UNIVERSITI TEKNOLOGI MARA

PREPARATION AND CHARACTERIZATION OF MAGNETIC KAOLINITE NANOCOMPOSITE AS METHYLENE BLUE ADSORBENT IN AQUEOUS SOLUTION

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ABSTRACT

Wastewater treatment of untreated dye effluent from industries is challenging due to requirement of adsorbent that is cost-effective, highly efficient, robust, and feasible to operate. In this study, magnetic kaolinite nanocomposite (MKN) derived from Malaysia's natural kaolinite clay mineral is proposed as an alternative adsorbent to treat dye contaminated water. Methylene blue (MB), a cationic azo dye, is used as the model of pollutant in this study. Three different clay:iron oxide mass ratio of magnetic kaolinite nanocomposite (denoted as MKN 1:1, MKN 2:1 and MKN 5:1) was successfully prepared in solution through the co-precipitation method. The pristine kaolinite (Kao), iron oxide (IO) and MKNs were characterized using techniques like Fourier Transform Infrared (FTIR) spectroscopy, X-ray powder diffraction (XRD), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), Brunauer–Emmett–Teller (BET) surface area analysis, vibrating sample magnetometer (VSM) and zeta potential measurement. Equilibrium adsorption study, kinetic and thermodynamic experiments were performed to understand the adsorption profile, mechanism, and spontaneity of reaction between MB and MKN. The stability of MKN is evaluated through metal leaching experiment and by comparing its structural, morphological, and magnetic characteristics with the spent MKN adsorbent (assigned as MKN1:1-MB). Findings shows that the BET surface area of MKN was enhanced up to 5-fold as compared to the pristine materials. MKN 1:1 has the highest magnetization properties (35.99 emu g^{-1}) that allows easy separation of MKN from reaction media via an external magnetic field. The MKN1:1 recorded an isoelectric point (IEP) of 5.3 with the highest adsorption capacity (18 mg/g) for MB removal, as compared to other MKNs and pristine kaolinite. Hence, MKN1:1 was chosen for the adsorption and stability studies. The optimum experimental condition for MB removal was achieved at pH = 6, reaction time = 240 min, and at 70 mg/L initial MB concentration. The adsorption data was best fitted to the Langmuir isotherm model (regression coefficient, R^2 = 0.9840) and in agreement with the pseudo-second order kinetic model (R^2 = 0.9986). The adsorption mechanism of MB towards MKN was governed by the electrostatic and specific chemical interaction. The adsorption process was spontaneous and exothermic in nature. No Fe leaching was detected even at pH 2. The spent MKN1:1 still preserve its magnetic strength and key morphological characteristics, that shows the high structural stability features of this nanocomposite. In conclusion, this study has demonstrated the potential of magnetic kaolinite nanocomposite as an environmental benign adsorbent for treating dye contaminated water.

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