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Review Article

A Review on Applications of Carbon Nanotubes (CNTs) in Solar Cells

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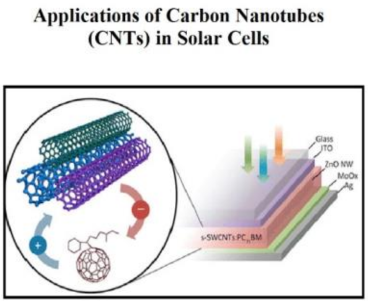
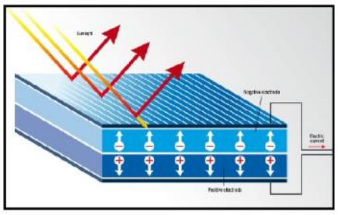
ABSTRACT

The world is looking for clean, renewable and cheap energy. For a long time, researchers have been trying to find materials to achieve this goal. The discovery of carbon nanotubes (CNTs) has opened new horizons in the field of their uses in the field of solar energy. The chemistry of carbon nanotubes involves chemical reactions that are used to change the properties of carbon nanotubes (CNTs). To attain desired properties that can be used in a wide range of applications, CNTs can be functionalized. Covalent and non-covalent modifications are the two primary types of CNT functionalization. This review focuses on how to use the synthesized CNTs by flame fragments deposition (FFD) technique, which is an easy and cheap method in which CNTs can be prepared at lower temperatures compared with other traditional techniques, in preparing CNTs composites in solar cell components to improve charge conduction, electrode flexibility and acting as active light absorbing materials.

GRAPHICAL ABSTRACT





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Introduction

With several commodity goods based on existing technologies, the conventional chemical industry has become a relatively mature industry. New product and consumer prospects are therefore more likely to come from specialty chemicals and new functionalities derived from new manufacturing methods, as well as new methodologies for microstructure regulation. It is a well-known fact that the microstructure of a substance is the key to determining its properties, in addition to its molecular structure. Therefore, regulating structures at micro- and nano-levels is important for new discoveries. Nanotechnology is the science that deals with design, synthesis, and application of materials and devices whose size and shape have been engineered at the nanoscale [1–4]. Nanomaterials are materials in nanostructures and must has at least one dimension in the nanoscale (1-100 nm), nanomaterials having different physical and chemical properties better than bulk materials of the same composition because of their size and structure [5,6]. Nano structures consists of nanoparticles, nanowires, quantum dots, clusters, and nanotubes [7]. Depending on the size and shape, nanomaterials can be classified into 0-D (quantum dots, nanoparticles), 1-D (carbon nanotubes, nanorods, and nanowires), 2-D (nanofilms, Nano sheets, Nano disks, Nano prisms, Nano plates), and 3-D nanomaterials [8–11]. Nanomaterials have unique optical, magnetic, electrical, chemical, and other properties. These properties have a large effect on electronics, sensors, energy devices, medicine, cosmetics, catalysis, and many other fields, for example the high-performance portable batteries, fuel cells, and solar cells are examples of the effect of nanomaterials in the energy [12–16].

CNTs

CNTs also know buckytubes that cylindrical carbon molecules that which have unique properties make it useful in a wide variety of applications: such as in nano-electronics, optics, large amounts of pure materials and materials applications [17–24]. CNTs also called as tubular fullerenes, that which consist from cylindrical graphene sheets with sp^2 hybrid bonded carbon atoms, when graphene sheet will be rolled upon itself yield to form different allotropes of carbon, that including graphite, fullerenes and CNTs [25]. CNTs are found in single walled carbon nanotubes (SWNTs) and multi-walled carbon nanotubes (MWNTs) structures [26]. Generally, carbon nanotubes are mainly synthesized by Laser Ablation method, Arc-Discharge method, Chemical Vapor Deposition method (CVD) [27,28] and Flame Fragment Deposition method (FFD).

Flame fragments deposition method (FFD)

CNTs were synthesized by flame fragments deposition method (FFD) by using a homemade chamber. The synthetization occurred without using any types of catalysts which mostly increase the impurities of synthesized CNTs and without need for sophisticated tools like the one used in classical (CVD) technique. It occurred at low temperature compared with that of CVD techniques [29,30]. The schematic diagram of the homemade flame fragments deposition instrument is shown in Figure 1.

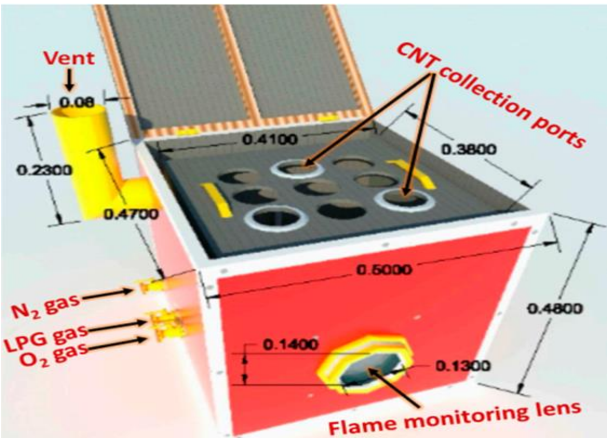

Figure 1: The homemade flame fragments deposition (FFD) instrument

Result and Dissection

Applications of CNTs

CNTs are the most rapidly growing nanomaterials in the field of nanotechnology due to their wide range of various applications in different fields, from materials science, medicine, electronics to energy storage [17,31]. Many attractive applications of CNTs can be achieved by the use of CNTs for the cases that require conductivity and a high absorption capacity and for the creation of high-strength composites, fuel cells, energy conversion devices, field-emission devices, hydrogen storage device semiconductor devices and solar cells [32].

Solar cells

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly to the electricity by the photovoltaic effect [33]. The operation of solar cells is dependent on the transition of free electrons by gaining the extra energy when photons from the sun light are attack at the film surface. After analyzing the band structure of the solar cell, we found that when the cell gain energy from the photons and generates free electrons, which recombines and generates some photovoltaic current, the the binding energy of the film will decrease, indicating that the maximum number of electrons is generated. Therefore, for increasing the efficiency of solar cell the thin film-based method must be used in which large amount of light is absorbed for a broader range of the solar spectrum [34]. There are different methods of classification of the photovoltaic cells based on their semiconductor materials, morphology and fabrication technique [35,36]. To illustrate solar cells, dye-sensitized solar cells (DSSCs) are discussed due to their simple manufacture and high efficiency, so they have attracted great attention from researchers from around the world [37]. This cell consists of five different layers [38]. The first layer consists of a transparent anode fabrication with a glass sheet, and treated with a transparent conductive oxide layer (TCO glass) (e.g., fluorinated tin oxide (FTO) SnO_2: F coated glass). The second layer includes layer of mesoporous oxide (usually TiO_2) deposited onto the anode to improve electronic conduction. A monolayer of charge transfer dye that is covalently bonded to the surface of the mesoporous oxide layer to promote the absorption of light. An electrolyte must contain a redox mediator in an organic solvent, which improves the regeneration of the dye. The last layer consists of a cathode made with a crystal coated with a catalyst (usually platinum) to achieve easy collection of electrons [38] (Figure 2).

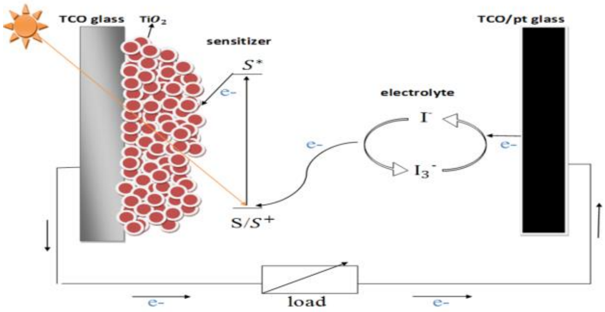

Figure 2: Schematic representation of a DSSC

This type of solar cell is believed to be able to provide alternative energy concept with a more inexpensive cost of the fabrication technology that is simpler than the one made from crystalline silicon before its solar cells. Although until now the energy conversion efficiency of DSSC has been produced by a lower than silicon solar cells, the type of DSSC solar cells is still the potential to produce a much large efficiency in the future [35,36,39]. Many attempts may be made to improve the efficiency of these cells by using the electrodes nanostructured metal oxides [40,41], various dye sensitization [41,42], and an electrolyte containing I^-/I_3^- redox couples [43,44]. Counter-electrode has not been studied extensively because of the fact that Pt has shown good electro catalytic function [45] despite the expensive cost of his deposition.

Conclusion

Recently, an alternative to platinum (Pt) is likely a variety of carbon materials such as graphite, carbon black, and carbon nanotubes (CNTs) that have been studied for Counter - electrodes with a relatively low cost for DSSC. The efficiency of DSSC was improved by the addition of CNTs in the TiO_2 photoanode. But the graphene may be more favorable than CNTs for charge separation because of its excellent conductivity and good contact with TiO_2. Solar cells are entirely made of carbon nanotubes (CNSCs). There is a different on the DSSC, and potentially give a real advantages beyond DSSCs.

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Authors' contributions

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

We have no conflicts of interest to disclose.

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