Study of FTIR and optical properties of $Mg_{0.9}Mn_{0.1}Nd_xFe_{2-x}O_4$ ferrite nanoparticles prepared via solution combustion method

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ABSTRACT
The present work describes the synthesis and characterization of Nd^{3+} doped magnesium-manganese ferrite nanoparticles. A series of magnesium-manganese ferrites having formula $Mg_{0.9}Mn_{0.1}Nd_xFe_{2-x}O_4$ (x = 0.1, 0.2, 0.3) has been prepared by SC method. X–ray study has predicted the single phase configuration of the present ferrite nanoparticles. The particle-size anticipated by means of Debye-Scherrer's method is found to decrease (19.2-13.5 nm). FTIR study has been carried out to understand the behaviour of M-O bonds stretching. The band gap has been viewed to increase (4.60-6.11 eV) with the increase in Nd^{3+} ions content.
Key words: Ferrites; Solution combustion method; FTIR; UV-visible spectroscopy, nanoparticles

1. INTRODUCTION

Ferrites are the forms of ceramic compound which are electrically insulator & magnetically conductor in nature. They are also have dielectric properties which means that when electromagnetic waves are made to pass through them, then these ferrites does not conduct electricity readily. It is the advantages of ferrites over other metals like nickel, iron & other transition elements which are electrically conducting. The other important factor in ferrites is porosity i.e. by adding the dopant into ferrites its porosity increases. In 1949, the story of ferrites started when the ferromagnetic materials of high resistivity is searching to get the reasonable losses due to the eddy current. There is interaction between oxygen & metal ion at intrinsic atomic level due to which ferrites exhibits high resistivity as compared to ferromagnetic metal. Due to this reason, ferrites are used in high frequency applications & technologically make them very valuable. The interesting thing about these materials is that their properties can be changed by the addition of different type of dopants. The cation distribution also affects their properties. A. Lakshman et al. [1] study the magnetic properties of Mg Mn ferrites in which In^{3+} & Cr^{3+} are used as dopants. B. S. Chauhan et al. [2] also used citrate precursor method to study the different properties of Mn-Mn ferrites substituted by indium, cobalt & aluminium. He used non-conventional citrate precursor method to study the magnetic properties of varied Mg Mn ferrites. The authors G. Kumar et al. [3] used citrate precursor technique to synthesized Mg-Mn ferrite substituted by indium & aluminium. Nilar Lwin et al. [4] used solution combustion method for the synthesis of Mg Mn ferrites of different composition & study their different properties. Literature shows that doping with donor cation such as aluminium, chromium and indium increases saturation magnetization initially with the increase of concentration of dopant. There is also increase in initial permeability of the material take place with the increase of concentration of dopant. To enhance their properties, we used Nd^{3+} ions as dopant. In our present work we study the structural, FTIR and optical properties of Nd^{3+} doped magnesium manganese ferrite.

2. EXPRIMENTAL

In this work, the sample is prepared by using solution combustion method with the help of hydrated nitrates of the ions. The detailed method is reported by the authors elsewhere [5]. The phase confirmation is performed by XPERT-PRO diffractometer while, the FTIR study is performed by Perkin Elmer-spectrum RX-1 FTIR and optical study has been done with the use of Shimadzu / UV-2600 Spectrophotometer.

3. RESULTS & DISCUSSIONS

3.1 Structural study

The XRD patterns of $Mg_{0.9}Mn_{0.1}Nd_xFe_{2-x}O_4$ ferrite nanoparticles are illustrated in Fig. 1. The diffraction peaks are at (220), (311), (400), (422), (511), (440) are observed which are found to be matching well with the JCPDS card no-17-0464, therefore, anticipates the development of spinel-cubic configuration with space group Fd3m-Oh[7]. The crystallite size of prepared single phase spinel magnesium manganese ferrite in powder form is computed from XRD analysis by means of Scherrer-formula [6]:

$$D = \frac{0.9\lambda}{\beta\cos\theta}$$

(1)

where particle size is represented by D, FWHM is represented by β, λ is 1.54 Å and angle of diffraction is represented by θ. The estimated particle size is found to decline (19.2-13.5 nm) with the rise in Nd^{3+} ions content.

3.2 FTIR study

Fig. 2 illustrates the FTIR study of $Mg_{0.9}Mn_{0.1}Nd_xFe_{2-x}O_4$ ferrite nanoparticles. The study indicated a noteworthy band in between 525-575 cm^{-1}. The observed band is corresponding to the oxygen-metal band stretching at A-site [7]. However, the oxygen-metal band stretching at B-site was not observed as the same may occur at frequency less than 400 cm^{-1}. Further, the central-frequency of observed band has been found move to the side of lesser frequency. This shift owes to rise in tetrahedral site radius [7].

3.3 UV-visible spectroscopy study

Fig. 3 illustrates the Tauc plots for $Mg_{0.9}Mn_{0.1}Nd_xFe_{2-x}O_4$ ferrite nanoparticles. The band gap is calculated by employing the following relation [8]:

$$(\alpha h\vartheta)^2 = A\left(h\vartheta - E_g\right)^m$$

(2)

Where absorption coefficient is denoted by α, edge width parameter is denoted by A, energy band gap is denoted by E_g while m =2. The band gap is observed to increase (4.60-6.11 eV) with the adding up of Nd^{3+} ions.

CONCLUSIONS

Magnesium manganese ferrite nanoparticles are effectively developed by solution combustion method. A decrease in particle size (19.2-13.5 nm) was found by increment of Nd^{3+}. In FTIR, indicated a noteworthy band in between 525-575 cm^{-1}. The band gap was viewed to increase (4.60-6.11 eV) by the enhancement in Nd^{3+} ions concentration.

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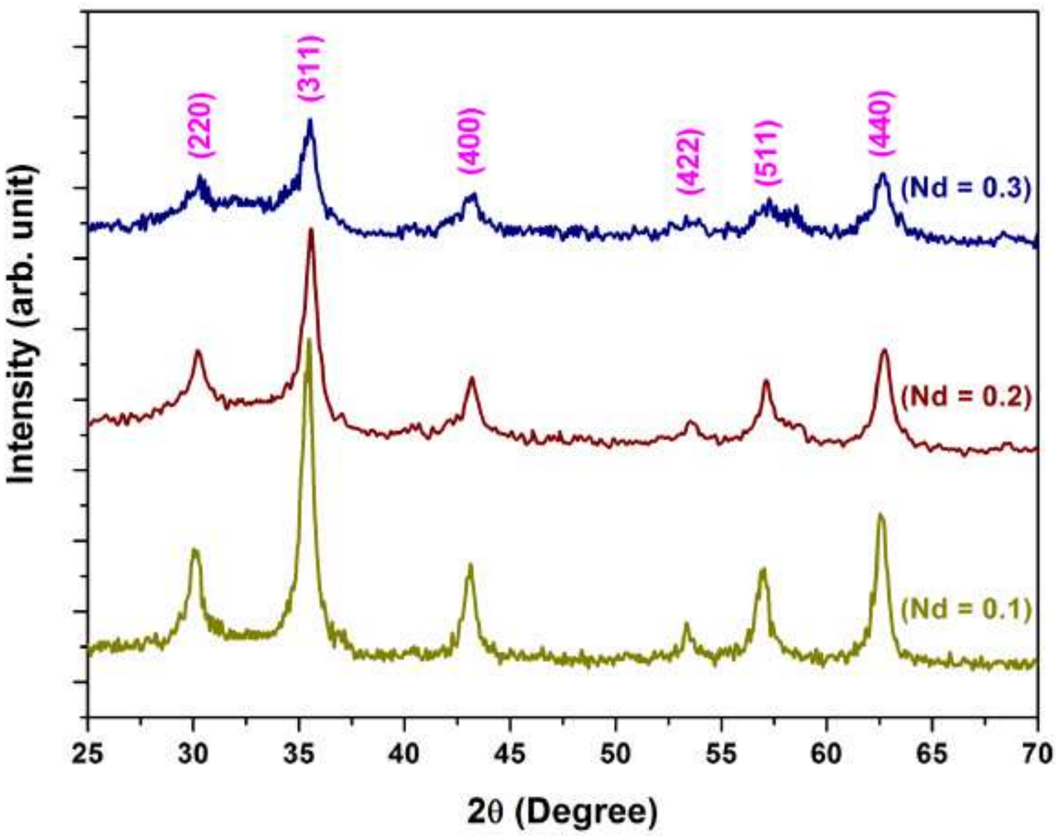

Fig. 1 X-ray diffraction patterns of $Mg_{0.9}Mn_{0.1}Nd_xFe_{2-x}O_4$ nanoferrites

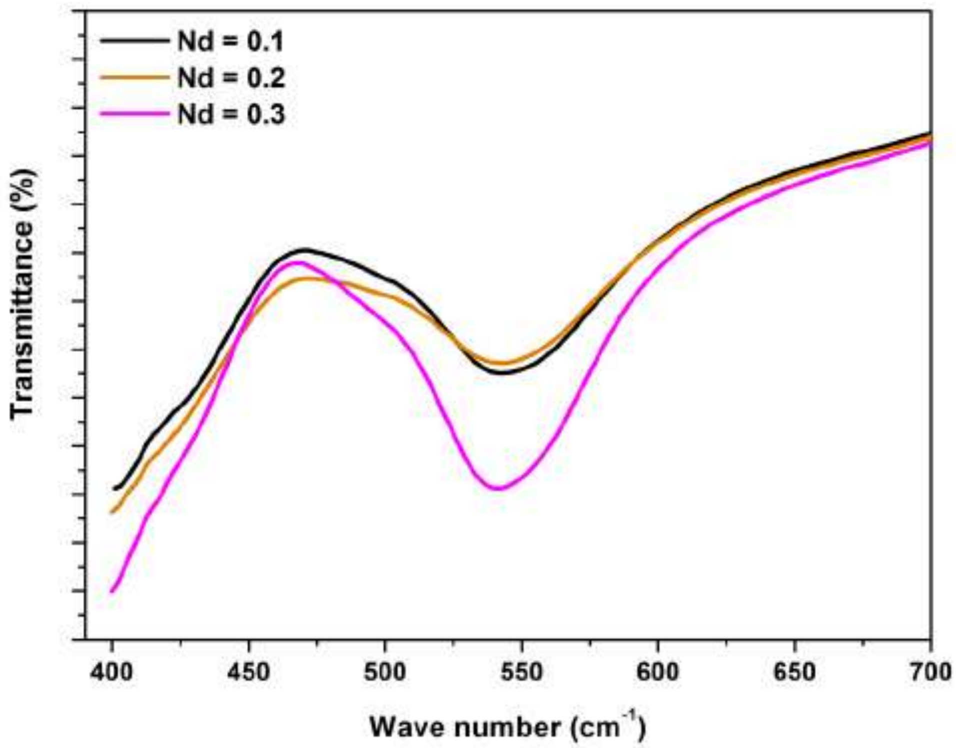

Fig. 2 FTIR spectra for $Mg_{0.9}Mn_{0.1}Nd_xFe_{2-x}O_4$ nanoferrites

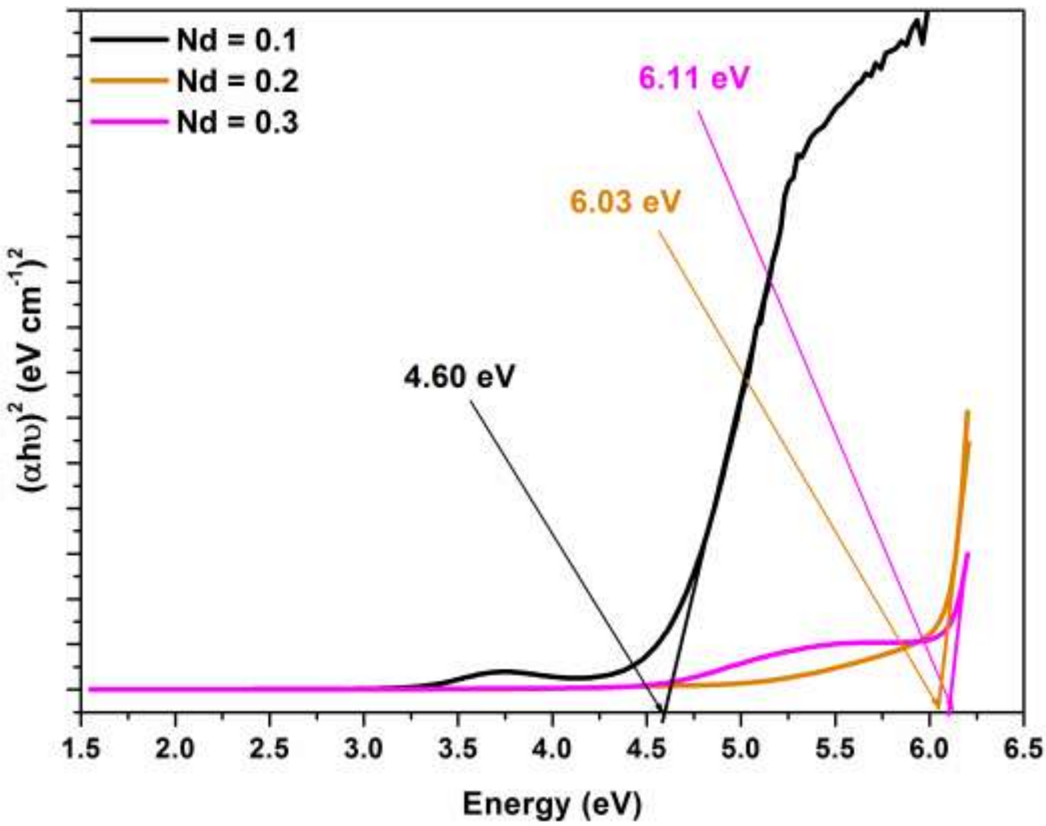

Fig. 3 Tauc plots for $Mg_{0.9}Mn_{0.1}Nd_xFe_{2-x}O_4$ nanoferrites