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Structural And Optical Property Of Core-Shell Tio_{2}/Sno_{2}nanocomposites Exhibiting Photocatalytic Behavior

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Abstract:

Here we report on the morphological and optical properties of TiO_2/SnO_2 nanocomposites prepared by a sol-gel method. The method comprises of a simple chemical reaction between Titanium isopropoxide solution and Water as well as subsequent addition of $SnCl_2$ solution to avail the coating of SnO_2 layer on the surface of TiO_2 nanoparticles . The as synthesized TiO_2 nanoparticles display strong UV absorbance characteristics. The XRD patterns verify the anatase phase of TiO_2 nanoparticles. The presence of both TiO_2 and SnO_2 in the sample is confirmed through XRD pattern. HRTEM images show clear evidence of formation of composite(core-shell) nanostructure in the sample. Optical properties of both TiO_2 and composite TiO_2/SnO_2 nanostructures are studied using UV-Vis absorption spectra, Photoluminescence and FTIR spectra. The performance of the composite nanostructure as a photocatalytic agent in comparison to the core TiO_2 nanostructures is also investigated for methyl orange dye under illumination of light. The Urbach energy of both the system is calculated and correlated with the photocatalytic degradation.

Keywords: *nanocomposties, XRD, HRTEM, Photoluminescence, photocatalytic, strain*

Introduction

The study of semiconductor nanoparticles has caught enormous attraction as an important area of research because of their unique optical and electrical properties which led them to find a place for the application in various fields. Generally coating a lower energy gap nanomaterial by a higher energy gap material yields core-shell nanostructures where the cores and shells may be any kind of colloidal particles, i.e. metals, insulators and all classes of semiconductors [1].Amongst core-shell nanostructures, TiO_2/SnO_2 nanostructures are highly useful in fabrication of photovoltaic devices as well as good photocatalytic agent as they show good TYPE 2 characteristics [2-4]. Akurati and his co-workers synthesized SnO_2/TiO_2 composite nanoparticles via a single-step method by adding evaporated precursor mixtures into an atmospheric pressure diffusion flame Photocatalytic activity of the composite particles is tested for the degradation of methylene blue and more improved photocatalytic activity than TiO_2 was observed [5]. Even degradation of 2-Propanol is reported with TiO_2/SnO_2 nanostructure acting as a photocatalytic agent [3]. In our work, we prepared core-shell TiO_2/SnO_2 nanoparticles via a simple sol-gel method and studied their photocatalytic activity for methyl orange dye under UV light illumination which is found to be greatly enhanced than TiO_2 nanoparticles.

Materials and method

Titanium iso propoxide, 2-Propanol, distilled water, tin chloride, hydrochloric acid are used as the main reactants. The core TiO_2 nanpoparticles was prepared via a simple sol gel procedure [6] and upon the core TiO_2 nanostructures a shell layer of SnO_2 was achieved following the procedure [7].

Structural Properties

Structural determination of TiO_2 and TiO_2/SnO_2 core shell nanostructures is done using X-ray diffraction as shown in fig 1(a). The XRD of TiO_2 is shown as a reference. In TiO_2/SnO_2 system, the characteristic peak of both SnO_2 (110) and TiO_2 (101) is observed. It apparently shows the formation of TiO_2/SnO_2 core shell structure while it is confirmed by HRTEM image, shown in fig 1(b). The TEM image (left) for TiO_2 and (right) core-shell TiO_2/SnO_2 nanostructures. No distinct particle is present in the core structure as we did not use any kind of surfactant in the reaction.

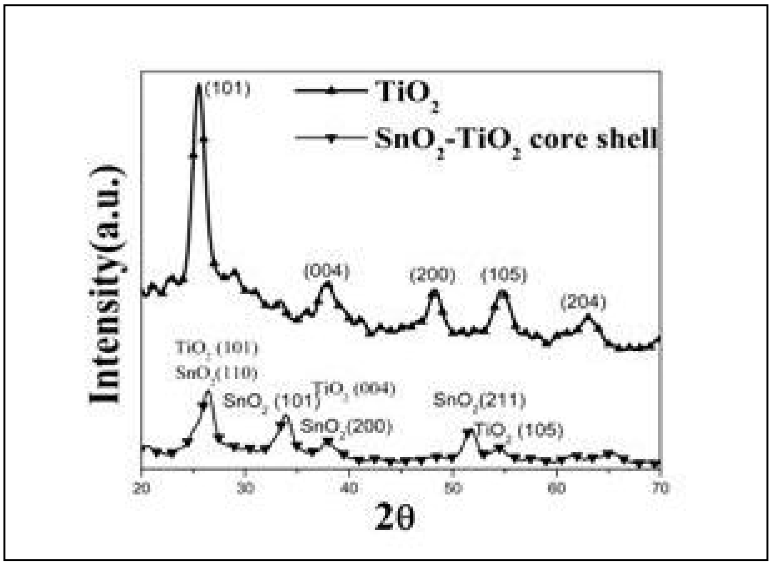


Figure 1(a): XRD

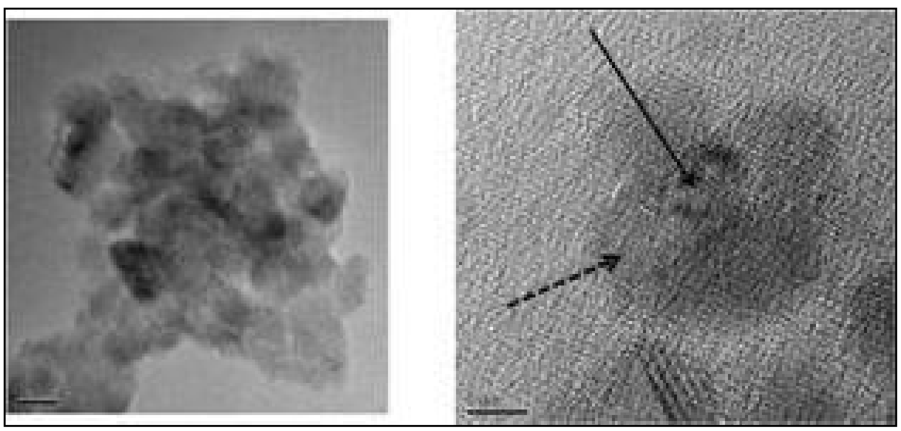
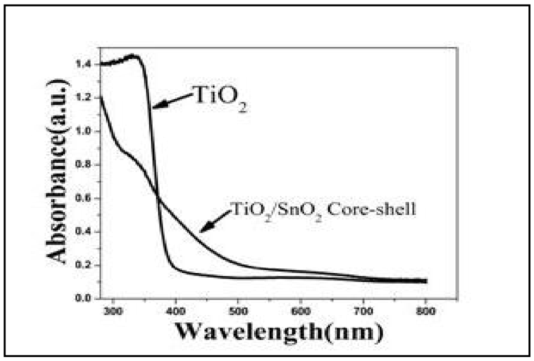


Figure 1(b): HRTEM

Optical Property analysis

Fig 2 (left) shows the UV-Vis absorption spectra where it is clearly seen that both core TiO_2 and core-shell TiO_2/SnO_2 structure show strong UV absorbance with a slight red shift in the core-shell structure. From PL (right) spectra, it is observed that the band edge emission peak of TiO_2 occurring at 375 nm is completely quenched in the core-shell TiO_2/SnO_2 structure. This is attributed to the formation of a TYPE 2 core-shell structure in the sample accompanied with less recombination resulting in quenching of band edge emission peak.



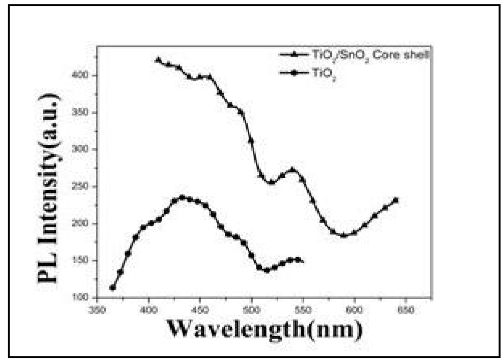


Figure 2: UV-Vis Absorption spectra *Photoluminescence Spectra*

Photoluminescence Spectra

Photocatalytic activity of both pure TiO_2 and TiO_2/SnO_2 core shell samples are studied by monitoring the decrease of the maximum absorbance of methyl orange (MO) at 464 nm [fig 3]. For UV irradiation the time interval was chosen to be 10, 20, 40 and 60 min respectively. Actually the absorbance at 464 nm of MO is due to functional group present in the system. The used photocatalytic agent is able to break the functional group hence producing the degradation..The percent degradation for both the system is listed in the table 1. The increase in degradation with TiO_2/SnO_2 core shell nanostructure over pure TiO_2 might be due to the presence of surface oxygen vacancies. This surface oxygen vacancies produce a great amount of distortion in the system. This distortion is proved from the higher value of Urbach energy [8] as listed in the table 1.

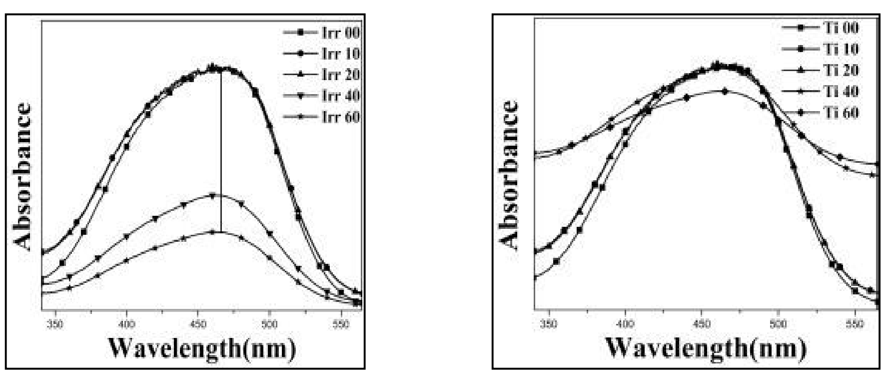


Figure 3: Degradation of MO

Sample	Urbach energy(meV)	Irradiation time(minutes)	Absorbance at 464 nm	Degradation $[(A_0-A)/A_0]$ 100%
TiO_2/SnO_2 core shell	1102.54	00	3.14	0
		10	3.14	0
		20	3.14	0
		40	1.50	52.20
		60	1.02	67.52
Pure TiO_2	109.41	00	3.14	0
		10	3.14	0
		20	3.14	0
		40	3.14	0
		60	2.98	5.1

Table 1

Conclusion

Thus, we have shown successful synthesis of both core TiO_2 and core-shell TiO_2/SnO_2 nanostructures with detailed study of their optical properties. In our work, we obtained that the core-shell TiO_2/SnO_2 nanostructures exhibit very high photocatalytic property and it is expected that the core-shell nanostructure can also be used as a photocatalytic agent under visible light illumination.

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