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Research paper

Synthesis and characterization of magnetic halloysite-iron oxide nanocomposite and its application for naphthol green B removal

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ABSTRACT

In the present work, a magnetic nanoadsorbent was prepared by incorporating magnetic iron oxide nanoparticles (Fe_3O_4) on the surface of halloysite nanotubes. The structure and morphology of the synthesized nanocomposite were investigated by using of FT-IR and field emission-scanning electron microscope. This nanoadsorbent was successfully applied for removal of naphthol green B from the aqueous solutions. Kinetic studies show the adsorption of naphthol green B on the surface of adsorbent could be characterized by the pseudo-second order model. Also, investigation of adsorption isotherms showed that the Langmuir model fitted better than the Freundlich model and naphthol green B forms a mono-layer on the surface of nanoadsorbent. Furthermore, spectrophotometric determinations for dye were done at $\lambda = 265$ nm and the results show the linearity in the range of 1.0–50 μg mL^{-1}.

1. Introduction

Nanocomposites with organic and inorganic nano-fillers have attracted immense interest from different fields (academic researches, industrial projects and etc.) because of the unbeatable characteristics of nanoparticles such as high surface reactivity, large surface area and relatively low cost (Liu et al., 2014; Fazelirad et al., 2015).

Halloysite nanotubes (chemical formula: $Al_2Si_2O_5(OH)_4 \cdot nH_2O$) is a double-layer aluminosilicate with an equal ratio of aluminium and silicon and has mainly hollow tubular structure. They contain two kinds of OH groups including of inner and outer which are located between the layers and surface of the nanotubes (Marini et al., 2014). Halloysite offers a cheap and low-tech alternative that has morphological similarity to multi-walled carbon nanotube (CNT). They have some advantages such as a large aspect ratio, unique combination of tubular nanostructure, natural accessibility, good bioadaptibility and high mechanical strength (Yuan et al., 2015; Zhang et al., 2016). Also, they show potential during the controlled release of active agents. So, halloysite can replace the more expensive CNT in different types of polymers (Lvov and Abdullayev, 2013; Xie et al., 2016). Because of the mentioned advantages of halloysite, this matter has attracted more attention in the recent years (Yu et al., 2014; Bielska et al., 2015; Ghanbari et al., 2016; Laha and Majumdar, 2016; Scarfato et al., 2016; Shu et al., 2016).

Synthetic dyes have long been applied in many industrial processes such as textile, dyeing, food, tile and ceramic, carpet and etc. Based on the mentioned extensive dye applications, there is an urgent need to improve control methods for wide dye pollutions in the environment and wastewaters. Dye pollution is a serious risk, because the common dyes usually have a synthetic and complex aromatic structure, which makes them very stable and difficult to biodegrade (Zhang et al., 2009).

Dye adsorption process by using of different sorbents has been widely reported (Aguiar et al., 2016; Belhouchat et al., 2016; Chinoune et al., 2016; Hajjaji et al., 2016; Zeng et al., 2016). However, the preparation of magnetic halloysite nanocomposites and the removal of naphthol green B (NGB) by this sorbent have never been reported previously. In the present research, iron oxide nanoparticles were combined to halloysite to prepare the Fe_3O_4-halloysite nanoadsorbent. The synthesized nanoadsorbent was studied morphologically by Fourier transform-infrared (FT-IR) spectroscopy and field emission-scanning electron microscope (FE-SEM). Finally, naphthol green B was successfully removed from the sample solutions by using of the prepared magnetic halloysite nanocomposite.

2. Experimental

2.1. Reagents and standards

All chemical reagents had the highest purity and there was no need for purification process. Iron (III) chloride ($FeCl_3.6H_2O$), iron (II) sulfate ($FeSO_4.7H_2O$), ammonia (NH_3) and hydrochloric acid (HCl) were

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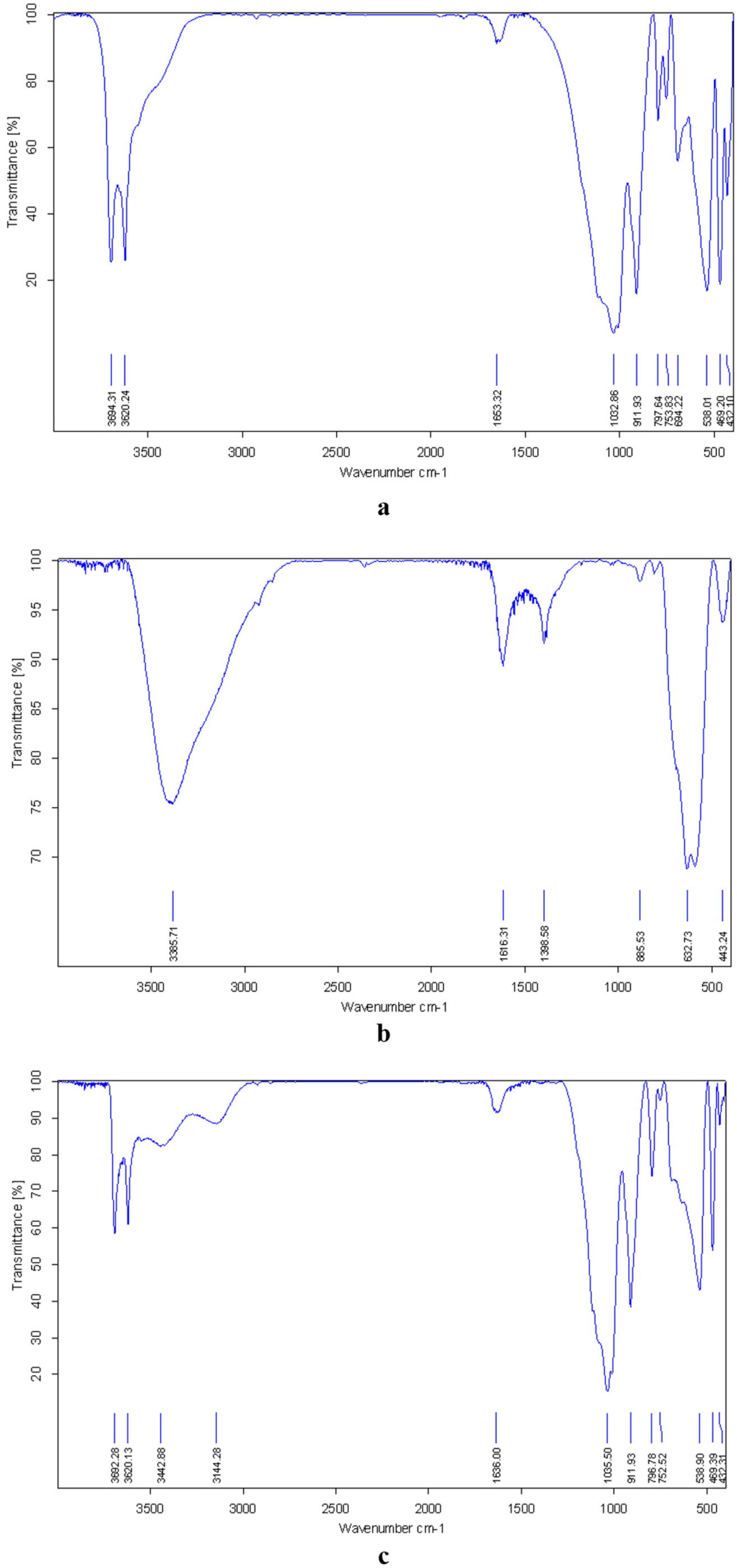

Fig. 1. The FT-IR spectra of a) halloysite, b) iron oxide nanoparticles and c) iron oxide-halloysite nanocomposite.