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A Cumulene/CNTs Nanocomposite for Removal of Organic Dyes from Aquatic Media

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Extended Abstract

Currently, the use of organic dyes in various industries inevitably leads to improper waste disposal, contamination of the environment and, as a result, to permanent environmental degradation [1]. Different techniques have been developed to remove the dyes from wastewater [2]. Among them, adsorption seems to be the most promising way due to the relative simplicity of its implementation and the availability of a wide range of highly efficient materials [3]. The possibility of employing different carbon-based nanomaterials for purification of dye-contaminated aquatic media is being actively studied nowadays [4].

Considering the aforementioned, the novelty of the present research lies in testing a new nanocomposite synthesized at our laboratory for adsorption removal of some dyes from aquatic media. This material represents Taunit-M carbon nanotubes (CNTs) modified with organic ligands. The technology for the CNT synthesis is described elsewhere [5]. The modification procedure was as follows. First, hexamethylenetetramine was slowly added to anhydrous sulfuric acid to start the polycondensation reaction; the mixture was stirred and cooled. The resulting viscous solution is called *cumulene*. Then, the CNTs were mixed with this solution, the system was thoroughly stirred, heated to 180 °C, and kept for 2 h at 180-200 °C. The product was washed with water until the sulfuric acid was completely removed, and dried in a drying oven at 110 °C. The CNT content in the obtained cumulene/CNTs nanocomposite is 14-15 wt%. The characteristics of the nanocomposites are as follows: specific surface area – >2500 $m^2\ g^{-1}$, average pore width – 2.6 nm, and average pore volume – 2.7 $cm^3\ g^{-1}$.

The adsorption capacity of this nanomaterial was estimated with respect to the anionic dye alizarin red S (ARS - $C_{14}H_7NaO_7S$) and the cationic dye malachite green (MG - $C_{23}H_{25}ClN_2$). Kinetic tests were performed in a dynamic mode. 100 mL of 1500 mg L^{-1} ARS and MG aqueous solutions were separately fed, using a peristaltic pump, to an adsorption cell containing 0.03 g of the material sample. The optical density of the solution was recorded every 180 s, with further determination of the dye equilibrium concentration and estimation of the adsorption capacity of the material.

Thus, it was found that the maximum adsorption capacity of the adsorbent regarding the ARS and the MG dyes is 2674 mg g^{-1} (reached within 80 min) and 1863 mg g^{-1} (reached within 135 min), respectively.

Furthermore, the adsorption interaction of the adsorbent under study with the organic dyes can be described quite well by the known diffusion models and the equations of chemical kinetics implemented herein. The analysis of the data obtained makes it possible to assume that the dye adsorption process takes place in a mixed-diffusion mode, with a significant contribution of chemisorption being a limiting stage.

Based on these results, it may be concluded that the cumulene/CNTs nanocomposite can be effectively used to remove the organic dyes from aquatic media.

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