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Comparative Analysis onStructural and Optical Characterizationof SnO_2 and Ag Doped SnO_2 Nanoparticles

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Abstract: Tin oxide (SnO_2) nanoparticles and Silver (Ag) doped SnO_2 nanoparticles synthesized via facile sol-gel route have been investigated in the present study for conditions relevant to their utilization for optical applications. The as-synthesized nanoparticles were evaluated by different characterization tools for structural, morphological and optical descriptions. X-Ray Diffraction (XRD) studies and Field EmissionScanning Electron Microscope (FE-SEM) studies indicate decrement in crystallite and particle size for Ag doped SnO_2 nanoparticles than bare SnO_2 nanoparticles suggesting an enhancement in surface area for the Ag doped SnO_2 nanoparticles.The Ag doped SnO_2sample was found to be optically enhanced than that of bare SnO_2 nanoparticles as understood from Ultra Violet–Diffuse Reflectance Spectroscopy(UV-DRS) analysis. The findings from the present study assert that the Ag doped SnO_2 nanoparticles present feasibility for energy and optical applications.
Keywords: SnO_2, Sol-gel, Silver, Optical, Energy.

1. Introduction

Nanotechnology is a field that is flourishingday by day, influencing all domains of human life [1]. Innovative applications of nanoparticles are evolving rapidly inthe current scenario by the research outputs, conducted by materials scientists [2].Among the various types of semiconductor metal oxide nanoparticles, SnO_2 is highly remarkable and has been intensively studied for a long time due to its promising physical and chemical properties [3]. Doping noble metals into metal oxides will enhance their properties like absorption capabilities, electrical conductance, conductance band position, charge recombination rates, etc.,of metal oxidesefficiently [4]. Several studies have assessed the outcome of different dopants on the morphology and properties of tin oxide and many other oxides [5]. Ag nanoparticles can broaden the optical absorption region of SnO_2 nanoparticles [6]. Optical and adaptablefeatures of Ag doped tin oxide (SnO_2) areparticularly more fascinating for researchers due to its vast applicationsin varied fields [7]. The sol-gel technique is the most effective and popular technique for preparation of metal/oxide or metal/organics nanocomposites [8].The present work is aimed at the relative investigation of structural and optical studies of sol-gel prepared SnO_2 and Ag doped SnO_2 nanoparticles.

2. Experimental

2.1 Synthesis of SnO_2 and Ag doped SnO_2 nanoparticles

An aqueous solution of stannous chloride di-hydrate and oxalic acid was prepared by dissolving distilled water and isopropyl alcohol under magnetic stirring for 30 minutes. Ammonia wasthen added to the aqueous solution while stirring to form precipitate and was left under constant stirring for 24h.It was then washed with distilled water for 4 to 5 times and the final filtered product was annealed for 4h at 400^{o}C in order to remove any residues and particulates for bare SnO_2 nanoparticles. For Ag doped SnO_2 nanoparticles, 3mol% of silver nitrate ($AgNO_3$) dissolved in water was added to the aqueous solution of stannous chloride di-hydrate and oxalic acid. Then a similar procedure involving stirring, washing and annealingat a certain temperature was followed to yield Ag doped SnO_2 nanoparticles.

2.2 Characterization Techniques

The as-synthesized $SnO_2$and Ag doped SnO_2 nanoparticles were analyzed by different characterization tools for probing their structural, morphological and optical properties. The crystal structure properties were analysed by XRD technique usingRICH SIEFEST X-Ray Diffractometer. The morphological characteristics were studied byF E I Quanta FEG 200 - High Resolution Scanning Electron Microscope**.**Lambda 35 UV-Visible/DRS-Spectrophotometer was employed to detect the optical properties of the samples.

3. Results and Discussion

3.1 X-Ray Diffraction Analysis

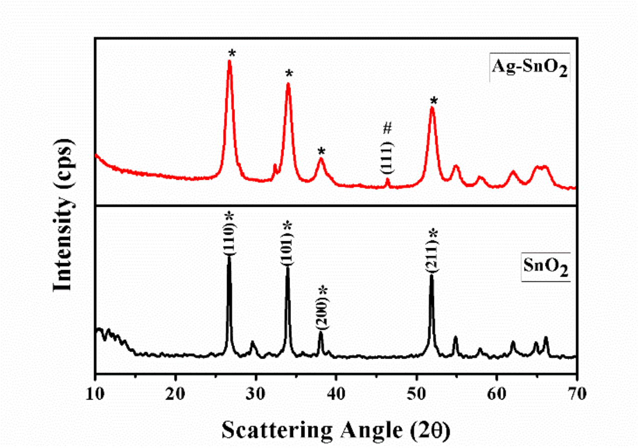

Fig.1. XRD pattern of SnO_2 and Ag doped SnO_2 nanoparticles

XRD patterns of the as-synthesized SnO_2 and Ag doped SnO_2 nanoparticles are shown in Figure.1.It is observed that both the patterns contain peaks corresponding to SnO_2 nanoparticles which were indexed as * in the figure. Those peaks are in good agreement with the standard JCPDS file.no (041-1445)belonging to tetragonal rutile structure of SnO_2 nanoparticles [9, 10]. The Ag-SnO_2 nanoparticles pattern comprises of an additional peak indexed as # which refers to the existence of silver nanoparticles in the sample. The said peak positions match well with the JCPDS file.no (87-0597) of silver nanoparticles [11].Scherrer's equation was used to calculate the average crystallite size [12] of the samples and it was found to be 32 nm and 25 nm for SnO_2 and Ag doped SnO_2 nanoparticles. The reduced crystallite size in the case of Ag doped SnO_2 nanoparticles, is due to the silverdopant in the sample [13].

3.2 Field Emission Scanning Electron Microscopy (FE-SEM) Studies

FE-SEM images of SnO_2 and Ag doped SnO_2 nanoparticles is as shown in Fig.2.The images clearly portray the surface morphology of the samples and it was observed thatboth the samples have uniform size distribution throughout the area [14]. There seems to be a slight agglomeration here and there which may be consequentialto preparation conditions of the samples [15]. The average particle size of the samples as calculated from FE-SEM images was found to be 46 nm and 16 nm for SnO_2 and Ag-SnO_2 nanoparticles. The decrement of particle size in Ag-SnO_2 when compared to SnO_2 would result in enhancement of surface area for the sample which is a highly preferred phenomena for photovoltaic applications [16].

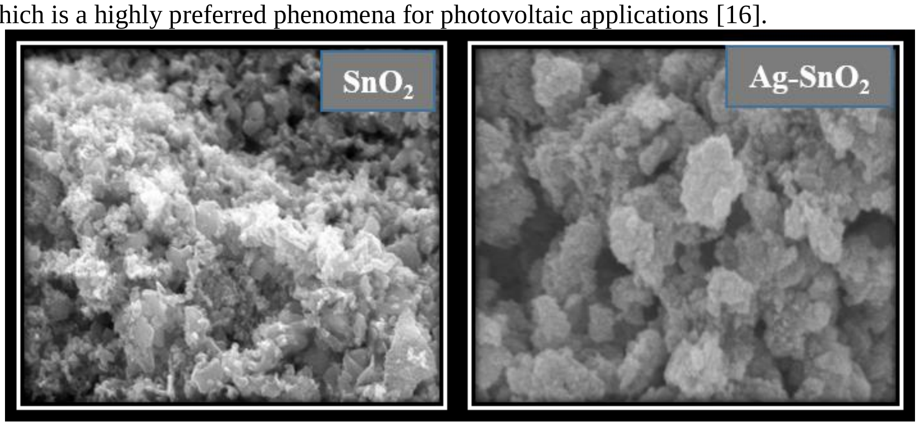

Fig.2. FE-SEM images of SnO_2 and Ag doped SnO_2 nanoparticles

3.3 UV-Visible/DRS Studies

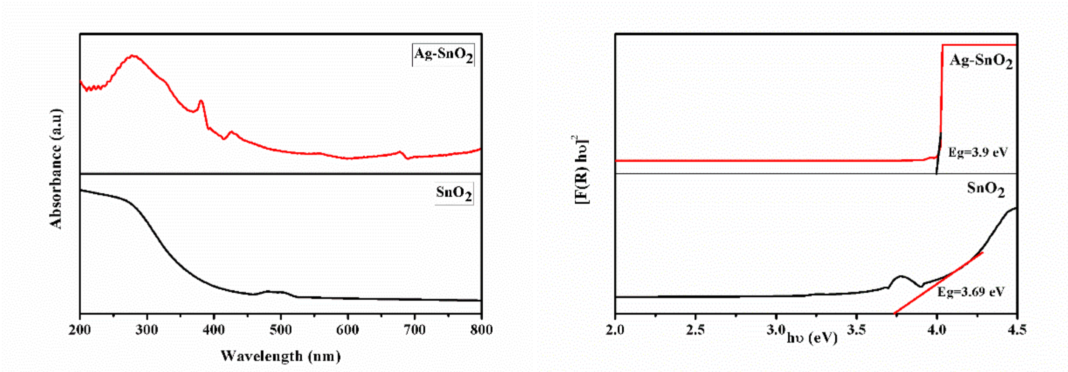

Fig.2. UV-Visible Absorption Spectra and K-M plot of SnO_2 and Ag doped SnO_2 nanoparticles

The absorption spectra of the samples are shown in Fig.3. From the spectra of the samples, it can be seen that the absorption intensities of Ag-SnO_2 nanoparticles are shifted to the visible region when compared with SnO_2 nanoparticles. This could be ascribed to the charge transition between the Ag and SnO_2 in the sample [14]. This extensive absorption recognised in the visible region of the spectrumis attributed to the silver nanoparticles in the sample Ag-SnO_2 [17]. The optical band gaps of the nanoparticles were deduced by K-M plots and were found to be 3.69 eV and 3.9 eV for SnO_2 and Ag-SnO_2 nanoparticles respectively.

4. Conclusions

SnO_2 nanoparticles and Ag-SnO_2 nanoparticles were successfully synthesized via facile sol-gel route in the present study.The FE-SEM analysis revealed reduced particle size for Ag-SnO_2 than that of bare SnO_2 nanoparticles thus suggesting an augmentation of surface area in the former.UV-Vis spectra show thatthe Ag-SnO_2 nanoparticlespossess better absorption in the visible region when compared to bare SnO_2 nanoparticles. Thus we could conclude that when compared to bare SnO_2, the Ag-SnO_2 nanoparticles possess prominent structural and optical properties owing to the effect of the Ag dopant thereby enabling their application in photovoltaic devices especially in DSSCs.

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