International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 09 | Sep 2023 www.irjet.net p-ISSN: 2395-0072

Synthesis and characterization of structural and Magnetic Properties of ZnO doped SnO_2 Nano Composites

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Abstract: *The magnetic properties of SnO_2 ZnO Nano Composites nanoparticles of metal oxides are studied here. The subjected nano composites nanoparticles of metal oxides were synthesized using the chemical route method i.e. microwave-assisted co-precipitation method. The synthesized samples were characterized by the methods of X-ray diffraction, FTIR Spectroscopy, UV-VIS Spectroscopy, and vibrating sample magnetometer (VSM) for the magnetic properties of the samples. The results suggest that samples are of nano size and are magnetic. The hysteresis curves of the samples results were analyzed and retentivity, coercivity, and hysteresis loss of the samples were compared. The comparative study suggests the applications of the samples as per their properties of magnetic behavior.*

Keywords: *Magnetic, nano-materials, nano-composites, Vibrating Sample Magnetometer*

1. INTRODUCTION

The nano-composite materials have been the subject of interest and complete study since long before. The interest in the heterogeneous systems comprised of nanoparticles is the thrust area/field because of their present and prospective utilitarian applications. That these nanoparticles are fundamentally related to the high surface-to-volume ratio and the high total inter-facial area of the embedded nanoparticles. Furthermore, many size-dependent functional properties can be enriched by nanoparticles and the hosting materials with interesting multi-functionalities [1].

Magnetic nanoparticles are the most popular functional nanofillers [2,3] for the thrust area. The magnetic properties of the resultant nano-composites are affected and sometimes are limited by various factors, such as the degree of dispersion/aggregation of nanoparticles, the strength ofinter-particle interactions, and the effect of the surface on the nanoparticle's magnetism [4,5]. Some aspects are still perplexing, such as the extent to which the interface between magnetic nanoparticles and the given enclosure influences their properties [6-12].

Since the fundamental principle of nano-magnetism has long been established [13-14], a general prophetical picture of the magnetic properties of a given nano-composites or a family of nanocomposites are still not clear. This is due to the number of parameters that are not known completely and which obstruct the knowledge of the physical processes at the nanoscale and this will affect the interpretation of the measured magnetic properties of the nano-composites [15-16].

2. RESEARCH METHODOLOGY

Experimental Synthesis Techniques: - The formation of Ni-doped SnO_2 was performed by using microwave-assisted co-precipitation method in which $SnCl_2.5H_2O$ and Ni $(NO_3)_2$ were dissolved in 100ml of de-ionized water with appropriate molar concentration. The resultingsolution was continuously and steadily re-flexing by using a magnetic stirrer for 1 hour at room temperature to obtain a clear solution of acidic nature. Then ammonium solution (NH_4OH) was added dropwise with continuous stirring into the solution so that its pH was maintained at a value between 8 to 9 which was confirmed using a n electrode pH meter (pH meter was calibrated by using buffer solution). The resultant precipitated solution was kept for the aging process to stabilize uniform crystal size for about 24 hours. Now, the precipitate was filtered by using Whatman qualitative filter paper having pore size (20-25micro meter). The obtained precipitate was washed using distilled water and ethanol to release the impurities such as nitrate and chloride.

The precipitate cake was heated for 4 hours at 100 ^oC using a hot plate to remove water content. Now a part of the resultant sample is grind in agate mortar and pestle and sampling “as-synthesized sample” and other part was further calcined at 200.0^oC, 400 0^oC and 600 0^oC respectively and formed in powder form by using agate mortar and pestle. The as-synthesized sample, calcined sample and various calcined samples were kept in an air-tight container and used for further characterization techniques.

Sample Characterization: Complementary methods were used to exemplify the structure and phase of heat-treated samples. XRD of samples were recorded by a Philips X-ray diffractometer PW/1710; with Ni filter, with monochromatic Cu Kα radiation of wavelength 1.5418 Å at 50 KV and 40 mA, in the range, 2θ~ 10-80°. The investigation of the size, shape and particle distribution of the samples was carried out using a Transmission electron microscope (Hitachi-H7500) at 100 KV. For this intention, the dispersion of sample nano-particles was pipetted onto carbon-coated copper grids. Infrared spectra were recorded by using Fourier transform infrared spectrometer (Perkin Elmer 1600) ranging 2500-400 cm-1, on the pellets obtained by dispersing the samples in sodium bromide. UV visible spectrum was also recorded for the nano-particles 12 through a UV visible spectrometer. Vibrating Sample Magnetometer (V.S.M.) facilities were availed in CEERI, Pilani (Rajasthan). Vibrating Sample Magnetometer for Magnetic measurement, M vs H (±1.5 T) was used for the magnetic properties characterization for the field strength of ±1.5 T. The system used is capable of studying the magnetic properties of nano-composites, thin films, multi-layer and hetero-structure materials. Further system can measure and display Hall voltage, resistance, magneto resistance, I-V characteristics, Hall coefficient, carrier concentration and mobility of the given samples. The magnetic field strength ranging in between ±1.5 T with 5 mm variable magnetic air gap, magnetic field resolution is about 0 001 Oe and magnetic field homogeneity is about + 0. 1 % with over centered 50.8mm diameter circle uniform working area. Micro Sense Easy VSM software version 9.13Wa is used for the data acquisition and analysis.

3. RESULTS AND DISCUSSION

XRD Analysis: In Powder X-ray diffraction investigation, the crystalline phase of samples was calculated at room temperature using Rigaku Mini flex diffractometer with wavelength of radiation 1.54 Angstrom. In the x ray analysis, two matched Phases were obtained such as tin oxide which is indexed as A and Zinc oxide which is indexed as B. the observed xrd pattern

revealed the formation of nano-composites of tin oxide with Zinc oxide. The experimental and calculated peaks are well matched which signifies the formation of nano-composites. The figure

5.1 shows the comparative study of nickle oxide nano-composites.

4.2Fourier Transform Infrared (FTIR) Study: FTIR spectra of the SnO_2-ZnO. NCS were calcined at different calcination temperatures 200 0 °C, 400 0 °C and 600 0 °C for 2 hours, which are shown in Figure 1 Perusal of the figure shows the IR broad peaks at around 3400 cm-1, 1600 cm-1, 607 cm-1 and 680 cm-1. A broad band between 3600 cm-1-3330 cm-1 and broad band between 1700 cm-1 -1400 cm-1 have been at tributed to stretching mode of -OH group, peaks at 607 cm-1 and 680 cm-1 were attributed to different vibration modes of Sn-O-Sn and Ni-

O. At temperatures 200 °C, 400 °C, and 600 °C peaks represent the formation of both Sn-O-Sn and Ni-O but at temperatures, 600 °C peaks are highly intense because of increases in the lattice. The transmittance increases with an increase in the calcination temperatures at the fixed duration of heating 2 hours, It might be due to the increase of the condensation of the oxygen during the heating process

4.3Magnetic Properties: -Vibrating Sample Magnetometer (VSM), the magnetic property of nano-composites SnO_2-ZnO was analyzed using a vibrating sample magnetometer at room temperature. The magnetic hysteresis loop of the calcined samples is shown in Figure 2 It is clear from the results that the calcined nano-composites show a soft and ferromagnetic behavior.

It is clear from the magnetic hysteresis loop that the coercive force decreases with an increase of the temperature of ZnO in SnO_2 nano-composites and the retentivity also shows decrement with the increased temperature. Furthermore, coercive force decreases in very very small amounts with an increase in the temperature of ZnO in SnO_2 nano-composites.

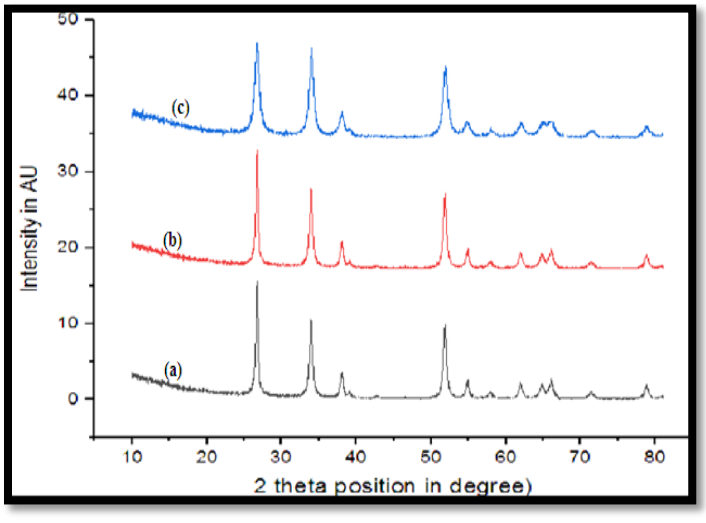

Figure 1 SnO_2-ZnO 10% NCS calcined for fixed duration 2 hours at (a) 200 °C (b) 400 °C

(c) 600°C

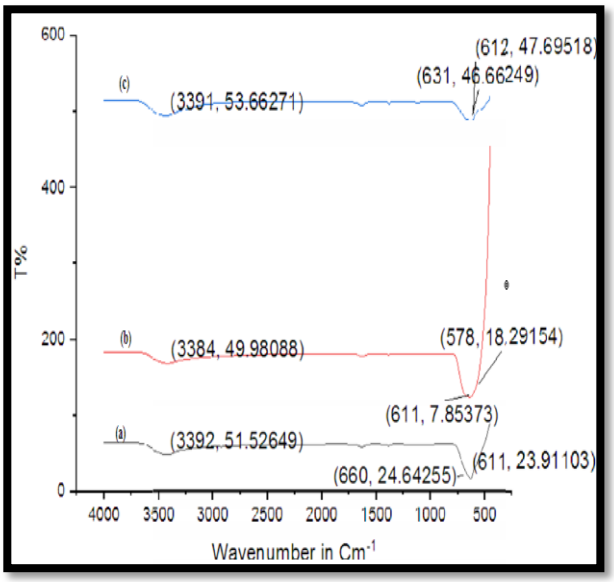

Figure 2: FTIR Spectra of SnO_2-ZnO 10% nano-particles calcined for fixed duration of 2hours at calcination temperatures (a) 200°C (b) 400°C (c) 600°C.

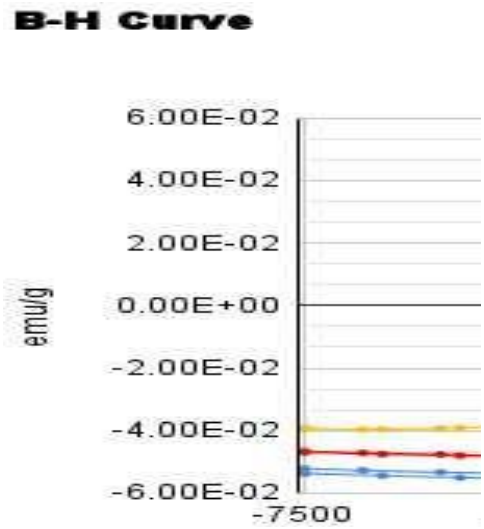

Figure 3 Hysteresis Loop of SnO_2-ZnO 10% nano-particles calcined for fixed duration of 2 hours

CONCLUSION: -

The experimental and calculated peaks x-ray diffraction results are well matched and signify the formation of nanocomposites. Figure 3 shows the comparative study ofnickel oxide nano-composites. The FTIR results show that the transmittance increases with increase in the calcination temperatures at the fixed duration of heating 2 hours, It might be due to the increase of the condensation of the oxygen during the heating process. It is clear from the magnetic hysteresis loop that the coercive force decreases with the increase of temperature of ZnO in SnO_2 nano-composites and the retentivity also shows decrement with the increased temperature. Furthermore, coercive force decreases in very very small amount with increase of temperature ofZnO in SnO_2nano-composites.

Acknowledgements

The authors acknowledge their thanks to Principal and technical staffs of MNS Govt. College, Bhiwani(Haryana) to provide laboratory facility for synthesis work and the technical staffs of Central Electronics Engineering Research Institute, Pilani and Central Instrumentation Laboratories, Panjab University, Chandigarh for the characterization of thesamples.

References

1. Chou, T.-W.; Sun, C.-T. Nanocomposites; DEStech Publications: Lancaster, PA, USA, 2012; ISBN 9781605950730.

2. Ajayan, P.M.; Schadler, L.S.; Braun, P.V. Nanocomposite Science and Technology, Wiley- VCH Verlag GmbH & Co. KGaA:Weinheim, Germany, 2003; ISBN 3527303596.

3. Alamri, H. Synthesis of New Magnetic Nanocomposite Materials for Data Storage. Master's Thesis, University ofWaterloo,Waterloo, ON, Canada, 2012.

4. Koksharov, Y.A. Magnetism of Nanoparticles: Effects of Size, Shape, and Interactions. In Magnetic Nanoparticles; Gubin, S.P., Ed.; Wiley-VCH Verlag GmbH & Co. KGaA: Weinheim, Germany, 2009; pp. 197–254.

5. Allia, P.; Barrera, G.; Tiberto, P.; Nardi, T.; Leterrier, Y.; Sangermano, M. Fe3O4 nanoparticles and nanocomposites with potential application in biomedicine and in communication technologies: Nanoparticle aggregation, interaction, and effective magnetic anisotropy. J. Appl. Phys. **2014**, 116. [CrossRef]

6. Manna, P.K.; Yusuf, S.M. Two interface effects: Exchange bias and magnetic proximity. Phys. Rep. **2014**, 535, 61–99. [CrossRef]

7. Binns, C.; Domingo, N.; Testa, A.M.; Fiorani, D.; Trohidou, K.N.; Vasilakaki, M.; Blackman, J.A.; Asaduzzaman, A.M.; Baker, S.; Roy, M.; et al. Interface

exchange coupling in Co nanoparticles dispersed in a Mn matrix. J. Phys. Condens. Matter **2010**, 22. [CrossRef] [PubMed]

8. Coey, J.M.D. Magnetism and Magnetic Materials; Cambridge University Press: Cambridge, UK, 2009; ISBN 9780521816144.

9. Colvin, V.L. The potential environmental impact of engineered nanomaterials. Nat. Biotechnol. **2003**, 21, 1166–1170. [CrossRef] [PubMed]

10. Meyer, D.E.; Curran, M.A.; Gonzalez, M.A. An examination of existing data for the industrial manufacture and use of nanocomponents and their role in the life cycle impact of nanoproducts. Environ. Sci. Technol. **2009**, 43, 1256–1263. [CrossRef] [PubMed] Appl. Sci. **2019**, 9, 212 25 of 28

11. Nardi, T.; Sangermano, M.; Leterrier, Y.; Allia, P.; Tiberto, P.; Månson, J.A.E. UV-cured transparent magnetic polymer nanocomposites. Polymer **2013**, 54, 4472–4479. [CrossRef]

12. Allia, P.; Tiberto, P.; Coisson, M.; Chiolerio, A.; Celegato, F.; Vinai, F.; Sangermano, M.; Suber, L.; Marchegiani, G. Evidence for magnetic interactions among magnetite nanoparticles dispersed in photoreticulated PEGDA-600 matrix. J. Nanopart. Res. **2011**, 13, 5615–5626. [CrossRef]

13. Sciancalepore, C.; Bondioli, F.; Messori, M. Non-hydrolytic sol–gel synthesis and reactive suspension method: An innovative approach to obtaining magnetite–epoxy nanocomposite materials. J. Sol-Gel Sci. Technol. **2017**, 81, 69–83. [CrossRef]

14. Esposito, S.; Dell'Agli, G.; Marocco, A.; Bonelli, B.; Allia, P.; Tiberto, P.; Barrera, G.; Manzoli, M.; Arletti, R.; Pansini, M. Magnetic metal-ceramic nanocomposites obtained from cation-exchanged zeolite by heat treatment in reducing atmosphere. Microporous Mesoporous Mater. **2018**, 268, 131–143. [CrossRef]

15. Knobel, M.; Nunes, W.C.; Socolovsky, L.M.; De Biasi, E.; Vargas, J.M.; Denardin, J.C. Superparamagnetism and Other Magnetic Features in Granular Materials: A Review on Ideal and Real Systems. J. Nanosci. Nanotechnol. **2008**, 8, 2836–2857. [CrossRef]

16. Gabriele Barrera , Paola Tiberto, Paolo Allia, Barbara Bonelli, Serena Esposito, Antonello Marocco, Michele Pansini and Yves Leterrier. Review Magnetic Properties of Nanocomposites Appl. Sci. 2019, 9, 212.