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RESEARCH ARTICLE

SYNTHESIS AND CHARACTERIZATION OF SURFACE MODIFIED RhoB-TiO_2

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ABSTRACT

The main objective of this work is to prepare the solar active materials such as TiO_2 with help of dye. The Rhodamine-B modified TiO_2 (RhoB-TiO_2) composite will used as DSSC. The PL studies are carrying out by the emission and excitation of TiO_2 is increased after addition of Rhodamine-B. UV study showed that the composite energy gab has shifted towards the visible region in electromagnetic spectrum (Red shift), and then band gap is indirect and allowed transition. In this type of RhoB-TiO_2 composite used for fabrication of optoelectronic device and fabrication of DSSC.

INTRODUCTION

The dye molecules are quite small (nanometer sized), so in order to capture a reasonable amount of the incoming light the layer of dye molecules needs to be made fairly thick, much thicker than the molecules themselves. In existing designs, this scaffolding is provided by the semiconductor material, which serves double-duty. DSSCs are currently the most efficient third-generation (2005 Basic Research Solar Energy Utilization 16) solar technology available. This makes DSSCs attractive as a replacement for existing technologies in "low density" applications like rooftop solar collectors, where the mechanical robustness and light weight of the glass-less collector is a major advantage [1]. They may not be as attractive for large-scale deployments where higher-cost higher-efficiency cells are more viable, but even small increases in the DSSC conversion efficiency might make them suitable for some of these roles as well. The size of the TiO_2 particles decreases, the fraction of the atoms located at the surface increases with higher surface area to volume ratios, which can further enhance the catalytic activity. The increase in the band gap energy with decreasing nanoparticle size can potentially enhance the redox potential of the valence band holes and the conduction band electrons, allowing photo-redox reactions, which might not otherwise proceed in bulk materials, to occur readily. By a decrease in particle size below a certain limit, surface recombination processes became dominant. Since most of the electrons and holes were generated close to the surface and surface recombination was faster than interfacial charge carrier transfer processes [2-11]. The aim of the present work is to prepare Dye sensitized solar materials (RhoB-TiO_2) using surface modified process and to study the structural properties, optical properties and morphological studies through XRD, UV, PL analysis, SEM technique.

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Experimental

Materials

All precursors were of analytical grade, purchased from alpha aesar: titanium (IV) oxide powder (99.8% pure, 32nm) in the anatase phase, Rhodamine-B, and chloroform.

Synthesis of RhoB-TiO_2

RhoB-TiO_2 was synthesized by dispersing 0.1gm of Rhodamine-B and 3gm of TiO_2 in 50ml of chloroform. This suspension was stirred for 3h at 70°C temperature. After that the mixture was filtered and repeatedly washed with chloroform to remove the unreacted Rhodamine B. The resulting solid was dried in an oven at 100 °C for 1h.

RESULT AND DISCUSSION

The prepared surface Modified-TiO_2 (Fig.1a) the peak positions and their relative intensities are consistent with the standard powder diffraction patterns of anatase-TiO_2 (JCPDS card # 21-1272). It has a main peak at 25.2° corresponding to the (101) plane. The peak position at 37.7, 47.8, 54.1, 62.5 and 69.4 are in accordance with the TiO_2 anatase phase. The lattice parameter of the pure TiO_2 [(Tetragonal) a=3.785 Å; c=9.513 Å] are also in accordance with the reported value (JCPDS card # 21-1272). The crystallinity of our sample is better and is confirmed from the XRD spectrum. These XRD spectrum (as seen in Fig.1a and Fig.1b,) indicates TiO_2 nanoparticles were dominant to the prepared RhoB-TiO_2 samples.

$D = K\lambda / \beta \cos\theta$,

The average crystalline size D for RhoB-TiO_2 is 34.67 nm from above equation. Where K is the Scherer constant, λ is the

Wavelength; β is the peak width of half maximum and θ is the Bragg diffraction angle.

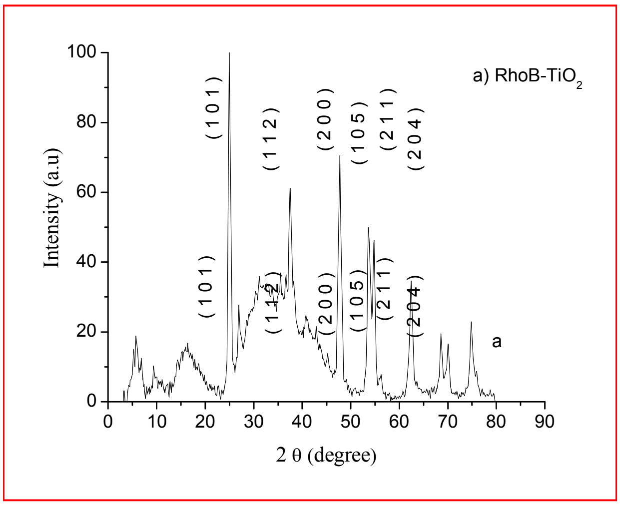


Fig.1 XRD pattern for RhoB -TiO$_2$

Morphological Analysis

Morphology of RhoB-TiO$_2$ was determined by SEM micrographs as seen in Fig.2. There was clear evidence that the modified surface has distinct features composed of sphere likes structures. Rho-B TiO$_2$ has been distributed well within the range of 70-90 nm.

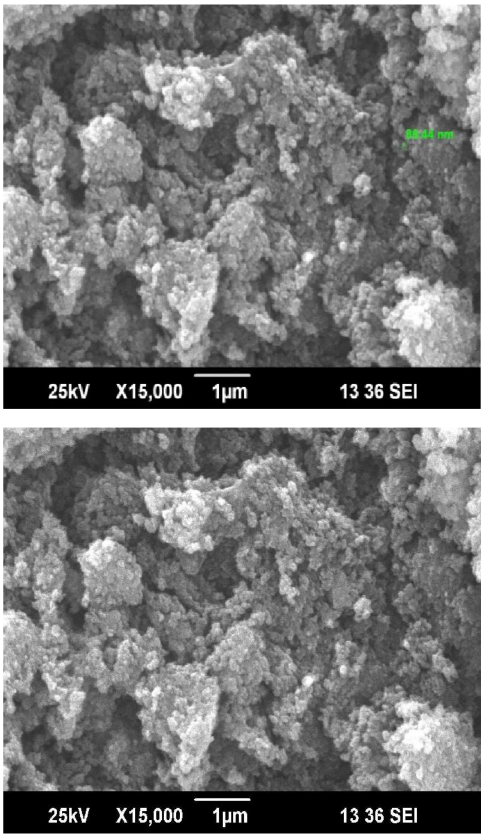


Fig.2. SEM micrograph of RhoB-TiO$_2$

Optical Properties

UV Studies

Absorption wave length of TiO$_2$ and RhoB-TiO$_2$ is 376 and 524 nm, which is shift toward the visible region in solar spectrum. The absorption of the RhoB-TiO$_2$ has been increased as compared to the TiO$_2$ as seen in Fig.3. So the prepared sample such as RhoB-TiO$_2$ is good absorption in the visible region at solar (electromagnetic) radiation. The energy band gap of the TiO$_2$ and RhoB-TiO$_2$ are determine from the plot of $(\alpha h\nu)^{1/2}$ vs hν and is shown in Fig.5a and Fig.5b. The plot is linear, indicating an indirect and allowed optical transition. The band gap of the TiO$_2$ and RhoB–TiO$_2$ are the 3.02 eV and 3.49 eV respectively. Band of RhoB-TiO$_2$ has been increased as compared to the TiO$_2$ due to quantum confinement effect.

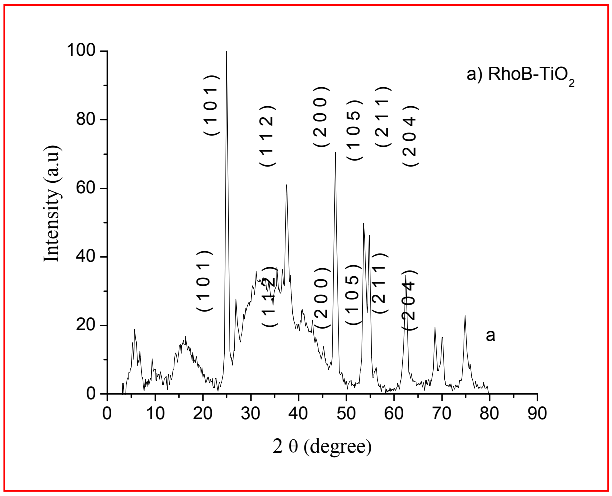


Fig. 3. UV Absorption spectrum for the a) TiO$_2$ and b) RhoB-TiO$_2$

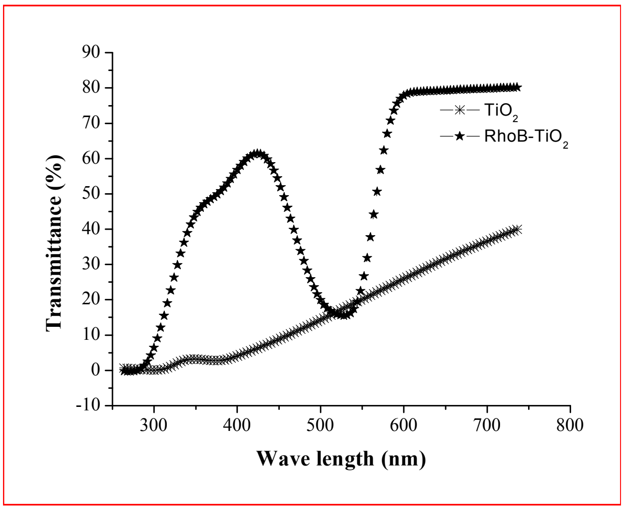
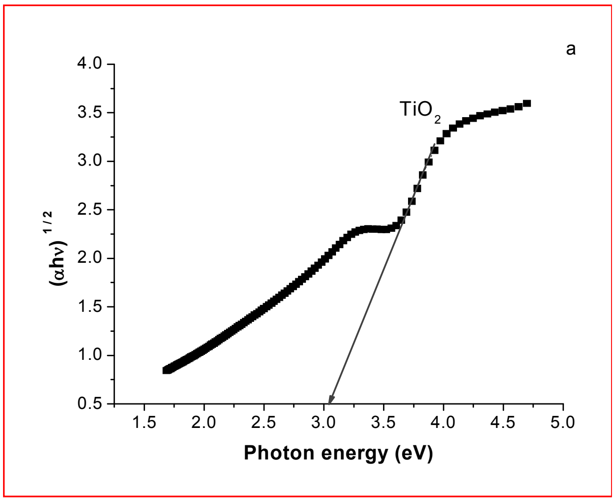


Fig. 4. UV transmission spectrum for the a) TiO$_2$ and b) RhoB-TiO$_2$



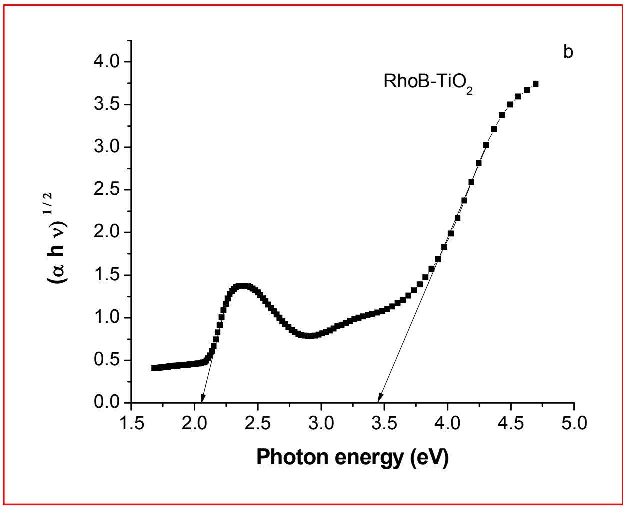


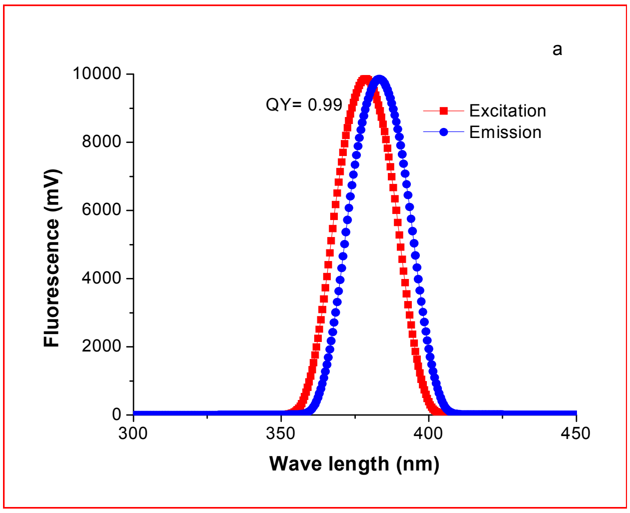
Fig.5. The energy band gap of the a) TiO_2 and b) RhoB-TiO_2

Photoluminescence

Fluorescence occurs when molecules absorbs light photons from the UV-Visible light spectrum, know as excitation, and then rapidly emits light photons as it returns to its ground state. Fluorescent compounds can be identified and quantified on the basis of their excitation and emission properties. The TiO_2 and RhoB-TiO_2 sample absorbed UV and Visible radiation respectively and utilized energy from it, and then excited to higher energy state. The excitation wave length is 378 nm and 524 nm which approximately equal to the maximum absorption wave length. The quantum yield of the TiO_2 and RhoB-TiO_2 are nearly equal to the ≈0.99 and 1 respectively as seen in Fig.6. The TiO_2 and RhoB-TiO_2 are using DSSC fabrication. Because from the PL excitation and emission spectrum of our prepared surface modified TiO_2 is active under the visible region. So the prepared samples are used to fabricate the DSSC. Because from the PL excitation and emission spectrum of our prepared surface modified TiO_2 is active under the visible region.

Energy Dispersive analysis

As the electron beam of the SEM is scanned across the sample surface, it generates X-ray fluorescence from the atoms in its path. The energy of each X-ray photon is characteristic of the element which produced it. The EDS microanalysis system collects the X-rays, sorts and plots them by energy, and automatically identifies and labels the elements responsible for the peaks in this energy distribution. The EDS data are provide conformation of TiO_2 element. 82.98% of Ti and 17.02% of O are present the surface modified TiO_2.



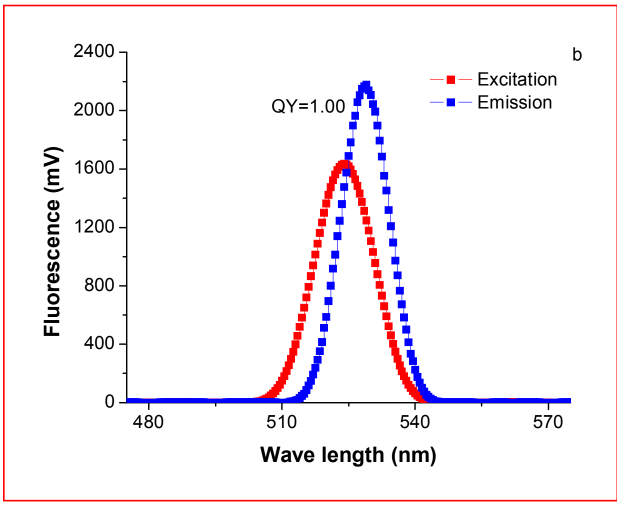


Fig.6. Excitation, Emission and Quantum yield spectrum for a) TiO_2 and b) RhoB-TiO_2

The original spectrum of element distributions over areas of interest and quantitative composition Table are seen Fig.7 and Table1 respectively.

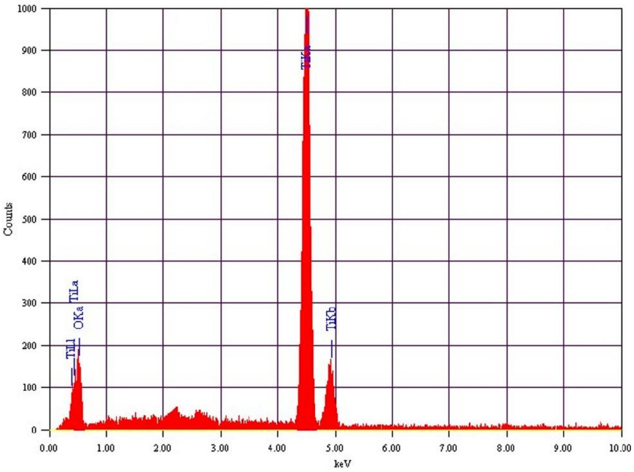


Fig.7. EDS spectrum for Surface modified -TiO_2

Table 1. Quantitative composition of surface modified TiO_2

Elements	KeV	Mass%	Atom%	K
O K	0.525	6.41	17.02	0.7259
Ti K	4.508	93.59	82.98	1
Total		100	100	

Conclusion

Surface Modified-TiO_2 peak positions and their relative intensities are consistent with the standard powder diffraction patterns of anatase-TiO_2 (JCPDS card # 21-1272). The crystallinity of prepared sample is better and is confirmed from the XRD spectrum. The average crystalline size for RhoB-TiO_2 is 34.67 nm. Morphology of RhoB-TiO_2 was determined by SEM micrographs. The energy band gap of the TiO_2 and RhoB-TiO_2 are determined from the plot of $(\alpha h\nu)^{1/2}$ vs hν. The band gap of the TiO_2 and RhoB-TiO_2 are the 3.02 eV and 3.49eV respectively. The prepared TiO_2 and RhoB-TiO_2 are used to fabricate the DSSC. Because from the PL excitation and emission spectrum of the prepared surface modified TiO_2 is active under the visible region. The EDS data are provide conformation of TiO_2 element. 82.98% of Ti and 17.02% of O are present the surface modified TiO_2

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