Nanotechnological Applications of Iron Oxide Nanoparticles (IONPs) and its correlation with Structural and Magnetic Properties

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ABSTRACT *Utilizing XRD, TEM and Magnetic Measurement methods, Nano-sized metal-oxide, including Fe_2O_3, are synthesized by precipitation process. XRD experiments indicate that Fe_3O_4 is shaped as α-Fe_2O_3, rather than if typically formulated magnetite ferro Nano-particles ie Fe_3O_4 or a combination of magnetite Fe_3O_4 and maghe-mite (γ-Fe_2O_3, cubic) which have a rhombohedra shape. Magnetic experiments found that Fe_2O_3, have five isolated electrons, hence it is paramagnetic. TEM has evaluated synthesize Fe_2O_3, particle size. TEM photos reveal that scale of Fe_2O_3, particles ranged between 15-42 nm which is in strong alignment with the currently expected Nano-material scale as compared with the established methods of Nano-material synthesis.*

Keywords: *Nano-material, iron-oxide, TEM, metal oxides, XRD analysis*

1. Introduction:

Transitional metal oxides uses are multiple including catalysts [Xu et al., 2003; Wei-zhong et al]. Iron oxides are among very common minerals which have a broad diversity of stoichiometries, textures, and other properties, a few important of these are FeO (wustite), γ- Fe_2O_3 (maghemite), - Fe_2O_3 (hematite), and Fe_3O_4 (magnetite) consisting of rock-salt, vacancy-rich reverse spinel systems, respectively; two former spinel systems are thermodynamically less suitable and more oxidized are - Fe_2O_3. Ferro oxides support for catalysts and are generally used as catalysts in industry. Metal-oxides are an significant class of materials used in study of the climate, electrochemistry, physiology, chemical sensors, magnetism and different other areas, an important use is heterogeneous catalysis, which is based on mixed magnetic oxides (MO- Fe_2O_3; M: Fe, Co, Cu, Mn) have been used to de-colorate many synthetic colors such as Bromo-phenol violet, Cu-phthalo-cyanin, Eosin yellowish, Evans-blue, Chicago sky-blue, Naphthol blue-black, phenol-purple, poly B-411, and reactive Orange 16. Both the catalysts are able to decompose H_2O_2 producing strongly reactive hydroxyl radicals and decolorize the synthetic coloring. The powerful (most) FeO- Fe_2O_3 catalyst (25 mg mL-1 with 100 mmolL-1 H_2O_2) develops 50 mg L-1.bromophenol blue decoloration of more than 90 per cent; Chicago sky brown, blue and black naphthol evaporates within 24 hours [Baldrin et al, 2006]. Aluminum stabilizes copper and iron mixed metal-oxide acts as active catalyst for benzene nitration during solid-liquid phase reaction, utilizing 69 per cent nitric acid as a nitrating agent, during reaction of nitro benzene [Chaubal & Sawant, 2006] carried out with 100 per cent selectivity. Gold catalysts assisted with titanium-and iron oxide are used for propyne hydrogenation [Lopez-Sanchez & David 2005], for catalytic dehydration of ethanol [Zaki 2005], Fe_2O_3, Mn_2O_3, and calcined physical mixtures of both ferric and manganese oxides with alumina and silica gel were used. The catalytic activity of catalysts dependent on the toluene amm-oxidation reaction [Rombi, et al., 2004] has been studied. Hydroxide from iron (III) was used to photo-oxidize 2-aminophenol in aqueous solution [Andreozzi et al., 2003]. The partial oxidation of propane to formaldehyde was conducted using uranium mixed oxide catalysts. Outstanding findings were reported for selective oxidation of propene and propane to formaldehyde using Fe / U catalysts [Taylor, et al, 2003], metal oxide containing activated carbon catalyst has achieved an effective and selective acylation of alcohols and amines utilizing carboxylic acids as acylating agents, the catalyst has been synthesized by carbonization of organic ion exchangers after the integration of Fe3 + ions with exchangeable resin cat-ions [Sreedhar et al., 2003]. Ethyl-benzene dehydrogenation was tested using Potassium-fostered Iron Oxide as a catalyst [Kettle et al., 2002]. [Bandara et al., 2001] documented sensitized photo-catalytic degradation of mono-, di- and tri-chlorophenols with aqueous suspensions of — Fe_2O_3 and —FeOOH. In the presence and absence of tetra-chloro methane at 723K [Sugiyama, et al., 2001], the oxidative dehydrogenation of propane on certain— Fe_2O_3 was achieved, The reactions of penta-methylene and hexa-methylene glycol to intra-molecular condensation over iron oxide is investigated [Grabowska et al., 2000]. Catalysts made up of iron oxide aided by sodium-promoted silica gel have been used to catalyze propene's gas phase ep-oxidation by

nitrous oxide. Selectivity of 40–60% propene oxide was reported at 6–12% propene conversions [Duma & V 2000]. such as iron oxide and silica, during the vapor process over nickel oxide [Dumaa et al., 2004]. Fine aero-gels dependent on particulate iron oxide were used as a mechanism for partial methanol oxidation [Wang & Willey 1999]. Benzoic acid oxidation was investigated using a Fenton-like reaction utilizing an inventive catalyst assisted by [Chou & Chihpin 1999]. Iron oxide and iron carbide acted as a trigger for tertiary alcohol degradation [Wang & Davis 1999]. An iron oxide / hydroxide catalyst [Lauwiner et al., 1999] was used to selectively minimize nitro groups in aromatic azo compounds. Reduction of aromatic nitro compounds with hydrazine hydrate has also been examined in presence of an iron oxide hydroxide catalyst [Benz et al., 1998]. Decoloration by mixed iron oxides in organic dyes by hydrogen peroxide with heterogeneous catalysis [Baldrian et al., 2006]; Owing to their peculiar magnetic properties (super-paramagnetism, strong manipulation, low curie temperature, nano-sized iron oxides-moderate magnetic resistance, non-toxicity, biocompatibility and low development costs enabling their use in diverse nanotechnology applications in large variety of areas. Often essential in biomedical applications are magnetic nano-particles, such as magnetic bio-separation [Miller and Orgel 1974], magnetic target drug delivery [Paecht et al., 1970], hyperthermia [Wang et al., 2011], magnetic resonance imaging [Chomoucka et al., 2010], magneto-fection [Kumar & Mohammad, 2011]. Because of their super-paramagnetic properties, strong target area and large option of surface functionalization these particles have the potential to communicate with various biological molecules in different ways. Within this paper we have synthesized nano-particles from α-Fe_2O_3 by utilizing ammonia as a precipitating agent through clear aqueous precipitation. This method involves the synthesis of Fe_2O_3 nanao-particles in a simple, inexpensive, and one step operation. Fe_2O_3 particles collected have scale varying from 60-100 nm. The synthesized nano-particles had XRD, magnetic resistance and TEM

2. Methods and Chemicals

2.1 Chemicals:

Both compounds used in analysis are in the category of analytical reagents bought from Merck, India, ferric nitrate $Fe_2(NO_3)_2$, which produce ammonium hydroxide (liquor ammonia) from SRL. The whole procedure used dionized water.

2.2 Synthesis:

500 ml of 0.1 $MFe_2(NO_3)_2$ solution is taken and aqueous ammonia applied with reducing and stirring continuously before the solution pH exceeded 10. Buckner funnel drained the precipitates thus collected, which was sprayed with purified water multiple times, precipitates are dried for 24 hours in oven at 70 ° C and calcined for 5 hours in a muffle furnace at 500 ° C. The substance collected was ground and sheathed via a sieve of 100 mesh thickness.

2.3 Equipments:

The X-ray diffraction powder (XRD) was conducted using the Philips PW 11/90 X-ray diffractometer method, with CuKα (l= 1.5405 Å) diluted nickel radiation. Magnetic tests were conducted using Model 155 Magnetometer vibrating instrument, TEM is conducted under 200KV with the Tecnai 20G2.

Results and Analysis:

3.1. X-ray studies:

Figure (1) demonstrates X-ray diffraction of the synthesized oxide, clear iron oxide X-ray diffraction pattern suggested iron oxide in form of α-Fe_2O_3 [Fig-1]. Several influential peaks are found in X-ray diffraction, and corresponding d-values are contrasted with [JCPDS file No. 85-0987] [Table-1] norm, X-ray diffraction reveals that metal oxide is pure α-rhombohedra-structured Fe_2O_3. Particle thickness is also measured using Shehreer method and determined as 28 - 49 nm which is in strong alignment with nano-sized particle size (up to 100 nm)

3.2 Magnetic Measurements:

This measure for iron oxide is 5.68 B.M. which reflects the idea that iron oxide produced is 5.92B.M. in form with real magnetic moment, it means that Fe_2O_3 produces five unpaired electrons, the oxide produced is r paramagnetic. In the case of iron oxide magnetic experiments are conducted at temperatures varying from 300K to establish Morin transition value represented in Fig 2 and listed in Table 2.

3.3 TGA/ DTA studies:

Transition to TGA / DTA reveals that endothermic plateau at 3640^C [Fig.3], clarifies that when FeO (OH) is cooked, it takes up some energy and extracts 1.5 water molecules. So, iron oxide temperature above 3640C is required for forming.

3.4 Surface Area Measurement:

BET approach was used to assess the approximate surface region of metal oxides. The metal oxides had an region m2/g.

3.5 SEM/TEM studies

SEM / TEM experiments were performed to establish the morphology and exact size of the synthesized Fe_2O_3 particles. SEM / Tem photos reveal that Fe_2O_3 nano-particles have particle sizes ranging between 15 and 40 nm [Fig. 4 & Fig.5].

4. Conclusion:

α-Fe_2O_3 corundum-structured nano-particles are effectively synthesized using aqueous precipitation process. From the TEM test, particles are observed to be of an average size range 15-42 nm. Magnetic experiments reveal that Fe_2O_3 has five unpaired electrons in existence, and thus paramagnetic ones, studies with XRD indicate that iron oxide is shaped as α-Fe_2O_3 instead of the typically known Fe_3O_4 magnetite nano-particles or combination of magnetite and maghemite. This approach is beneficial over nano-particles synthesis approaches because other approaches involve sophisticated instrumentation, highly qualified workers, costly materials and processes. The proposed method of precipitation is therefore very interesting and could have broad applications for the production of nano-sized iron oxide particles.

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Declaration of Interest Statement

There has no potential conflict of interest.

Table 1

X-ray diffraction data for iron oxide (α - Fe_2O_3)

S. No.	d (A^0) (Observed)	d (A^0) (Reported)	I/I0 × 100 % (Observed)	I/I0 × 100 % (Reported)	t (nm)
1.	3.6806	3.6775	35.78	58.7	43.8
2.	2.6980	2.6959	100.00	100	44.7
3.	2.5155	2.5135	83.14	63.1	49.6
4.	2.2033	2.2015	24.03	3.4	31.1
5.	1.8394	1.8379	36.98	6.1	43.1
6.	1.6949	1.6936	43.26	18.0	43.9
7.	1.4852	1.4840	26.88	18.1	45.8
8.	1.4511	1.4512	26.77	9.7	28.3

Table 2

Magnetic susceptibility data of iron oxide

Temperature(K)	Volt(mV)	Magnetic moment(e.m.u.)
300	5.75	0.0050
290	5.58	0.0051
280	5.38	0.0052
270	5.17	0.0054
260	4.96	0.0055
250	4.75	0.0057
240	4.54	0.0060
230	4.33	0.0062
220	4.13	0.0056
200	3.71	0.0049
180	3.29	0.0045
160	2.88	0.0043
140	2.46	0.0042
120	2.05	0.0041
100	1.63	0.0040

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Cosmos Impact Factor 4.236

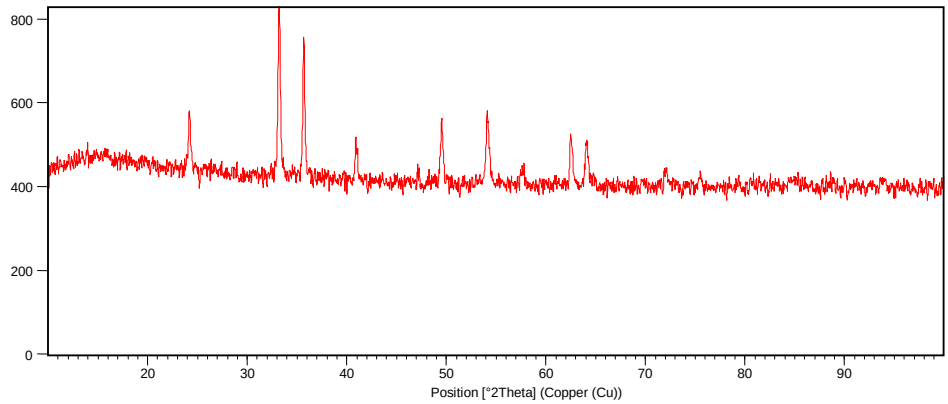


Fig.1- XRD spectra of synthesized iron oxide

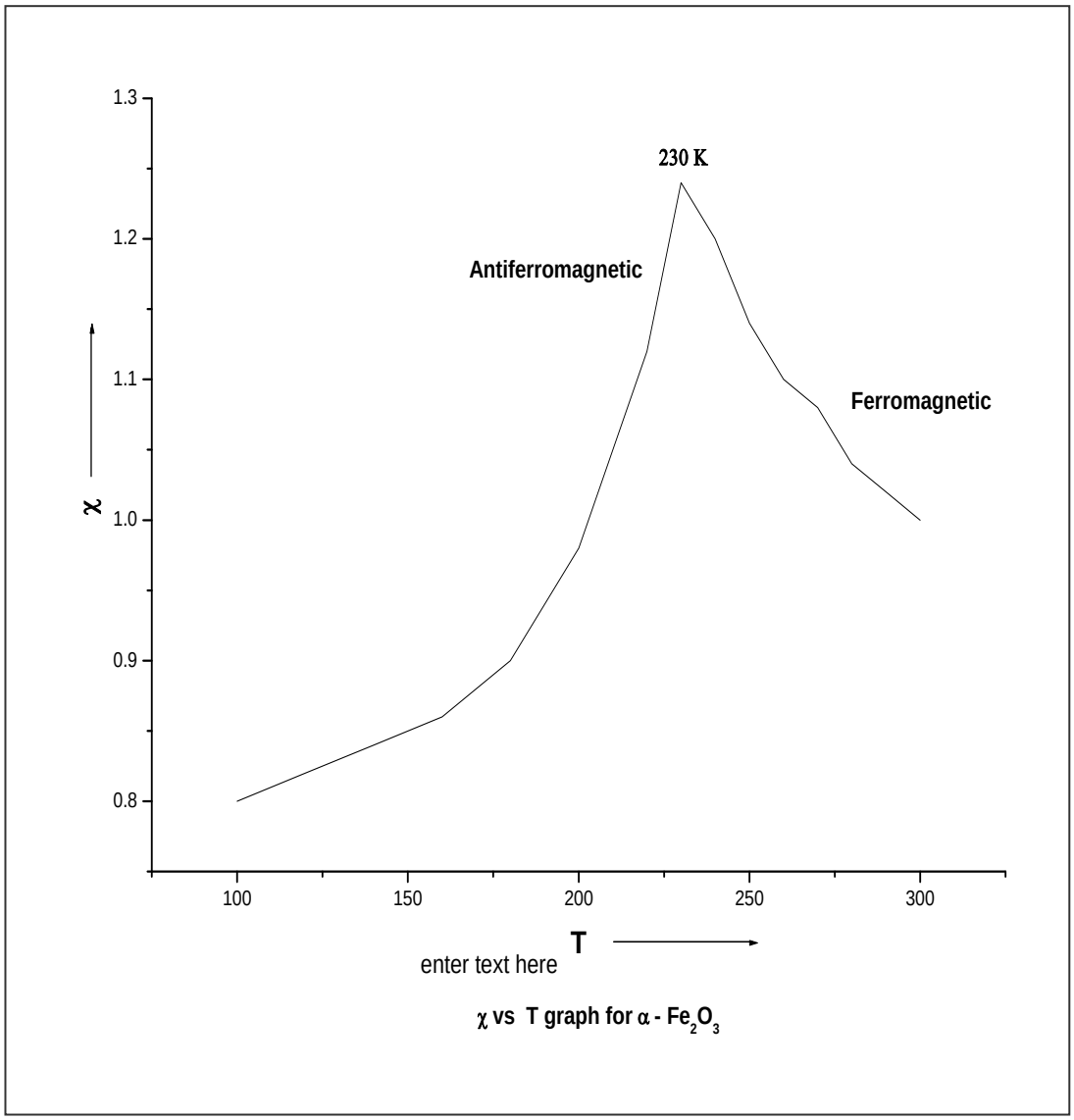


Fig.2- Magnetic measurements of synthesized iron oxide at different temperatures

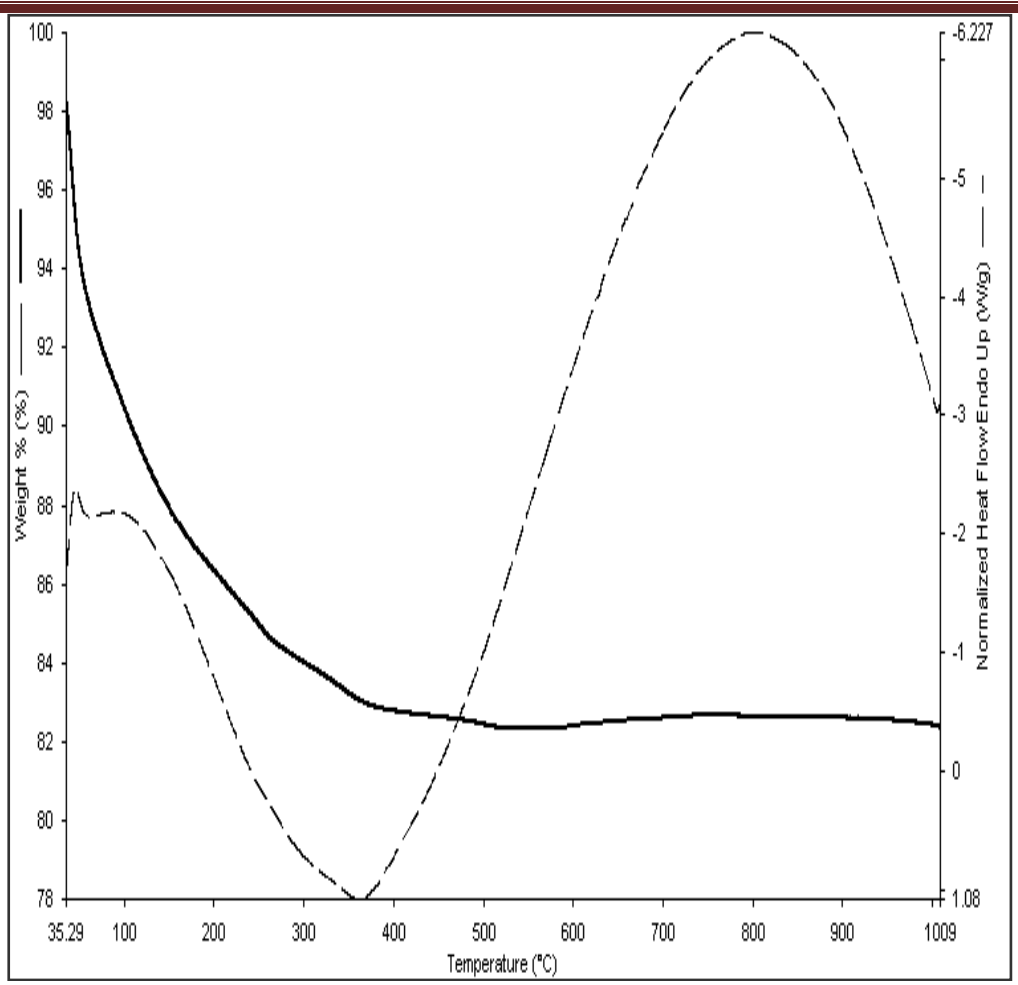
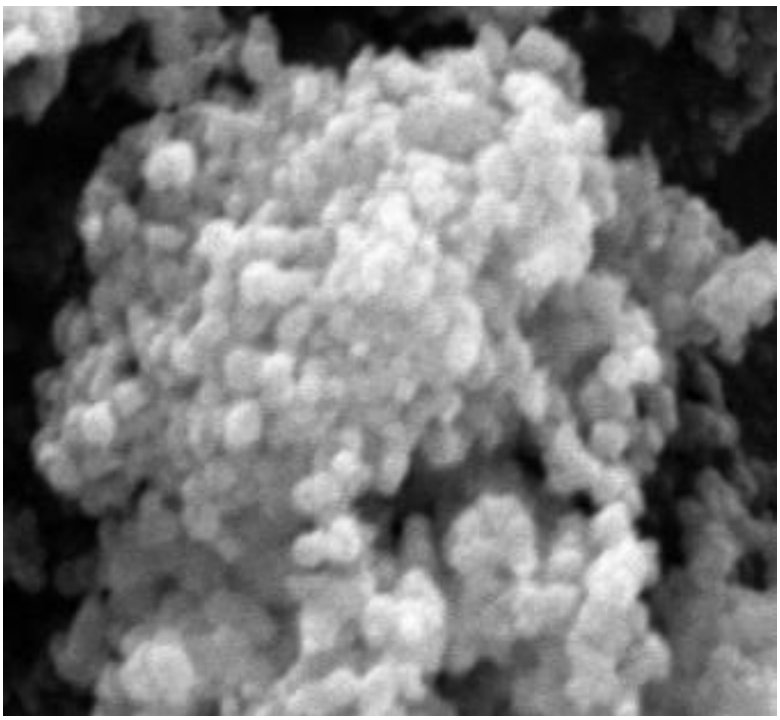
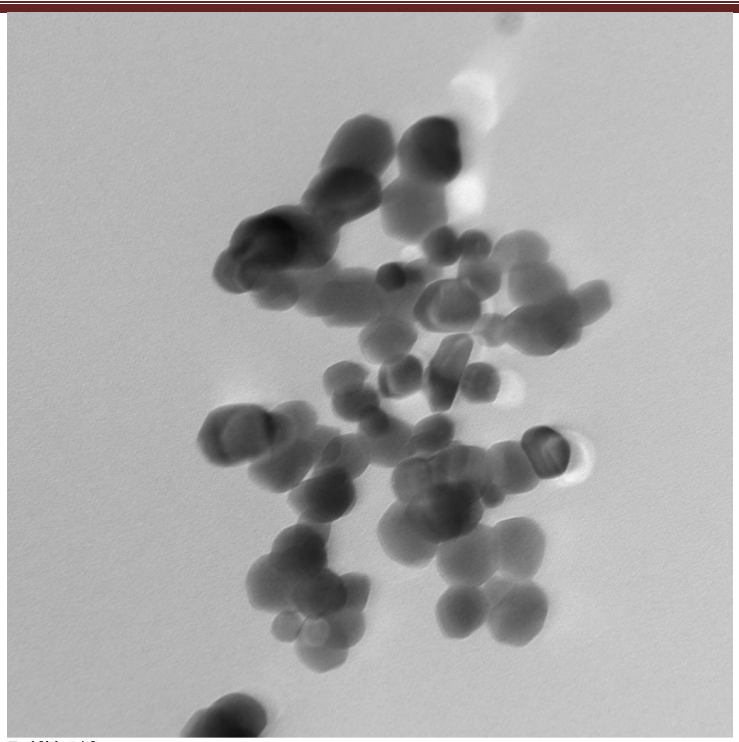


Fig.3. TGA/DTA curve of iron oxide heated at 70° C





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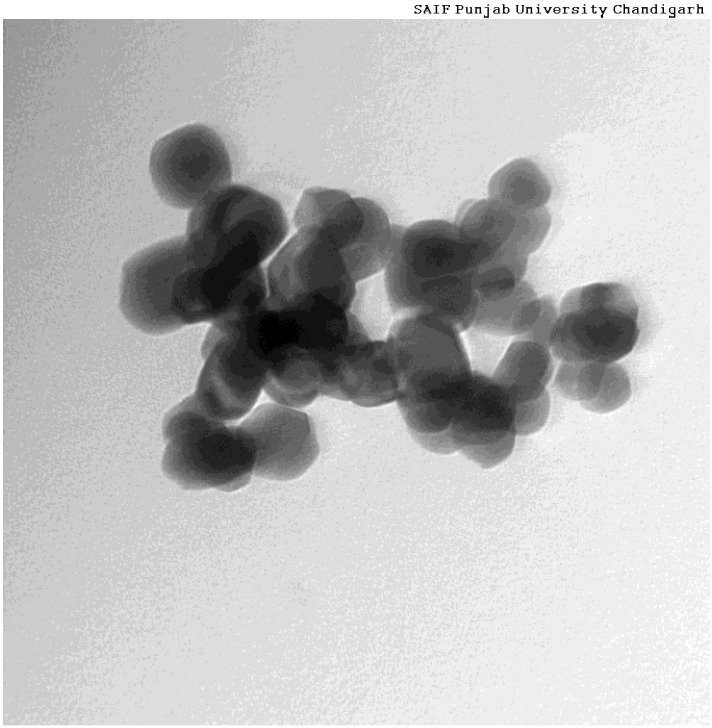

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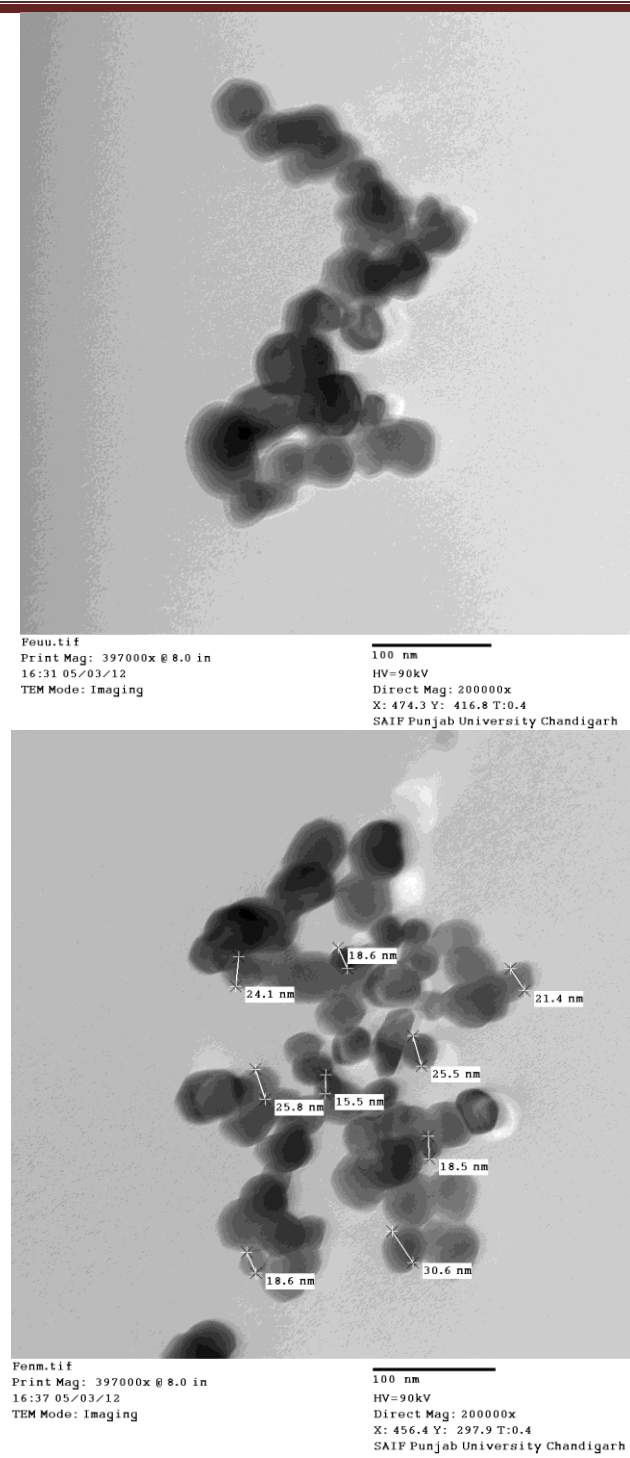

Figure 5: TEM images of iron oxide particles

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