Synthesis and Characterization of Iron Oxide nanoparticles by Solid-State Reaction

Akram Hosseinian*

School of Engineering Science, College of Engineering, University of Tehran, P.O. Box 11365-4563 Tehran, Islamic Republic of Iran- 09126156376

INTRODUCTION

Synthesis of oxide nanoparticles attracts more and more attention because these nanoparticles exhibit electrical, optical and magnetic properties that are different from their bulk counterparts. The study of Iron oxides has attracted intensive attention over the past decades due to the potential applications in catalysts, gas sensors, high density magnetic recording media, printing ink, ferro fluid, magnetic resonance imaging and especially biomedical field, etc.

Photocatalytic processes at semiconductor have received remarkable attention because of their potential application to the conversion of solar energy into chemical energy and pollution control. The photoassisted catalytic degradation of the dyes occurs by the active species created on the surface of metal-oxide semiconductor nanostructures in aqueous solution.

Iron oxides include α-Fe_2O_3, γ-Fe_2O_3 and Fe_3O_4. Among these Iron oxides, α-Fe_2O_3 has the corundum structure, while the other two have the cubic structure.

Various methods have been reported for the synthesis of Iron oxide nanostructures.

These methods include reduction of iron salts in micelles, thermal reactions using the electrochemical method, co-precipitation, microemulsion, hydrothermal synthesis and sol-gel method etc. All these methods to Iron oxide nanostructures are in general complicated and expensive.

There are many advantages in the solid-state reaction approach such as: (a) simple, cheaper and convenient; (b) involve less solvent and reduce contamination; (c) give high yields of products. In this paper, we synthesize Iron oxide nanostructures with different morphologies by solid-state reaction method.

EXPERIMENTAL DETAILS

A mixture of $FeCl_2.4H_2O$ (1 mmol, 0.199 g), $FeCl_3$ (2mmol, 0.324 g) and NaOH (8 mmol, 0.32 g) powders was ground for 30 min at room temperature. The powder was calcined at 500 °C for 1 hour in air and washed with distilled water for removing the halogen salt and dried in 60 °C.

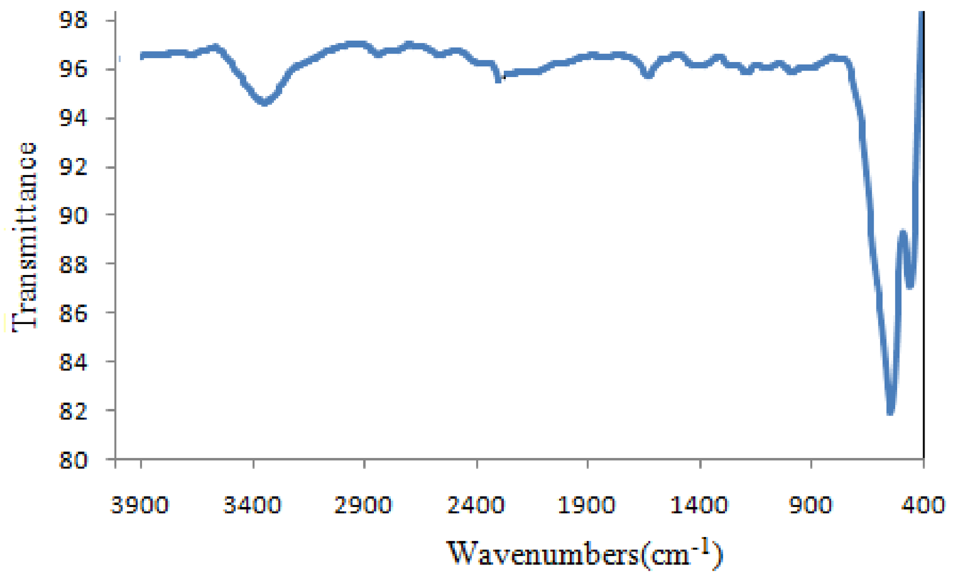
The obtained Iron Oxide catalyst (0.01g) was placed into a beaker of 35 mL 10 mg/L CR aqueous solution. photocatalytic degradation of CR on the Iron Oxide nanoparticles was carried out under irradiation of sunlight, After the reaction began, the mixture was sampled at different times and separated by centrifuging. Then, absorption spectra were obtained through a wavelength scan on a UV-Vis spectrophotometer.

RESULTS AND DISCUSSION

The reaction of $FeCl_2.4H_2O$ and $FeCl_3$ in 1:2 ratios in the presence of an excess amount of NaOH provided powdered material.

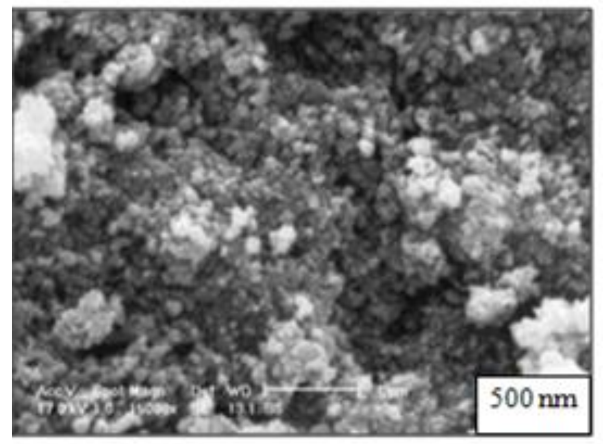
$$FeCl_2.4H_2O(s) + FeCl_3\,(s) + NaOH\,(s) \rightarrow$$
$$Fe_2O_3\text{ (nanoparticles)} + NaCl + H_2O$$

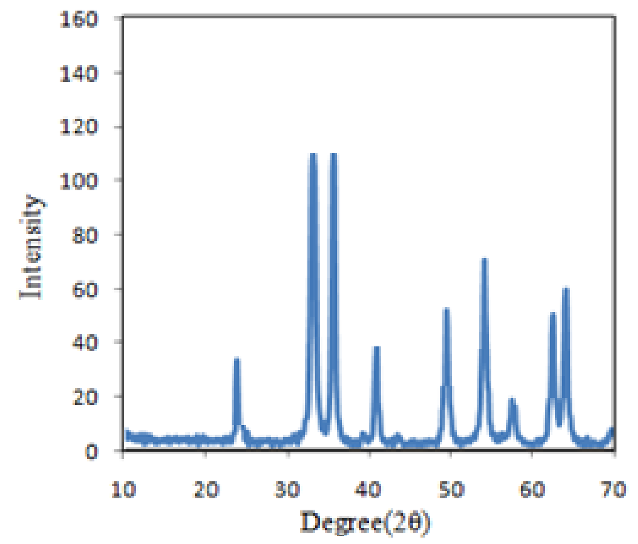
The IR of the sample is shown. The bonding in the region of the bands at 455 and 5445 cm^{-1} observed in sample can be attributed to metal oxygen stretching vibrational modes.

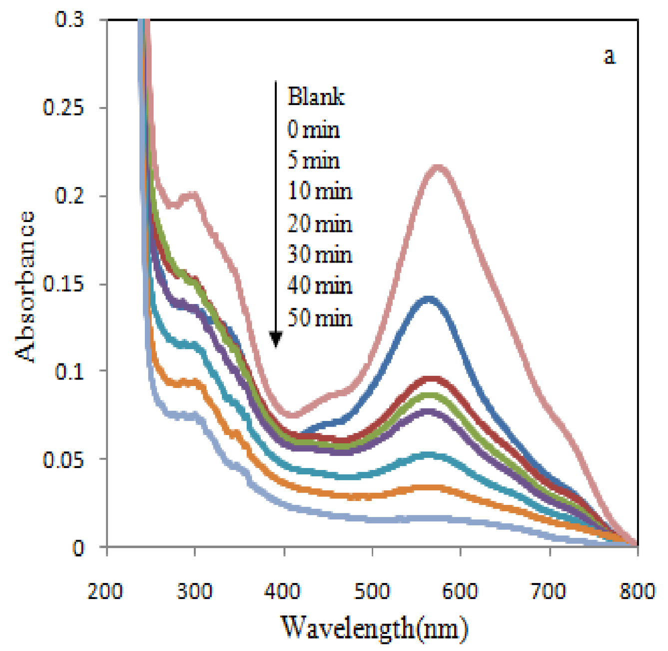


The crystal grain sizes were calculated from the FWHM in XRD pattern using the Debye–Scherrer's equation. The average size of the particles was 55 nm, in agreement with that observed from SEM images. . Fig.indicates a pure rhombohedral crystalline phase of α-Fe_2O_3.

Scanning electron microscopy was employed to study the morphologies of the Iron oxide sample.Fig shows that granular morphologies of Iron oxide are formed, when halogen salt NaCl are obtaned in the salt-assisted solid-state synthesis.







The degradation of Congo Red dye was recorded as a function of time in the presence of visible light Maximum absorbance occurs at about 550 nm for all samples. The photocatalysis performance demonstrates the photocatalytic properties of Iron oxide semiconductors decreases, as their sizes increase.

CONCLUSIONS

In summary, we report the preparation of granular morphologies of Iron oxide by solid-state reactions in the presence of NaCl salt. The salt obtained in reaction is expected to cause cage-like shells surrounding the Iron oxides particles, preventing their growth of nanoparticles. The photocatalytic experiments showed that α-Fe_2O_3 nanostructures are efficient in water treatment for the organic pollutant.

REFERENCES

[1] J. Zhong,Ch. Cao. Sensors and Actuators B, 145 (2010) 651.

[2] A.A. Firooz, A.R. Mahjoub, A.A. Khodadadi, Materials Chemistry and Physics, 115 (2009) 196.

[3] M. Galedari, M. Mehdipour Ghazi, S. R. Mirmasoomi, Chemical Engineering Research and Design 170 (2021) 248–255.

[4] J. Chena, S. Hec, Y. Liuc, Zh. Qiaoc, B. Huang, X. Lic, Q. Haob, H. Huang, G. Yangb, Applied surface Science 538 (2021) 148148.

[5] S.K. Apte, S.D. Naik, R.S. Sonawane, B.B. Kalew, J. Am. Ceram. Soc., 90 (2007) 412.