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SYNTHESIS AND CHARACTERIZATION OF NATURAL DYE SENSITIZER BASED SOLAR CELL

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Abstract **:** The present work on **"Synthesis and characterization of natural dye sensitizer based solar cell"** is divided into five chapters. The salient features of each chapter are given briefly., a brief account of usefulness and technologically importance of natural dye, so given as these are mainly useful for optoelectronic device fabrication particularly for solar cell applications. The applications and works on natural dye based DSSC in literature are reviewed. The background and the motivation of the project are also discussed. deals with preparation of dye sensitizer and photoanode are discussed. The Characterization techniques XRD, PL, and UV measurements are discussed in detail. an attempt is made to study the effect of dye sensitizer by I-V measurement technique. The theory and the experimental details of I-V measurement are discussed here.

KEYWORDS: **Synthesis ,characterization, natural dye, sensitizer, solar cell.**

INTRODUCTION

The Sun is the only source of heat and light for the entire solar system. Converting solar energy to usable forms like electricity or chemical fuels remains a huge challenge. Photovoltaic devices are the primary solar energy conversion systems to harvest the solar energy. These photovoltaic devices, more simply known as solar cells, convert the incident photon energy of the solar radiation into electrical energy through the generation and subsequent collection of electron-hole pairs. There are several challenges that need to be met for the Research & Development of solar cell technologies to make it a pragmatic solution to our energy crisis, High power conversion efficiency, and low cost long term stability, using abundant and biocompatible raw materials. The oldest type of photovoltaic cell is the photo electrochemical solar cell, used already by Becquerel for the discovery of the photovoltaic effect in 1839. In the photo electrochemical solar cell a semiconductor-electrolyte junction is used as a photoactive layer. While energy conversion efficiencies exceeding 16% have been achieved with the photo electrochemical solar cells utilizing semiconductor photo electrodes, instability of these solar cells by photocorrosion has left them without practical importance. Furthermore, the photoelectrochemical solar cells using some semiconductor materials as in the commercial solar cells, such as Si, does not offer any real advantages over the established solid state solar cells. In 1991, the dye-sensitized solar cell (DSSC) was developed by Grätzel which was named "GrätzelCell"[1,2].

Cell Assembly

A drop of 1ml electrolyte solution was added on photoelectrode. After that, the cell was assembled by putting the photoelectrode on counter electrode shifted about 1cm. The shift between the two electrodes is needed for the electrical contact. The cell has to be sealed, otherwise the electrolyte would evaporate. The dye solar cells were isolated using glue around the masked area. Two clamps were used to press the two electrodes together until the sealant became dry.

Characterization Techniques

X-Ray Diffraction

Diffraction effects are observed when electromagnetic radiation impinges on periodic structures with geometrical variations on the length scale of the wavelength of the radiation. The interatomic distances in crystals and molecules amount to 0.15–0.4 nm which correspond in the electromagnetic spectrum with the wavelength of X-rays having photon energies between 3 and 8 KeV. Accordingly, phenomena like constructive and destructive interference should become observable when crystalline and molecular structures are exposed to X-rays. In the following sections, firstly, the geometrical constraints that have to be obeyed for X-ray interference to be observed are introduced. Secondly, the results are exemplified by introducing the θ/2θ scan, which is a major x-ray scattering technique in thin-film analysis. Thirdly, the θ/2θ diffraction pattern is used to outline the factors that determine the intensity of X-ray reflections. We will thereby rely on numerous analogies to classical optics and frequently use will be made of the fact that the scattering of radiation has to proceed coherently, i.e. the phase information has to be sustained for an interference to be observed. The phenomenon of X-ray diffraction was shown in Fig 2.1. In addition, the three coordinate systems as related to the crystal, to the sample or specimen and to the laboratory that have to be considered in diffraction are introduced. Two instrumental sections related to the θ/2θ diffractometer and the generation of X-rays by X-ray tubes supplement the chapter. One-elemental metals and thin films composed of them will serve as the material systems for which the derived principles are demonstrated.

3.1 I – V Characterization

Prepared solar cells (1cm^2 size) were characterized by current-voltage (I-V) characteristics. Photocurrents and voltages were measured using a keitheley source meter 2400, with a 80 W halogen lamp and AM 1.5G, and the light intensity was adjusted. Quality of the solar cell is determined by a parameter called solar cell efficiency that is simply defined by a ratio;

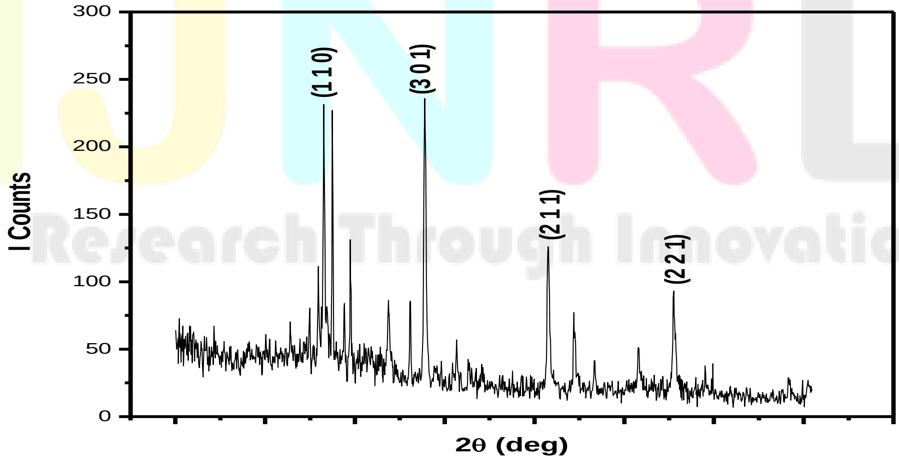
$$\eta = \frac{P_{\max}}{P_L}, \qquad \text{------------------ (3.3)}$$

where P_{max} is the maximum solar cell power and P_L is power of the incident light. So, solar cell efficiency and P_{max} are associated by a linear dependence. At constant power of incident, light change in P_{max} reflects peculiarities in solar cell efficiency and quality of the cell as well. Maximum power created of solar cell can be simply found by measuring its I-V characteristic under external biasing as well as measuring current of illuminated solar cell without bias and voltage changing loadings. The past measurements used to study spectral peculiarities of maximum electric current power created by the solar cell. The dependence of solar cell power versus voltage illuminated by halogen lamp for two samples is depicted in Fig.3.1. The change in position of P_{max}

reflects tuning in the cell resistance. It is no wonder because etching of solar cell reduces the sample effective cross-section area, so it boosts its sequential resistance[22].

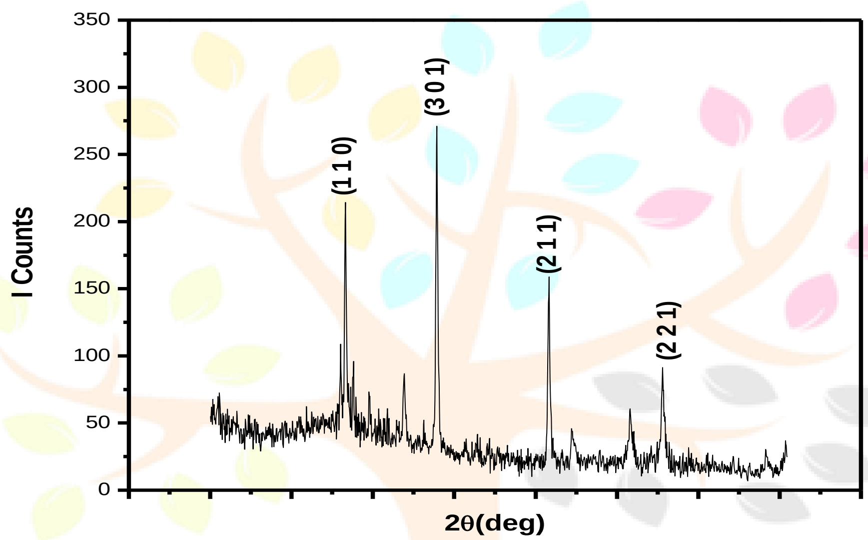
Results and discussion

The photoanode was prepared by using anthocyanins dye coated on TiO_2 films having different thickness. The thickness of the film was varied by using different rpm such as 3000, 4000, 5000, 6000 of spin coating machine. To study the microstructural characterization, XRD patterns are recorded for TiO_2 samples prepared at different rpm and then they are compared. The diffraction patterns were recorded using the XPERT-PRO diffractometer system.



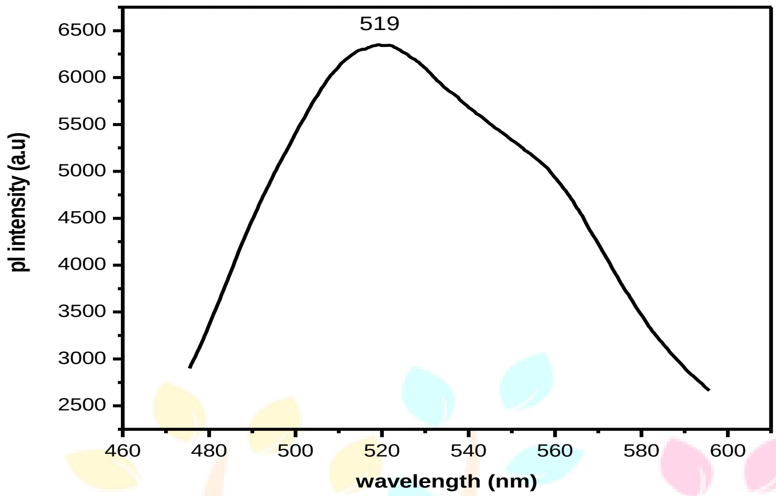
Position2θ(deg)		d - Spacing A º		FWHM	(h k l)	Matched by
Observed	JCPDS	Observed	JCPDS			
27.4927	27.465	3.24436	3.24491	0.3150	(1 1 0)	73-1765
37.7864	37.281	2.38087	2.41000	0.1956	(3 0 1)	72-0519
54.4515	54.411	1.68512	1.68487	0.2732	(2 1 1)	84-1284
65.5259	65.624	1.42459	1.42153	0.0563	(2 2 1)	84-1284

Fig.4.1: XRD Pattern for TiO_2 samples prepared at 3000 rpm and comparison of observed and JCPDS values of 2θ and d spacing values.



Position 2θ(deg)		d - Spacing A º		FWHM	(h k l)	Matched by
Observed	JCPDS	Observed	JCPDS			
27.5793	27.508	3.23436	3.23996	0.4629	(1 1 0)	65-0192
37.8652	37.226	2.37610	2.41344	0.2982	(3 0 1)	72-0519
54.4731	54.459	1.68450	1.68351	0.0010	(2 1 1)	65-0192
65.6264	65.330	1.42265	1.42721	0.5930	(2 2 1)	65-1118

Fig.4.1: XRD Pattern for TiO_2 samples prepared at 3000 rpm and comparison of observed and JCPDS values of 2θ and d spacing values.



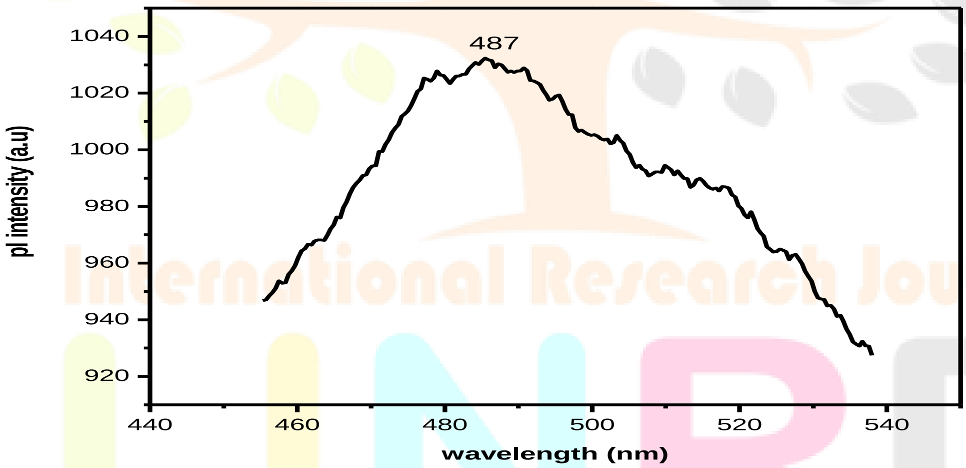


Fig.4.9: Photoluminescence spectra of TiO_2 prepared at 3000 rpm.

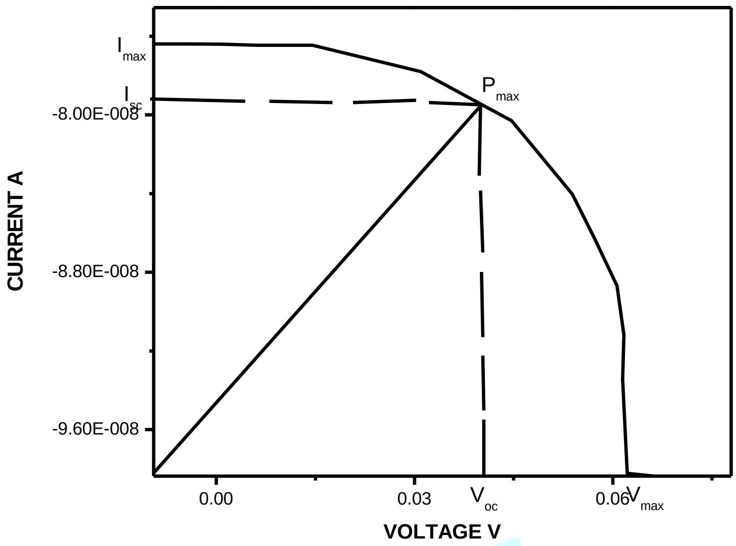


Fig.4.37: I-V measurement spectrum for Anthocyanine dye coated TiO_2 prepared at 6000 rpm.

Conclusion

The synthesized nanostructured porous TiO_2 samples were sensitized by natural dye. The structural characterization was done by XRD. The XRD pictures showed the features of TiO_2 and natural dye (blackrice). They are nanostructured in nature. Initially the samples are characterized with photoluminescence and the band gap calculated from the PL spectrum show that the band gap increases with increase in the rotation per minute. The band gaps calculated from the UV absorption spectrum are in the range 2.38 eV to 2.55 eV which is in agreement with PL measurements. To study the suitability of these samples for solar cell applications and sensors, the samples were optimized using UV absorption. The DSSC prepared at the ratio 3000 rpm as shown maximum efficiency.

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