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Chemical synthesis of Fe_3O_4 nano particles for the degradation of Malachite Green and Methyl Orange under visible light irradiation

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ABSTRACT

Keeping observation of importance and applications of Fe_3O_4 nanoparticles in various fields, we have synthesized Fe_3O_4 nanoparticles by one of the convenient and inexpensive method. The synthesized Fe_3O_4 nanoparticles were characterized by UV-Visible Spectroscopy, Infrared spectroscopy (IR), Scanning Electron Microscopy (SEM) and Zeta potential analyzer. A band at 405 nm in the UV–vis spectrum confirms the formation of Fe_3O_4 nanoparticles. FTIR analysis confirms the formation of Fe –O bond. As obvious from SEM, the synthesized Fe_3O_4 nanoparticles are spherical in shape with 20-60 nm in size. Zeta potential analysis reveals that the synthesized Fe_3O_4 nanoparticles are stable due to the electrostatic repulsion. The photocatalytic activity of Fe_3O_4 nanoparticles was studied for degradation of Methyl Orange and Malachite Green under sunlight.

Keywords: *Chemical synthesis, Fe_3O_4 nanoparticles, Zeta potential, Dye degradation.*

1. INTRODUCTION

The emergence of nanotechnology has provided a widespread research in recent years by intersecting with various branches of science and forming impact on all forms of life [1-5]. Nanoparticles have expressed significant advances due to wide range of applications in the field of sensors, bio-medical, catalysts, antimicrobials, electronics, optical fibers, bio-labeling, agricultural and in other areas [6-10].

In recent times, an extensive research has been focused on nano-structured magnetite because it posses inimitable magnetic and electric properties and its application in medical diagnosis and therapy, target drug delivery, cancer hyperthermia treatment, magnetic resonance imaging and nano-sorbents in environmental engineering.

Fe_3O_4 particles have attracted much interest because they belong to the class of materials having non-toxicity and biological compatibility by the presence of Fe ions [11].

2. MATERIALS AND METHODS

2.1. Chemicals used

Ferric Chloride, Sodium hydroxide, Methyl Orange, Malachite Green was purchased from Aldrich Chemicals and used as such.

2.2. Synthesis of Fe_3O_4 nanoparticles

In this chemical method, Fe_3O_4 nanoparticles were synthesized by adding 100ml of 2.5M Sodium hydroxide solution into 100ml of 0.25M Ferric Chloride drop by drop while stirring at 400rpm and 60ºC. The nanoparticles were washed with deionised water for three times and dried in a hot air oven at 50º C.

2.3. Dye degradation using Fe_3O_4 nano particles

To study the degradation of dye using Fe_3O_4 nanoparticles, we have used Methyl Orange (MO) and Malachite Green (MG). The dye solutions were prepared by dissolving 0.1g dye in 100ml distilled water. About 0.1g or 0.01 g of Fe_3O_4 nanoparticles and 10ml of dye solution were taken in a beaker and kept in sunlight. After 24 hours and 48 hours, the solution in the beaker was centrifuged using research Centrifuge for 20 minutes at 8000 rpm. The supernatant of the each centrifuged solution was collected using micro pipette and diluted in 1:2 ratio with water and the OD (Optical Density) was taken in a UV-Visible spectrometer.

2.4. Preparation of standard dye solutions and determination of OD value

Dye solutions of various concentrations were prepared by diluting the stock solution. The UV-visible spectra of MO and MG solutions show peaks at 565nm and 620nm respectively. The OD of the standard dye solutions was measured at maximum wavelength of 565nm for MO dye and 620nm for MG dye.

3. RESULTS AND DISCUSSION

3.1. UV-Vis Spectroscopic analysis

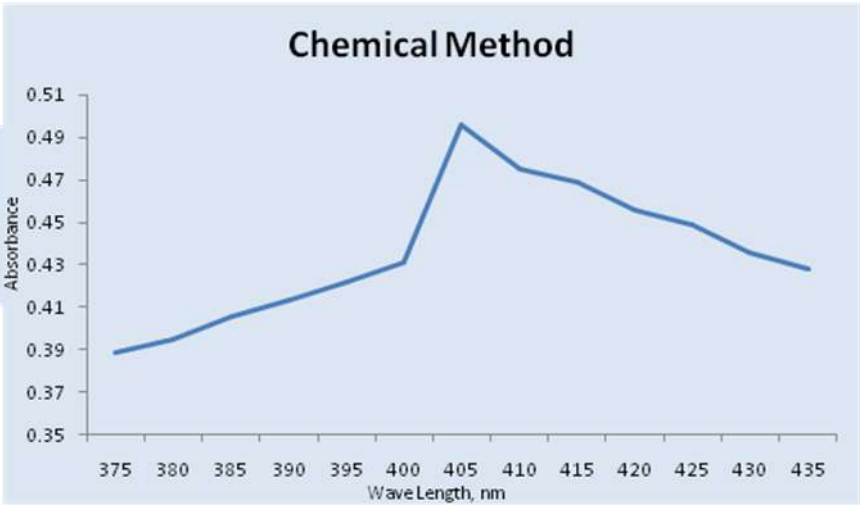

Figure 1. UV/Visible spectrum of synthesized Fe_3O_4 nanoparticles

UV-vis spectrum of synthesized Fe_3O_4 nanoparticles is shown in figure 1. Characteristic surface plasmon absorption band is observed at 405 nm for the Fe_3O_4 nanoparticles synthesized by chemical method.

3.2. FTIR analysis

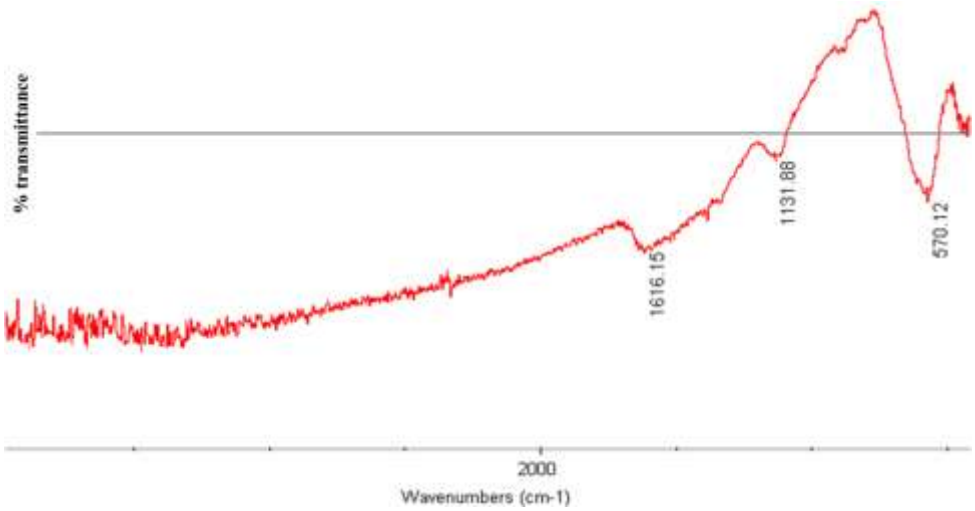

Figure 2. FTIR spectrum of synthesized Fe_3O_4 nanoparticles

The FTIR spectrum of synthesized Fe_3O_4 nanoparticles is shown in figure 2. For the IR spectrum of Fe_3O_4 nanoparticles, the absorption band appears at 570.12cm^{-1} which can be attributed to Fe_3O_4. Bands obtained at 1131.88cm^{-1} and 1616.15cm^{-1} may correspond to asymmetrical HO-H.

3.3. Scanning electron microscopic analysis (SEM)

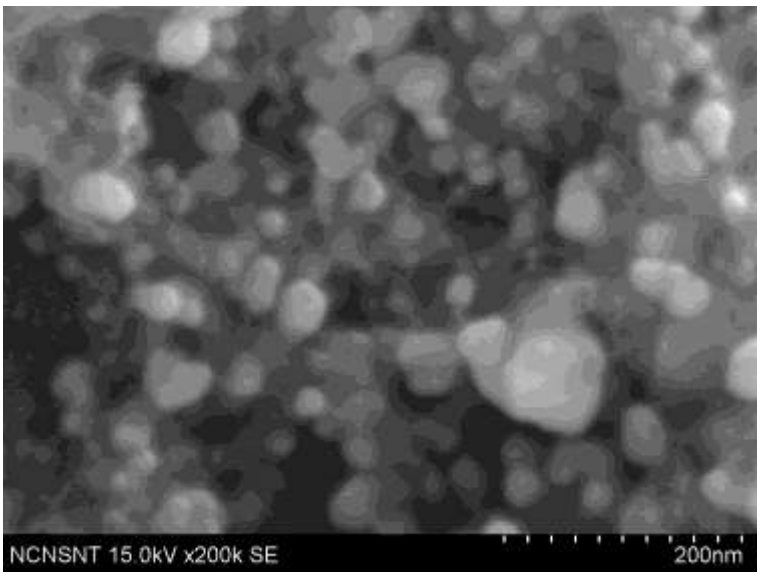

Figure 3. SEM image of synthesized Fe_3O_4 nanoparticles

The scanning electron micrograph for chemically synthesized magnetite nanoparticles is shown in figure 3. Most of the magnetite nanoparticles are within 20-60 nm in size. The shape of the nanoparticles is spherical.

3.4. Zeta potential analysis

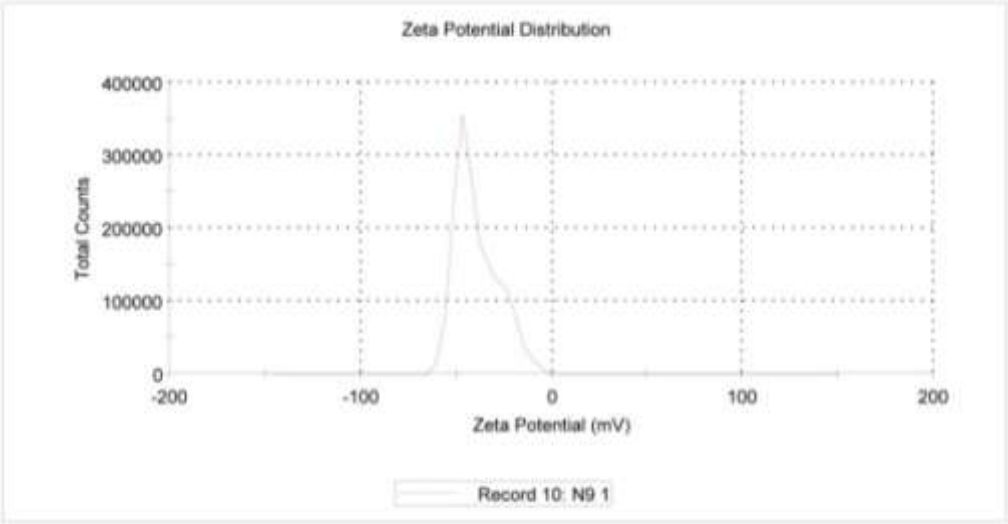

Figure 4. Zeta potential distribution of chemically synthesized Fe_3O_4 nanoparticles

Zeta potential of the most of the chemically synthesized Fe_3O_4 nanoparticles is −39.3 mV. This result reveals that the chemically synthesized nanoparticles are stable due to the electrostatic repulsion.

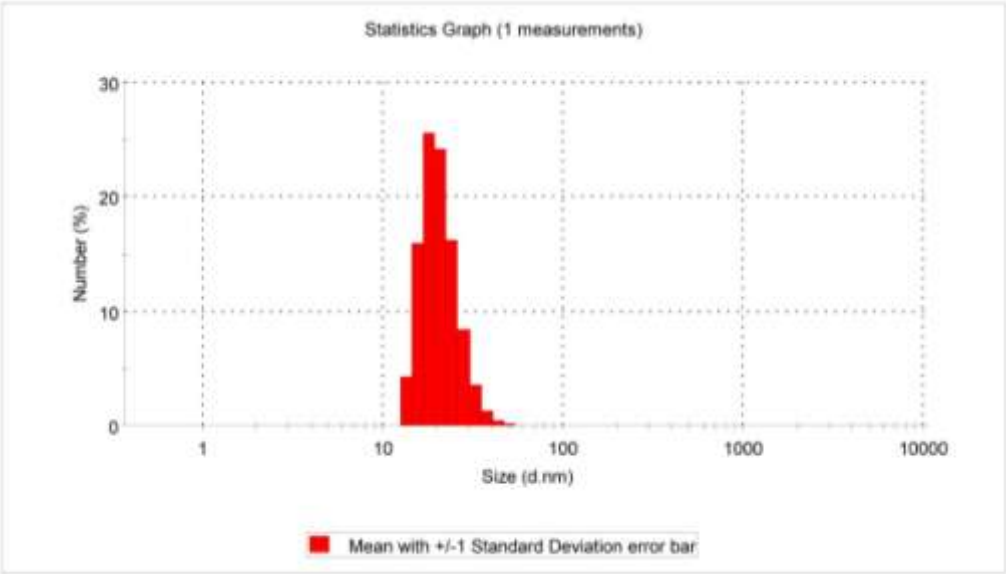

Figure 5. Size distribution of chemically synthesized Fe_3O_4 nanoparticles

The above graph indicates that, 25.5 % of chemically synthesized nanoparticles have average diameter of 18.17 nm. 24.2 % of chemically synthesized nanoparticles have average diameter of 21.04 nm. Chemically synthesized nanoparticles are in the diameter range of 13.54 to 58.77 nm.

3.5. Dye degradation of Fe_3O_4 nanoparticles

When the weight of Fe_3O_4 nanoparticles used for dye degradation is 0.01g, the OD values of MO dye solution after 24hours and 48 hours are 0.643 and 0.562 respectively. When the weight of Fe_3O_4 nanoparticles used for dye degradation is 0.1g, the OD values of MO dye solution after 24hours and 48 hours are 0.484 and 0.249 respectively.

When the weight of Fe_3O_4 nanoparticles used for dye degradation is 0.01g, the OD values of MG dye solution after 24hours and 48 hours are 0.345 and 0.244 respectively. When the weight of Fe_3O_4 nanoparticles used for dye degradation is 0.1g, the OD values of MG dye solution after 24hours and 48 hours are 0.750 and 0.042respectively.

4. CONCLUSION

In this work, Fe_3O_4 nanoparticles were synthesized by using chemical method. The characterization of Fe_3O_4 nanoparticles were obtained by UV, FTIR, SEM and Zeta analyzer. The excellent photocatalytic activity of the Fe_3O_4 nanoparticles suggests that they have promising applications in the dye degradation and pollutants clearance.

5. REFERENCES

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