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Research Article

Ayurvedic synthesis of γ-Fe_2O_3 nanoparticles and its Characterization

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Abstract

Ayurveda has great importance in the synthesis of Bhasma (ash), as the procedure involved is cost effective, on toxic and eco-friendly. This paper outlines the novel and modern process is used to synthesize iron oxide nanoparticles (Lauha bhasma) with successive purification steps using herbal ingredients. The synthesized samples were characterized using X-ray diffraction, Vibrating Sample Magnetometer, Particle Size Analyzer and Transmission Electron Microscopy to identify how the purification steps influenced the structural, magnetic, morphology properties of iron oxide nanoparticles. From X-ray diffraction it was observed iron oxide nanoparticles have cubic structure. VSM studies also confirmed the same as XRD studies with well-defined loss of hysteresis loop of a coercive field and the remnant magnetization. The synthesized sample exhibit super paramagnetization at room temperature.

Keyword: *Ayurveda, Lauha bhasma, iron oxide nanoparticles, X-ray diffraction, Vibrating Sample Magnetometer, TEM.*

Introduction

There are many methods for the synthesis of iron oxide nanoparticles like sol-gel method, solution combustion method, co-precipitation method etc., which involves chemicals, environmental toxic. But the synthesis in ayurvedic method involves herbal products that are nontoxic, environmental friendly and rapid procedure. Many reviewers have gone through the procedure but usage of modern equipment like muffle furnace etc., is seen in the present process. Ayurvedic bhasma is the oldest form of Nanotechnology. It is a scientific process in which metal is transformed into therapeutically active form using herbal ingredients it is called as nano medicine for various chronic diseases. The electrical, optical, thermal, inorganic, chemical and biological behavior of nano particles gets changed due to basic character got changed i.e., from metal to nano. Gamma Iron Oxide Nano particles-Maghemite is metastable phase between magnetite and hematite. Oxygen ions are cubic close packed with both octahedral and tetrahedral sites occupied by iron in the crystalline structure of maghemite (You Qiang *et al*, 2006). The main distinct feature of maghemite is the presence of vacancies in Fe sites paralleled with crystal symmetry loss. γ-Fe_2O_3 is n-type semiconductor material with very small band gap of 2.1 eV has numerous applications in medical fields like in drug delivery systems as nano carrier and applications in numerous fields: Coatings, lithium batteries, lithium iron phosphate batteries acts as targeted drug in wear-resistant materials. In this paper, firstly a speedy method for the synthesis of iron oxide nanoparticles by ayurvedic method was discussed. Secondly, various characterization techniques were performed to confirm the excellence of nanoparticles.

Materials and Method

Materials involved in the process were iron filings (precursor material), sesame oil (edible oil), butter milk, rice gruel solution, panchagavya (cow urine), horse gram decoction and triphala.

A modern synthesis involves six purification steps:

1. Iron turnings or iron fillings were taken as precursor material. In first purification step iron fillings were treated with sesame oil i.e., used to eliminate rust, greasy material.
2. In second purification step the material obtained from previous step was quenched with buttermilk that removes impurities and oil content embedded.
3. In third purification step the material obtained from earlier step was treated with rice gruel solution, panchagavya (cowurine) and Horse gram decoction. Importance of rice gruel solution is that it contains phytic acid, removes Fe^{3+} ions. panchagavya (cow urine) acts as antibacterial agent. Horse gram decoction contains Gallic acid removes Fe^{3+}ions get reduced to Fe^{2+}ions. (Balaji Krishnamachary *et al*, 2012; Singh Neetu *et al*, 2010).

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4. This state enters mucosal cells easily into the body. These three steps were considered as normal purification steps involves aging for half an hour repeat the process for seven times and heat treated at 530^0C-560^0C.
5. In fourth purification step the material obtained from prior step was treated with triphala decoction constitutes Phyllanthus emblica, Terminalia chebula and Terminalia bellerica plays a major role in the synthesis acts as blood cleansing agent.
6. In fifth purification step the material attained from earlier step was exposed under sunlight, contamination get removed.
7. In concluding purification step the material from prior step was heat treated at 95^0C-100^0C by addition of triphala decoction. These three steps were considered as special purification steps involve aging the ingredients for half an hour repeat the process for seven times. Reason behind consecutive repetitive steps was removal of impurities and to obtain better results. The final product obtained is Lauha bhasma (iron ash).

Characterization Techniques

The average crystallite size, structure and lattice parameters were measured by Bruker D8 X-ray diffractometer using Cukα-radiation (λ=0.154 nm). Size and magnetic property of the samples were observed by Lakeshore, Model number 7410.The average particle size is obtained by HORIBA SZ-100 Particle Size Analyzer. The morphology of the nanoparticles was observed by JEM-100 CXII Transmission electron microscope.

Result and Discussion

XRD Diffraction analysis

Figure 1a, 1b, 1c, 1d, 1e and **1f** show the procedure of the proposed structure of the γ-Fe_2O_3 nano particles. The crystallite size of iron oxide nanoparticles was calculated from full width at half maxima (FWHM) of the peaks using the Scherrer formula (B.D Cullity *et al*, 1978).

$$D = \frac{0.9\lambda}{\beta Cos\theta} \quad (1)$$

Here D is the average crystallite size perpendicular to its reflecting planes. β is the full width at half maximum (FWHM) of the XRD all peaks. λ is the wave length of the X-ray.θ is the Bragg's angle. Using Scherrer formula the average crystallite size of the final Lauha bhasma is 25 nm. **Figure 2** specifies the final product Lauha bhasma indicating γ-phase of Fe_2O_3 compared with the standard JCPDS data (card no.39-1346) containing hkl planes at (2 2 0), (3 1 0), (3 1 1), (4 0 0), (4 2 1), (4 3 0), (5 1 1), (4 4 0)(Ruipeng Fu *et al*,2008).It indicates the cubic system with lattice parameters a=8.351.Formation of γ-Fe_2O_3indicatesthat we have obtained the desired results. Fe^{2+} ions produced were used as medicine for the treatment of anemic.

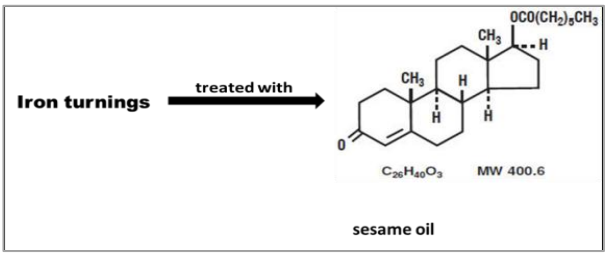


Figure 1a: Step 1 preparation

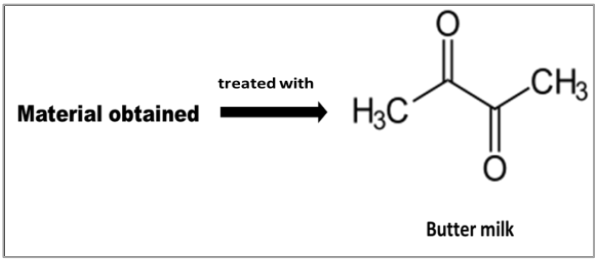


Figure 1b: Step 2 preparation

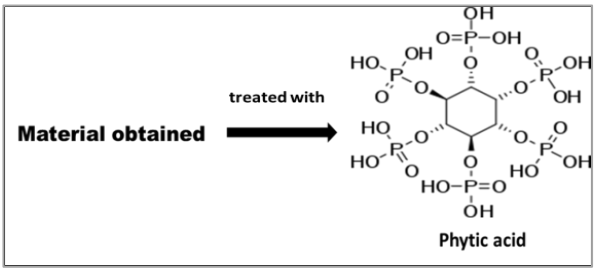


Figure 1c: Step 3 preparation and continues

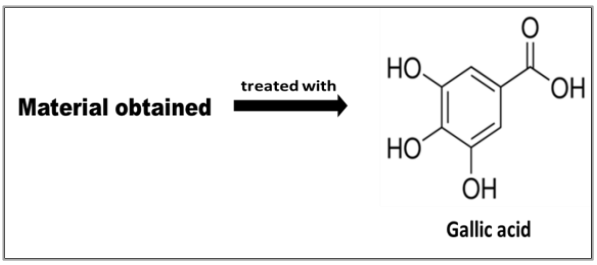


Figure 1d: Step 3 preparation

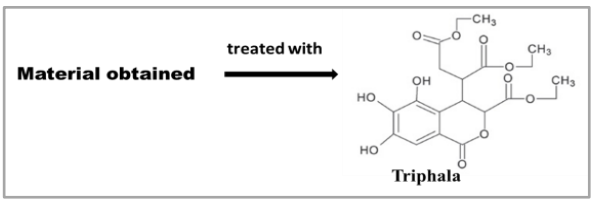


Figure 1e: Step 4 preparation

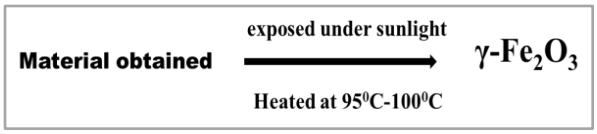


Figure 1f: Step 5 preparation

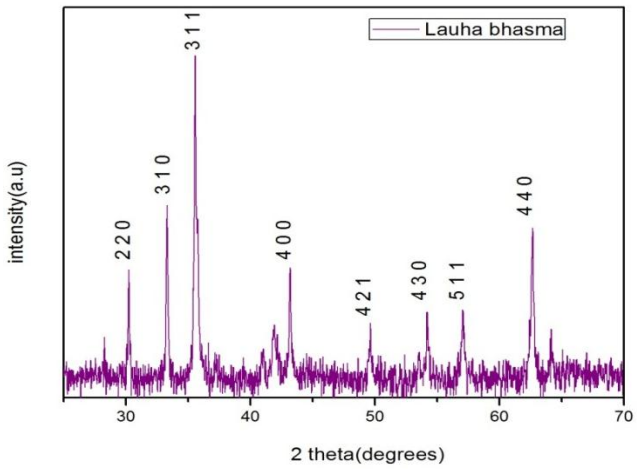
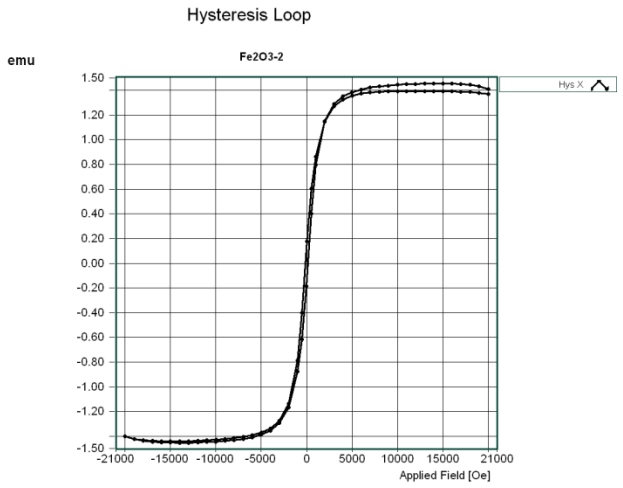


Figure 2: XRD spectrum of iron oxide nanoparticles (Lauha bhasma)

Vibrating Sample Magnetometer (VSM)

At room temperature magnetization (M) vs. applied field (H) study was performed to monitor the magnetic behavior of iron oxide nanoparticles. From **Figure 3** there is hysteresis loss observed with a coercive field (HC) of 152.59 Oe, saturation magnetization of 45.186 emu/g and remnant magnetization of 5.555 emu/g for the final sample of Lauha bhasma. Thus the sample is exhibiting super paramagnetic behavior.



Parameters

	Upward Part	Downward part	Average	Parameter 'definition'
Hysteresis Loop				Hysteresis Parameters
Hc Oe	154.301	-150.879	152.590	Coercive Field: Field at which M/H changes sign
Ms emu	1.457E+0	-1.454E+0	1.455E+0	Saturation Magnetization: maximum M measured
Mr emu	-1.822E-1	1.755E-1	1.789E-1	Remanent Magnetization: M at H=0
S	0.125	0.121	0.123	Squareness: Mr/Ms
S*	0.014	0.095	0.054	1-(Mr/Hc)(1/slope at Hc)

Figure 3: M-H loop showing hysteresis of Lauha bhasma

Particle Size Analyzer (PSA)

The as prepared iron oxide nano particles were ultra-stably suspended in the solution (0.05 gm of iron oxide nano particles in 10 ml of ethanol). The histogram of the particle size of final Lauha bhasma is observed in **Figure 4.** The scattering angle of the beam is 90°. Average Particle size observed from histogram is 30 nm. It is in good agreement with the crystallite size calculated from XRD pattern.

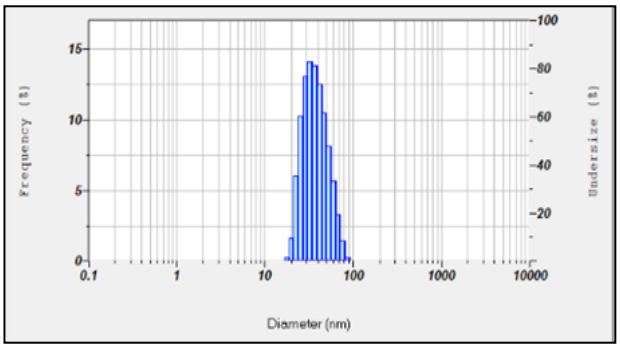


Figure 4: Particle analyzer histogram of Lauha bhasma

Transmission Electron Microscopy (TEM)

Dimension and morphology of nanoparticles could be analyzed best from TEM. **Figure 5**represents TEM image of iron oxide nanoparticles synthesized through modern route. In micrograph the particles were well distributed. By calculating crystal structure at 100 nm scale, 27nm were obtained which is in good agreement with X-Ray Diffraction results. It was observed that the morphology of γ-Fe_2O_3 was cubic with smooth surface (Mohammad Kooti *et al*, 2011).

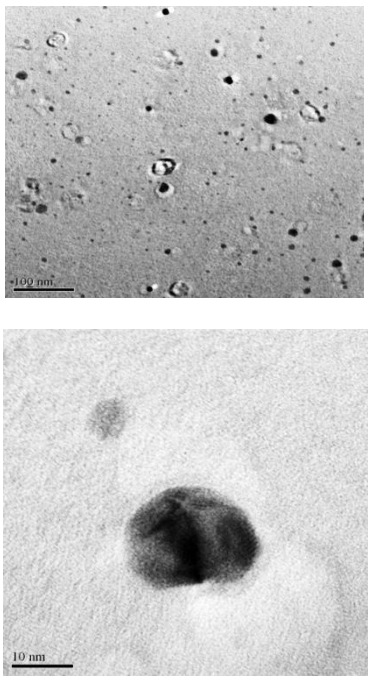


Figure 5: TEM micrographs of Iron oxide nanoparticles

Conclusion

The modern method of synthesizing Lauha bhasma (iron oxide nano particles) was successful, which was observed from XRD. By undergoing normal and special purifications the sample was tuned into fine nano particles. We have investigated structural and magnetic properties. X-ray diffraction was used to indicate the face-centered cubic structure for iron oxide nano particles, which is good agreement with particle size analyzer and TEM result. VSM indicates super paramagnetic behavior of the sample.

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