

Properties of structural, optical and morphological study of Fe₃O₄ nanoparticles through organic pollutant

¹ Paranjothi V ² Anandhi Sarangapani

Department of Physics

Faculty of Arts & Science

Bharath Institute of Higher Education and Research

Chennai-India 600 073

¹jothiragava@gmail.com ²anandhi818@yahoo.co.in

Address for Correspondence

¹ Paranjothi V ² Anandhi Sarangapani

Department of Physics

Faculty of Arts & Science

Bharath Institute of Higher Education and Research

Chennai-India 600 073

¹jothiragava@gmail.com ²anandhi818@yahoo.co.in

Abstract

In present study, the synthesis of illustrated that wet chemical reduction method is an applicable way for synthesis of Magnetite Iron nanoparticles. X-ray diffraction patterns of the Iron nanoparticles prepared with confirm that the peaks are well defined and agree well with the JCPDS data of cubic structure. SEM images of the Fe₃O₄ nanoparticles micrograph of the Fe₃O₄ nanoparticles at room temperature indicates the particles are non-uniform in size and shape. No characteristic morphology is observed. This might be due to agglomeration of nanostructures. The FT-IR spectra indicated the formation of magnetite Iron nanoparticles. The chemical structure information of the products is studied by FTIR spectra. Absorption spectra of both the dyes reveal that Fe₃O₄ nanoparticles has undergone significant photocatalytic degradation however, MG dye (82 %) attained more degradation percentage than the MB dye (78 %).

Key words: FTIR, Photocatalytic activity, magnetite Iron oxide nanoparticle, MG and MB etc., ..

INTRODUCTION

Nanomaterials are cornerstones of nanoscience and nanotechnology. Nanostructure science and technology is a broad and interdisciplinary area of research and development activity that has been growing explosively worldwide in the past seven years. Nanomaterials

Research Paper

are already in commercial use, with some having been available for several years or decades. The range of commercial products available today is very broad, including stain-resistant and wrinkle-free textiles, cosmetics, sunscreens, electronics, paints and varnishes. Nanocoatings and nanocomposites are finding uses in diverse consumer products, such as windows, sports equipment, bicycles and automobiles. There are novel UV-blocking coatings on glass bottles which protect beverages from damage by sunlight, and longer-lasting tennis balls using butyl-rubber/nano-clay composites. Nanoscale titanium dioxide, for instance, is finding applications in cosmetics, sun-block creams and self-cleaning windows, and nanoscale silica is being used as filler in a range of products, including cosmetics and dental fillings. The chemical co-precipitation method is a convenient, ambient conditions and low cost for synthesis high amount of nanopowder. In the present study $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ and $\text{FeCl}_2 \cdot 6\text{H}_2\text{O}$ distilled water, sodium hydroxide as a reducing agent. Magnetic nanoparticles are basically nano-dimensional materials that can respond to the magnetic field. There is a growing interest on the synthesis and characterization of magnetic nanoparticles due to their superior functions in various applications [9, 10]. The presence of magnetic characteristics as well as easy and safe synthesis of the nanoparticles in the laboratory environment increase the utilization of the materials in the different application fields and get noticeable consideration among the scientists. The main purpose of green synthesis research is to improve a synthesis method for obtaining the environment friendly, non-toxic, superparamagnetic and low cost magnetic nanoparticles [11-13]. The purpose of this study was to improve the synthesis method for obtaining magnetic nanoparticles (Fe_3O_4) by using ferric chloride hexa-hydrate, ferrous chloride tetra-hydrate and by extraction of MG and MB. By this way, an easy, economic and environmentally friendly synthesis was aimed with using organic solvents and physical steps with surface active materials. The obtained magnetic nanoparticles were characterized using fourier transform infrared spectroscopy (FT-IR), zeta potential measurements, ultraviolet-visible spectroscopy (UV-Vis) and X-ray diffraction (XRD) methods.

MATERIALS AND METRHODS

Magnetites were prepared in laboratory by co precipitation method using following reagents. $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, NaOH and $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$, were used with deionized water as solvent. All the chemical reagents were analytical grade, obtained from Merck (India) and used without further purification.

The Fe₃O₄ nanoparticles were prepared based on co- precipitation of Fe³⁺ and Fe²⁺ under the sodium hydroxide as precipitating agent. Briefly(0.2M) of FeCl₂.4H₂O and (0.4M) of FeCl₂.6H₂O were dissolved in 100 ml distilled water, the solution was heated to 70°C under various stirring at 750 rpm, 1 mol of sodium hydroxide was dropped slowly into the solution. The resulting suspension was vigorously stirred for another 1 hr the color of solution changed to black precipitates solution changes indicates Fe₃o₄ NPS. The black magnetic precipitates obtained were washed several times with distilled water and ethanol. Finally Fe₃O₄ NPs were collected and dried for 6 hr at 80° C in Hot Air Oven.

RESULT AND DISCUSSION

INFRARED ABSORPTION STUDIES :

Infrared spectroscopy was used to detect the presence of surfactants absorbed at the nanoparticles surface Fig 3.1 shows the FT-IR spectra of Fe₃O₄ which are recorded in the region 400 – 4000 cm⁻¹. The vibrational frequencies of the various chemical bonds in the nanoparticles can be assigned from FT-IR spectra in terms of peak position. The sample can be identified by the assignments of stretching and bending modes of vibrational frequencies which can be divided in three regions. The first one goes from 4000 to 1500 cm⁻¹ are five bands appear at 3422.07, 2926.17, 2854.79, 2275.41 and 1629.91 due to -OH vibrations of water. The second region from 1580 to 900 cm⁻¹ corresponds to the area where vibrations due to the surfactant molecules should appear. In this case, broad bands at 1402.74, 1122.33, 1035.62 and 969.86cm⁻¹ were detected to C-N vibrations coming from the amines. Finally, between 850 to 250 cm⁻¹, two main bands can be observed at 574.27 and 448.13 cm⁻¹, which corresponds to Fe₃O₄. Similar observation was reported by **L.Cabrera et al., (2008)**

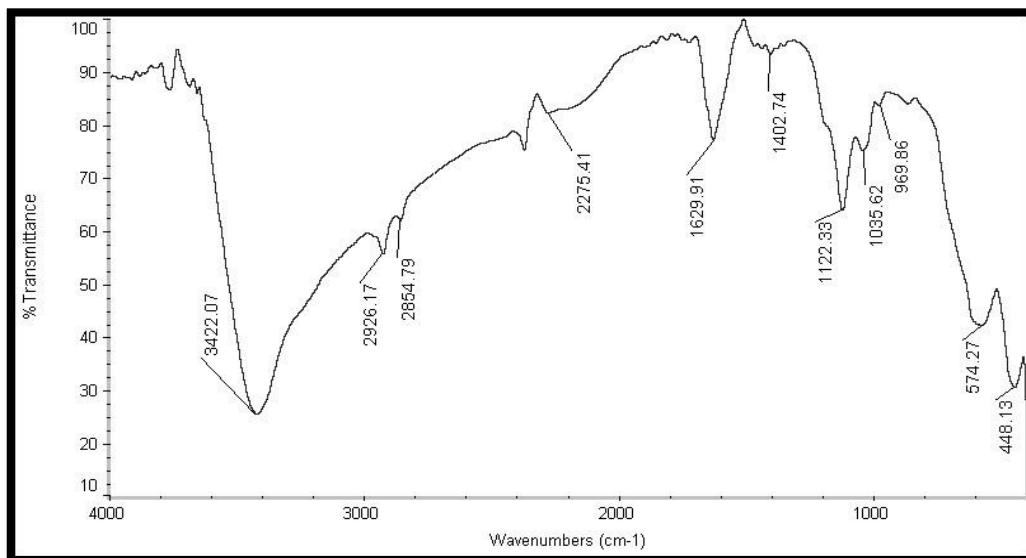


Fig. 1 Infrared spectrum of Fe₃O₄ nanoparticles

Structural and phase studies of Fe₃O₄ nanoparticles

From the Fig 1, the diffraction peak indicated at $2\theta=30.22^{\circ}$, 35.5° , 57° and 63° corresponding to (220), (311), (511) and (440) planes of the Fe₃O₄ phase. From this observation, it can be seen that the product is high crystalline and no characteristics peaks are observed from the impurities. The observed peaks and structure are good agreement with the reported values of **Hironori Iida et al., (2007)**. The crystallite size of the Fe₃O₄ product is determined by using Debye Scherrer's formula

$$D = \frac{K\lambda}{\beta \cos\theta}$$

where $K=0.89$ is the shape factor, λ is the X-ray wavelength of CuK α radiation, β is the full width at half maximum of the peaks and θ is the Bragg's angle and the crystallite size is 3.4 and 5.10 nm for (311) and (440) plane. thus the overall crystalline size of magnetite (Fe₃O₄) is 4nm.

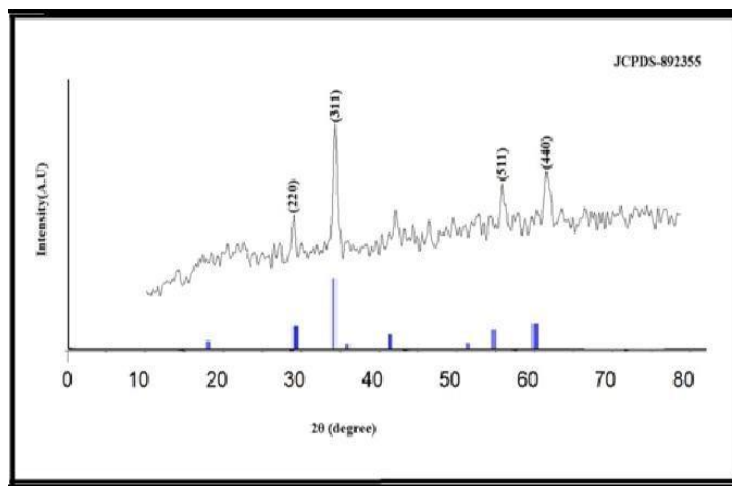


Fig.2. X-ray diffraction pattern of Fe₃O₄ nanoparticles

Photocatalytic activity

Photocatalytic activity of the synthesized Fe₃O₄ nanoparticles sample was analyzed by the degradation of aqueous methyl green (MG) and methylene blue (MB) dye solutions under UV light illumination. Fig.(a & b) represents the degradation absorption spectra of MG and MB dyes in the presence of Fe₃O₄ nanoparticles as photocatalyst. For both MG and MB dyes, before the reaction the dye solution was prepared and kept in dark, it is observed that the solution of both dyes remained stable. Further, when the Fe₃O₄ nanoparticles photocatalyst added to the dye solution and kept in a dark environment after a certain time period it was observed that degradation of dye content is very minimum and is negligible. This indicates that degradation of dyes was not only due to the prepared photocatalysts but also due to the use of UV-light irradiation. It is well-known that, when the surface of the catalyst irradiates by the photon of UV-light, electrons present in the conduction band could get excited to the valence band which generates the same number of holes in the valence band. These holes will interact with the surface of the catalyst, to generate the active oxygen species such as OH•, HO₂• and O₂•- radicals, which leads to dye degradation (Foletto et al., 2013). From results, it is evident that MTO photocatalyst attained 82 and 78 % of degradation for MG and MB dyes, respectively. Fig. 3.6 illustrates the degradation percentage rate of MTO sample against MG and MB dyes at different time periods for 90 min.

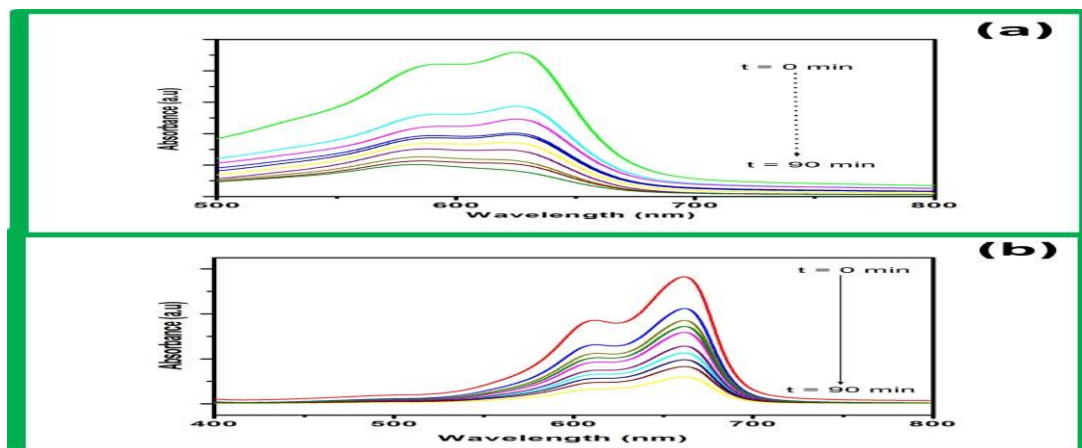


Fig. 3 UV-absorption spectra of (a) MG and (b) MB dye degradation at different time intervals between 0 – 90 min

CONCLUSIONS

The study of the physics aspect of nanoparticles is typically important to characterize various properties. The application of nanostructure is wide in many fields based on their magnetic recording, magnetic sensing, drug delivery (DDS), magnetic resonance imaging (MRI) and cancer therapy. In the present study is to prepare Fe_3O_4 nanoparticles were prepared by chemical co-precipitation method by using ferrous, ferric sulfate and 1, 6 hexanediamine as a base. The Fe_3O_4 nanoparticles were characterized by.

- FT-IR study also confirms the bonding of magnetite (Fe_3O_4) nanoparticles.
- XRD study confirms the cubic structure of Fe_3O_4 nanoparticles the average particle size of the magnetite obtained from the peak broadening was 4nm.
- Results of photocatalysis has shown the ability of Fe_3O_4 nanoparticles in degrading organic pollutants.

REFERENCES

- 1 Amyn s – Teja, Pei- Ayoung Koh. Journal of Crystal Growth and Characterization of Materials, 55 (2009) 22-45.
- 2 Abharya A, Gholizadeh A. Iran. J. Chem. Chem. Eng. Research Article Vol. 2020;39(2). Cabrera, L., S.Gutie Errez, N. Menendez, M.P Morles, P. Herrasti. Journal of Electrochemica Acta, 53 (2008) 3436-3441

Research Paper

3. Deepa Thapa, V.R.Palkar, S.K.Malik. Journal of Materials letters, 58 (2004) 2692-9694.
4. Foletto, E.L., Simões, J.M., Mazutti, M.A., Jahn, S.L., Muller, E.I., Pereira, L.S.F. and de Moraes Flores, E.M., 2013. Ceramics International, 39(4), pp.4569-4574.
5. HaoYan, Jain Chengzhang, Cheaxia you, Zherwer, Song, Berwei You, Yue Jhen, Journal of Materials Chemistry and Physics, 113 (2009) 46-52
6. Hironori Iida, Kosuke Takayannagi, Takkuya Nakamishi, Tetsuya Osaka. Journal of colloid and Interface science, 314 (2007) 274-280
7. Martinez-Mera, M.E. Espinosa-Pesqueira, R.Pesquera, R.Perreg-Herrandez, J.Arenaz,Alatorre, Journal of materials letters, 61 (2007) 4447-4451
8. Qing Cheng, Lihua Zhu, Chen Yu, Heqing Tang. Journal of Luminescence, 128 (2008) 18901895
9. Sivakumar, P., R. Ramesh, A. Ramanand, S. Poonnusamy, C. Muthamizhelvan. Journal of Materials Research Bulletin, 46 (2011) 2208-2211.
10. Wang, J., Liu, J., Chao, D., Yan, J., Lin, J. and Shen, Z.X., 2014. Advanced Materials, 26(42), pp.7162-7169.
11. Wei Zhang, Fenglei Ghen, Ruoyu Hong, Journal of Particuology, 9 (2011) 179-186
12. Y. Chen, M. Ruan, Y.F. Jjiang, S.G. Cheng, W. Li. Journal of Alloys and Compounds, 493 (2010) 136-138