Synthesis of magnetic activated carbon/Fe2O3 nanocomposite for the removal of acid methyl orange from water

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Abstract
In this study, In this study, AC/Fe_3O_4 synthesis was investigated to remove the MO from water. Batch adsorption studies were carried out at different contact time, initial concentration (50–300 mg/L) and adsorbent dose (0.05–0.30 g) and pH in range (1-11) on the removal of methyl orange (MO) at the temperature of 25◦C.The results indicated that percentage of the removal of MO increased with increasing contact time as well as the adsorbent dose. The results also indicated that increasing the initial concentration of methyl orange resulted in a gradual decrease in the percentage of dye removal. The optimum pH=2 was determined for the removal of Mo .

Keywords: Magnetic activated carbon, Methyl Orange, Adsorption, Wastewater

Introduction
Dyes are widely used in many industries, such as food, paper, printing and textiles. Color wastewater has been produced ever since the dye technique was invented, which makes water pollution more and more serious and even endangers human's health [1]. dye wastewater treatment methods mainly include chemical oxidation, coagulation/flocculation treatment, biological treatment, photodegradation method, membrane filtration method [2] and adsorption [3,4]. Among these methods, adsorption is considered to be a high efficiency, low cost and ease of operation in dye wastewater treatment technology[1].
Many adsorbents such as activated carbon (AC), biosorbents, zeolites, nano-perfluorooctyl alumina, multiwalled carbon nanotubes and cellulose-based wastes [5,6,7] were reported to decolorize wastewater[1,8]. Activated carbon has excellent adsorption performance, but it is difficult to separate from water. Using traditional filtration, coagulation, flocculation, clarification, and sedimentation processes to separate Activated carbon from water has high cost or poor effect. Magnetic activated carbon has been effectively used to remove dyes, heavy metals, phenols, antibiotics, and other organic matters because it can be separated from water rapidly under an external magnetic field. The application of Magnetic activated carbon in the above fields has achieved excellent results, but the effect of treatment of MO by Magnetic activated carbon remains to be explored[9].

Yang et al [9] synthesized magnetic Fe3O4/AC nanocomposite from rice husk based AC, which demonstrated perfect magnetic separation performance and a high adsorption capacity for methylene blue from aqueous solution. Zhu et al. successfully prepared the magnetic cellulose/Fe_3O_4/AC composites and investigated its adsorption property toward congo red [11].

In this article, we prepared the magnetic activated carbon to improve the adsorption capacity of of methyl orange as a toxic substance from aqueous solution. We examined the effect of contact time, initial contraction, pH, and adsorbent dose on the removal of MO from wastewater.

Experimental

1. Material

All the chemicals used during the research work were of analytical grade and used without further purification. powder activated carbon (AC) (with surface area 737.54 m^2/g), ferric chloride hexahydrate ($FeCl_3 \cdot 6H_2O$), sodium hydroxide (NaOH), hydrochloric acid (HCl) ,and Methyl orange (MO). The chemical structure of MO is shown in Figure 1.

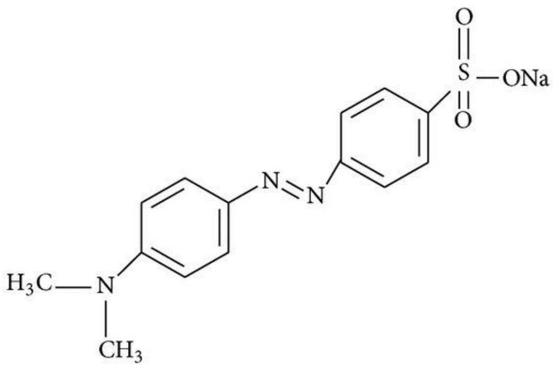

Figure 1. Chemical the structure of methyl orange dye.

3. Preparation magnetic AC/Fe_2O_3 nanocomposite

The activated carbon was dried at 110 °C then for prepare composite of activated carbon/ Fe_2O_3 nanoparticles, 10 g of AC were contacted with 80 mL of 2.5M $FeCl_3$ for 24 h at 70 °C using a shaker with 120 rpm, and after reacting time, adsorbents washed with deionized water repeatedly. Washing continued until a neutral pH (6.0–7.0) was achieved. The adsorbent was then dried at 100 °C in an air oven overnight. AC and Fe-AC were kept in a desiccator for removal tests.

4. Batch adsorption experiments

Batch adsorption experiments were performed on magnetic stirring with a stirring speed of 100 rpm at 25 ^oC, using 250 mL Erlenmeyer flasks contain 0.05-0.3 g ACM and 100 mL different concentrations of MO solution with different pH values. The pH values of the MO solutions were adjusted by adding 0.1 mol/L HCl or 0.1 mol/L NaOH solution. the concentration in time t, determined at 463 nm using UV–vis spectrophotometer. The amount of MO adsorbed and The percent of the dye removal at equilibrium condition,(qt, mg/g) was calculaed by the following equations:

$$\mathrm{Re}\% = \frac{(C_o - Ct)}{C_0} \times 100$$

$$q = \frac{C_o - Ct}{W} V$$

where C_o (mg/L) is the initial MO concentration and C_t (mg/L) is MO concentration at time t (min), V (L) is the volume of the solution and W (g) is the weight of the dry adsorbent.

Results and discussion

3.1. Effect of pH

The pH value is a very important parameter that affects the adsorption efficiency of MO. The effect of pH value on the adsorption of MO was investigated within the pH range 1–11. Fig. 2, shows that the MO removal efficiencies change from 64% to 95%, and the maximum adsorption was observed at pH 2. MO occurs as quinoid form, while at higher pH it rearranges into its azo structure[11].

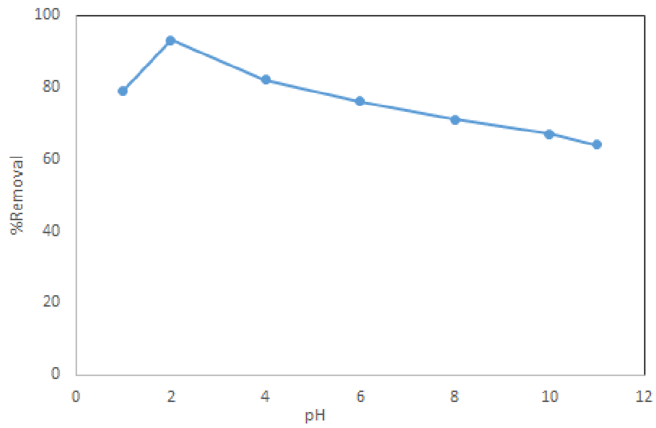

Figure 2- the effect of pH the MO removal efficiency
(initial concetration=50ppm, adsorbent dose=0.3gr)

3.2. Effect of contact time and initial concetration of MO

The initial concentration of MO has significant effect on the MO adsorption. The results are shown in Fig. 3. With the increase of MO initial concentration from 50 to 300 mg /L the removal efficiencies drop quickly. Also with the increase of contact time from 5 to 30 min Gradually increased . the removal efficiencies of MO is increased rapidly in the first 5 min and then decreases with time until reached equilibrium. The MO removal efficiencies could reach up to 87% in the first 5 min and 95% within 30 min at the temperature of 25^oC.

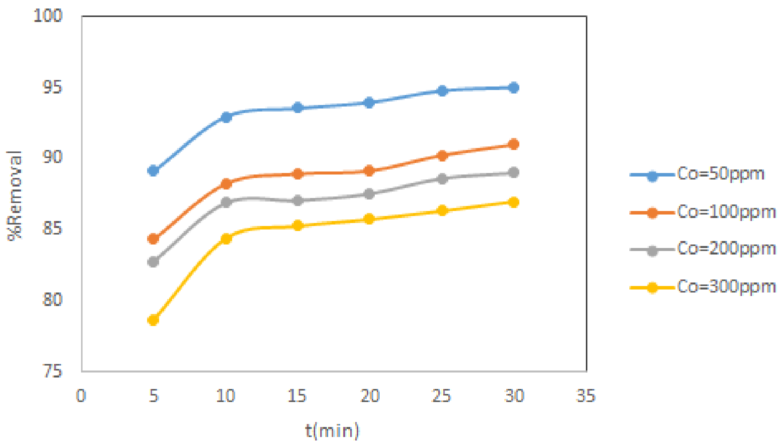

Figure 3- the effect of contact time and initial concetration the MO removal efficiency (pH=2, adsorbent dose=0.3gr)

3.3. Effect of adsorbent dosage

The adsorbent dose is a crucial parameter in adsorption studies because it determines the capacity of adsorbent for a given initial concentration of dye solution. As shown in Fig. 4, the removal efficiencies are increased and adsorption capacities decrease rapidly with increasing ACM composite dosage. The increase in dye removal efficiencies is due to increased available sorption surface and the availability of more adsorption sites [12]. It was also observed that the removal efficiencies almost reached constant value 95% after the ACM composite dosage was increased to 0.30 g.

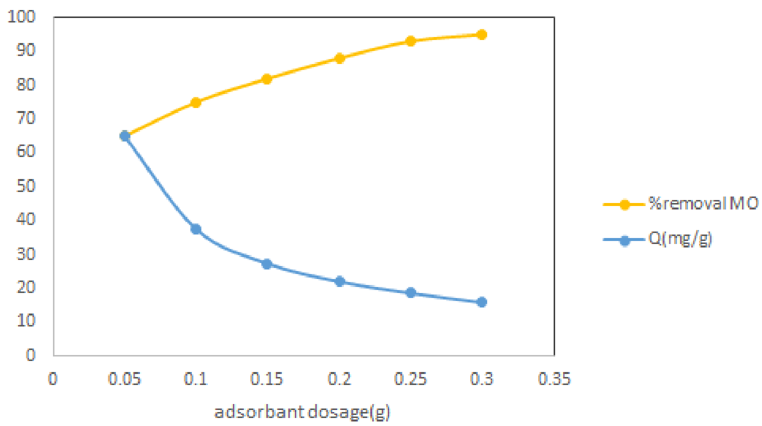

Figure 4- the effect of adsorbent dosage on the MO removal efficiency and the adsorption amounts (pH=2, initial concetration=50ppm)

Conclusions

In this study, we have reported a simple method for the preparation of activated carbon/Fe_3O_4 nanoparticle composites. The obtained composites contained Fe_3O_4 nanoparticles inside the pores of activated carbon. These exhibited a high specific surface area and porosity and a super magnetic property that allows them to be easily manipulated by an external magnetic field. Next, the adsorption studies were performed as a function of adsorbent dosage, initial concentration of MO, contact time, and solution pH. For ACM, the maximum removal efficiency 98% was obtained under the optimum conditions of adsorbent dosage 0.30 g, pH 2, contact time 30 min and temperature 25 ^{o}C with MO concentration 50 mg/L. Finally, it could be concluded that ACM can be effectively utilized for the removal of MO from wastewater.

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