Synthesis and Characterization of Multishapes of Fe₃O₄ Nanoparticle by Solve-Hydrothermal Method Using Microwave Radiation

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Abstract:

Iron oxide(Fe_3O_4) nanoparticles of different sizes and shapes were synthesized by solve-hydrothermal reaction assisted by microwave irradiation using ferrous ammonium sulfate as a metal precursor, oleic acid as dispersing agent, ethanol as reducing agent and NaOH as precipitating agent at pH=12. The synthesized Fe_3O_4 nano particles were characterized by X-ray diffraction (XRD), FTIR and thermal analysis TG-DTG. Sizes and shapes of Fe_3O_4 nanoparticles were characterized by Scanning Electron Microscopy (SEM), and atomic force microscopy (AFM).

Key words: Magnetite, microwave, oleic acid, SEM, AFM

Introduction:

There has been an increasing interest recently towards the synthesis and fabrication of magnetic nanoparticles mainly magnetite (Fe_3O_4). Besides the high surface to volume ratio and high surface energy, these nanomaterials have been found to have distinguished thermal, magnetic and chemical properties that made them suitable for several applications. In industry magnetic nanomaterials have been used in magnetic fluids for heat transfer [1-3],catalysis [4-7], corrosion inhibitors [8], energy and magnetic storage devices [6, 9] electronic devices [5]. In environmental applications magnetite nanoparticles were used for removal of toxic heavy metal ions like Cu(II), Cr(VI), Cd(II), Pb(II), Hg(II), Tl(I), As(III), Ag(I) [5, 10-15] and organic pollutants [16-19] from waste water. In biomedical applications magnetite nanoparticles were used in magnetic resonance imaging (MRI), contrast agents, drug delivery and therapy [4, 20-25]. The compatibility of these applications is mainly controlled by phase, size and morphology of nanomaterials. Several methods have been reported on the synthesis of different sizes and morphologies of iron oxide Fe_3O_4 and γ-Fe_2O_3 nanoparticles which mainly involve simple wet chemical [15, 19, 26-30], hydrothermal [9, 31-33], electrochemical [34] and microwave methods [35, 36]. Since magnetite nanoparticles are susceptible to oxidation by atmospheric oxygen, the

synthesis of this oxide is best performed in presence of protecting agents like PPy [31], polyethylene glycol [35] and reducing agents like trisodium citrate and ethylene glycol [31]. The microwave method is attracting more attention compared with conventional heating methods because of rapid and controlled production of high yield advanced materials as well as it is safe and needs less energy [35]. Da-Peng Yanga, et al [35] synthesized spherically shaped Fe_3O_4 nanoparticles with average size of ~100 nm by microwave using ferric chloride ($FeCl_3 \cdot 6H_2O$), ethylene glycol, anhydrous sodium acetate (CH_3COONa) and polyethylene glycol, while Z. Kozakova, et al. [36] obtained uniform spherical Fe_3O_4 nanoparticles with average dimensions of 200 nm in 30 min using microwave using ammonium acetate, ammonium carbonate ($NH_4)_2CO_3$ or aqueous NH_3 as precipitant. This work presents the synthesis of multi shapes of Fe_3O_4 nanoparticles like spherical , plate, and nano flowers by solve thermal method assisted by microwave radiation, by using $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$ as iron precursor, oleic acid as reducing agent, ethanol and NaOH.

Materials and Methods:

All of the the following chemical reagents in this work are of analytical grade and were used as received from suppliers:. $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$ (Sigma Aldrich), sodium hydroxide NaOH, 96% (BDH), ethanol 99%, oleic acid ($C_{18}H_{34}O_2$) and acetone (Fluka).

Instruments:

FT-IR spectra were recorded on Shimadzu 8400 S FT-IR spectrophotometer using KBr pellet. Scanning electron microscope (SEM) analyses were acquired using type SEM TE SCAN VEGA 2 Cheech. A few drops of nanoparticle suspension were applied on a carbon coated copper grid followed by vacuum drying. Atomic force microscope images AFM were acquired using AFM model AA 3000 SPM 220V Angstrom Advanced INC. USA. Samples were prepared by applying few drops of nanoparticles dispersed in acetone by sonication for 20 min, on a glass slide followed by vacuum drying at room temperature. Thermal gravimetric analyses (TGA) were performed using Perkin Elmer TGA 4000 thermo gravimetric analyzer in a synthetic N_2 atmosphere at heating range 30°- 900°C and heating rate of 20 °C/min. X-ray diffraction analyses (XRD) were recorded using SHIMADZU 6000 X-Ray Diffract meter with a high-intensity Cu K α radiation (λ=1.54180Å) and a graphite monochromatic source. Magnetic susceptibility of the prepared oxide was measured by using a magnetic balance Model MSB-MK I. Preparation of Fe_3O_4 nanoparticles by microwave irradiation was performed in a domestic microwave oven (mode LG, MS2042X frequency 2.450 MHz, maximum power 1000 W), fixed with a wireless camera to watch capsulate reactor.

Preparation of Fe_3O_4 by solve-hydrothermal microwave method

Fan Zhang, et al [33] prepared Fe_3O_4 nanospheres by hydrothermal method by heating a mixture of $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$ as iron precursor, oleic acid as reducing agent, ethanol and NaOH in an autoclave at 180° C for 10 h. In this work we used the same reactants to prepare Fe_3O_4 nano crystals but by using microwave technique. To a solution mixture of oleic acid ($C_{18}H_{34}O_2$) (6.2 ml) and ethanol (7.02 ml) in three-neck round-bottomed flask was added sodium hydroxide NaOH (0. 562 g, 8.9 mmol) with vigorous stirring under argon atmosphere at room temperature A white viscous solution was formed. To this solution was added, the iron precursor $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$

(0.352g, 0.898 mmol) with vigorous stirring. The final pH of the reaction mixture was adjusted to 12.   A dark green precipitate appeared immediately. After stirring for further 30 minutes under continuous argon flow, the mixture turned brown.   The resultant suspension was then transferred into a homemade 30 mL Teflon autoclave which was sealed, and heated in the microwave domestic oven (second level, 6 second ON and 16 second OFF) at 190 ° C for 15 min. The system was then allowed to cool naturally to room temperature. The color of the mixture was black. The steps of separation of the product are illustrated in Figures (1a-e).The product was collected and separated by permanent magnet which took more than 20 min, washed several times with distilled deionized water (DDW), followed by ethanol, then vacuum dried at 80°C for 10 h and stored under nitrogen atmosphere for characterization by XRD, FTIR, SEM, AFM, and TG analyses.
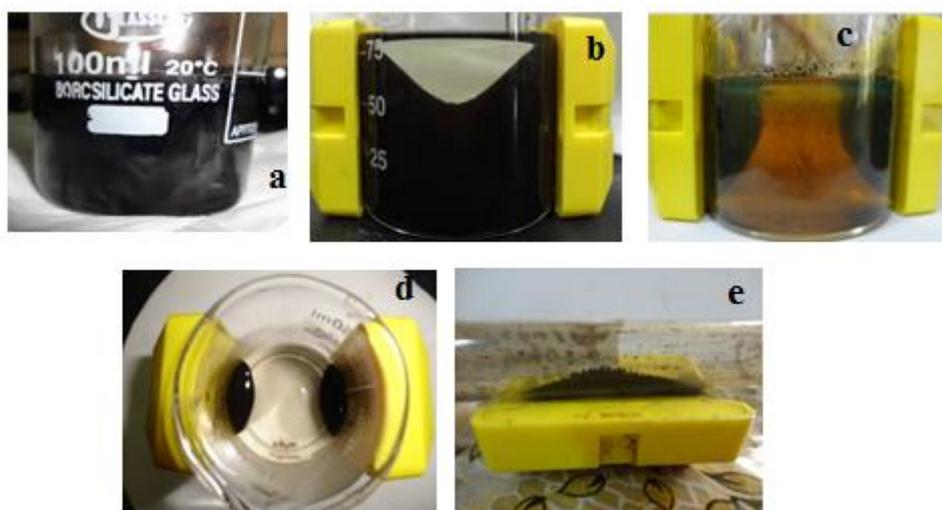

Fig. (1): Separation and of iron oxide Fe₃O₄ by permanent magnet

Results and Discussion:

X-Ray diffraction analysis

Figure (2) shows the XRD pattern of Fe_3O_4 nano particles obtained by using solve-hydrothermal by microwave radiation method, using Cu K α (λ=1.54056 A $^{o.}$) radiation with 2θ in the range (10-60$^{o)}$**.** Five main diffraction peaks were observed at 2Ө =30°,   35.6°,   43.3°,   54°,   57.1°, correspond respectively to the planes (220, 311, 400, 422, and 511 respectively) of Fe_3O_4 nanostructures which came in agreement with the card (space group: JCPDS Nos. 26-1136) X-ray diffract meter with a high-intensity Cu K α radiation (α=1.54056Å) and a graphite monochromatic a. The results indicated a cubic structure of Fe_3O_4 with lattice parameters a=b=c=8. 0903A° and α = β= γ = 90° and agreed with the structure of an inverse spinel type oxide [2, 35, 37, 38]. Crystallite size measurements were determined from the full-width at half maximum (FWHM) of the strongest peaks assigned to the reflection planes (220), (311), (400) and (511) (Table (1)) using the Debye-Scherer approximation [39]

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

Where (D) is crystallite diameter, (K) = 0.9 is the constant, λ is the wavelength of the X-rays, (β) is the peak breadth of the XRD peak, and θ is the Bragg angle (in radians or degrees). The calculated crystal average size is (25.5) nm.
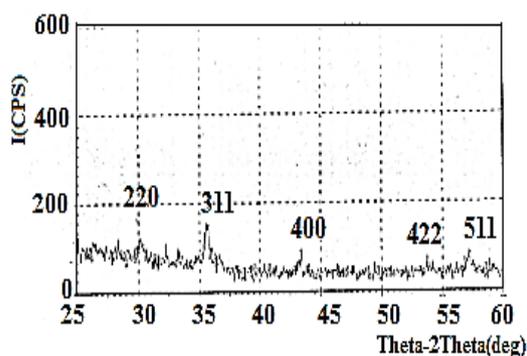
Fig. (2): XRD patterns of the Fe$_3$O$_4$ synthesized by solve-hydrothermal microwave method

Table (1): Average particle size of the synthesized Fe$_3$O$_4$ nanoparticles calculated from Scherer's equation

Diffraction peak at 2Θ (deg.)	FWHM	Size (nm)	Average size (nm)
30°.2	0.416	25.5	
35°.6	0.445	18.9	25.55
43°.3	0.266	32.8	
57°.1	0.366	25.0	

FT-IR Spectrophotometry

Figure 3 shows the FT-IR spectrum of the prepared Fe$_3$O$_4$ coated with oleic acid (OA). The spectrum displayed an absorption band at 3006 cm^{-1} which was assigned to the stretch vibration of vinylic =C-H group [40, 41]. The broad peak at 3122 cm^{-1} can be assigned to surface and bulk OH groups in magnetite [40]. Two absorption sharp peaks were observed at 2923.8 and 2852.5 cm^{-1} were attributed to the CH$_2$ and CH$_3$ stretching vibrations [41]. The intense peak at 1701 cm^{-1} was assigned to the C = O stretching vibration of carboxylate anion [42]. The two new bands at 1639 and 1541 cm^{-1} were assigned to the asymmetric (COO$^-$) and symmetric (COO$^-$) stretching vibrations. This indicates that the carboxylate group is present as both mono and bidentate bonding group i.e. oleic acid has been both physically and coordinatively adsorbed on the surface

of magnetite nanoparticles. The bands observed at 1454.2 and 900 cm^{-1} were attributed to the O–H in-plane and out-of-plane vibrations respectively. The absorption peak observed at 584 cm^{-1} corresponds to the Fe–O stretching vibration related to the magnetite phase [40] ,
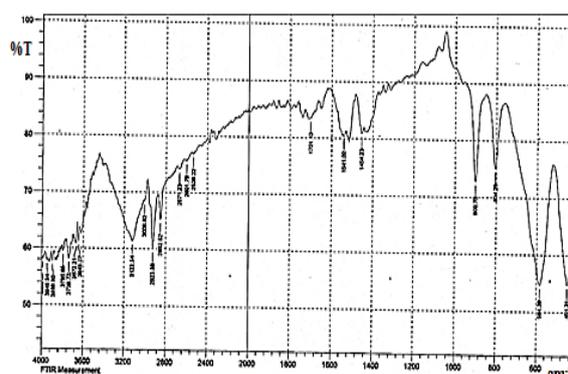

Fig.(3): FTIR Fe$_3$O$_4$ synthesized by solve- hydrothermal microwave Scanning electron microscopy (SEM)

The SEM micrographs of Fe$_3$O$_4$ reveal the presence of three types of morphology like spherical, sheets and flowers nanostructures as is shown in Figures 4a and b and the average particle sizes of spherical Fe$_3$O$_4$ nanoparticles are (50-200nm). The thickness of thorns in flower shaped nanostructures are about (8-10nm) while the diameter and length of nanosheets are 0.8-1µm and 1-2µm respectively. The same morphology of copper oxide nanoparticles was reported by Volanti et. al using the same method [1].
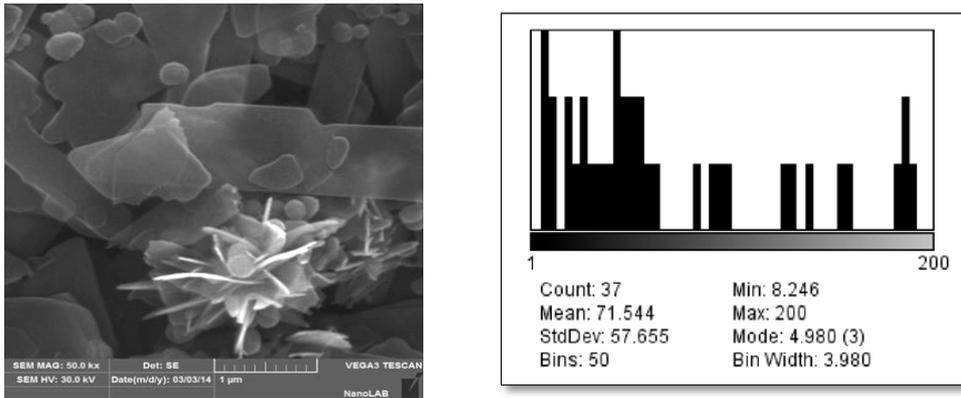
Fig.(4a): SEM micrograph and particle size distribution of solve-hydrothermally synthesized Fe₃O₄ nanoparticles under microwave radiation showing different sizes of nanospheres, nanosheets, and flower shaped nanostructures.
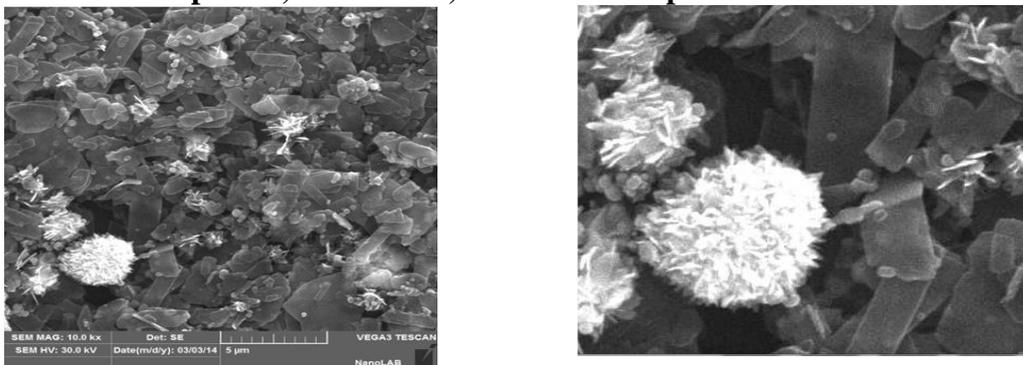

Fig. (4b): SEM micrograph of solve-hydrothermally synthesized Fe₃O₄ nanoparticles under microwave radiation showing several flower shaped nanostructures (left) and a zoom view that shows the presence of spherical and sheet like nanoparticles(right)

Atomic force microscopy (AFM)

Figure (5) shows the 2D, 3D views and particle size distribution of Fe_3O_4 by AFM analysis which reflects the variation and existance of large aggregates of nanoparticle as plates and flower nanostructure as those shown in SEM micrograph with average size about 91.02 nm.
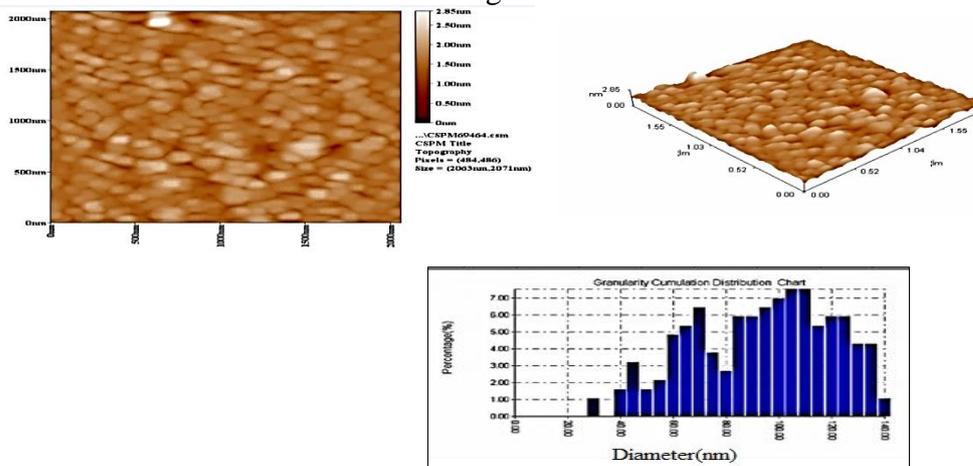

Fig.(5): AFM 2D, 3D views and particle size distribution of Fe₃O₄ nanoparticles synthesized by solve hydrothermal microwave method

Thermo gravimetric analysis (TGA)

The TGA/DTG curves of Fe_3O_4 MNPs coated with OA under N_2 atmosphere at heating range 30°- 900°C and heating rate of 20 °C/min are shown in Figure (6). The TG curve displays three steps of thermal decompositions with weight losses of 0.1, 2.4 and 1.20 which at temperature ranges 30-150, 150-380 and 380-620 °C at peak temperatures 76.75, 309.58 and 616.8 °C

as demonstrated by the DTG curve. The first step corresponds to vaporization of adsorbed solvent molecules present in the sample. The second step is attributed to the removal of free oleic acid adsorbed on the surface of Fe_3O_4 MNPs [43]. The third step is attributed to oxidation and removal of the remaining coordinatively adsorbed oleic acid and phase transition from Fe_3O_4 to hematite [42]
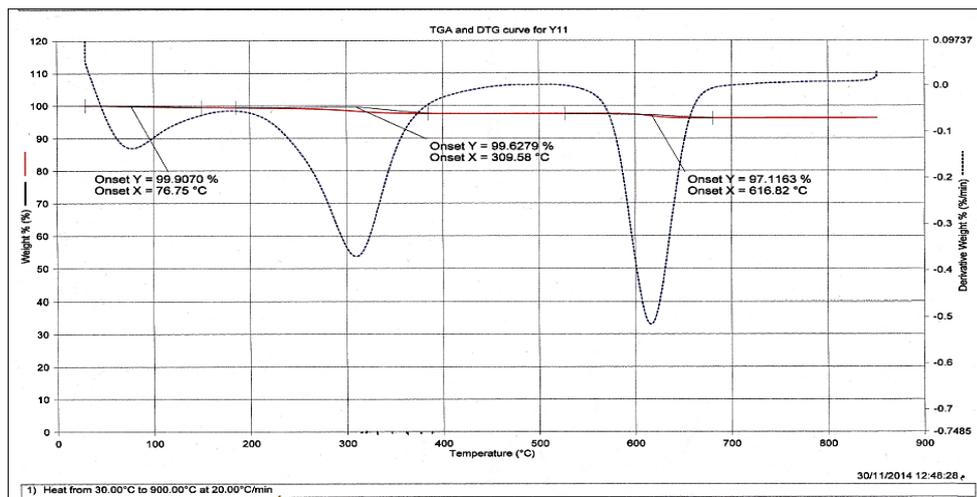

Fig. (6): TGA and DTG thermograph of Fe_3O_4 nanoparticles prepared by solve-hydrothermal microwave method

Conclusion:

Iron oxide (Fe_3O_4) nano particles of different sizes and shapes were synthesized by solve-hydrothermal reaction assisted by microwave irradiation using ferrous ammonium sulfate as a metal precursor, oleic acid as dispersing agent, ethanol as reducing agent and NaOH as precipitating agent at pH=12. XRD analysis supported the inverse spinel structure. The FTIR and thermogravimetric analyses supported the conjugation of Fe_3O_4 with oleic acid through the carboxyl group which behaved as mono and bidentate ligand

References:

[1]Volanti, D. P.; Keyson, D.; Cavalcante, L. S.; Simoes, A. Z.; Joya, N, R. ; Lpngo, E. ; Varela, J. A.; Pizani, P.S. and Souza, A. G. 2008.

Synthesis and characterization of CuO flower-nanostructure processing by a domestic hydrothermal microwave. *J. Alloys. Comp.*, 459**:**573-542.

[2]Lopez, J. A.; González, F.; Bonilla, F. A.; Zambrano, G. and Gómez M. E. 2010. Synthesis and characterization of Fe_3O_4 Magnetic nanofluid. *Revi. Latinoam. de Metalurgiay Mat.* **,** 30 (1): 60-66.

[3]Nkurikiyimfura, I.; Wanga Y. and Pan, Z. 2013. Heat transfer enhancement by magnetic nanofluids-A review. *Renew. Sust. Energ. Rev.,* 21: 548–561.,

[4]Qiaug, Y.; Sharma, A.; Paszcynski, A. and Meyer, D. 2007**.** Conjugates of enzyme-magnetic nanoparticles for bioremediation. *Nanotechnol..* 4, :656-659**.**

[5] Liu, X. L.; Zhong, Z.; Tang, Y. T.; and Liang, B. 2013, Review on the synthesis and applications of Fe_3O_4 nanomaterials. *J. Nanomat.*, 2013: 1-7.

[6] Wei, S.; Wang, Q.; Zhu, J.; Sun, L.; Line, H. and Guo, Z. 2011. Multifunctional composite core–shell nanoparticles. *Nanoscale*, 3: 4474–4502.

[7] Mrówczyński, R. 2014, New magnetic nanoparticles for catalysis and bioapplication, *PhD Thesis*, der Humboldt-Universität zu Berlin,

[8] El-Mahdy, G. A.; Atta, A. M. and Al-Lohedan, H. A. 2014. Synthesis and evaluation of poly (sodium 2-acrylamido-2-methylpropane sulfonate-co-styrene)/magnetite nanoparticle composites as corrosion inhibitors for steel. *Molecules*, 19(2):1713-1731.

[9] Han, C.; Zhao, D.; Deng, C. and Hu, K. 2012. A facile hydrothermal synthesis of porous magnetite microspheres. *Mat. Lett.*, 70: 70–72.

[10] Mahdavi, S., Jalali, M., and Afkhami, A. 2012. Removal of heavy metals from aqueous solutions using Fe_3O_4, ZnO, and CuO nanoparticles. *J. Nanopart. Res.*, 14(846): 1-18.

[11] Gong, J.; Chen, L.; Zeng, G.;Long, F.; Deng, J.; Niu, Q.and He, X. 2012. Shellac- coated iron oxide nanoparticles for removal of cadmium (II) ions from aqueous solution. *J. Environ. Sci.(China).*, 24(7): 1165-1173.

[12] Carlos, L.; Fernando, G. S.; Mónica, E.; González, C. and Mártire, D. O. 2013. Applications of Magnetite Nanoparticles for Heavy Metal Removal from Wastewater. From Waste Water-Treatment Technologies and Recent Analytical Developments, *Licensee In Tech©*, Chapter 1, Universidad Nacional de La Plata, La Plata, Argentina; 63-77

[13] Hua, M., H.;Zhang S.; Pan B.; Zhang, W.; Lv, L. and Zhang, Q. 2012. Heavy metal removal from water/wastewater by nanosized metal oxides: A review. *J. of Hazard. Mater.*, 211– 212: 317– 331

[14] Gao, M.; Li, W.; Dong, J.; Zhang, Z., and Yang, B. 2011. Synthesis and Characterization of superparamagnetic $Fe_3O_4@SiO_2$ core-shell composite nanoparticles. *World J. Condens. Matt. Phys.*, 1(2):49-54.

[15] Neyaz, N.; Sadiq, M.; Zarger, S., and Siddiqui. W. A. 2014. Synthesis and characterisation of modified magnetite super paramagnetic nano composite for removal of toxic metals from ground water. *Int. J. Environ. Sci.*, 5(2): 260-269.

[16] Qu, X.; Alvarez, P.J.J. and Li , Q. 2013. Applications of nanotechnology in water and wastewater treatment, *Water Res.*, 47:3931-3946.

[17] Lakshmanan, R. 2013. Application of magnetic nanoparticles and reactive filter materials for wastewater treatment. *PhD Thesis*, Royal Institute of Technology, School of Biotechnology, Stockholm: 62 pages.

[18] Guang, P. X.; Zeng, M.; Huang, D. L.; Feng, C. L.; Hu, S.; Zhao, M. H.; Lai, C., Wei; Z., Huang, C.; Xie, G. X. and Liu, Z. F. 2012. Use of iron oxide nano-materials in wastewater treatment: A review, *Sci. Total Environ.*, 424: 1–10.

[19] Liua, Q.; Wanga, L.; Xiaoa, A.; Gaoa, J.; Dinga, W.; Yua, H.; Huoa, J., and Ericsona, M. 2010. Templated preparation of porous magnetic microspheres and their application in removal of cationic dyes from wastewater. *J. of Hazard. Mater.*, 181(1-3) :586–592.

[20] Montazeri, H.; Amani, A.; Reza H.; Shahverdi, E.; Haratifar, al din, and Shahverdi A. R., 2013. Separation of the defect-free Fe_3O_4-Au core/shell

fraction from magnetite-gold composite nanoparticles by an acid wash treatment, *J. Nanostr. Chem.*, 3(25): 1-6.

[21] Willard, M. A.; Kurihara, L. K.; Carpenter E. E.; Calvin S. and Harris, V. G. 2004. Chemically prepared magnetic nanoparticles, *Int. Mat. Rev.*, 49 (3–4):125-170.

[22] Kayal, S. and Ramanujan, R. V. 2010. Anti-cancer drug loaded iron–gold core–shell nanoparticles (Fe@Au) for magnetic drug targeting. *J. Nanosci. Nanotechnol.*, 10(9):5527-5539.

[23] Kumar, K. S.; Kumar, V. B. and Paik P, 2013. Recent advancement in functional core-shell nanoparticles of polymers: synthesis, physical properties, and applications in medical biotechnology, *J. Nanopart.*, 2013:1- 24.

[24] Purushotham S. and R. V. Ramanujana, 2010. Modeling the performance of magnetic nanoparticles in multimodal cancer therapy. *J. App. Physi.*, 107, (114701):1-9.

[25] Cheng, J.; Wu, W.; Chen, B.; Gao, F.; Xu, W.; Gao, C.; Ding, J.; Sun, Y.; Song, H.; Bao, W.; Sun, X.; Xu, C.; Chen, W.; Chen, N.; Liu, L.; Xia, G.; Li, X. and Wang, X. 2009. Effect of magnetic nanoparticles of Fe_3O_4 and 5-bromotetrandrine on reversal of multidrug resistance in K562/A02 leukemic cells, *Int. J. Nanomedicine*, 4:209-216

[26] Tamer, U.; Gundogdu Y.,; Boyac, I. H. and Pekmez, K. 2010. Synthesis of magnetic core–shell Fe_3O_4–Au nanoparticle for biomolecule immobilization and detection, *J. Nanopart. Research.* 12(4):1187–1196.

[27] Nyiro-Kosa, I.; Recnik, A. and Posfai M. 2012. Novel methods for the synthesis of magnetite nanoparticles with special morphologies and textured

assemblages, *J. Nanopart. Research,* 14(1150):1-10.

[28] Tresilwised, N.; Pithayanuku P. and Plank, C. 2005. Factors affecting sizes of magnetic particles formed by chemical co-precipitation. *J. Pharm. Sci.*,32(3-4):71-76.

[29] Basavaiah, K., and Prasada Rao, A.V. 2012. Synthesis of polystyrenesulfonic stabilized magnetite nanoparticles, *Chem. Sci. Trans.*, 1(2): 382-386.

[30] Cha, Y.-J.; Kim, M.-J.; Choa, Y.-H.; Kim, J.; Nam, B.; Lee, J.; Kim, D. H. and K. H. Kim. 2010. Synthesis and characterizations of surface-coated superparamagentic magnetite nanoparticles. *IEEE Trans. Magn*, 46(2): 443 – 446.

[31] Zhao, B. and Nan, Z. 2011. Preparation of stable magnetic nanofluids containing Fe_3O_4@ PPy nanoparticles by a novel one-pot route. *Nanoscale Res. Lett.* , 6(230): 1-8.

[32] You, L.-J., Xu, S., Ma, W.-F., Li, D., Zhang, Y.-T., Guo, J., Hu, J. J., and Wang, C.-C. 2012. Ultrafast hydrothermal synthesis of high quality magnetic core phenol −formaldehyde shell composite microspheres using the microwave method. *Langmuir*, 28(28):10565−10572.

[33] Zhang, F; Braun, G. B.; Pallaoro, A.; Zhang, Y.; Shi, Y.,; Cui, D.; Moskovits, M.; Zhao, D. , and Stucky, G. D. 2012. Mesoporous multifunctional upconversion luminescent and magnetic "nanorattle" materials for targeted chemotherapy. *Nano Lett.,* 12 (1): 61–67

[34] Ibrahim M.; Serrano, K. G.; Noe, L.; Garcia,C. and Verelst ,M. 2009.. Electroprecipitation of magnetite nanoparticles: An electrochemical study, *Electrochim. Acta*, 55(1):155–158.

[35] Yang, D.-P.; Gao, F.; Cui, D.-X., and Yang, M. 2009. Microwave rapid synthesis of nanoporous Fe_3O_4 magnetic microspheres, *Curr. Nanosci.*, 5, 485-488.

[36] Kozakova, Z.; Bazant, P.; Machovsky, M.; Babayan V. and Kuritka, I. 2010. Fast microwave-assisted synthesis of uniform magnetic nanoparticles. 14th Czech and Slovak Conference on Magnetism, Košice, Slovakia, July 6–9, 2010, *Acta Phys. Polon., A.* 118(5): 948-949.

[37] Teng, X. and Yang, H. 2004. Effects of surfactants and synthetic conditions on the sizes and self-assembly of monodisperse iron oxide nanoparticles, *J. Mat. Chem.*, 14(4): 774-779.

[38] Yang, X.-C.; Shang, Y.-L.; Li, Y.-H.; Zhai, J.; Foster,N. R. ; Li,Y.-X. D. and Pu, Z., Y. 2014. Synthesis of monodisprese iron oxide nanoparticles without surfactants, *J. Nanomat.*, 2014: , 1-5

[39] Monshi, A.; Foroughi, M. R. and Monshi; M. R. 2012. Modified, Scherrer equation to estimate more accurately nano- crystallite size using XRD. *World J. Nano Sci. Engi.,* 2: 154-160.

[40] Businova, P.; Chomoucka, J.; Prasek, J.; Hrdy, R.; Drbohlavova, J.; Sedlacek ,P. and Hubalek, J. 2011. Polymer- coated iron oxide magnetic nanoparticles-Preparation and characterization. *Nano conference* 2011, *Brno, Czech Republic*, EU. 21. – 23. September 2011:1- 6.

[41] Mahdavi, M.; Bin Ahmad, M.; Haron, M .; Namvar, F. and Amin , J. 2013. Synthesis, Surface modification and characterisation of biocompatible magnetic iron oxide nanoparticles for biomedical applications, *Molecules*, 18(7):7533-7548.

[42] Zhang, L.; He, R. and Gu, H.-C. 2006. Oleic acid coating on the monodisperse magnetite nanoparticles, *App. Sur. Sci.*, 253(5): 2611–2617.

[43] Zhao, S.-Y.; Lee, D. K.; Kim, C. W.; Cha, H. G.; Kim, Y. H. and Kang, Y. S. 2006. Synthesis of magnetic nanoparticles of Fe_3O_4 and $CoFe_2O_4$ and their surface modification by surfactant adsorption, *Bull. Korean Chem. Soc.*, 27(2): 237-242.

تحضير وتشخيص دقائق Fe_3O_4 النانوية متعددة الاشكال بطريقة المذيب – الهيدروحرارية بواسطة اشعة الميكروويف

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الخلاصة:

حضرت دقائق Fe_3O_4 النانوية من مختلف الأحجام والأشكال بطريقة المذيب-هيدروحرارية بواسطة إشعاع الميكروويف باستخدام كبريتات الأمونيوم الحديد كمصدر للفلز، وحامض الأوليك كعامل مشتت، والإيثانول كعامل مختزل وهيدروكسيد الصوديوم كعامل ترسيب في دالة الحموضة = 12. شخصت دقائق Fe_3O_4 النانوية من حيود الأشعة السينية (XRD)، تحليل الاشعة تحت الحمراءوالتحاليل الحرارية (TG-DTG). شخصت الحجوم والأشكال للدقائق النانوية Fe_3O_4 بواسطة المجهر الإلكتروني الماسح (SEM)، ومجهر القوة الذرية (AFM).

الكلمات المفتاحية: مغناتايت، ميكروويف، حامض الأوليك،SEM، AFM.