SYNTHESIS AND APPLICATION OF IRON OXIDE NANOPARTICLES FOR EFFICIENT ADSORPTION OF ACID RED DYE FROM WATER

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Abstract

Many industries like textile, paper, printing, plastic, food and cosmetic are utilising dyestuff to give different colours to their goods. The waste of these industries contain a large amount of dyes which is normally discharged in the drain water without proper treatments. This paper presents the work for the synthesis of iron oxide nanoparticles and their application for the removal of acid red dye form water. The characterization of iron oxide nanoparticles was carried out with SEM, XRD and Vibrating sample magnetometer. The as synthesized iron oxide nanoparticles were used for the efficient removal of acid red dye from water. After the removal of dyes, maghemite nanoparticles can be separated from the water by magnetic separation. The results showed that iron oxide nanoparticles can successfully be employed for the wastewater treatment.

Keywords: Iron oxide nanoparticles, adsorption, dye removal, textile wastewater

1. INTRODUCTION

Many industries like textile, paper, printing, plastic, food and cosmetic are utilising dyestuff to give different colours to their goods. The waste of these industries contain a large amount of dyes which is normally discharged in the drain water without proper treatments [1-4].The photosynthetic movement of the aquatic life may affected by dyes because of the decrease in light penetration [5-7]. Additionally, some dyes are toxic and carcinogenic for many aquatic species like fishes and other microbes. Moreover, these dyes are responsible for severe damage to humans in the dysfunction of the kidney, reproductive system, liver, brain and central nervous system [8]. Therefore different methods and technologies are demanded to eradicate dyes and their waste from wastewater streams.

In recent years iron oxide nanoparticles are being studied extensively in the fields of clinical diagnosis, cancer treatment, drug delivery and removal of heavy metals and toxic materials from water. This paper presents the work for the synthesis of iron oxide nanoparticles and their application for the removal of acid red dye form water. The characterization of iron oxide nanoparticles was carried out with SEM, XRD and Vibrating sample magnetometer. The as synthesized iron oxide nanoparticles were used for the efficient removal of acid red dye from water. After adsorption of dyes, iron oxide nanoparticles can easily be separated from the water by magnetic separation. The used iron oxide nanoparticles can easily be recovered and reused many times. The results showed that iron oxide nanoparticles can successfully be employed for the wastewater treatment.

2. EXPERIMENTAL

2.1. Synthesis of iron oxide nanoparticles

Firstly benzyl ether (15 ml) was heated to 130 °C in reflux apparatus. Then Iron pentacarbonyl (0.5 ml, 2.5 mmol) was added. The temperature increased to reflux (300 °C) and maintained for 10 hours until a black solution was obtained. The resultant maghemite nanoparticles were precipitated with the addition of methanol and subsequently separated by centrifugation.

2.2. Removal of dye by maghemite nanoparticles

Maghemite nanoparticles (20 mg) were added to aqueous solutions of Acid Red 27 (50 ml) with different initial concentrations. Then the solution were shaken at 250 rpm at 25 °C until the attainment of equilibrium. After adsorption of dye maghemite nanoparticles were separated by magnetic separation. The dye removal efficiency was calculated by using equation.

$$Dye\ removal\ _{\%} = \frac{C_o - C_e}{C_o} \times 100 \quad (1)$$

Where c_o is the initial concentration of Acid Red 27 dye in the solution, and c_e is the equilibrium concentration.

3. RESULTS AND DISCUSSION

3.1. Surface morphology

The shape of synthesized nanoparticles is nearly spherical as observed by scanning electron microscope and is shown in **Figure 1**. The particles size of iron oxide nanoparticles is ~30 nm which also confirmed by XRD studies.

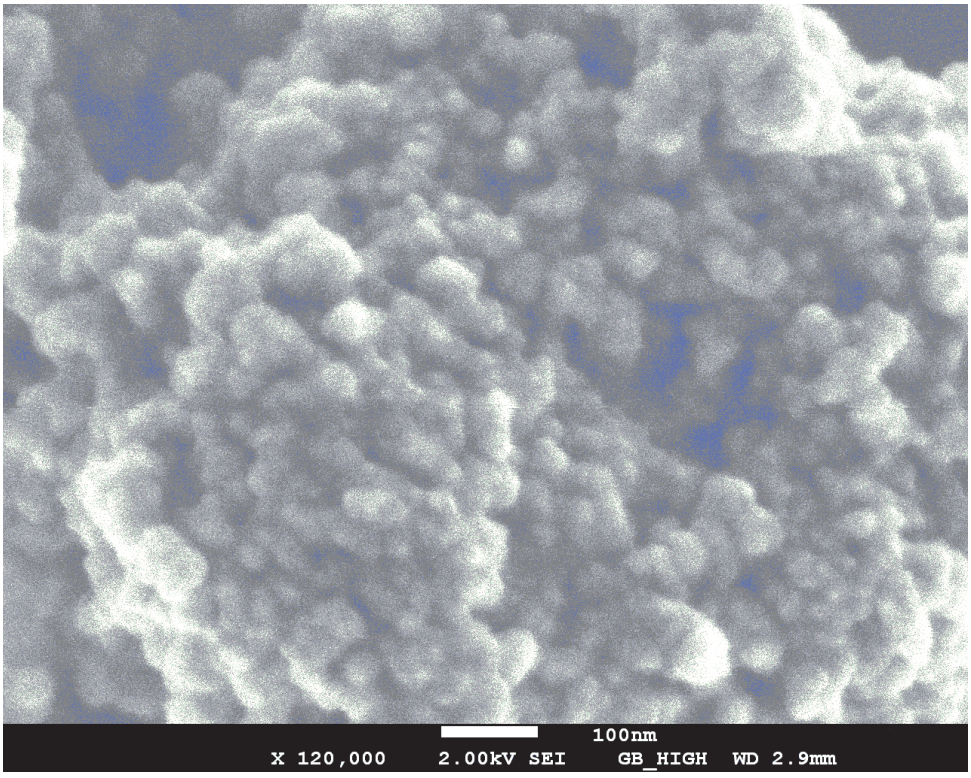

Figure 1 SEM image of iron oxide nanoparticles

3.2. XRD analysis

XRD spectra of as prepared nanoparticles is presented in **Figure 2** which proves the synthesis of pure maghemite nanoparticles. The crystallite size is found to be 30 nm calculated according to the Scherrer equation:

$$D = \frac{K\lambda}{(b\ cos\theta)} \quad (2)$$

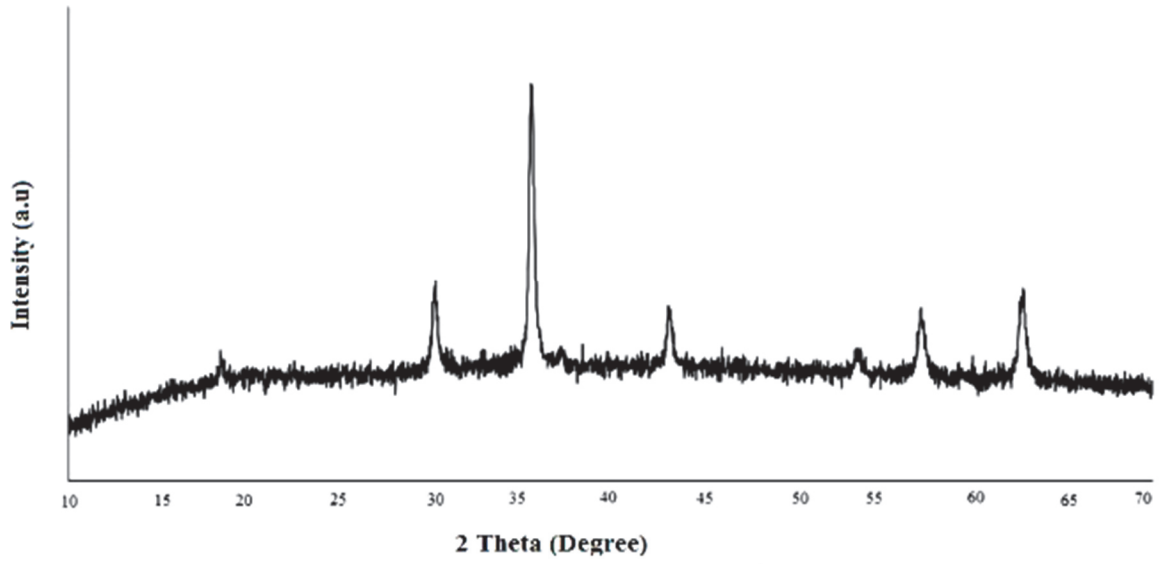

Figure 2 XRD spectra of maghemite nanoparticles

3.3. Magnetic properties

The magnetic hysteresis loop of maghemite nanoparticles as measured with the help of vibrating sample magnetometer is shown in **Figure 3**. The magnetic saturation value of maghemite nanoparticles is found to be 65 emu/g.

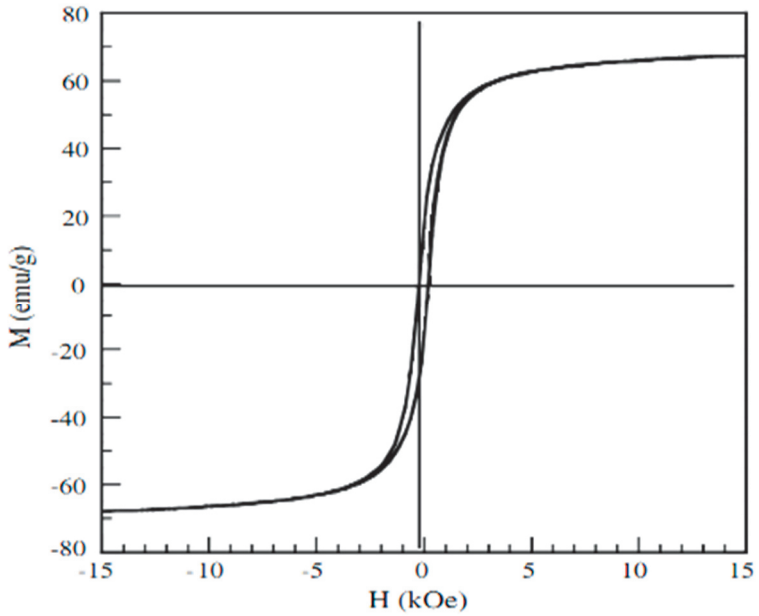

Figure 3 Magnetic hysteresis loop of maghemite nanoparticles

3.4. Removal of Dye

In order to investigate the dye removal efficiency of prepared iron oxide nanoparticles, experiments were carried out at 25 °C and pH of 6. The initial concentrations of Acid Red 27 dye were 10 mg/L, 20 mg/L and 30 mg/L. The dye removal percentage by as prepared iron oxide nanoparticles at different initial concentrations as a function of time is shown in **Figure 4.**

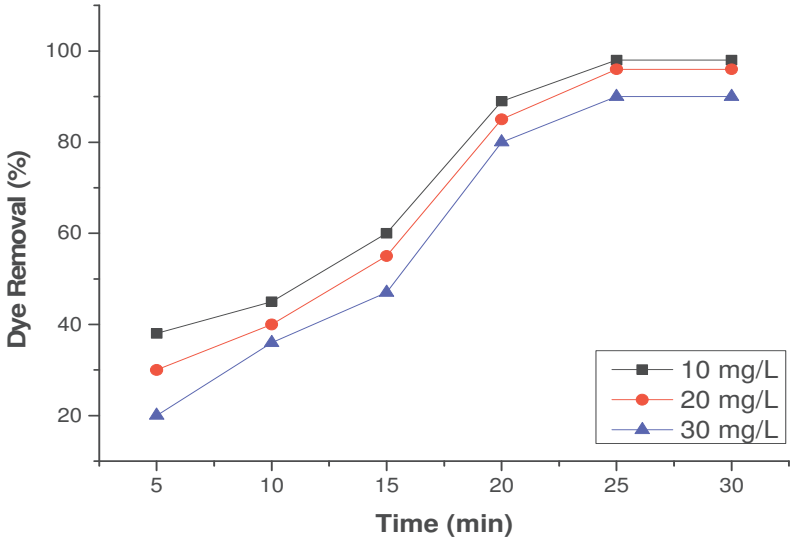

Figure 4 Dye removal at different initial concentrations under the effect of contact time

It can be observed from the results that with the increase in the initial concentration of dye in solution, the adsorption also decreases. The adsorption of dye is very rapid and equilibrium adsorption was attained in 25 minutes. This rapid adsorption may be due to small size and high surface area of maghemite nanoparticles. A much higher equilibrium adsorption time as compared to this work is reported by the other adsorbents for the adsorption of acid red dye as observed by Qiao et al. [9] who reported equilibrium time of 24 hours onto bentonite and equilibrium time of 21 days was reported onto chitosan [10].

4. CONCLUSIONS

In this research work synthesis of iron oxide (maghemite) nanoparticles was carried out successfully. The as prepared nanoparticles were characterized by SEM, XRD and vibrating sample magnetometer. The removal of Acid Red 27 dye from water was measured by UV visible spectrophotometer. The prepared maghemite nanoparticles were used for the removal of Acid Red 27 dye from water. The adsorption rate was quite fast and equilibrium was attained in 25 minutes. The results showed that iron oxide nanoparticles can successfully be employed for the wastewater treatment.

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