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Dye Sensitized Solar cell materials -TiO_2 with Hesperidin

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Abstract: In this paper, have been discussed systematic studies of surface Modified TiO_2. The samples are characterized by XRD, FE-SEM, PL, UV and I-V. The main objective of this work is to prepare the PV material such as TiO_2 with help of dyes. The surface modified TiO_2 (Hes-TiO_2) composite will used as DSSC. The PL studies are carrying out by the emission and excitation of TiO_2 and Hes-TiO_2. UV study showed that the composite energy gab has shifted towards the lower wavelength in electromagnetic spectrum (blue shift), and then optical band gap is an indirect and allowed transition. In this type of Hes-TiO_2 composite used for fabrication of optoelectronic device, because the quantum yields of the TiO_2 and Hes-TiO_2 approximately equal to the unity. The solar energy conversion efficiency is increased 70% for the surface modified-TiO_2 as compared to TiO_2.

Keywords: Hesperidin, FESEM, Excitation, Emission, Quantum yield and DSSC.

I. INTRODUCTION

Recent researchers are focusing in the field of energy conversion that is light energy into electrical energy. Energy consumption and demand is increasing from day to day. In recent days the interest on the TiO_2 has increased tremendously, since TiO_2 is a promising and multifunctional material, which can be implemented in solar cell fabrication due to its attractive physical, chemical and optical properties. Among the various forms of Nanostructural Titania, nanotubular Titania has attracted increasing interest due to its highly ordered structure and the convenient controlling of the size. The modified form of TiO_2 composites such as Photosensitized dye doped-TiO_2 is interest for their potential application, such as electrolytes in dye-sensitized solar cells, anti reflection coating, photocatalysts and so on [1-6]. Hesperidin shows a characteristic flavanone absorption spectrum with UV maxima at 286 and an inflection of low intensity at 330 nm. Hesperidin appear to be extremely safe and without side effects. Hesperidin has nontoxic both to the human beings and to nature, easily assimilated, non accumulative and caused no allergic reactions. Hesperidin is an abundant and inexpensive by-product of Citrus cultivation and is the major flavonoid in sweet orange and lemon. In paper work is focusing in the direction of systematic sample preparation, characterization, and find out optical parameters from physical phenomena such as absorption, transmission, reflection, and also application of solar cells in the form of DSSC for using Hesperidin pigment [8, 9].

II. MATERIALS AND METHODS

MATERIALS

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

SYNTHESES OF SURFACE MODIFIED-TIO_2

Surface modified-TiO_2 was synthesized by dispersing 0.1gm of hesperidin 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 hesperidin. The resulting solid was dried in an oven at 100 °C for 1h [8]

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III. RESULT AND DISCUSSION
STRUCTURAL ANALYSIS

The surface Modified-TiO_2 (Fig.1) 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 is shown inTable.1)

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

The average crystalline size D for Hes-TiO_2 is 24.37 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.

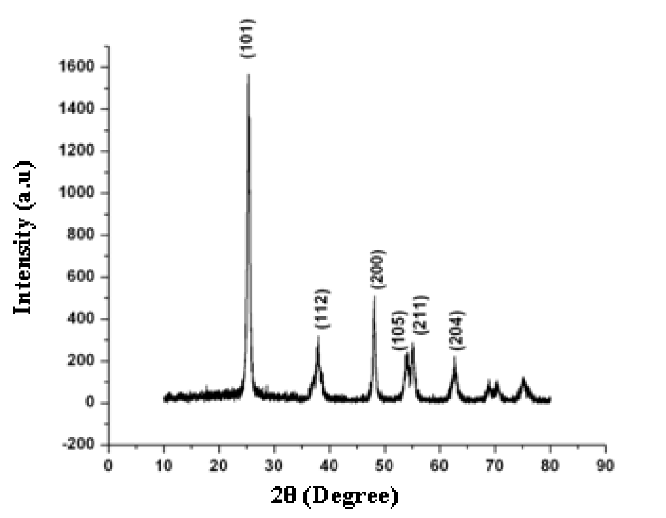

Fig.1 XRD spectrum for Hes-TiO_2

Standard JCPDS data of TiO_2 (JCPDS No.21-1272)			Hes-TiO_2
2 Theta	Intensity	Plane (hkl)	2 Theta
25.281	100	101	25.22
37.8	20	004	37.88
48.049	35	200	48.13
53.890	20	105	54.02
55.060	20	211	55.37
62.688	14	204	62.515
68.760	6	116	68.62
70.309	6	220	70.166
74.029	2	107	74.94

Table1. Comparison of standard TiO_2 anatase and Hes-TiO_2

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MORPHOLOGICAL ANALYSIS

Morphology of Hes-TiO_2 was determined by FESEM micrographs as seen in Fig.2. There was clear evidence that the modified surface has distinct features composed of sphere likes structures. Hes-TiO_2 has been distributed well within the range of 20– 30 nm which is the favorable range to exhibit for DSSC.

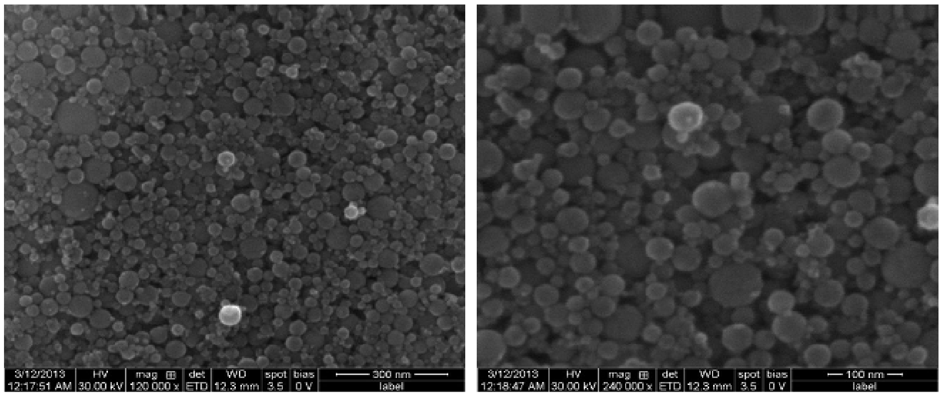


Fig .2. FESEM micrograph of the Hes-TiO_2

OPTICAL PROPERTIES AND UV STUDIES

The optical method provides a very simple way of finding the band gap as compared to the electric method using the thermal excitation which is less reliable because of the fact that the effective mass of electrons and holes also influence most of the electrical parameters. The measurement of m* is not very reliable since it is coupled with many other parameters. Hence optical method is less ambiguous. The optical energy band gap of the TiO_2 and Hes-TiO_2 is determined from the plot of $(\alpha h\nu)^{1/2}$ vs hν and is shown in Fig.3. The plot is linear, indicating an indirect and allowed optical transition. The optical energy band gap of the TiO_2 and Hes–TiO_2 are the 3.02 eV and 3.2 eV respectively, which means that absorption of Hes–TiO_2 shift toward the lower wavelength in solar spectrum. The absorption of the Hes-TiO_2 is increased as compared to the TiO_2.

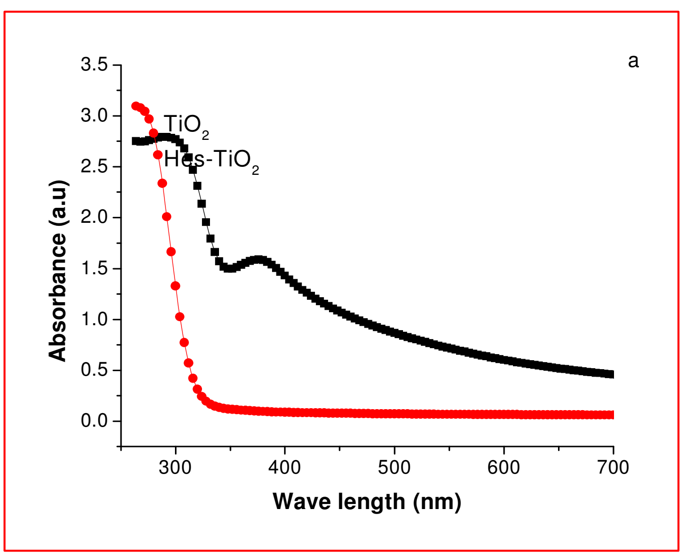
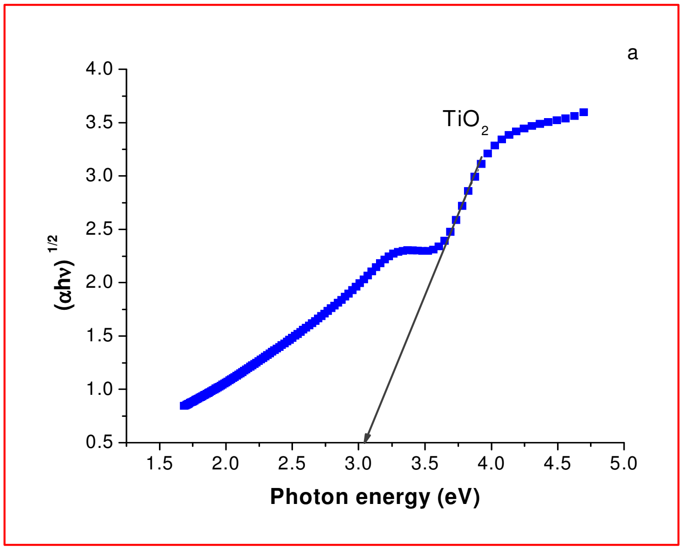


Fig .3. Absorption spectrum for TiO_2 and Hes-TiO_2



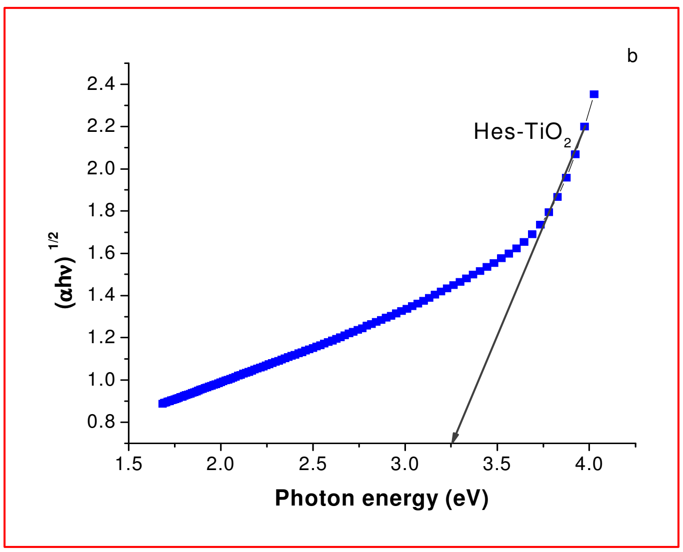


Fig .4. Direct and allowed band gap Extrapolation for a) TiO_2 and b) Hes-TiO_2

PHOTOLUMINESCENCE

The TiO_2 and Hes-TiO_2 sample absorbed visible radiation corresponding to their band gap 3.02 eV and 3.2 eV respectively and then excited to higher energy state. The excitation wave length is 378.5 nm and 379 nm which approximately equal to the maximum absorption wave length; it was confirmed from the absorption spectrum. The quantum yield of the TiO_2 and Hes-TiO_2 are nearly equal to the ≈0.99 and 1 respectively as shown in Table 2.

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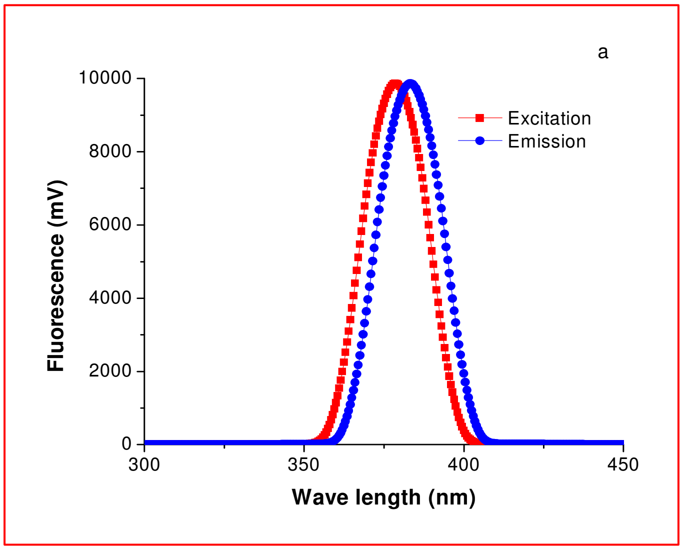

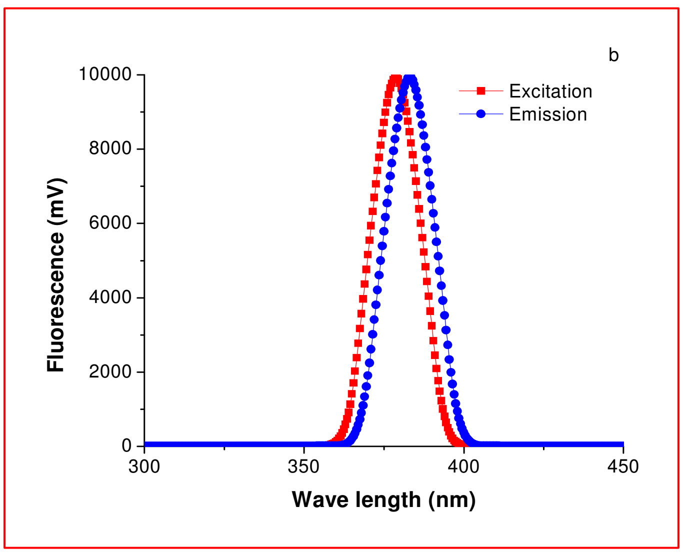

Fig .5. PL emission and excitation spectrum for a) TiO_2 and b) Hes-TiO_2

Table .2.Excitation, emission wave length and Quantum yield of the TiO_2 and Hes-TiO_2

Sample	Excitation (λ) nm	Emission(λ) nm	Quantum Yield
TiO_2	378.5	383.5	0.99
Hes-TiO_2	379	383	1.00

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IV. J-V CHARACTERIZATION

The photocurrent-voltage characteristics were performed using a Keithley model 2400 source measuring unit. A solar simulator with 60 W (AM 1.5) mercury lamps served as a light source and an effect area of 0.052 cm^2. The prepared sample was pelletized by using Pelletizing machine (Hydraulic type) and the radius of sample is 0.5 cm and height is 0.05cm. The photocurrent density voltage curves (J-V curves) for DSSC based on TiO_2 and Hes-TiO_2 is shown in Fig. 6 and Fig.7 the corresponding values are summarized in Table 3. The Hes-TiO_2 shows an improved total energy conversion efficiency of 7.997% which is 70% higher than the TiO_2 (1.596%). The improvement of the Hes-TiO_2 is mainly ascribed to the improvement of short-circuit current density (Jsc) compared to TiO_2 [9-13].

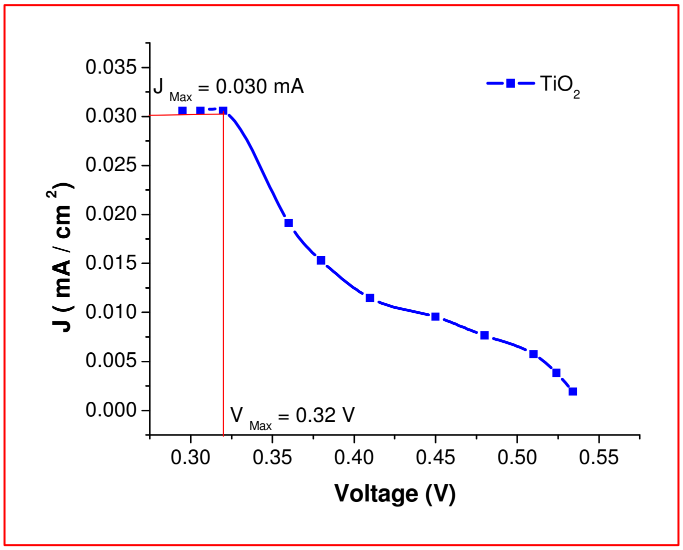

Fig .6. J-V Characteristic of TiO_2 nanoparticles

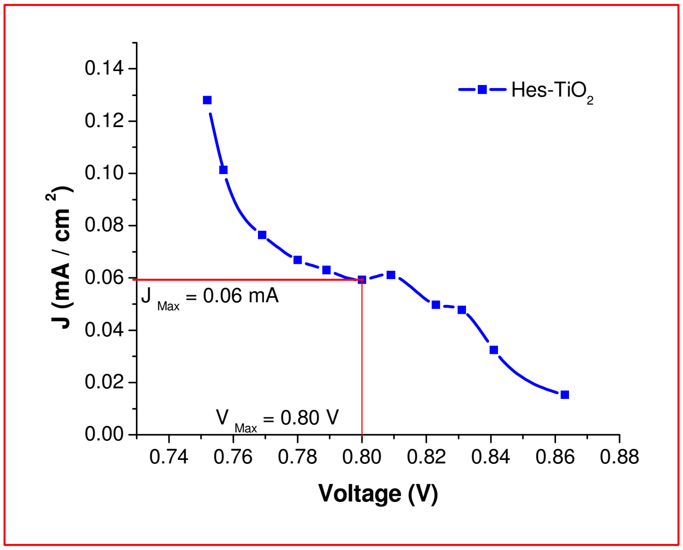

Fig .7. J-V Characteristic of Hes-TiO_2 nanoparticles

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Table.3 J_{SC}, V_{OC} and efficiency for TiO_2 and Hes-TiO_2

Sample	**J_{SC} (mA/cm^2)**	**V_{OC}**	**FF %**	**Efficiency %**
TiO_2	0.0305	0.534	58.80	1.596
Hes-TiO_2	0.128	0.863	43.44	7.997

V. MECHANISM FOR HES-TiO_2 DSSC

A Photosynthetic unit is the smallest group of (Hesperidin) pigment molecules which take part in a photo-chemical act or conversion of light energy into chemical energy. The photosynthetic unit has a photocentre, which consist of a TiO_2 nanoparticle and it absorb light energy at 378-383nm wavelength. The Hesperidin molecules absorb light of visible wavelength. On the absorption of light energy by the Hesperidin molecules get excited. The excited Hesperidin molecules hand over their energy to TiO_2 nanoparticle by the resonance and come to ground state. The TiO_2 nanoparticle gets excited by the absorption energy from the Hesperidin molecules. And extrudes an electron after which TiO_2 nanoparticle comes to ground state repeat the cycle. Mechanism for Hes-TiO_2 DSSC is shown in Fig.8.

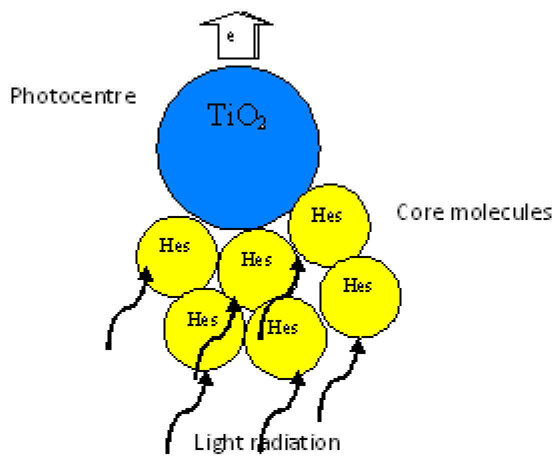

Fig .8. Harvesting of light by a photosynthetic unit

VI. CONCLUSION

The structural property of Hes-TiO_2 has been studied by X-Ray diffraction technique. The surface morphology of the prepared nanopowders shows sphere like structure. Hence, we can conclude that, the prepared nanoparticles shows better structural, morphological and Optical property. A high performance DSSC was developed using surface modified process. It was found that dye-sensitized solar cell characteristics fabricated with surface modified TiO_2 were remarkably better than those with TiO_2. TiO_2 nanoparticles have smaller particle size and exhibit slightly higher surface area for dye absorption when they were used in combination with much larger Hesperidin molecules.

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