IMPROVING QUANTUM EFFICIENCY WITH THE HELP OF DYE

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ABSTRACT

Solar energy has potential to fulfil an important part of the sustainable energy demand of future generations. Developing affordable and highly efficient photovoltaic technologies has always been a cherished goal of material scientists and device community. Exploring non- silicon alternatives based on the novel scientific opportunities afforded by the emergence of nanotechnology (the so-called third generation cell) has gained significant momentum in this respect during the past two decades. With respect to the present status of PV technologies, improvements in three areas have to be made: cost, applicability and sustainability. Semiconductor-grade silicon wafers still being relatively expensive, great efforts have been put into the development of potentially cheaper thin-film solar cells. Dye Sensitized Solar Cells developed by O'Regan and Gratzel have attracted lot of interest and is considered as a promising future technology, owing to its inherent cost reduction potential, which is based on the use of inexpensive components, its relatively simple production technology and its wide applicability. The significant collective efforts by the scientific community over the past 20 years have not only pushed the efficiencies higher but have brought over several new ways of making robust and durable DSSC cells fairly affordably with good efficiencies[1]. In this paper, we studied detail literature review about the quantum efficiency of the dye sensitized solar cell.

1.0 INTRODUCTION

DSSC are the devices for the conversion of visible light into electricity and have attracted much attention as low-cost photovoltaic cells and become a rapidly expanding field with potential applications[2]. In DSSC, the dye as a sensitizer should possess certain important features for efficient performance, namely, a broad and strong absorption from visible to near-infrared region, high-molar extinction coefficients in the visible and near-infrared region for light-harvesting, good photo-stability. The most successful sensitizers are Ruthenium based complexes because it has better efficiency and high durability, high absorption in the visible range of solar spectrum, excellent electron injection. However, these advantages are offset because Ru is a rare metal with a high price and its toxic nature. They also possess low molar extinction coefficients and restricted near infra-red (NIR) absorption. However, efficient Ru-free sensitizers that could also lead to an efficient light harvesting with a decrease in total cell cost are also studied.

Thus, research into Ru-free dyes, including metal-free organic dyes and metal-complex porphyrin dyes, has intensified because of the high cost of Ru metal [3]. Metal-free organic dyes offer superior molar extinction coefficients, low cost, and a diversity of molecular structures. Recently, novel photosensitizers such have achieved solar to electrical power conversion efficiencies up to 5–9% [2]. Numerous porphyrin dyes have been tested as light-harvesting components for DSSCs on account of their intense absorption in the visible region of the solar spectrum and their appropriate redox properties for sensitization of TiO_2 films [4]. The success of these dyes lies in their tunable physicochemical properties as well as in their high extinction coefficients in the visible part of the solar spectrum[5]. These properties make them as potential candidates for applications in areas such as optoelectronics, catalysis and chemosensing.In the case of self-assembled porphyrins, its molecular structures play an important role as the photosynthetic systems of bacteria and plants containchromophores based on porphyrins, which efficiently collect and convert solar energy into chemical energy [3,4]. Inspired by efficient energy transfer in naturally occurring photosynthetic reaction centers, numerous porphyrins and phthalocyanines have been synthesized and tested in DSSCs [3].

On the other hand, natural dyes have also been studied widely for usage as DSSC sensitizer because of their large absorption coefficients in visible region, relative abundance, ease of preparation, and environmental friendliness. Most importantly, the synthesis route for natural dye-based DSSC is not cost-effective [6, 7].

2.0 TYPES AND CHARACTERISTICS OF SOLAR CELL MATERIALS

Type	Material	Structure/ process	Measured conversion efficiency (%)	Advantages	Disadvantages (necessary improvements)
Si-based	Single crystal silicon	n-type Si layer doped on single crystal p-type Si layer	25.0	High efficiency, high reliability	Not suited for mass production, high cost, variable raw material price
	Polycrystalline Si	n-type Si layer dopedon polycrystalline p-type Si layer	20.4	Lower cost than single-crystal Si, high efficiency, high reliability	Lower efficiency than single crystal Si, variable raw material price
	Amorphous Si	p-layer and n-layer deposited by CVD process	9.5	Relatively small use of Si material, lower cost than single crystal Si	Lower efficiency than single crystal SI, light degradation
Compound-based	GaAs	Metal-organic CVD	26.1	High efficiency, endure radiations in space	Low deposition rate, using toxic As, high cost
	CdTe	p-type CdTe polycrystalline layer on n-type CdS layer	16.7	A variety of production methods, optimum band gap for generation, lower cost than single crystal Si	Using highly toxic Cd, dependent on the amount of Te resources
	CIS/CIGS	Vapour deposition of CIS/ CIGS	19.4	High optical absorbance	Dependent on In resources

Dye-sensitized	Dye, semiconductor, electrolyte	Place dye-absorbed TiO_2 electrode in electrolyte	10.4	Capable of production by simple process in open air, colourable, transparent, maintain generation characteristics under room light etc.	Ultra-violet degradation
Organic thin film based	Fullerene polymer	Apply mixture of p-type polymer and n-type fullerene	5.2	Little thickness, capable of manufacturing by inexpensive application process	Ultraviolet degradation ,low efficiency

RESULT

After study all paper the following result have been concluded on the basis of their types of photo-electrode, types of sensitizers, types of electrolyte and quantum efficiency (%).

DSSC type	**Author**	**Photo-electrode and method of preparation**	**Sensitizer**	**Electrolyte**	**Efficiency**	**References**
DSSC with Ru-complex dyes	Nazeeruddin et al.	TiO_2prepared by doctor blade method	cis-X_2Bis(2,2'-bipridyl-4,4'-dicarboxylate) ruthenium(II) complexes ($X=Cl^-$, Br, I^-, CN^-)	Lithium iodide/tri-iodide	10%	9
	O'Regan et al.	TiO_2 prepared by doctor blade method	Ru 2,2'bipyridine-4,4'dicarboxylic acid (μ-(CN) Ru (CN) 2,2bipyridine)$_2$	Lithium iodide/tri-iodide	7.1%	10
	Nazeeruddin et al.	TiO_2 prepared by doctor blade method	Di-tetrabutyl ammonium cis-bis (isothiocyanato) bis (2,2'-bipyridyl-4,4'-dicarboxylato) ruthenium(II)	Lithium iodide/tri-iodide	11.2%	11
	Sanchez Carballo et al.	TiO_2 prepared by screen printing method	Dichloro(p-cymene)-	Lithium iodide/tri-iodide	7.5%	12

			ruthenium(II) dimer([Ru(p-cymene)Cl_2]$_2$ Mer-[$RuCl_3$ (dmso)(tmen)]			
DSSC with metal free organic dyes	Shi et al.	TiO_2 prepared by screen printing method	4-(bis-(4-bromo-phenyl)-amino)-benzaldehyde	Lithium iodide/tri-iodide	5.35%	13
	Zhou et al.	TiO_2 prepared by electro-spray deposition	Triphenylamine moiety as the electron donor, a cyanoacrtlic acid as the electron acceptor, and a novel tetrathienaoanene as the π- bridge	Lithium iodide/tri-iodide	10.1%	14
	Gratzel et al.	TiO_2 prepared by doctor blade method	Phenyl dihexyloxy-substituted TPA (DHO-TPA) Y123	Co(I/III) complex	10.3%	15
DSSC with quantum-dot dyes	Lee et al.	TiO_2 prepared by spin coating method	Zinc porphyrin dye having an acrylic acid at the meso-positionCdS quantum dots	Na_2S, S and KCl	4.22%	16
	Pan et al.	TiO_2 films	$CdSe_{0.45}Te_{0.55}$ alloyed quantum dots	Na_2S, S and KC	6.36%	17
	Santra et al.	TiO_2 prepared by SILAR method	Manganese acetate mixed with cadmium nitrate/ CdS/CdSe quantum dots	Sulfide/ polysulfide	5.42%	18
DSSC with pervoskite-based sensitizers	Kojima et al.	TiO_2 prepared by screen printing method	$(CH_3NH_3)PbI_3$	Lithium iodide/tri-iodide	3.8%	19
	Im et al.	TiO_2films	$(CH_3NH_3)PbI_3$	Lithium iodide/tri-iodide	6.54%	20
	Kim et al.	TiO_2prepared by spin coating method	$(CH_3NH_3)PbI_3$	Lithium iodide/tri-iodide	9.7%	21

DSSC with natural dyes	Zhou et al.	TiO_2 prepared by doctor blade method	Mangosteen pericarp	Lithium iodide/tri-iodide	1.17%	22
	Wongcharee et al.	TiO_2 prepared by doctor blade method	Hibiscus surattensis	Lithium iodide/tri-iodide	1.14%	23
	Alhamed et al.	TiO_2 prepared by sol-gel method	Raspberries	Lithium iodide/tri-iodide	1.50%	24
	Chang et al.	TiO_2nanofluid	Ipomea	Lithium iodide/tri-iodide	0.28%	25

CONCLUSION

In this paper, we reviewed on the basis of efficiency of the different types of sensitizers used in DSSC, including Ru-complex dyes, metal-free organic dyes, quantum dots sensitizer, pervoskite-based sensitizer and natural dyes. Ru complexes have shown the good photovoltaic properties such as broad absorption spectrum, suitable excited and ground state energy levels, relatively long excited-state lifetime, and good stability. It is clear that research into the sensitizers for DSSC is progressing and new Ru-based structures are continued to be reported. Ru-based complexes are considered as best for the production of efficient DSSC.

Ru-complex dyes are achieving efficiencies over 12.3% and with metal-free organic dyes, a maximum of 10% efficiency has been reported. On the other side, quantum dot sensitizer produces an efficiency of 6.36% and nearly 20%of efficiency is achieved using perovskite-based sensitizer. Finally, natural dyes are in the way of improvement in stability and efficiency with 1.7% as the highest reported efficiency.

There are ample of opportunities for further development in regard to the repeatability and reliability of these dyes as well as all other components employed in DSSC for the purpose of commercialization. In summary, DSSC offers a low-cost, high-efficient option for entry into the commercial market of solar cells. Hence, there still remains scope for further development for this technology.

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