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TEMPERATURE DEPENDENT MAGNETIC PROPERTIES OF NANOCRYSTALLINE SODIUM FERRITE

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ABSTRACT

Nanocrystalline $NaFeO_2$have been synthesized by sol-gel method and subsequent solid-state reaction. Transmission electron microscopy (TEM), X-ray diffraction (XRD) and magnetic measurement using physical property measurement system (PPMS) have been done. Transmission electron microscopy (TEM) indorses the formation of nanosized crystallites. X-ray diffraction (XRD) study reveals the orthorhombic crystal structure of the synthesised sample. Magnetic properties of sodium ferrite nanoparticles show that the synthesized nanoparticles possess superparamagnetic behaviour at room temperature. Also, it has been found in temperature dependent study that magnetization first increase with increase in temperature and then afterwards at high temperature it starts decreasing.The mechanism responsible for the observed magnetic behaviour will be discussed.These nanoparticles find applications in bio-medical sciences and treatment of various disease such as cancer.

Keywords*: Nanocrystalline, orthorhombic, temperature, TEM, magnetic.*

CXLVI. INTRODUCTION

Delafossite compounds (ABO_2 structure) where A is monovalent metal and B is trivalent metals have been considered as precise promising materials in semiconductors field due to its high transparent, electrical conducting[1-4], luminescence properties [5,6].These delafossite oxides play important roles in diverse photoelectronic and photoelectrochemical applications[7-9].$NaFeO_2$Delafossite compound is a stable compound in the Na–Fe–O system with non-magnetic monovalent metal cations and magnetic trivalent cations. In present study synthesized the delafossite $NaFeO_2$nanoparticles have been done using sol gel technique and mainly temperature dependent magnetic study presented.

CXLVICXLVI. EXPERIMENTAL

The precursors chemicals such as sodium nitrate ($NaNO_2$), ferric nitrate ($Fe(NO_3)_3.9H_2O$), citric acid ($C_6H_8O_7.H_2O$), ethylene glycol $(CH_2OH)_2$ has been used for the synthesis of sodium ferrite ($NaFeO_2$). $NaFeO_2$ nanoparticles have been synthesized by sol-gel method. For the synthesis, 0.1M solution of sodium nitrate ($NaNO_2$) and 0.2M solution of ferric nitrate ($Fe(NO_3)_3.9H_2O$) have been prepared in ethylene glycol and

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subsequently, drop-wise solution of sodium nitrate has been added in ferric nitrate. In this mixture, 0.2M citric acid has been added. It is well known fact that the metal nitrates acts as oxidants and form complexes while the citric acid as fuel and chelating agent in combustion reactions [10]. Further, the calcination of this dried powder has been done at 400^{o}C to obtain crystalline nanoparticles. The magnetic study (M-H) and temperature dependent magnetic properties have been carried out using Physical property measurement system (PPMS) Cryogenics limted USA.

CXLVIICXLVIICXLVII.RESULT AND DISCUSSION

Transmission electron microscopy (TEM) image for synthesized delafossite$NaFeO_2$nanoparticles confirmed its spherical morphological with particle size 40nm.X-ray diffraction (XRD) patterns of the synthesized $NaFeO_2$ nanoparticles confirmed that the formation of hexagonal phase of orthorhombic structure with $Pn2_1a$space group (JCPDS file no.76-0600) [11]. The nano crystallite size (D)calculated from the full-width at half maximum (FWHM) of the intense crystallite peak (201), using Williamson-Hall formula [12].

$$\beta \cos\theta = C\varepsilon \tan\theta + \frac{K\lambda}{D\cos\theta}$$

where λ is the wavelength of the X-ray radiation used (λ = 1.54060 Å), θ is Bragg's angle, β is the full width at half-maximum, ε is the strain in the particle is well in agreement with TEM results.

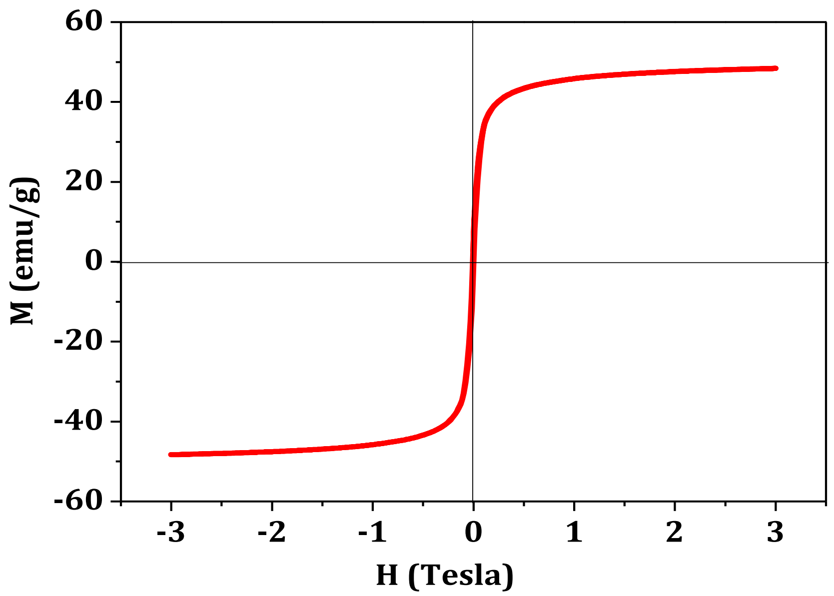

Figure 1 M-H of $NaFeO_2$ nanoparticles at room temperature

Fig. 1 displays the magnetization versus applied magnetic field hysteresis (M–H) loops of delafossite $NaFeO_2$nanoparticles at room temperature in the range of magnetic field at ±3 Tesla. The zero coercive field (H_C) and remanence magnetization (M_r) confirming the superparamagnetic behaviour of $NaFeO_2$ nanoparticles

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as shown in Fig. 1. The value of magnetic saturation has been calculated from the M-H hysteresis loops and found to be 52 emu/g respectively.

Fig. 2 displays the temperature dependent magnetization of nanocrystalline $NaFeO_2$ from 0 K to 320 K at 30 Oe magnetic field. It has been observed that the magnetization increase linearly with increase in temperature till 155 K and attain maximum magnetization 3.8 emu/g. Afterwards, magnetization drops linearly at 281 K with value 3.53 emu/g. The further roses again linearly till curie temperature. It has been observed that there is minute loss in magnetization as temperature changing.

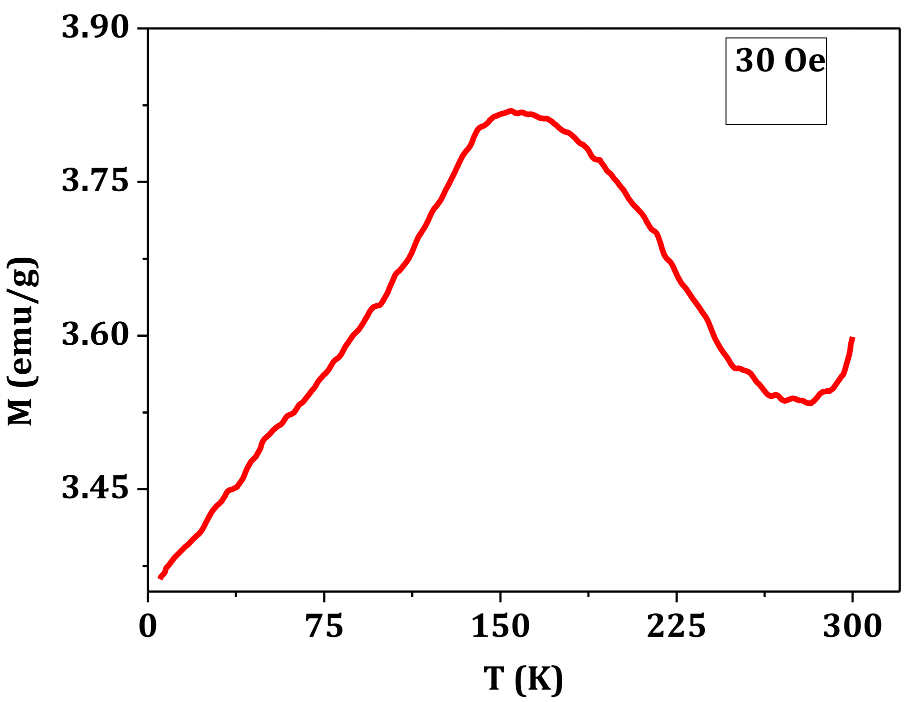

Figure 2.M-T of $NaFeO_2$ nanoparticles at 30Oe magnetic field.

CXLVIII. CONCLUSION

Delafossite $NaFeO_2$nanomaterial has been synthesized by sol-gel method. The average particle size of the $NaFeO_2$ nanoparticles is 40 nm by using Transmission electron microscope and it also corroborates with X-ray diffraction (XRD). The magnetic study explore that $NaFeO_2$ possesses superparamagnetic properties at 300 K. Magnetization versus temperature study confirms that with increase and decrease in temperature magnetization increases and decrease like steps. Superparamagnetic properties of obtained nanoparticles are useful in in vitro and in- vivo applications such as gene therapy, drug carrier and hyperthermia.

CXLIX. ACKNOWLEDGMENTS

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