International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST218567

# Quantum dot solar cells for future electric prospects - A small Review

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**Article Info**
Volume 8, Issue 5
Page Number : 494-498

**Publication Issue**
September-October-2021

**Article History**
Accepted : 16 Oct 2021
Published : 30 Oct 2021

## ABSTRACT

Owing to their versatile electro-optic properties semiconductor quantum dots (QDs) are gaining greater attention towards photovoltaic applications. Although hybrid solar cells, which are obtained by the blend of carbon-based and inorganic resources have the probable to attain higher energy conversion efficiencies, the current efficiencies are stumpy. Strategy aspects especially the electronic structure of the inanimate materials which are used as the electronic acceptors in mixture solar cells plays an important role in providing good performance. Among the four major inorganic material types which were scrutinized namely cadmium mixtures, silicon, metallic oxide nano particles besides short band gap nanoparticles, Cadmium Sulphide (CdS) quantum dots are having higher (>4%) power conversion efficiencies. As far as the academic and industrial communities are concerned, dye -sensitized solar cell has attained high priority in accordance with its good efficiencies, ease in manufacturing, low cost etc., Despite the above-mentioned advantages or the positive characteristics of vivid solar cells, the heed is towards the solar cells through extremely tinny absorber, solar cells by quantum dots absorber coatings. In accordance with which we have discussed about the quantum dot solar cells keeping electrical parameters as the highest priority. Herein we present some small review on recent studies in QD solar cells considering their electrical and impedance properties, effect of incorporation of nano materials in solar cells.

Keywords : Quantum dots, photovoltaic, solar cells, nano materials

## I. INTRODUCTION

The needs of this current world demand the emerging technologies, as of which it is necessary to accelerate the already existing technology in order to meet the present needs. Quantum dots (QDs) solar cells finds a hand in replacing the photovoltaic solar cells due to their outstanding versatile electro-optic properties and vast range of solar applications which has become the reason for extended and deep studies regarding quantum dots and their applications.

Nano-particles of a semiconductor are generally termed as quantum dots because the quantum effects get introduced at this size which control the dynamisms at which electrons and holes can be in the atoms. By way of the concept of energy is linked to wave length, it means that the electro-optic possessions can be finely adjusted by the variation of mass. QDs are the artificial nano structures which possesses many varied properties depending on their material and shape.

The QD solar cells have the advantages of high thermal and moisture stability, solution processability, superficial fabrication and low-cost accessibility, high absorption coefficient, tuneable band-gap energy and several exciton generations due to which they are considered as utmost favourable next-generation solar cells. All these advantages pull in the gravity of studying quantum dot solar cells and its applications over the conventional solar cells.

## II. LITERATURE SURVEY

Matthew et al.,[1] has mentioned in his article about the prominence that the organic materials have due to their efficient utilization of high throughput and also solution processing. Author has also discussed about the hybrid solar cell highlighting its advantages besides to its low power conversion efficiencies and then compared the electronic structure of four major inorganic material types with the optimal design components of inorganic materials along with the drawbacks of control change competences of these strategies.

Fu et al.,[2] have introduced about the Dye-sensitized solar cells outlining the wide range attention it has gained from industrial and academic fields due to its high efficiency and ease in preparation along with being eco-friendly. They[2] have designed a dye sensitized solar cell which is contrast to the double-decker structure of the conventional dye-sensitized cell and has the characteristics of being eco-friendly, economically lower cost, easier recovery, easy encapsulation and modularization etc., The authors[2] have also mentioned that after proper optimization the obtained power conversion efficiency was about 4.16% for an area of 2.5 $cm^2$.

Dittrich[3] have discussed about the types of solar cells which have grabbed the care in the historical few years. Solar cells with tremendously tinny absorber, solar cells by quantum dots absorber sheets got a stand in that class. Further the authors have also mentioned that the concentration was set on organised clear electron electrodes and absorber materials which were manufactures at low temperatures using wet chemical deposition methods.

Similar to Dittrich[3] and Chung[4] have also discussed about the Dye-sensitized solar cells based on titanium oxide stating that they are the lost cost replacements for conservative solid-state photo voltaic devices which were build using materials like Si, CdTe etc., Further the authors[4] have made a note regarding the durability problems that the characteristic dye-sensitized solar cells agonize from due to their usage of carbon-based electrolytes comprising iodide/ triiodide redox duo causing thoughtful glitches such as conductor erosion besides having an advantage of relatively higher power conversion efficiencies. Following which the authors have come up with a solution processable p type direct band gap semi-conductor $CsSnI_3$ in a view that it can be used for hole transmission instead of fluid electrolyte. Further they have stated that the resulting solid-state dye-sensitized solar cell would put out a control change efficacy of 10%.

Guillén et al.,[5] have discussed about the dye-sensitised solar cells build with nano-structured zinc oxide in combination imidazolium based ionic-liquid electrolytes (dual combination of two ionic fluids) that are maintained at room temperature. Further the authors have also mentioned that the arrangement of this flush free electrolyte along with flavours such as lithium and tert-butyl pyridine yielded a photo conversion efficacy of 3.4% at one sun light for an area of 0.6 $cm^2$.

It is quite clear from the survey that the work done so far does not meet the requirements of high efficiency, as a result of which we are to study and work on quantum dot solar cells having good efficiency.

## III.SURVEY EXPERIMENTATION

Matthew et al.,[1] has discussed about various emerging characterization techniques for the study of nano particles such as Transient absorption spectroscopy, conductive AFM, electron tomography and kelvin probe microscopy. Fleeting absorption spectroscopy was used to divulge high speed electron transmission from $P_3HT$ to Si NCs, recommending the material mixture of $P_3HT$: Si NCs. The authors concluded regarding the conductive AFM that the capability of forming a link between nano morphology and electronic performance will make it an easy and important tool to characterize hetero-junction active layers. The same authors have also declared that electron tomography was very useful for hybrid films following the greater change in electron compactness of conjugated polymers and mineral nanoparticles which provides the capability for a successful construct of volumetric depiction of a mixture film. Whereas kelvin probe microscopy calculates the electro static interaction in between two objects preferably over direct current flow.

Fu et al.,[2] have mentioned three stages in the design of their dye sensitised solar tubes i.e. Photo anode fabrication, assembly of the anodes, measurement and characterization. Discussing in detail the same authors have mentioned that the photo anodes were obtained by the coating of $TiO_2$ nanoparticle film over the surface of metal substrates and the platinum wire which acts as pawn electrode was warped around the photo electrode and thereby both the electrodes were engrossed in the electrolyte (acetonitrile solution along with 0.6 M 1-butyl-3 methylimidazolium iodide, 0.025 M iodine, 0.3 M 4-tert-butyl pyridine, 0.05 M lithium perchlorate and 0.05 M guanidine thiocyanate) filled glass tube whose end was sealed with wax. Also, the electrode morphology was captured using FESEM.

Chung[4] have described a new type of all-solid-state, inorganic solar cell system which has p-type straight band gap semi-conductor $CsSnI_3$ and n-type nano porous $TiO_2$ with N719 dye. The same authors have also reported about $CsSnI_3$ that it is a good fit for this purpose in accordance to energy gap of 1.3 eV and outstanding mobility 585 $cm^2V^{-1}$ at RT. They have also originate that $CsSnI_3$ is solvable in polar organic solvents like acetonitrile and methoxy acetonitrile as a result it is solution processable and can be moved into the pores of $TiO_2$ molecularly in order to make close associates with dye particles as well as $TiO_2$.

Guillén[5] have mentioned that the ZnO electrodes which are to be put on F-doped $SnO_2$ transparent electrodes were manufactured from the commercial ZnO powder comprising nanoparticles of 20 nm size and wurtzite structure. Further the procedure involved in manufacturing of ZnO suspension was discussed. Later the devices (with electrolyte composition) using Thermo Orio Xenon 450W arc lam which was attached to a water sieve, 325 nm UV obstructive sieve and IR cut off filter. The same authors have also mentioned about the ways of measurements classified depending upon the light intensity/ photo currents, photo voltages and current voltage curve etc.

## IV. RESULTS AND DISCUSSIONS FROM SURVEY DATA

Figure 1 presents the short circuit current density ($J_{sc}$) effects with respect to iodide concentration ($I_2$ concentration) for 1-propyl-3-methylimidazolium iodide based ZnO dye sensitized solar cell. The $J_{sc}$ was recorded for both green and white light. Here it is clear that the $J_{sc}$ values for green light is higher compare to white light, except for the $I_2$ values lesser than 0.02 mol/dm$^3$. For the case of $J_{sc}$ green light curve the $J_{sc}$ increased till 0.03 and then decreased slowly with $I_2$ concentration. In similar way for $J_{sc}$ white light, the curve (i.e., $J_{sc}$) increase till 0.05, then decreased. These decrease and/or change in the short circuit current density values with respect to iodide concentration are due to influence of 1-propyl-3-methylimidazolium iodide/1-ethyl-3-methylimidazolium dicyanate (PMII/EMIDCN) mixing ratio and photo currents.

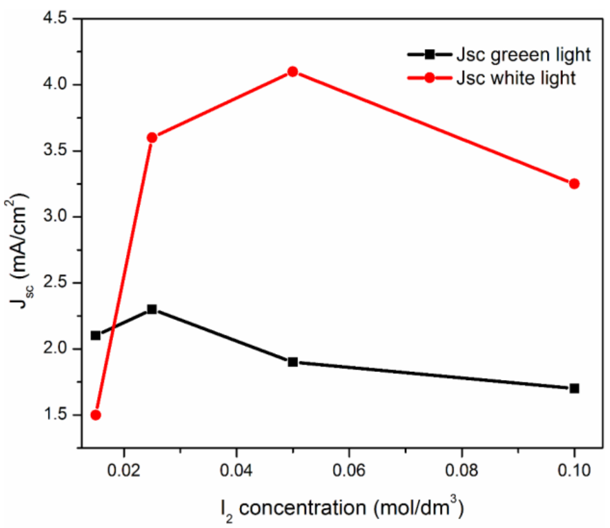


Figure 1: Representative curves of Guillén[5]. Curves represents the short-circuit photo current density for 1-propyl-3-methylimidazolium iodide based ZnO dye sensitized solar cells against molar concentration of $I_2$.

Figure 2 presents the open circuit photo voltage ($V_{oc}$) for 1-propyl-3-methylimidazolium iodide based ZnO dye sensitized solar cells against molar concentration of $I_2$. Here it can be seen that the $V_{oc}$ decreased drastically with respect to $I_2$ concentration till 0.025, then the $V_{oc}$ change was slow due to influence of PMII/EMIDCN mixing ratio.

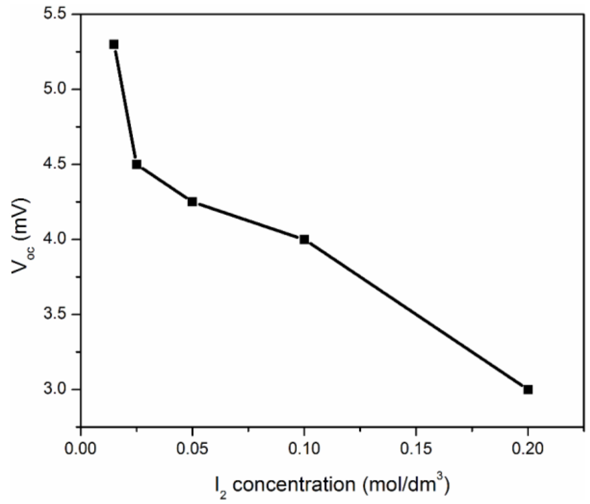


Figure 2: Representative curves of Guillén[5]. Curves represents the open circuit photo voltage for 1-propyl-3-methylimidazolium iodide based ZnO dye sensitized solar cells versus molar concentration of $I_2$.

Figure 3 illustrates the impedance measurements at various illuminations which have showed two significant arcs decreased their individual sizes with increase in intensity of light. The hypothetical effect is outcome of decrease in charge transmission and diffusion resistances.

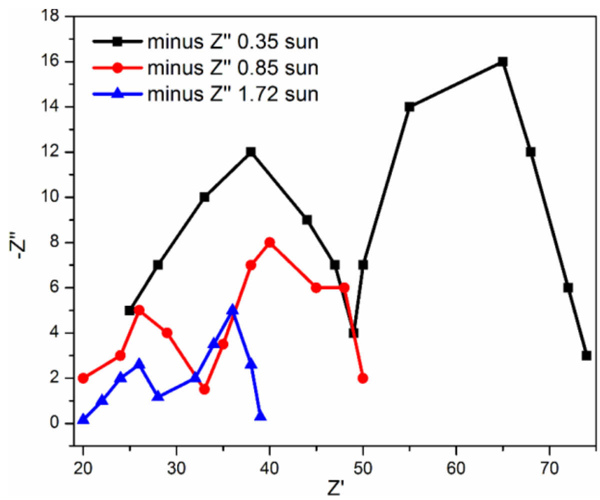


Figure 3: Representing the impedance spectrums of 1-propyl-3-methylimidazolium iodide based Zno solar cells under different illuminations.

## V. CONCLUSION

The evolution of inorganic nanostructured solar cells is keenly based on extremely thin nano composite absorbers and also on QD solar cells. The surface chemistry of inorganic nano particles is also a key factor. Nano morphology of the nano particles is related to surface the chemistry. In fact, it is important to maintain equilibrium amid interfacial and incessant conducting paths inside the photo active sheet. Besides even organic photo voltaic cells are sustaining some weight due to their cost benefits but their combination with the inorganic solar cells so called as hybrid cell are unable to meet the theoretical efficiencies. The electrolyte composition has a key effect on the cell's photo electrochemical parameters while designing a cell as a result of which perfect selection must be done for electrolyte and its composition. In the previous few ages numerous research groups have started to work regarding the solar cells having quantum dots as absorber (width even <100 nm). The need for the quantum dot solar cells is gaining strength due to the complex limiting factors of the inorganic nanoparticle solar cells. Acknowledging all the requirements, it is important to comprehend a low cost reliable and efficient enough solar cell making use of low-cost metal electrodes that are coated with catalytic materials such as carbon fibres.

## VI. REFERENCES


[1]. Matthew Wright; Ashraf Uddin; Organic—inorganic hybrid solar cells: comparative review, Solar Energy Materials and Solar Cells, Volume 107, 2012, Pages 87-111, ISSN 0927-0248, https://doi.org/10.1016/j.solmat.2012.07.006

[2]. Fu, Yongping & Lyu, Zhibin & Wu, Hongwei & Hou, Saocong & Cai, Xin & Wang, Dang & Zou, Dechun. (2012). Dye-sensitized solar cell tube. Solar Energy Materials and Solar Cells.102.212–219, https://doi.org/10.1016/j.solmat.2012.03.029

[3]. Dittrich, Thomas & Belaidi, Abdelhak & Ennaoui, Ahmed. (2011). Concepts of inorganic solid-state nanostructured solar cells. Solar Energy Materials & Solar Cells. 95. 1527-1536. https://doi.org/10.1016/j.solmat.2010.12.034

[4]. Chung I, Lee B, He J, Chang RP, Kanatzidis MG. All-solid-state dye-sensitized solar cells with high efficiency. Nature. 2012May23;485(7399):486-9. https://doi.org/10.1038/nature11067. PMID: 22622574

[5]. Guillén, E. & Idígoras, Jesús & Anta, Juan. (2010). Solvent-free ZnO Dye-sensitized Solar Cells. ECS Transactions. 25. https://doi.org/111-122. 10.1149/1.3300428

[6]. G. Martin A, Third generation photovoltaics: solar cells for 2020 and beyond, Physica E: Low-dimensional Systems and Nanostructures 14 (2002) 65–70



**Cite this article as :**

Kapivardhan Y, Ramaiah V, Srinivas K, "Quantum dot solar cells for future electric prospects - A small Review ", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 8 Issue 5, pp. 494-498, September-October 2021. Available at doi : https://doi.org/10.32628/IJSRST218567
Journal URL : https://ijsrst.com/IJSRST218567