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ADSORPTION PROPERTIES OF MODIFIED ADSORBENTS FOR DYES

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Abstract: This study investigates the adsorption properties of modified adsorbents based on bentonite and gossypol resin for the removal of methylene blue (MB) from wastewater. The effects of temperature and concentration on the adsorption process were analyzed. Experimental results indicate that the optimal adsorption temperature is 303 K. Furthermore, the reusability (desorption) of the adsorbents was evaluated, showing a decrease in adsorption efficiency starting from the third cycle. These results demonstrate that the modified adsorbents are effective for removing dyes from wastewater.

Keywords: adsorption, bentonite, gossypol resin, methylene blue, wastewater, isotherm, desorption, temperature effect.

Introduction. In the textile industry, the dyeing of fibers is one of the key processes. As the industry develops, dyes released into wastewater pose significant environmental challenges. Among the dyes commonly present in such wastewater, methylene blue (MB) is widely used in the dyeing process and exists in aqueous solutions in cationic form.

Several methods exist for removing dyes from wastewater, including biological treatment, coagulation, electrochemical adsorption, and oxidation. Among these, adsorption is considered the most effective method. Therefore, modified adsorbents based on bentonite and gossypol resin, possessing microporous structures and active functional groups (OH and COOH), can be effectively used for wastewater treatment.

Materials and Methods To obtain adsorption isotherms, working solutions of MB with concentrations ranging from 1 to 100 mg/L were prepared. The concentration of dyes was determined using a scanning spectrophotometry method with a UV-755 spectrophotometer in the wavelength range of 190–1100 nm. The effect of temperature was studied in the range of 30–50 °C. The adsorption capacity of MB was measured by determining the optical density at wavelengths of 660 nm and 530 nm.

Ten different MB solutions (50 mL each) were prepared, and 0.05 g of the modified adsorbent was added to each. The flasks were shaken and left until adsorption equilibrium was reached. After equilibrium, the optical density of the solutions was measured, and the concentrations were calculated using a calibration curve. Based on these measurements, a standard calibration graph was constructed.

The amount of adsorbed dye was determined using the following equation:

$$A = \frac{(C_0 - C_1) * V}{m}, \tag{1}$$

where C_0 and C_1 are the initial and equilibrium concentrations of MB in the solution (mg/L), respectively; V is the volume of the solution (L); and m is the mass of the adsorbent (g).

Results and Discussion: The adsorption properties of methylene blue (MB) on the modified adsorbent (GLB-3) based on Logon bentonite and gossypol resin were studied at various temperatures and concentrations (Figure 1).

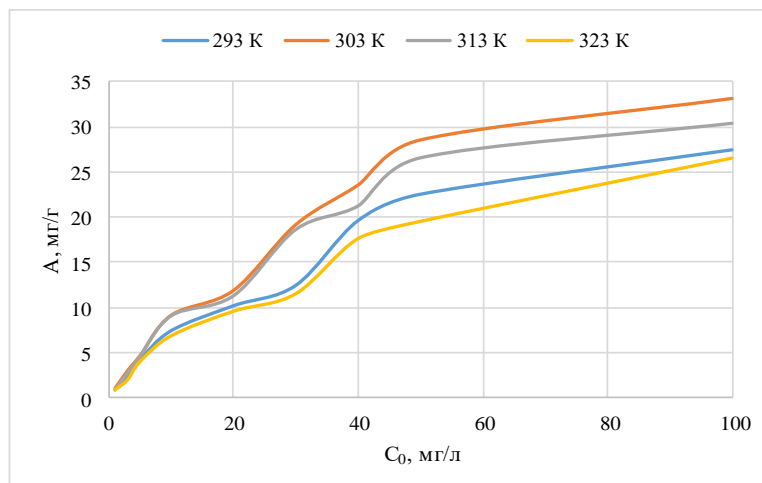


Figure 1. Effect of temperature on the adsorption of MB on GLB-3

From the adsorption isotherms of MB on GLB-3, it can be observed that the adsorption amount increases with the initial temperature rise from 293 K to 303 K, then gradually decreases between 303 K and 313 K, and drops sharply at 323 K. Therefore, it can be concluded that the optimal adsorption temperature for MB on GLB-3 is 303 K.

Furthermore, at all temperatures, the adsorption of MB increases sharply up to a concentration of 50 mg/L, reaching its maximum at 100 mg/L.

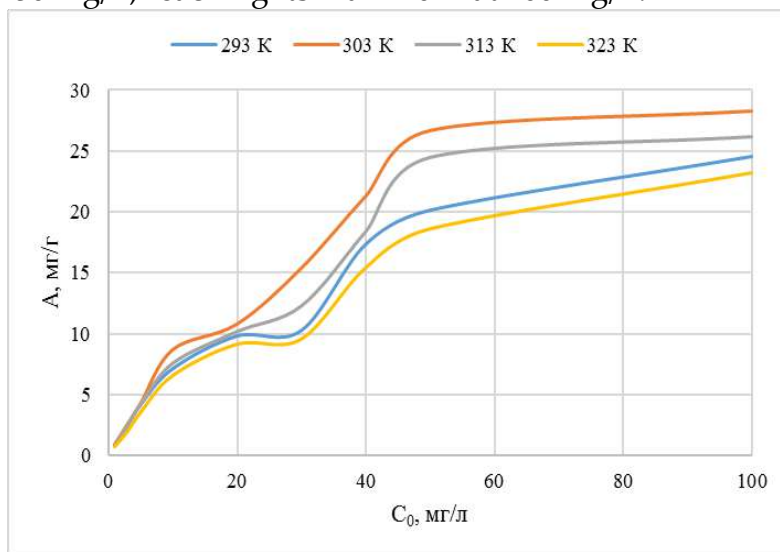


Figure 2. Effect of temperature on the adsorption of MB on GShB-3

The effect of different temperatures and concentrations on the adsorption of MB by the modified adsorbent (GShB-3) based on saline bentonite and gossypol resin was studied (Figure 2).

From the figure above, it can be seen that the adsorption of MB on GShB-3 behaves similarly to GLB-3: the adsorption amount increases with the initial temperature rise from 293 K to 303 K, then gradually decreases between 303 K and 313 K, and drops sharply at 323 K. Therefore, the optimal adsorption temperature for MB on GShB-3 can also be considered 303 K.

The adsorption capacity of MB on the adsorbent based on saline bentonite was found to be slightly lower compared to the adsorbent based on Logon bentonite. Based on these observations, the adsorption durability of MB on the modified adsorbents at 303 K was studied. Initially, 500 mL of MB solution (100 mg/L) was prepared, and 0.5 g of each adsorbent sample was added and mixed. The adsorbent was then separated from the solution by filtration, and the MB concentration in the filtrate was determined using a UV-755 spectrophotometer. The filtered adsorbent was heated at 200 °C to remove the adsorbed substances, and the process was repeated up to five cycles (Table 1).

Table 1. Determination of the desorption properties of MB on the modified adsorbents

No	Namuna	1 (mg/g)	2 (mg/g)	3 (mg/g)	4 (mg/g)	5 (mg/g)
1	GLB-3	33.2	30.5	20.4	15.3	14.4
2	GShB-3	28.4	26.8	18.2	12.6	11.3

The results indicate that the adsorption of MB on the modified adsorbents remains almost unchanged during the first and second cycles, but decreases sharply from the third cycle onward. This suggests that the modified adsorbents are surface-active, and a large part of the MB uptake occurs through chemisorption.

Conclusion: The obtained results allow for the selection of optimal conditions for using the modified adsorbents to remove dyes from wastewater. These findings also indicate that these adsorbents can effectively purify wastewater from dye residues.

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