The Properties of Mn-Zn Forrester Synthesis Using Nano Crystalline

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Abstract
Magnetic nano-materials are extensively studied because of their wide range of applications. The Mn-Znferrite is amongst the most important magnetic materials and has attracted a great interest in technology because f its use in memory or data storage devices, magnetic recordingheads, switches and other electromagnetic gadgets. Low temperature single phase nano crystalline $Mn_xZn_{(1-x)}Fe_2O_4$(x = 0.4, 0.5 and 0.6) were prepared by decomposition of precursor by sunlight. Stoichiometric amounts of manganese oxide, zinc oxide and ferric oxide are taken as starting materials. Mixture of these oxides were homogenized by using ball-mill and then treated with a ligand to produce a precursor. The samples obtained after the decomposition of precursor were characterized by frared spectral analysis (IR), X-ray diffraction (XRD) and atomic absorption spectroscopy (AAS). The lattice parameters increase with increase inMn content (8.4386-8.4552 A0). The particle size, determined by Scherer formula, is found to be in nano range between 17nm to 26nm. The saturation magnetization values are in the range 22.47emu /g - 41.63emu /g and hysteresis loss is found to be lowfor all the samples. TheCurie temperature (Tc) is in the range 473K –558.

Keywords
Nano Material, Magnetic Properties, Oxides, Sunlight, Self-Decomposition

I. Introduction

Magnetic iron oxide nanoparticles are of high interest duetotheir unique properties. Among them Mn–Znferrites are oneof the most widely used magnetic materials dueto their lowhysteresis loss and high saturation magnetization The applicationsof these versatile magnetic material ranges from actuators, electromagnetic gadgets, switches, sensors, transformers etc.[1] to biomedical applications [2-3]. Eventhough, it has many applicationsin various fieldsas bulkmaterial [4] as well as their new applications asnanoparticles [5], an increasein the demand for thevelopment of new synthesis routes for Mn–Znferrite nanoparticles, still exists and are exploredby different group ofresearchers. Therefore, the improvement and understandingof various new synthesis routes that allow the achievement of highly crystalline materialsis a constant need. Asreported in the literature by different researchers [6-7]. It isvery importantto have the accurate control of chemical composition and particle size distribution for the preparation of high quality Mn–Zn ferrite powders. The most common methodof producing Mn–Znferrite powdersin the large amount in industry is via the traditional ceramic technology,involving solid phase reactionsat high temperatures, of mixture of oxides [8-9], whichis often faced with difficultiesof providing high quality powders required for the high performance devices becauseof thepoorphase andcompositional control,in homogeneitiesin compound, aswell as of larger and wider particle size distributionsand impurities. Many novel and innovative wet-chemical methods are tried successfully in recent years to prepare high quality ultrafine powders or nanopowders, including the co-precipitation [10]-[11], hydrothermal process [12-13], sol–gel [14-15] and sol–gel auto-combustion [16-17]. In this study a novel method was tried in which solid oxides of manganese, zinc and iron were ball milled to obtain a homogenous mixture which was then treated with a igandhydraziniumacetate to obtain a precursor which was exposed to sunlight andon drying undergoes auto combustion- self decomposition- to give ultrafine Mn-Znferrite. 2.Experimental The stoichiometric amounts of pure 99.9% manganese dioxide (Sigma-Aldrich make), zinc oxide (Thomas Baker make) and ferric oxide (Thomas Baker make) was taken as starting materials. The mixture was then ball-milled with ball to material ratio of 10at 80rpm speed for 10hrsin Acmas Technocracy Ball Mill (model Acm - 8203)to obtain a powdered mixture. This mixture was then treated with calculated amount of aqueous hydrazinium acetate and homogenized to a thick paste. The resulting paste containing mixed metal oxides was exposed to sunlight as shown in the fig. 1 it dried slowly bythe sun rays. It was observed that, on drying the paste swells and undergoes auto combustion- self decomposition- to finely divided solid powder which was found to be magnetic in nature. The procedure was repeated for other samples and, the final product, in eachcase, was used for characterization as well as to study the structural, magnetic and electrical properties.

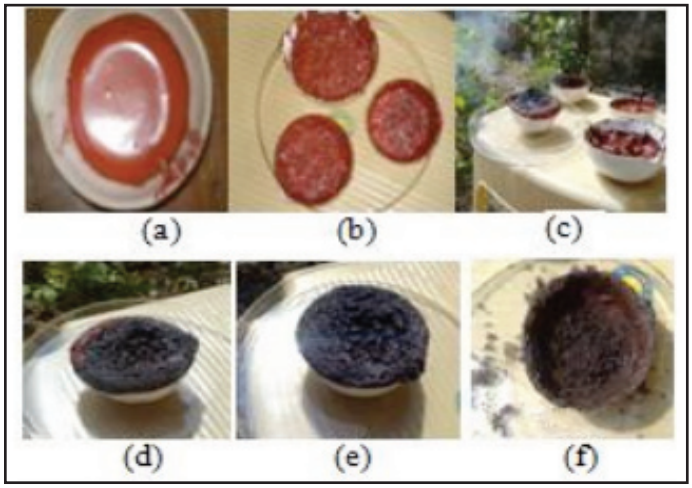

Fig. 1 (a) to (f): Photos showing different stages ofPhoto-catalytic auto combustion self- decomposition of aprecursor

The IR spectra of Mn-Znferrite samples were recorded by using FTIR Shimadzu ModelIRrestige21seriesspectrophotometer.In a typical experiment, the solid ferritesample was finely ground along with the pure and dry KBr, in the ratio 1:10. Fine grinding is required for thesampletobe uniformally mixed with KBr. The mixture was then putina sample holder and placed in the sample chamber of theIRspectrophotometer. The absorption spectrum for the sample was recordedin the wavelength range1000cm-1to 400-1Atomic absorptionspectroscopy is a method for elemental analysis.It is also usefulin detecting, both qualitatively andquantitatively, the trace metals and it isindependent of themolecular form of the metal in the sample. The method ishighly sensitive andcandetect different metalsin concentrationof less than one ppm.

II. Results and Discussion

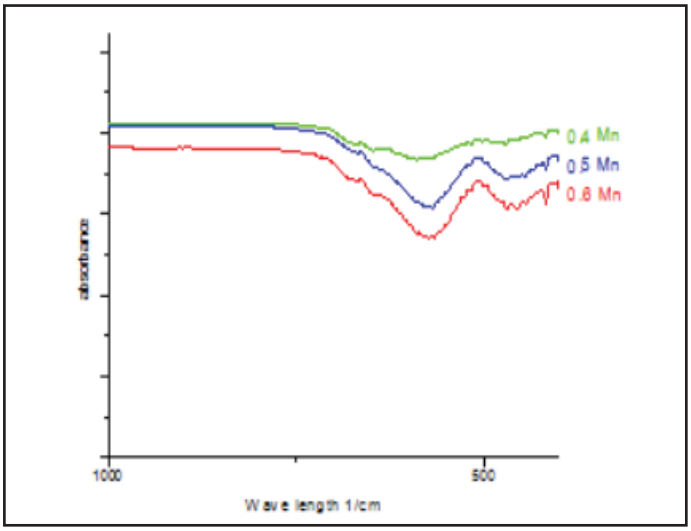

Fig. 2: IR Spectra of $Mn_xZn_{(1-x)}Fe_2O_4$

The infrared spectra of all the ferrite samples are shown inthe Fig. 2 recorded in the range of 1000-400cm-1.Infrared spectraof various ferrites have been studied byWaldron [18], reporting two bandsin the region1000cm-1to 200cm-1. Heattributed the high frequency (υ1) band totetrahedral metal-oxygen bondand second frequency (υ2)bandto octahedral metal-oxygen bond corresponding to: (a)MeT−O−MeOstretching vibration600-550cm-(b)MeOO stretching vibration450-385cm-1hereis oxygen,MeOis metalin the octahedral site andMeTin the tetrahedral site. The metal-oxygen absorption bands (a) and (b) are pronounced for all spinel structures and essentially for ferrites, which are also seen in these samples.IR spectral data of all the ferrite samples preparedby thesemethods are found to show two peaks in the range588-569cm-1and 462-447cm-1which arein agreement with the reported value [19-20].

Table 1: AAS Analysis Data for Ferrite Samples

Composition	Mn content		Zn content		Fe content	
	Theol. %	Exptl. %	Theol. %	Exptl. %	Theol. %	Exptl. %
$Mn_{0.4}Zn_{0.6}Fe_2O_4$	9.27	9.78	16.56	16.18	47.15	47.46
$Mn_{0.5}Zn_{0.5}Fe_2O_4$	11.65	11.82	13.86	13.39	47.36	47.59
$Mn_{0.6}Zn_{0.4}Fe_2O_4$	14.04	14.37	11.14	11.25	47.57	46.43

The results obtained for Fe, MnandZnions in eachsampleare given in the Table 1 and the same are in agreement withthe assigned stoichiometric compositions for the ferrite samples within the permissible experimental error.

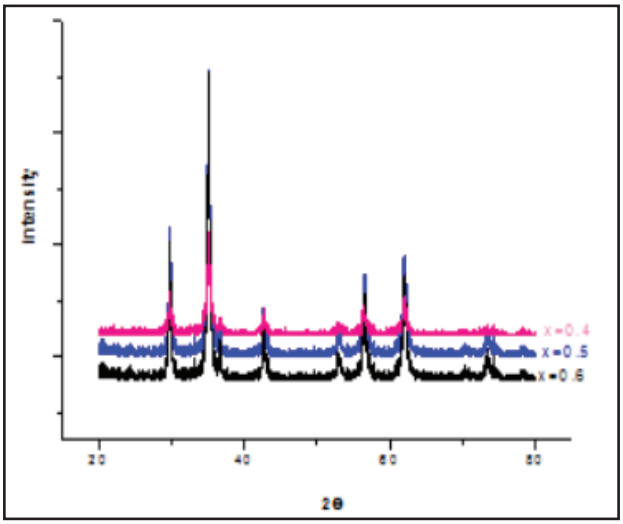

Fig. 3: X-ray Diffraction Patterns of Samples $Mn_xZn_{1-x}Fe_2O_4$

Fig. 3 shows the X-ray diffraction patterns of samples $Mn_xZn_{1-x}Fe_2O_4$, where x = 0.4, 0.5, and 0.6 nanoparticles. All the peaks correspondto cubic spinel ferrite structure for all the samples and confirm the formationof single phaseferrite. Average crystallite sizes were calculated byusing XRD databy measuring the full-width at half maximum (FWHM) for most intense characteristic (311) peak for Eachsample withthe helpof the Scherer formulaas givenin equation (1), and arein the range16-26nmfor differentMnconcentrations

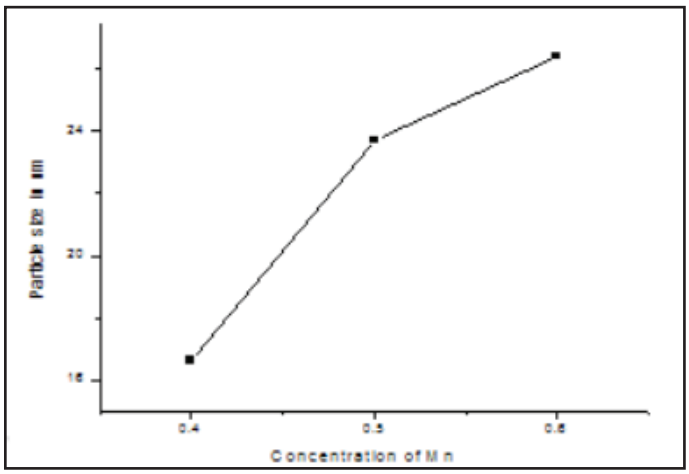

Fig. 5:Variation of Particle Size with Mn Content

Fig. 5 shows The crystallite sizesare foundto increase with Mncontentandin the range16–26 nmfor different compositions. It isobserved that crystallite sizeof 16nmis observed for the ferrite sample with Mnconcentrationof x=0.4 whichincreasesto 26forMnconcentration of x=0.6it may be duetothe larger sizeof ionic radiusof Mn2+ions as shown in fig. 5

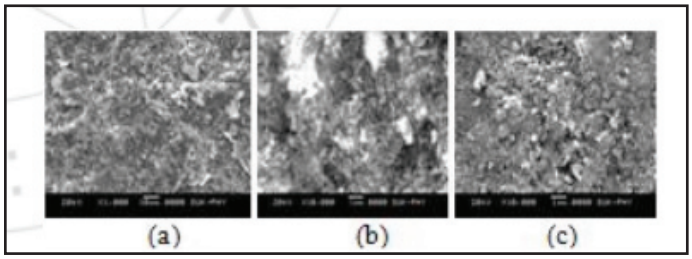

Fig. 6: Show SEM Images of $Mn_xZn_{1-x}Fe_2O_4$ (x=0.4, 0.5, and 0.6) Nanoparticles

The morphology of $Mn_xZn_{1-x}Fe_2O_4$, where x=0.4, 0.5, and 0.6 nanoparticles is shown in SEM micrographsin Fig. 6(a),(b) and (c). For all compositions the Mn–Zn ferrites show similar morphology of particles.Asseenin Fig. 6 particles show very strong agglomeration due to magneticcharacteristicof particles and are of uniform grain size.

II. Conclusion

The simple mechano chemical method using metallic oxides, as starting material, adopting photo catalytic auto combustion- self decomposition for the synthesis of the final material was found to produce high performance nanoparticles of Mn -Zn mixed ferrite material.

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