Polyaniline Based Dye-Sensitized Solar Cells

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Abstract
A lot of people are interested in dye-sensitive solar cells (DSSCs) since they are inexpensive, simple to make, and have a respectable photochemical conversion efficiency. Solar cells' design, development, electrodes, and electrolyte composition have a significant impact on how photochemically efficient they are. The cost of DSSCs is decreased while maintaining efficiency thanks to the usage of conductive polymers in solar cells. On FTO glass and flexible substrates, polyaniline is a promising conductive polymer mostly utilised as a counter electrode catalyst. It makes it possible to produce solar cells in huge quantities at considerable cost reductions. The viability of polyaniline and its composites as a counter-electrode catalyst for DSSCs is examined in this research.

Keywords: Polyaniline, Dye-Sensitized Solar Cells, Photovoltaic Response

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Introduction

Fossil fuels have been the main source of energy for humans for about two centuries, and as a result, we are currently experiencing major issues. Environmental danger results from excessive carbon dioxide and other greenhouse gas emissions. Due to the rising global energy use, the cost of fossil fuels is going up. The high increase rate of renewable energy consumption shows that there is a greater need than ever for a reliable, affordable, and carbon-free source of energy.

Due to the availability of its resource—sunlight—and the absence of any hazardous effects, solar energy has been seen as one of the most promising renewable energy sources. The quantity of solar energy that the sun emits onto the planet in one hour is equal to the whole amount of energy required by humans annually. However, due to technological and thermodynamic limitations as well as a few other factors, such a high energy output has not been attained. For residential end users, conventional commercial solar cells using crystalline and polycrystalline silicon have an energy conversion efficiency of over 20%. However, there are several issues, such as expensive and challenging fabrication processes. One potential replacement for silicon solar cells is dye-sensitized solar cells (DSSCs).

Literature Survey

The literature review of photovoltaic materials based on polyanilines is covered in this part. Yu et al. investigated the photovoltaic performance of counter electrodes made of polyaniline (PANi/MPt, where M = Mo, Pd, and Co). According to the study's findings, the power conversion efficiency of PANi/CoPt, PANi/PdPt, and PANi/MoPt counter electrode systems is on the order of 8.08%, 7.26%, and 6.83%, respectively [1]. Amorphous silicon/polyaniline n-i-p heterojunction solar cells were created by Wang et al using a layer of polyaniline that conducts holes (PANi). They reported open-circuit voltages (VOC) in the 0.5-0.7 V range using the spin-casting process with various polyaniline dispersions corresponding to film conductivities. Their research emphasises the PANi's limiting mechanism brought on by electrophoresis effects [2]. The counter electrode in dye-sensitized solar cells (DSSCs) was built by Li et al utilising microporous polyaniline (PANI), a less costly alternative to platinum. The DSSC with PANI counter electrode outperformed the DSSC with Pt counter electrode in this experiment, achieving an overall energy conversion efficiency of 7.15%. They came to the conclusion that PANI electrode is a preferable option for DSSCs due to its superior photoelectric characteristics, straightforward preparation process, and low cost [3]. Li et al. produced an in situ electropolymerized polyaniline (PANI) film with an electropolymerized charge capacity by doping different counterions into the fluorine tin oxide glass. They found that varied doping counterions had a significant influence on the morphology and electrochemical activity of electropolymerized-PANI film. They provided a comparative analysis of the impact of these varied doping counterions on key performance metrics for the electropolymerized-PANI counter electrode-based DSSCs. Their study demonstrates that a dye-sensitized solar cell using PANI-SO_4 as the counter electrode has a photovoltaic conversion efficiency of 5.6%, which is equal to the 6.0% of the dye-sensitized solar cell using Pt counter electrode under the same experimental conditions [4]. Sulfonated polyaniline (SPAN) film was employed by Valaski et al. in the creation of a polyaniline/poly(3-methylthiophene) photovoltaic system as an intermediary layer between the electrode, tin oxide (TO), and the active layer (PMT). Under monochromatic illumination, this experiment attained incident-photon-to-collected-electron efficiency of 12.1% and power conversion efficiency of 0.8% [5].

By using the cyclic voltammetry (CV) technique, Zhang et al. created polyaniline films with controllable thickness and applied them to fluorine doped tin oxide (FTO) glass substrates. The accumulation of polyaniline (>70 nm) on both dispersed and compact layers led to an increase in the reactive interface and charge transfer. In this study, alternating current (AC) impedance spectroscopy, scanning electron microscopy (SEM), and atomic force microscopy (AFM) are used to monitor the nanostructured polyaniline film. When compared to a DSSC with an electrodeposited platinum counter electrode, the optimised manufacture of a dye-sensitized solar cell (DSSC) with a PANI counter electrode boosted the short-circuit photocurrent density by 11.6% [6]. Tan and colleagues used polyaniline (PANI) thin films with nano-islands embedded on their surface as the buffer layer in organic solar cells based on a mixture of poly[2-methoxy-5-(30,70-dimethyloctyloxy)-1,4-phenylenevinylene] (MDMO-PPV) and [6,6]-phenyl-C61 butyric acid methyl ester (PCBM). The performance of solar cells was enhanced as a result of this experiment [7]. In this study, Tang et al. created a microporous hybrid polymer comprising poly (acrylic acid), gelatin, and polyaniline (PAA/Gel/PANI) using two phases of solution polymerization. Then, a gel-electrolyte with high liquid absorbency and high conductivity is created using this synthesised hybrid polymer. A quasi-solid state dye-sensitized solar cell (QS-DSSC) with a 6.94% light-to-electric energy conversion efficiency is created using the gel electrolyte that has been manufactured. By coating a surface-interpenetrated conducting polymer, such as polyaniline doped with camphor-sulfonic acid (PANI: CSA), on a low-cost plastic substrate made of polyethylene terephthalate (PET), Lee et al. created an ITO-free organic electrode that performs admirably in flexible organic solar cells. The experiment yields an average power conversion efficiency of 3.570.2% for an organic solar cell with the created ITO-free organic electrode under light of 100 mW/cm2, open-circuit voltage of 0.83 V, and a fill factor of 0.49 [9]. In a sulfuric acid-based solution containing aniline monomers, Lin et al. used cyclic voltammetric synthesis to electropolymerize polyaniline counter electrode on fluorine-doped tin oxide (FTO) glass substrates. The effects of surface morphology and electrocatalytic activity were observed in this experiment, where the polyaniline CE's thickness was controlled by varying the sweep-segment number. This shows that at the 27-sweep-segment, a good electrocatalytic activity for the I/I3 redox couple is observed. An energy conversion efficiency of 5.92% was demonstrated by a dye-sensitized solar cell built with the produced PANI, which is equivalent to that of DSSCs with sputtered-Pt CE [10]. Tan et al. developed PANI films using electrochemistry and a conjugated molecule called 9-anthracene methyl acid (AMA) with a short chain length and an electrically active conjugated structure as the dopant. The effects of AMA doping on the optical and electrical characteristics of PANI films are discussed in this study, and it is suggested that AMA doped PANI films may be very helpful in flexible photovoltaic devices because organic hybrid solar cells with AMA doped PANI films exhibit better photovoltaic performance [12].

Ecker et colleagues concentrated on the implications of the hole extraction efficiency on the functionality and stability of the organic solar cell. With varying PANI to poly (styrene sulfonate) (PSS) ratios of 1:1, 1:2, and 1:5, which result in different HTL transmittance and conductivity, the researchers produced organic solar cells with PANI-based hole transport layers (HTLs). The study demonstrates that the HTL conductivity directly affects the power conversion efficiency of the cell, and that performance rises with decreasing PSS concentration while stability increases with increased PSS content [12].

Conclusions

The smart grid, which is used in our daily lives, depends on solar cells. Photovoltaic cells must be transparent, flexible, light weight, inexpensive, and have a high energy conversion efficiency in order to be used in the smart grid. Organic, inorganic, and hybrid materials offer better futures than semiconductors in terms of low cost and light weight. Photovoltaic cells have been made in hybrid materials with the benefits of organics or inorganics chosen carefully.

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