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FULL PAPER

Preparation and characterisation of SnO–Fe_2O_3 nanocomposites

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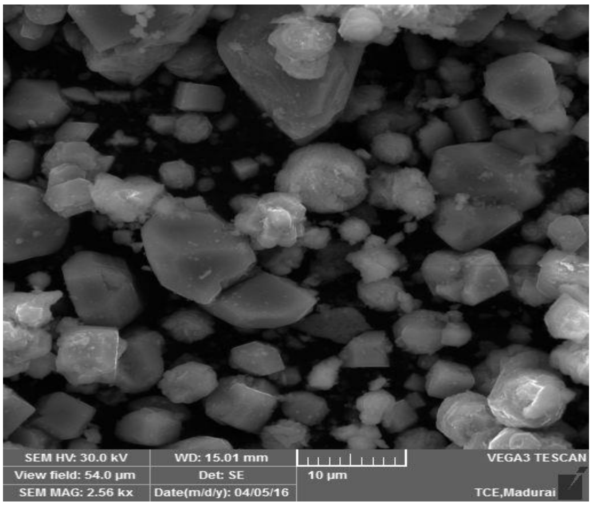
ABSTRACT: Nanocomposites are novel materials which are yet to be explored and utilised in many applications. Nanocomposites can be tailored by the volume fraction of the matrix, fibre, and also by the size and shape of the nanomaterial in the composite. Preparing nanocomposite with a desired shape and size still remains a challenge. In the present work, SnO–Fe2O3 nanocomposite was prepared using sol gel route with Ferric chloride and Tin chloride as precursors. The prepared nanocomposite was characterised by X-ray diffraction (XRD), ultraviolet visible spectroscopy (UV), scanning electron microscope (SEM), and Fourier transform infrared spectroscopy (FTIR). The crystallite size obtained was approximately 60 nm, with a band gap of 3.55 eV. The band gap of the composite could further be tuned with nanosize.

KEYWORDS: Nanocomposite; SnO–Fe2O3; Sol Gel, Thin ferrite, UV, FTIR

GRAPHICAL ABSTRACT:



1. Introduction

Nanocomposites are composites in which at least one of the phase has dimensions in nano range (1-100nm). Composites are also called as tailored materials, nanocomposites offer advantage of tuneable properties of the composite with nanosize in addition to the volume fraction of the base or matrix. The property of composite is decided by the volume fraction of fiber, volume fraction of matrix, nature of matrix, length of fibre and shape of fibre. The property of nanocomposite is decided by the size and shape of nanophase material in the composite. Nanocomposites are 21st century

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materials which have several opportunities in aerospace, automotive, biotechnology, electronics and energy sector [1,2]. Nanocomposites can also be classified as ceramic matrix nanocomposite, polymer matrix nanocomposite, metal matrix nanocomposite and CNT nanocomposites [1,3]. Nanocomposites have been investigated in academic environments, scientific laboratories, and industries. Ceramic nanocomposites have attracted a great deal of attention from many researchers because of easy processing techniques, low cost of material (in case of oxides), and novel properties. Ceramic nanocomposites can be prepared by sol gel process [4,5], offering some advantages including, chemical homogeneity, purity, and stoichiometry control.

Iron oxide nanoparticles (Fe_2O_3) are super paramagnetic materials and have been used in catalysis, sensors and terabit magnetic storage devices. They are generally not toxic but less biocompatible and the issue is resolved with by coating iron oxide nanoparticles with a biocompatible polymer [5–8]. Fe_2O_3 nanocomposites with graphene oxide, silica and starch are investigated in the literature and find applications in catalysis, hyperthermia and selective removal of heavy metal ions from aqueous solution [9–11].Tin oxide (SnO) finds applications in solid state gas sensor materials, oxidation catalyst and transparent conductor [12]. Carbon encapsulated tin oxide nanocomposites have been used as an anode and demonstrated high performance in sodium ion batteries [13]. Tugsten oxide-Tin oxide nanocomposites have been used for ethylene sensing applications [14].Tin oxide is widely used as a gas sensing material for its high sensitivity and selectivity [15]. Mahdi Salehi and co-workers have investigated on structural, magnetic and electrical properties of pure and Dy-doped Fe_2O_3 nanostructures using chemical thermal decomposition technique [16]. Also the structural charactrizations and application of magnetic $(ZrO)_2Fe_2O_3$ nanoparticles in the organic reactions as the hetrogeneus catalyst has been reported by Arash Ghorbani-Choghamarani and co workers [5].

Preparing a composite of tin oxide with iron oxide will improve the magnetic and optical properties and hence broaden their range of applications as cited by Wei-Wei Wang [17]. In their work SnO-Fe_2O_3 sheet like nanocomposites were synthesised by simple hydrothermal method and increasing reaction time showed a transition from nano-sheet to nanorods. A literature search also reveals the fact that SnO-Fe_2O_3 nanocomposites have been reported only be

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Wang and co-authors. Alternative techniques to prepare the $SnO-Fe_2O_3$ nanocomposites would be interesting and is necessary to confirm any change in morphology or size of nano-particles with that reported by Wang. In this research study, $SnO-Fe_2O_3$ with the particle size of 60 nm was synthesised using a simple sol gel technique.

2. Experimental

Ferric chloride pentahydroxide is mixed with 50 ml of distilled water and hydrochloric acid .The solution is stirred for 30 min to get a gel of iron oxide. This is followed by simultaneous heating and stirring at 90 °C for nearly 8 h as demonstrated in Figure1. Tin chloride powder is added to the water bath with continuous stirring for another three hours at 100 °C. The obtained residue is heated at 600 °C for 2 h to get the desired powder composite. Finally the powder is grained with a motor and pestle to get the nanocomposite.

Fig. 1. Stirring the solution.

3. Results and Discussions

The prepared nanocomposites are characterised by XRD technique (Figure 2) to determine their crystallite size.

The peaks obtained at diffraction angles of 35 & 54 are due to Fe_2O_3 and SnO respectively. The results are in confirmation with JCPDS 41-1445 and JCPDS39-1346.The crystallite size of the nanocomposites determined by Debye Scherer method .The presence of narrow peaks indicates the existance of microparticles in the sample.

$D = 0.91\ \lambda / \beta\cos\theta$, Where,

λ= wavelength of the incident rays (1.54 A),

D= size of the particle (nm),

β= full width at half maximum

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θ= diffraction angle

The crystallite size of nanoparticles obtained is 60 nm. The SEM image (Figure 3) of the composite shows a mixture of micro and nanoparticles. However, some particles within 100 nm was observed in the SEM image.

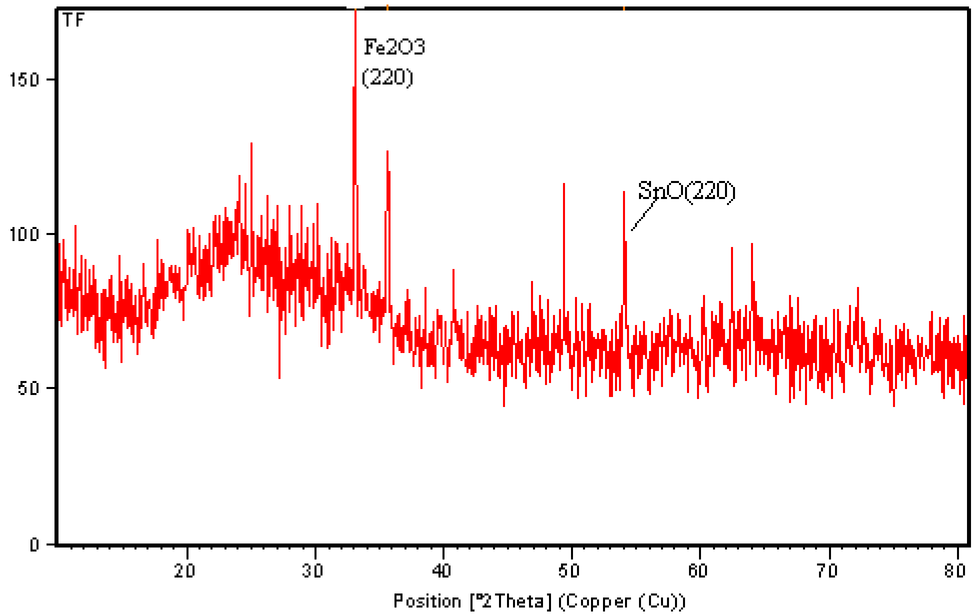

Fig. 2. XRD pattern of prepared SnO-Fe_2O_3 nanocomposite

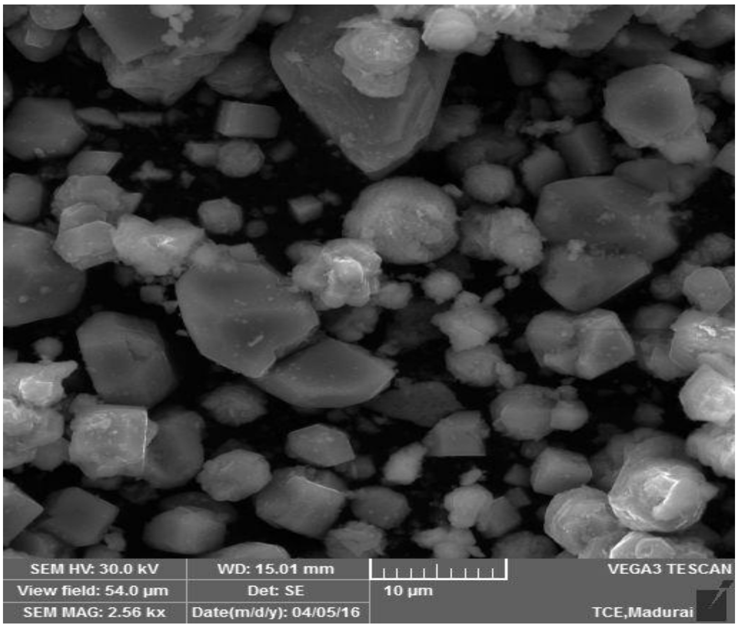

Fig. 3. SEM image of prepared SnO-Fe_2O_3 nanocomposite.

The nanopowders are also characterised by UV-Vis spectrophotometer to identify its band gap. Taucs plot (Figure 4) is made to determine the bang gap of SnO-Fe_2O_3

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nanocomposite. The X- axis (A) indicates hν and the Y axis (B) indicates $(\alpha\ h\nu)^{0.5}$. The band gap is close to 3.55 eV. The chemical identity of the composite is investigated through the FTIR spectrum shown in Fig 5. The peak at 529 cm^{-1} indicates Sn-O-Sn bond and 1710 cm^{-1} indicates the bonding in iron oxide. The peaks above 3000 cm^{-1} indicated the C-C and O-H groups.

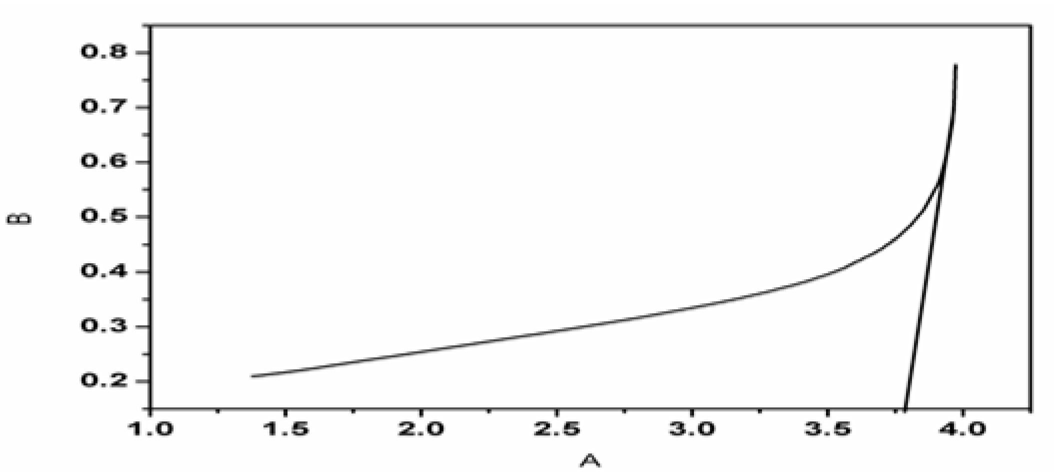

Fig.4. Taucs plot of $SnO\text{-}Fe_2O_3$ nanocomposite.

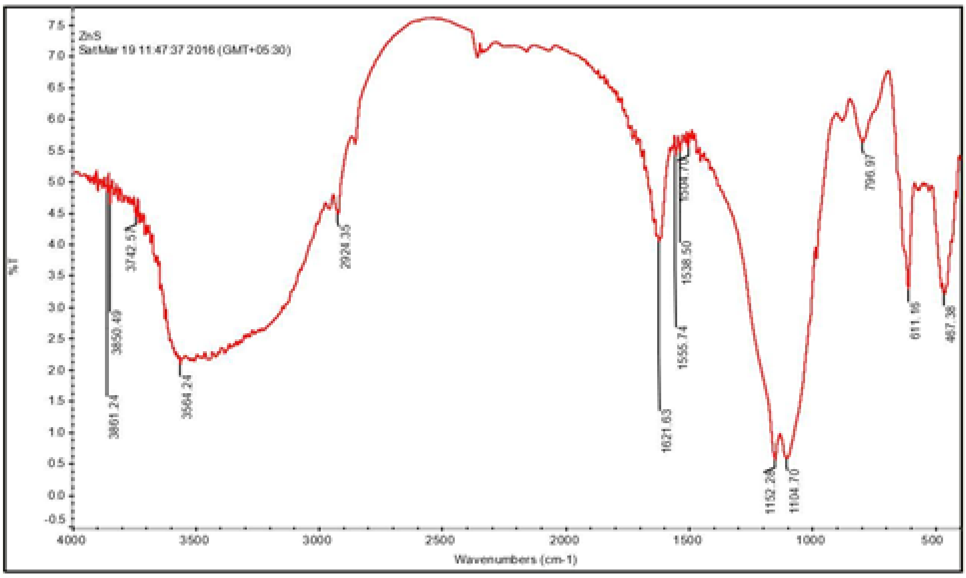

Fig .5. FTIR of $SnO\text{-}Fe_2O_3$ nanocomposite.

4. Conclusions

$SnO\text{-}Fe_2O_3$ nanocomposite was synthesized using sol gel route against the existing hydrothermal route in literature. The XRD pattern and SEM images revealed that the obtained powders contain mixture of micro and nanoparticles. A band gap of the nanocomposite was found to be 3.55 eV.

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The chemical identity of compound was verified through FTIR spectrum, showed the peaks at 1710 cm^{-1} and 529 cm^{-1} corresponded to the Fe-O and Sn-O bonds. As reported earlier by Choghamarani *et al.*[5], the vibration peaks in 447-579 and 3428 cm^{-1}, corresponded to Fe–O, and OH bonds, respectively. In the present work, we obtained the peaks in the range 467-811 and 3428 cm^{-1}. The variation in peaks can be due to distortion created by the Tin oxide .The use of hydrochloric acid could have been the reason for obtaining tetragonal nano-crystals. However, further investigation is required to study the variation of volume of HCl and its impact on morphology as reported for TiO_2nanocrystals [18].

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