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A literature survey of nanomaterials for dye sensitized solar cells

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Abstract
This paper provides a survey of the advance in the literature of nanomaterials for dye sensitized solar cell. The survey highlights that most exploratory studies focus on variable nanomaterials the role of dye sensitized solar cell. The positive role of photoelectrochemical system fact, there are some methodological reservations about the outputs from these exploratory studies. A general observation from these studies is that the literature produced the antithetically results and there is no consensus neither on the existence.

Keywords: DSSCs, nanoparticles, nanocomposites, Tio2, electrical energy

Introduction

The world demand for energy is expected to double by the year 2050 and triple by the end of the century. An abundant supply of energy is necessary for global political, economic and environmental stability [1]. However, as a non-renewable energy source, the exhaustion of fossil fuel is inevitable and imminent. Renewable energy especially solar energy has attracted much attention, because it directly converts solar energy into electrical leaving no environmental affect [2]. Recently, chemists have been interested for a long time in the harnessing of sunlight, useful chemical transformations or to convert the light directly into electrical energy. Interest in the research and development dye sensitized solar cells is now spread across numerous academic and industrial laboratories [3]. Many features of DSSCs are unique and important cheap photovoltaic technology. In this literature survey focuses that is an overview nanomaterial composite and particles, performance features of all components of the DSSCs. Carbon based counter electrodes are compatible substitute to Pt based counter electrodes caused its properties like chemical permanence, high conductivity anticorrosive in electrolyte and low cost. The component used in DSSC, metal oxide film is one of the prevalent components to simplify better dye absorption, transport and separation of charge carriers [4]. Key factor to acquire supreme performance is to select of mesoporous TiO2 having paid development electrode and light scattering layer. The concept is to organized light scattering layer wherein the lower conversion of photon caused thin mesoporous TiO2 layer can be recouped [6]. As a counter electrode, platinum was mostly used for this motive because of several advantages such as robustness, chemical stability, excellent electrocatalytic activity for reducing triiodine and high electric conductivity as compared to other used materials [5]. DSSCs have been introduced to literature by O'Regan and Gratzel in 1991 with PCE of 7.9%.

Literature Survey

Beula *et al* (2020) examined those gold nanoparticles as a capping layer over anatase TiO2 film was coated using DC sputtering method which was used as a photo-electrode. The properties of the prepared photoanode and expected absorption band, an additional absorption band at 397-500 nm associated with the surface plasmon resonance was observed in the absorption spectrum of the TiO2-Au film [4]. Dye sensitized solar cells with TiO2-Au yielded higher short circuit current density with 4.8% efficiency, which is 69% greater than that obtained using TiO2 photoanode without capping. The fast transmission of excited electrons, separation of charge carriers and the reduced rate of electron hole recombination in the electrode caused by the introduction of gold capping layer must be liable for the enhanced operation of the cell [7].

Oh *et al* (2020) explained that graphene based nanocomposites are usable as flexible transparent displays for electronic devices. However, the power conversions of graphene based nanocomposites are more proficient than that of indium tin oxide. The strength of graphene is due its ability to enable various components in existing solar cells, leading to the overall improvement in power conversion efficiency. Graphene can act as an electron acceptor and intermediate layer in tandem solar cells [8]. Depending on the properties of graphene and graphene based material, researchers have modified the structure to create a novel type of light reaping materials.

Manaa *et al* (2019) reported that the combination of advanced statistical physics modeling and density functional theory investigation for the interpretation of the adsorption of paprika dye on TiO2 surface for dye sensitized solar cells [9]. By using a statistical physics modeling method, an adequate monolayer model with four energies was successfully used to interpret the adsorption process at a microscopic level. Researchers pay particular attention to the adsorption modes, geometries and energies between the paprika dye and TiO2. The density functional theory simulation determined different binding modes which participated in the adsorption of paprika dye on TiO2 surface: monodentate coordination via hydrogen atom bond, monodentate coordination via oxygen atom bond and bidentate

coordination via two oxygen atoms bond [10]. In particular, calculations showed that the interaction between the paprika dye and TiO2 is strengthened with the bidentate coordination mode via the two hydroxyl and ether functionalities groups involved in the adsorption process.

Gupta *et al* (2020) analysis that novel sol gel route was adopted for the synthesis of undoped and Cu/S co-doped TiO2 nanoparticles with constant content 0.05% of non-etal sulfur and diverse content from 0.1 to 0.5% of metal Copper. The formation of anatase TiO2 crystalline phase was observed from XRD results with the crystalline size less than 11 nm for all the synthesized samples. The UV-Vis analysis revealed that co-doping with Cu/S altered the optical properties of TiO2 and extended absorption in the visible light region with red shift in band gap energies. EDAX analysis confirmed the purity of Cu/S co-doped TiO2 nanoparticles and also the evident presence of titanium, oxygen, copper and sulfur atoms in stoichiometric ratio [11]. In photovoltaic measurements, under simulated solar irradiation the DSSC based on Cu/S co-doped TiO2 with 0.3 at% Cu and 0.05 at% S has exhibited the best power conversion efficiency of 10.44% with significantly improved short circuit current density of 22.05 mA/cm2. Power Conversion efficiency is attributed to the appropriate particle size, enhanced surface area, higher dye adsorption and hence improved short circuit density. In contrast, the undoped TiO2 nanoparticles based DSSC has displayed a power conversion efficiency of 6.37% with short circuit current density of 14.85 mA/cm2.

Adenigba *et al* (2020) explained that semiconductor oxide layer ZnO and TiO2 coated FTO glass act as photoelectrode and enhanced power conversion by dye sensitized solar cells for fabrication process. Moreover, Silver nanoparticles were synthesized using the cell free extracts of Coelastrella sp MG257917. The influence of the nanoparticles embedded at different quantity at different quantity and different dye loading time on optical properties of the modified photoanode was carried out using UV-vis spectroscopy. The fabricated cells were exposed to a dark and light intensity of 100 mW/cm2 to evaluate the solar to electrical conversion efficiency. The nanoparticles were spherical and the particle size ranged from 21-105 nm. The EDX examination revealed that silver was the element with the highest composition (97.96%). The optimum quantity of CO-AgNPs to TiO2 was 1:1 while the dye loading time was 15 hours. The solar to electrical conversion efficiency of the biosynthesized CO-AgNPs cells was 1.09% (light) and 0.95% (dark) while conversion efficiency of the TiO2 cell was 0.03% (under light) and 0.004% (dark) [12].

Enizi *et al* (2020) reported that the crystal architecture of TiO2 was successfully tailored via a low temperature hydrothermal process in the presence of D-mannitol for feasible applications in dye sensitized solar cells. After physical measurements, the synthesized nanocrystallites of A-TiO2, where a fascinating power conversion efficiency of 6.0% was obtained, which showed excellent performance compared with commercial anatase-TiO2 (CA-TiO2: 5.7%) and rutile-TiO2 (R-TiO2) obtained without D-mannitol (3.7%) [13]. Moreover, a smart approach was developed via the A-TiO2 catalyst to synthesize pharmaceutically important C-3 alkylated 4-hydroxycoumarins through different activated secondary alcohols under solvent-free, and heat/visible light conditions. In addition, the catalytic activity of the so-produced A-TiO2 catalyst under solvent free conditions exhibited remarkable recyclability with up to five consecutive runs with negligible reduction, which is superior to existing reports, and clearly reveals the novelty, and green, sustainable nature of the synthesized A-TiO2 catalyst [14]. A plausible reaction mechanism of both coupling partners was activated through the interaction with the A-TiO2 catalyst to produce valuable C-3 alkylated 4- hydroxycoumarins with 95% yield and high selectivity.

Bai *et al* (2020) discussed that to m ake use of broad spectrum solar energy remains a main target in the photoelectrochemical area. Novel promising photoelectrode CeO2:Fe/Yb/Er nanomaterials supported on upconversion nanomaterials doped with transition-metal ions are reported to improve broad spectrum absorption and scattering properties in dye sensitized solar cells for the first time [15]. The results demonstrate that the materials have stronger upconversion luminescence than CeO2:Yb/Er samples when the Fe3+ ion doping concentration is 2 mol% and 33.3% higher photoelectric conversion efficiency than a pure P25 electrode, which are attributed to the special light scattering properties and excellent dye absorption capacity of the CeO2:Fe/Yb/Er nanomaterials [16]. Accordingly, doping Fe3+ transition metal ions in the upconversion material CeO2:Yb/Er provides a new research idea for improving the photoelectric conversion efficiency.

Zhang *et al* (2020) showed that the counter electrode is a crucial part and catalyzing the reduction of the oxidized state to the reduced state for a redox couple in electrolyte. Developing efficient and economical electrocatalytic materials to replace the traditional platinum counter electrode has attracted attention. In the present study, gama-MoC/Ni@NC material was used. This material was synthesized by solid-state pyrolysis of related compounds of molybdate, oxalate, melamine and nickel salts. This composite catalyst achieves power conversion efficiency of 5.26%, which is equivalent to the one based on the traditional Pt counter electrode (5.65%). Although the PCE of DSSC based on gama-MoC/Ni@NC is slightly lower than that of Pt, the synthesis method is simple and cost effective [17].

Ye *et al* (2020) studied that the polynanostructure of two dimentional layer nanostructure molybdenum disulfide thin films were synthesized onto the fluorine doped tin oxide (FTO) glass substrate via the pulse mode electrochemical deposition method at room temperature and ambient pressure. According to the HR-TEM results, it was observed that the poly nanostructural 2D MoS2 owing the short range order nanostructure offered the numerous edge planes to provide plenty active sites for an efficient counter electrode of the DSSCs [19]. In combination with a dye sensitized TiO2 working electrode and an iodine based electrolyte, the DSSC assembled with the poly nanostructural 2D MoS2 counter electrode showed a photovoltaic conversion efficiency of 6.08% under the illumination of AM 1.5 (100 mWcm-2), which was comparable to that with Pt counter electrode (6.43%) [18].

Conclusions

The aim of this study is to survey the literature dealing with the causal relationship between nanomaterials and conversion efficiency of dye sensitized solar cell. There is a growing literature that examines the causality relationship between nanocomposites, renewable energy, electricity consumption and economic growth. The bulk of this literature focuses on

developing, developed and emerging countries. It is the most important policymakers to understand the relationship between renewable energy consumption and economic growth in order to effective energy and environmental policies. A general conclusion from these studies is that there is no a consensus view neither on the presence nor on the direction of the relationship between cause and effect and these variables in the literature. Thus, the author should focus more new approaches, aspects and use new nanomaterials based on a set of common variables for different literature and different intervals of time to get more persona grata and better results and understanding of energy consumption-economic growth relationship.

References

1. Hamann Thomas W. Advancing beyond current generation dye-sensitized solar cells. Energy & Environmental Science,2008:11:66-78.
2. Gong Jiawei, Jing Liang, Sumathy K. Review on dye-sensitized solar cells (DSSCs): fundamental concepts and novel materials. Renewable and Sustainable Energy Reviews,2012:16(8):5848-5860.
3. Zhang Qifeng. ZnO nanostructures for dye-sensitized solar cells. Advanced Materials,2009:21(41):4087-4108.
4. Beula R Jeba. Transforming polymorphs of Co-doped TiO2 nanoparticles: an efficient photo-electrode for dye-sensitized solar cells. Applied Nanoscience,2020:10(4):1173-1181.
5. Demir Enes. A novel monodisperse metal nanoparticles anchored graphene oxide as counter electrode for dye-sensitized solar cells. Nano-Structures & Nano-Objects,2017:12:41-45.
6. Ilahi Novita Asma. Electrospinning Titanium Dioxide (TiO2) nanofiber for dye sensitized solar cells based on Bryophyta as a sensitizer. Journal Of Physics: Conference Series. IOP Publishing, 2017, 795(1).
7. Ge Zhongwei. Preparation of Cu-doped ZnO nanoparticles via layered double hydroxide and application for dye-sensitized solar cells. Journal of Physics and Chemistry of Solid, 2020, 109833.
8. Hong Siao-Ting, Lu-Yin Lin. Fabrication of TiO2 nanoparticle/TiO2 microcone array photoanode for fiber-type dye-sensitized solar cells: Effect of acid concentration on morphology of microcone." Electrochimica Acta,2020:133:135278.
9. Ghadari, Rahim. Phthalocyanine-silver nanoparticle structures for plasmon-enhanced dye-sensitized solar cells." Solar Energy,2020:198:283-294.
10. Biswas Rajat, and Suman Chatterjee. Effect of surface modification via sol-gel spin coating of ZnO nanoparticles on the performance of WO3 photoanode based dye sensitized solar cells. Optik,2020:212:164142.
11. Saravanan S, Dubey R S. Study of Al-Doped and Al/N Co-Doped TiO2 Nanoparticles for Dye Sensitized Solar Cells. J. Mater. Environ. Sci,2020:11(1):8-14.
12. Xiao Bing-Chang, Lu-Yin Lin. Substrate Diameter-Dependent Photovoltaic Performance of Flexible Fiber-Type Dye-Sensitized Solar Cells with TiO2 Nanoparticle/TiO2 Nanotube Array Photoanodes. Nanomaterials,2020:10(1):13.
13. Gupta Anuradha. Novel synergistic combination of Cu/S co-doped TiO2 nanoparticles incorporated as photoanode in dye sensitized solar cell. Solar Energy,2020:**203:**296-303.
14. Zhang Xiaowen. Nitrogen-doped carbon encapsulating γ-MoC/Ni nanoparticles as efficient counter electrodes for dye-sensitized solar cells. Journal of Coordination Chemistry, 2020, 1-11.
15. Jiao Shouzheng. Development of Rapid Curing SiO2 Aerogel Composite-Based Quasi-Solid-State Dye-Sensitized Solar Cells through Screen-Printing Technology. ACS Applied Materials & Inter,2020:12(43):48794-48803.
16. Oh Won Chun. Hybrid of Graphene based on quaternary Cu 2 ZnNiSe 4–WO 3 Nanorods for Counter Electrode in Dye-sensitized Solar Cell Application. Scientific Reports,2020:10(1):1-10.
17. Adenigba Victoria Olaide. A Plasmonic Effect of Coelastrella sp Mediated Silver Nanoparticles Embedded in TiO2 Photoanode for Dye-Sensitized Solar Cells.
18. Bai Jingyi. Upconversion luminescence enhancement by Fe 3+ doping in CeO 2: Yb/Er nanomaterials and their application in dye-sensitized solar cells. RSC Advan,2020:10(32):18868-18874.
19. Manaa Marwa Ben. Combined statistical physics models and DFT theory to study the adsorption process of paprika dye On TiO2 for dye sensitized solar cells. Journal of Materials Research and Tech,2020:9(2)1175-1188.