3M photoelectric calorimeter. The adsorption value was calculated by the formula:

$$A = (C0 – C1)V/m, \quad (1)$$

where C0 and C1 are the initial and equilibrium concentrations of the solution, V is the volume of the solution, and m is the mass of the adsorbent.

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To describe the experimental data, the Dubinin-Radushkevich adsorption model was used. The Dubinin-Radushkevich equation can be represented in the following form:

$$A=Amax \exp(-k\cdot\varepsilon 2) \quad (2)$$

where k is a constant (mol2/kJ2) related to the adsorption energy; ε - Polyani potential (kJ/mol).

The discussion of the results. Adsorption of methylene blue on activated charcoal from peanut shells and activated charcoal from pine cones

Adsorption isotherms of methylene blue on peanut shell samples are shown in fig. 1. In many works devoted to sorption dyes on materials of plant origin, the time of limiting adsorption does not exceed several hours. In the same time even for carbon adsorbents, the fact long-term establishment of equilibrium during the adsorption of MB.

Taking into account the shape of the obtained adsorption isotherms, the experimental results are described using the Dubinin-Radushkevich model. The results of applying the Dubinin-Radushkevich model for the adsorption of MG on the two studied adsorbents are presented in Table 1.

Table 1.

Results of application of the Dubinin-Radushkevich model for the adsorption of MG on the studied adsorbents

Samples	A, mg/g	K, l/g	E, kDj/mol	R^2
A-UCA	1,4213	0,0684	2,703	0,9551
AU-SHC	2,6018	0,0322	3,940	0,9473

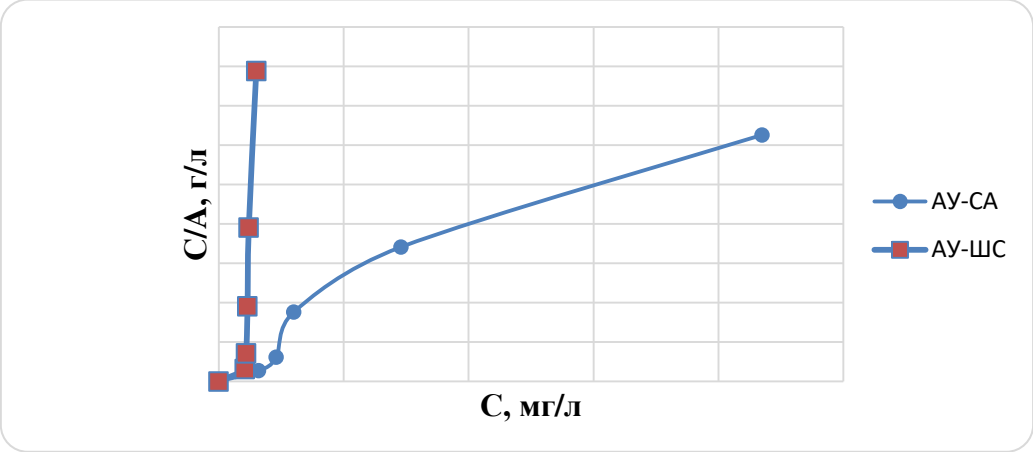

Figure 1. Isotherms of MG adsorption on peanut shells and pine cones

The value of the free energy of adsorption E is very important, since at a value of E < 8 kJ/mol, physical adsorption takes place; at 8 < E < 16 kJ/mol – chemisorption. The calculated values of the free energy of adsorption for all the studied soil samples (Table 1) are less than 8 kJ/mol, which indicates the physical nature of the interaction of the adsorbate with the adsorbent. The E values calculated using the Dubinin-Radushkevich equation correspond to the most complete occupation of all exchange positions of porous structures and reflect in total all, including the weakest, interactions of absorbed anions with the exchange phase. ValuesE for both samples is very insignificant:

for AU-SA 2.70 kJ/mol, for AU-ShS 3.94 kJ/mol.

Conclusion. The sorption properties of waste plant material - peanut shells and pine cones, in relation to the cationic dye methylene blue (MG) were studied.

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