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Mechanosynthesis and characterization AFe_2O_4 (A: Ni, Cu, Zn)-activated carbon nanocomposite as an effective adsorbent for removal dodecanethiol

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A B S T R A C T

In this study, nanocomposites of monoferrite-activated carbon (Ferrite-AC) have been prepared by mechanosynthesis technique. Nanocomposites can be utilized as adsorbent for desulfurization of hydrocarbon liquid fuels. Nanocomposites were characterized by scanning electron microscopy (SEM), energy dispersive X-ray (EDS) analysis, Fourier transform infrared (FTIR), X-ray powder diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Brunauer-Emmet-Teller (BET) and vibration sample magnetometer (VSM). Results showed that $NiFe_2O_4$-AC had better performance between other adsorbents. Adsorption rate of dodecanethiol was improved by increasing $NiFe_2O_4$-AC concentration. XPS results showed that the dodecanethiol was oxidized by the catalyst surface. BET surface erea of $NiFe_2O_4$-AC nanocomposite was 626 m^2/g with porous structure.

1. Introduction

Sulfur is an impurity in fuels. When fuels are burned, sulfur is released as sulfur dioxide. Sulfur dioxide can affect both the environment and health [1,2]. Sulfur removal from hydrocarbon liquid fuel has been optimized by adsorption [3–6], extraction [7–10], oxidation [11–15], and bioprocesses [16–19]. However, there are differences in the performance of these techniques. Adsorption desulfurization is an effective method for desulfurization of hydrocarbon liquid fuel due to the high desulfurization rate, commercial method, moderate conditions and low cost. New adsorbent materials such as zeolites [20–30], transition metals on porous matrix [20,26,31,32], aluminium oxide [33] and silica gel [34] have high capacity for sulfur removal. Sulfur removal in liquid hydrocarbon fuels has been studied by activated carbons (AC) as adsorbents due to high surface areas. Furthermore, various modification methods can be used for improving adsorption capacity [34] specially when are loaded with ferrites. This is due to the interaction between metal and sulfur compounds. T.J. Bandosz reported that mercaptan compounds were adsorbed on activated carbon at room temperature [35]. Pore characteristics such as morphology, pore size and surface property affect on capacity of AC. Different materials such as alkali metals, transition metal oxides, alkaline earth metals, and rare earth metal oxides can be utilized for modification of carbon surface [36]. In the present work, nanocomposite of active carbon (AC) catalysts were prepared by mechanosynthesis method for sulfur removal of hydrocarbon liquid fuel. $NiFe_2O_4$-AC nanocomposites provide some advantages in adsorbing certain materials. This research aims to achieve high desulfurization from hydrocarbon liquid fuel by ferrite-activated carbon nanocomposite. Among the methods of synthesis, mechanosynthesis is fast, inexpensive and industrial method. Nanocomposites were characterized by scanning electron microscopy (SEM), Fourier transform infrared (FTIR), energy dispersive X-ray (EDS) analysis, X-ray powder diffraction (XRD), X-ray photoelectron spectroscopy (XPS) and Brunauer-Emmet-Teller (BET). Vibration sample magnetometer (VSM) was utilized to study of magnetic properties.

2. Experimental

2.1. Materials and characterization

All materials were commercially available and were used without further purification. Powder X-ray diffraction (XRD) patterns were ac-

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Table 1
Preparation conditions for samples 1–7.

Sample no.	Kind of sample	Morphology and particle size
1	AC	Irregular shapes
2	$NiFe_2O_4$	Irregular shapes; 100 nm
3	$ZnFe_2O_4$	Irregular shapes; 200 nm
4	$CuFe_2O_4$	Irregular shapes; 100 nm-200 nm
5	AC-$NiFe_2O_4$	Irregular shapes; 50 nm- 500 nm
6	AC-$ZnFe_2O_4$	Hexagonal shapes; 200 nm-400 nm
7	AC-$CuFe_2O_4$	Hexagonal and uniform shapes; 150 nm

cumulated from a diffractometer of the Philips Company with X'PertPro monochromatized Cu Kα radiation ($\lambda = 1.54$ Å). FT-IR spectra were recorded on Magna-IR, spectrometer 550 Nicolet in KBr pellets in the range of 400–4000 cm^{-1}. Microscopic morphology of the samples was characterized by FESEM (Mira3 tescan). The energy dispersive spectrometry (EDS) analysis was studied by XL30, Philips microscope. Vibrating sample magnetometer (VSM, Meghnatis Kavir Kashan Co., Kashan, Iran) was used to study magnetic properties of the samples at room temperature. X-ray photoelectron spectroscopy (XPS) was done on ESCALab220i-XL electron spectrometer using Al Ka radiation. The power was 300 W, pass energy of 50.0 eV and a step size of 0.1 eV. Xpspeak 4.1 software was used to analyze the data. The specific surface area was obtained using the Brunauer–Emmett–Teller (BET) method. Pore size distribution (PSD) plot was calculated by the Barrett–Joyner–Halenda (BJH) method using the desorption branch in a Micromeritics Tri-Star 3020 nitrogen adsorption apparatus.

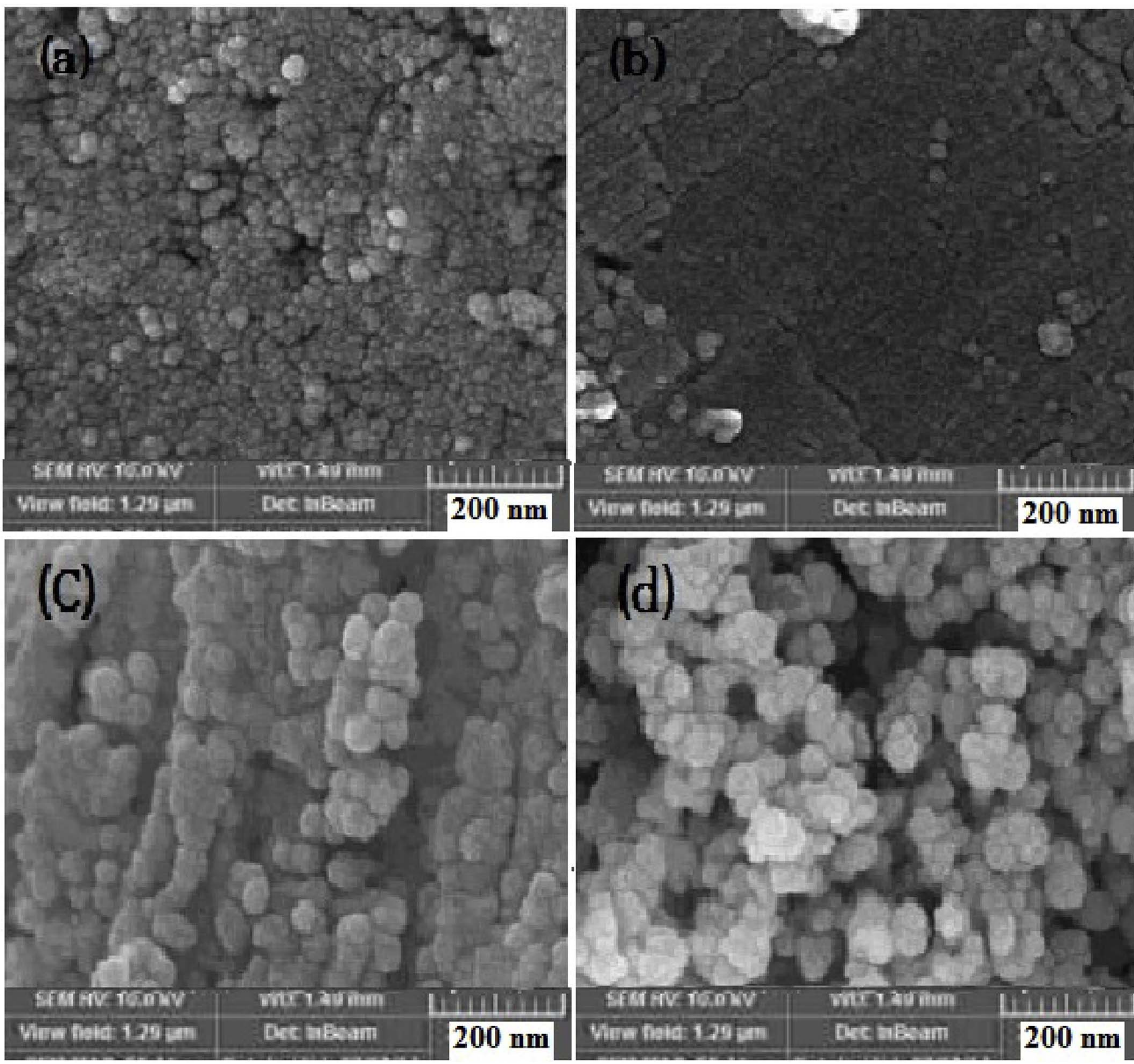

Fig. 1. SEM images of (a) sample 1, (b) sample 2, (c) sample 3 and (d) sample 4.