SYNTHESIS AND APPLICATION OF MAGNETIC NANOCOMPOSITES AS ADSORBENT FOR THE REMOVAL OF DYES FROM COLORED WASTEWATER

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Abstract

Wastewater containing dye pollutants caused by textile industry has become one of the most serious threats to ecological system [1]. Adsorption is one of the most advantageous techniques applied for the removal of non-biodegradable dyes from wastewater, due to its simplicity, efficiency and relatively low costs [2]. In recent years the application of magnetic nanocomposites as adsorbent materials has been investigated due to their unique physical and chemical properties [3,4].

In this work, new magnetite/carbon nanocomposites (MCN) were synthesized by the combustion method [5], varying the magnetite/carbon ratio in their composition. The synthesized materials were characterized by the most indicated and modern methods: X-Ray Diffraction, Fourier transform infrared spectroscopy, magnetic properties, N_2 adsorption-desorption isotherm, Thermal analysis and Scanning Electron Microscopy. The synthetized materials were applied as adsorbents for the removal of an anionic (Acid Orange 7 (AO7)) and a cationic (Rhodamine 6 G (R6G)) dyes.

The MCN materials have a specific surface between 485-1095 m^2/g and a saturation magnetization between 0.67-14.30 emu/g. With increasing carbon content, the specific surface area of the materials increased and also the dye removal efficiency, from 91.24% to 95.12% for AO7 and from 92.35% to 98.92% for R6G. Further studies were performed using sample MCN_3 containing magnetite:carbon in a ratio of 1:4.

The effect of the working conditions: solution pH (2÷12), the amount of adsorbent (0.25÷3 g/L), the initial dye concentration (10÷250 mg/L) and temperature (25°C, 40°C and 55°C), on the dyes removal efficiency was studied. Removal yields of the investigated dyes of over 92% (AO7) and 98% (R6G) were obtained working under normal conditions: solution pH and room temperature (25°C).

The absorption capacity of the MCN_3 nanocomposite was further evaluated for the simultaneous adsorption of investigated dyes from binary systems. For this purpose, the optimal working conditions established for the adsorption of dyes from single systems, were selected as initial conditions for the adsorption from the binary systems. For the simultaneous adsorption of dyes, the removal efficiency decreased (74.13% for AO7, and 77.61% for R6G), which indicated that in the bicomponent system the adsorption of dyes is competitive.

Kinetic studies indicated that the adsorption process was best described by the pseudo second order model for investigated dyes. The data obtained at equilibrium fitted best with Sips isotherm model, and the maximum adsorption capacities were determined as: 136.36 mg/g for AO7 and 266.87 for R6G. The determined values for thermodynamic parameters: Gibbs free energy (ΔG^0), enthalpy (ΔH^0), and entropy (ΔS^0) showed that the adsorption is a spontaneous and endothermic process.

The very good capacity of regeneration and reuse of the MCN_3 nanocomposite were highlighted by the yields of more than 75% obtained for the removal of the investigated dyes, even after six simultaneous adsorption-desorption cycles (Fig. 1).

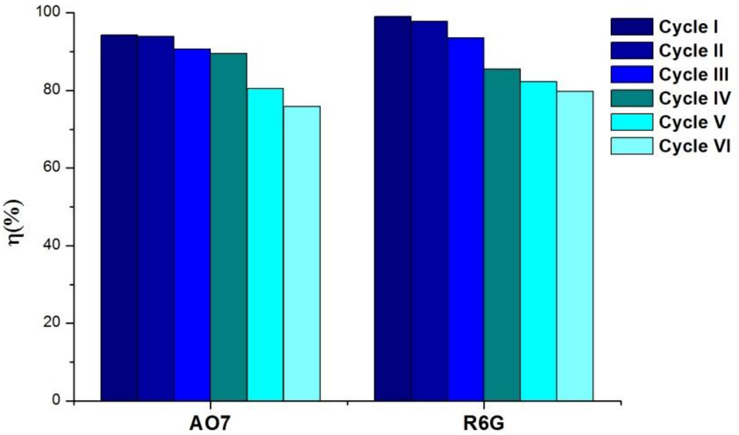

Fig.1. Reusability of MCN_3 nanocomposite in adsorption/desorption cycles

The experimental results obtained, demonstrate that the synthesized nanocomposites can be successfully used as adsorbents for the removal of the dyes from single and binary systems, even working under normal conditions (solution pH, room temperature), which is important for a possible application for the decontamination of colored industrial wastewater.

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