Synthesis of Fe3O4 nanoparticles from Ferric Nitrate by Sol-Gel Method

تخليق جزئيات النانونية
لأكسيد الحديد المغناطيسي "Fe3O4"
من نترات الحديديك بواسطة طريقة محلول - غروي

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Abstract :

Fe_3O_4 nanoparticles were synthesized from Ferric Nitrate by Sol-Gel method with annealing under vacuum. The phase structures, morphologies, particle sizes, chemical composition, and magnetic properties of Fe_3O_4 nanoparticles were characterized by TEM ,U.V and XRD . The results indicated that the size, the corresponding saturation magnetization value and coercivity value of Fe_3O_4 nanoparticles increase with the increase of temperature . Fe_3O_4 nanoparticles was studied under different atmospheres and temperatures.

Keywords: Ferric Nitrate , Fe_3O_4 nanoparticles , properties and characterization.

الملخص :

خلقت جزيئات النانونية لأكسيد الحديد المغناطيسي من نترات الحديدك بواسطة محلول -غروي مع درجة الحرارة العالية وتحت ضغط. التراكيب الطوري، المرفولوجيات والاحجام الجزئية تركيب الكيميائي ، الصفات المغناطيسية من جزئيات النانونية الأكسيد الحديد المغناطيسي " Fe_3O_4"دراسة التحاليل بواسطة اجهزة TEM, XRD and U.V. والنتائج تشير إلى الحجم والقيم المغناطيسية لمواضع الارتباط والقيم الحساسة بزيادة جزيئات النانونية لأكسيد الحديد المغناطيسي " Fe_3O_4" مع زيادة درجة الحرارة . جزيئات النانونية لأكسيد الحديد المغناطيسي " Fe_3O_4" درست تحت درجات حرارة مختلفة وتحت ضغط .

الأشياء الرئيسية: نترات الحديديك ، جزئيات النانونية لاكسيد المغناطيسي" Fe_3O_4" والخواص و التحاليل.

Introduction :

In the past decade, a variety of methods have been developed to form highly structure-controlled materials of functionalized metals, semiconductors and copolymer nanoparticles on the nano- or microscale. As a versatile kind of material, magnetite has attracted much attention in recent years.

Ferrite iron (Fe_3O_4) is a traditional magnetic material used in magnetic storage media, solar energy transformation, electronics, ferrofluids, biomedicine and catalysis [1-4]. During the last decade, significant research has been done in the field of nanosized magnetic particles, due to their potential for biomedical applications, such as improving the quality of Magnetic Resonance Imaging (MRI) , and drug delivery systems [5 – 6].

Fe_3O_4 nanoparticles have been the subject of intense interest because of their potential applications in several advance technological areas due to their promising physical and chemical properties. Generally, these properties depend on the size and structure of particles . Fe_3O_4 nanoparticles find wide applications in the field of biomedical, as anticancer agent and corrosion protective pigments in paints and coatings [7- 9]. The magnetic atoms or ions in such solid materials are arranged in a periodic lattice and their magnetic moments collectively interact through molecular exchange fields, which give rise to a long-range magnetic ordering.

Among all iron oxide nanoparticles, Fe_3O_4 represent the most interesting properties due to of its unique structure i.e. the presence of iron cations in two valence states, Fe^{2+} , Fe^{3+} on tetrahedral and octahedral sites with an inverse cubic spinel structure. The coercivity and remenance values for the super paramagnetic nano Fe3O4 nanoparticles have been found to be zero by the earlier reported methods [10-13]. Presently, cell labelling strategies find application of superparamagnetic ferrite either through conjugating the magnetic nanoparticles to the cellular surface of the stem cell or by internalization of the particles into the cell. Superparamagnetic ferrite can work in both of these ways, since the potential to manipulate their surface chemistry is plentiful and their sizes along with other attributes promote their successful uptake into cells. The superparamagnetic nano ferrites also interface well with MRI technology.

The use of superparamagnetic particles play a crucial role in the diagnostic imaging modality technique finds application in the study of stem cell [14-15].

In this paper Fe_3O_4 nanoparticles were synthesized by heating to 40^0C at 2 hours and at 80^0C for 2 hours to obtained Sol Gel followed by drying for 6 hours at 120 ^{0}C and then annealing at 200^0C and 400^0C in oven under vacuum to obtain Fe_3O_4 powder .

Experimental Materials :

Ferric nitrate ($Fe(NO_3)_3.9\ H_2O$) and ethylene glycol (C2H6O2) of analytical grade were obtained from Sinopharm Chemical Reagent Co ,Ltd ,China. The reagents were used without further purification.

Physical parameters of Ferric nitrate ($Fe(NO_3)_3.\ 9\ H_2O$) and Glycol (C2H6O2) are reported in table 1 and 2 respectively.

Table 1. General Characteristics of Ferric nitrate ($Fe(NO_3)_3.\ 9\ H_2O$)

Molecular formula	Ferric nitrate ($Fe(NO_3)_3.\ 9\ H_2O$)$\geq$ 98.5 %
Appearance	White Powder
Molecular weight	404
Company	Sinopharm chemical reagent Co ,Ltd ,China

Table 2. General Characteristics of Ethylene Glycol (C2H6O2)

Molecular formula	Ethylene Glycol (C2H6O2) $\geq$ 99 %
Appearance	liquid
Molecular weight	62.07
density	1.111- 1.115
Company	Sinopharm chemical reagent Co ,Ltd ,China

Preparation of Magnetite Nanoparticles :

The procedure of synthesizing magnetite nanoparticles [16-19]is described as follows:

20.2 gram ferric nitrate was first dissolved in 25 mL ethylene glycol with vigorous stirring speed 500r.p.m in 100 mL three necked flask glass with out cover for 2 hours at 40 ^{0}C, and then the solution was heated to 80 ^{0}C and kept at the temperature to obtain brown gel. The gel was obtained after 2 hours and then dried at 120 ^{0}C for about 4 hours in petri dish . After drying, the xerogel was annealed at temperature range 200 and 400 ^{0}C under vacuum. Finally, different size magnetite nanoparticles were obtained.

Transmission Electron Microscope (TEM) Test :

For TEM Test , a small amount of sample was dissolved in 3mL of deionized water in test tube and the solution was stirred by ultra-sonication . Then 10 µ L sample was transferred to clean Copper Grid and kept for drying for TEM test. The TEM micrographs of samples were observed by CM 12 Philips Transmission Electron Microscope .

Results and Discussion :

Plate 1,2,3 ,4,5,6 ,7 and 8 (TEM) at at 200 0C and plate 9,10,11,12,13,14,15,16,17,18 and 19 (TEM) at at 400 0C shows the top-view TEM images of the Fe3O4 Nanoparticle plate (TEM) 1 The size of the Fe3O4 nanoparticle is clear from the TEM. The surface of Fe3O4 nanoparticle shows several large meandering wrinkles. The size of Fe3O4 nanoparticle can be clear from TEM image . Fig (1 and 2) X-ray diffraction shown the graph all of Magnetite and Fe3O4 nanoparticle. Fig (3and 4) U.V shown the graph all of Magnetite and Fe3O4 nanoparticle respectively dispersed in chloroform.

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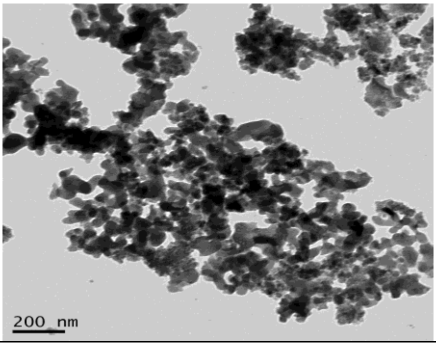


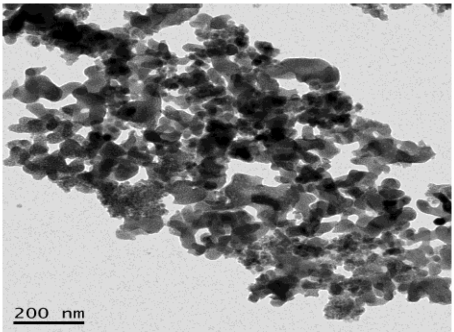
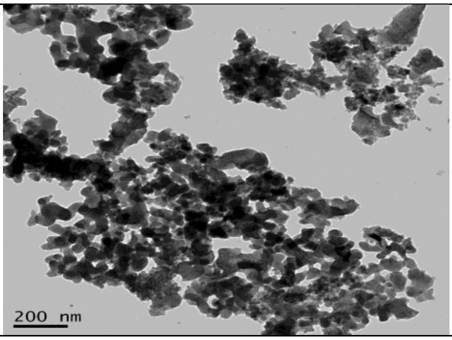


Plate1: Fe_3O_4 200 ^0C	Plate2: Fe_3O_4 200 ^0C



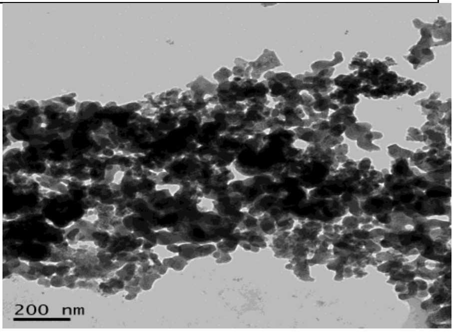


Plate3: Fe_3O_4 200 ^0C	Plate4: Fe_3O_4 200 ^0C

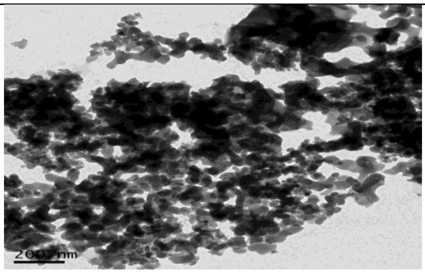


Plate 5: Fe_3O_4 200 ^0C

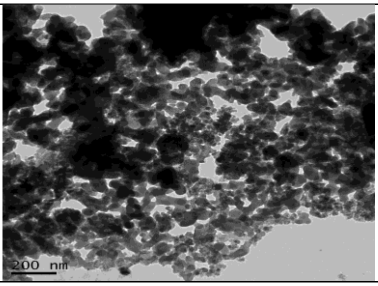


Plate 6: Fe_3O_4 200 ^0C

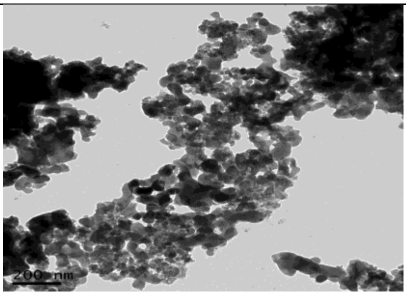


Plate 7: Fe_3O_4 200 ^0C

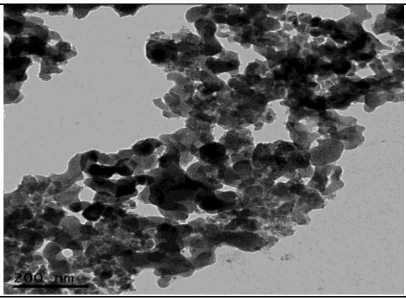


Plate 8: Fe_3O_4 200 ^0C

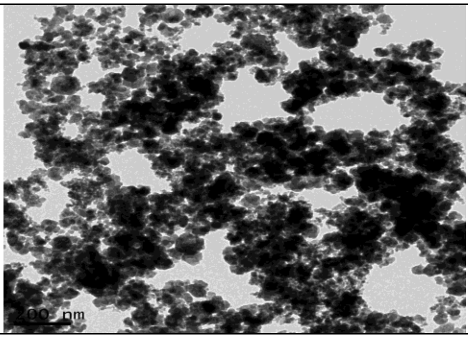


Plate 9: Fe_3O_4 400 ^0C

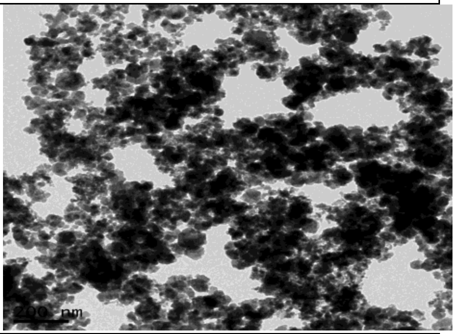


Plate 10: Fe_3O_4 400 ^0C

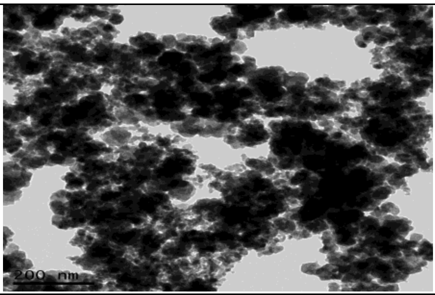


Plate 11: Fe_3O_4 400 ^0C

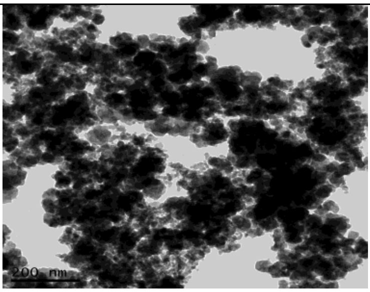


Plate 12: Fe_3O_4 400 ^0C

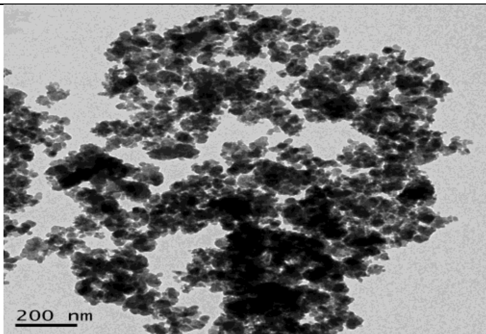


Plate 13: Fe_3O_4 400 ^{0}C

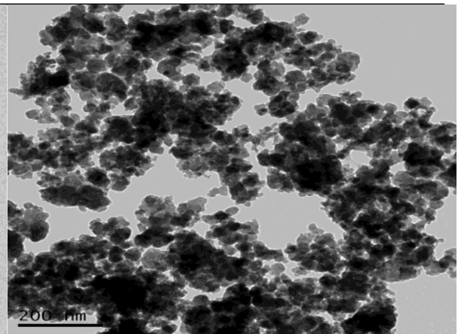


Plate 14: Fe_3O_4 400 ^{0}C

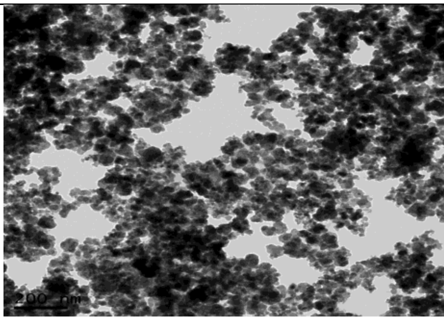


Plate 15: Fe_3O_4 400 ^{0}C

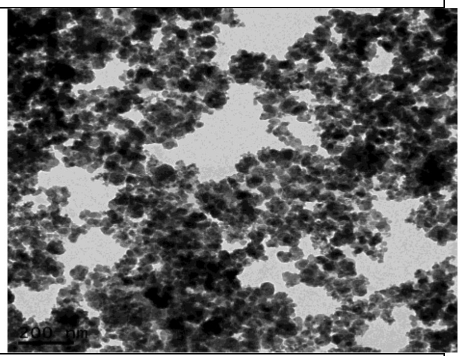


Plate 16: Fe_3O_4 400 ^{0}C

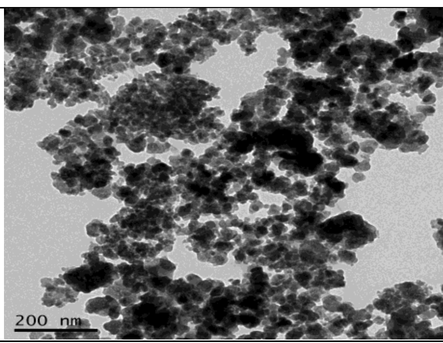


Plate 17: Fe_3O_4 400 ^{0}C

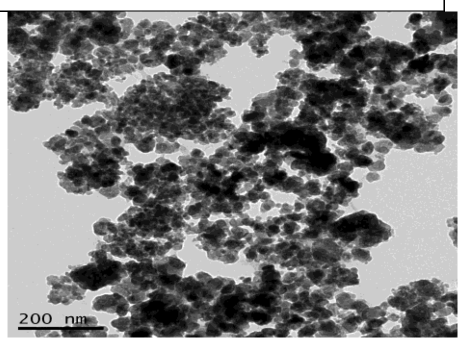


Plate 18: Fe_3O_4 400 ^{0}C

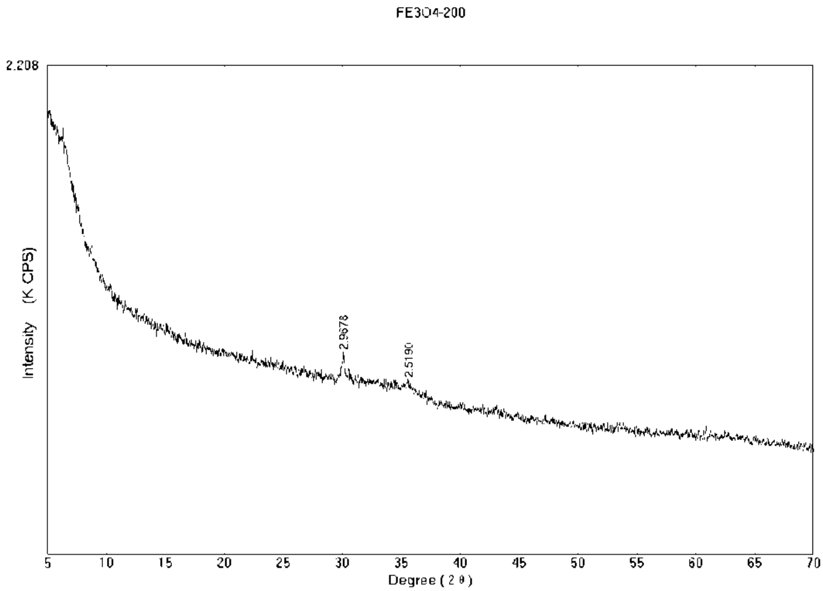


Fig .1: XRD for Fe_3O_4 Nanoparticle at 200 ^0C

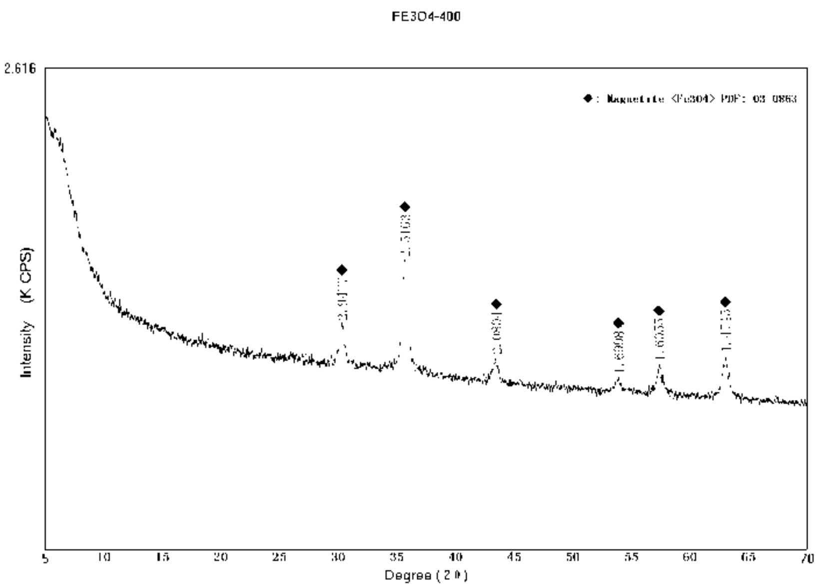


Fig .2: XRD for Fe_3O_4 Nanoparticle at 400 ^0C

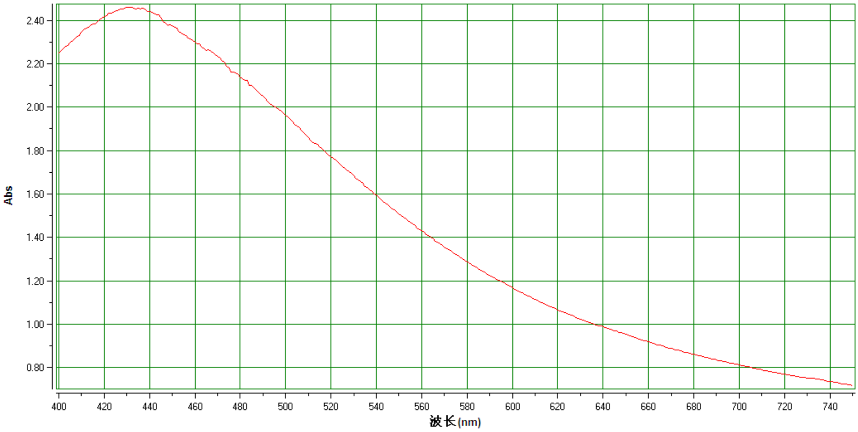


Fig.3 : U.V of Fe_3O_4 200 ^0C

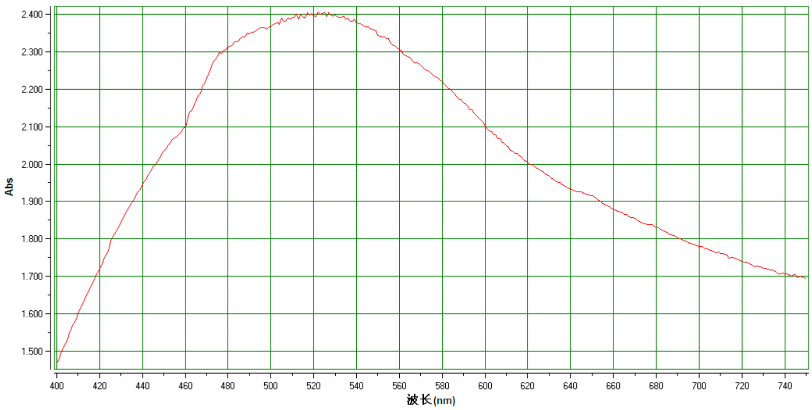


Fig. 4 : U.V of Fe_3O_4 400 ^0C