AUTHOR'S PROOF

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High performance methyl orange capture on magnetic nanoporous MCM-41 prepared by incipient wetness impregnation method

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Abstract—The Magnetic nanoporous material Fe/MCM-41 was prepared, and its physical characterization studied, to determine the effect of its properties on separation efficiency of methyl orange (MO) from wastewater by adsorption process. The experimental results were analyzed for both adsorbent mesoporous material samples, MCM-41 and magnetic Fe/MCM-41, in order to select the best operating conditions for the different studied parameters, which are: constant temperature (20 °C), pH: (2) adsorbent dosage (0.03 gm), contact time (10 minute) and concentrations (30 mg/L). The results demonstrate that the adsorption processes can be well fitted by the Langmuir isotherm model for pure MCM-41, with a correlation coefficient of (0.999), and fitted by the Freundlich isotherm model for magnetic Fe/MCM-41, with a correlation coefficient of (0.994). The adsorption kinetics of MO on to MCM-41 and Fe/MCM-41 are well described by a pseudo-second-order kinetic model.

Keywords: Separation, Wastewater, MCM-41, Methyl Orange, Adsorption

INTRODUCTION

Synthetic dyes with complex aromatic structures are commonly used in numerous industries, including the manufacture of textile, leather, printing, and food, plastic and pharmaceutical products. These dyes are organic materials that contain complex chemical compounds that are stable in certain temperature, light, and oxidizing environments, and in these environments they are not biodegradable [1].

Methyl orange (MO) [$C_{14}H_{14}N_3SO_3Na$] is one of the most common dyes. Its chemical formula and molecular composition are depicted in Fig. 1. MO can be used as both a pH indicator for titrations or as dye for many industries. It can be synthesized by the interaction of dimethylanilin, sulfanilic acid, and sodium nitrite. The IUPAC name for MO is 4-dimethylaminoazobenzene-4'-sulfonic acid sodium salt.

Dye pollution can be minimized by chemical, physical and biological processes, such as through chemical oxidation, coagulation, filtration and membrane separation, or microbial degradation [2]. However, these methods have their difficulties and limitations, including the possible generation of secondary pollutants, a high cost of use, and low removal efficiency. Adsorption process has been established as an alternative method with high potential for the removal of dyes from wastewater, and the adsorbent most commonly used is activated carbon [3-7]. The use of activated carbon has many disadvantages, though [8]. It is quite expensive, and is ineffective and non-selective against disperse and vat dyes [9]. This has driven many to search for more effective and economic sorbents as potential replacements for activated carbon.

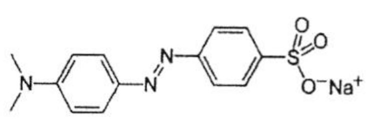

Fig. 1. Molecular structure of methyl orange.

Recently, magnetic nanoporous silicas have generated much interest in the combined use of mesoporous structure with appropriate magnetization [10,11]. Such a combination allows separation remediation to be brought about in liquid-phase processes by the implementation of an external magnetic field. The magnetic characteristics for nanoporous materials suggest fantastic prospects for their use in different fields, including sorption, catalysis, photonics, separation, and drug delivery, and as components in electronic devices. For separation applications, it is necessary to prepare such magnetic nanoporous materials with tunable shell thickness and controllable surface area for adsorption [12-15].

This study focuses on the preparation and characterization of mesoporous silicate nanocomposite magnetic Fe/MCM-41, consisting of magnetic Fe_2O_3 nanoparticles scattered inside pores of mesoporous MCM-41, and its implementation in the separation of organic MO dye from wastewater. The effects of pH solution, adsorbent dosage, MO concentration, and contact time on removal efficiency and adsorption capacity were also investigated. The magnetic Fe_2O_3 precursor Fe $(NO_3)_3 \cdot 9H_2O$ was loaded onto the mesoporous support MCM-41 by using the incipient wetness impregnation method. The use of MO was prompted by its positive charge in solution. Furthermore, the orange color of MO allows easy visualization and spectrophotometric observation of the system during separation experiments. The novelty of this study is relating to the application of a nanoporous MCM-41 as a magnetic adsorbent for removal of methyl orange (MO) dye pollutants from

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