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Organic solar cells: short review

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Abstract On the earth's surface, the sun is a source of light energy. Electrical energy was produced when solar energy was converted into free energy charged within the particles of some materials. Organic solar cells (OSCs) have gotten a lot of attention because of their advantages like low cost and flexibility. It is semi-transparent, non-toxic, and ideal for mass production. OSCs with high-performance active layer materials, electrodes, and interlayers have made significant progress, as have novel device architectures. In particular, active layer material innovation allows for the possibility of achieving high performance in OSC by using absorbent materials; polymers are commonly used as absorbent layers to induce light absorption efficiency and device performance.

Keywords: organic solar cells, donor layers, acceptor layers, stability of solar cells.

1. Introduction

Human existence has alwa-ys been based on energy. Today, in the twenty-first century, finding renewable and clean energy to replace traditional fossil energy is still critical. Solar energy is the source of all other clean energy, including wind energy, hydropower, and ocean energy. Solar energy has been invested as one of the clean energy sources, with Bell Telephone Laboratories inventing the first silicon solar cell in 1954.

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The family of solar cells invented in these laboratories includes Si cells, inorganic thin-film technologies, and emerging photovoltaic cells (PV) (1), Various inorganic thin-film solar cells have also been commercialized, while the performance of emerging photovoltaic such as OSCs, dye solar cells (DSSCs), perovskite solar cells (PSCs), and others have improved significantly. Organic solar cells (OSCs) have gained popularity in recent years as a low-cost, flexible, semi-transparent, non-toxic, and ideal for large-scale processing alternative to other PV technologies. According to best research cell efficiency scheme provided by the National Renewable Laboratory Energy (NREL), PCE in organic solar cells (OSCs) has increased rapidly in recent years, Organic solar cells (OSCs) made first-generation OSCs with a single active layer sandwiched between two electrodes with working functions, with the latest OSCs yielding a certified PCE of 18.2% (2), demonstrating their potential for future practical applications. However, due to the difficult dissociation of excitons (electron-hole pairs) and the efficient recombination of electrons and holes, single-layer devices had a low PCE of less than 0.1%. (3). Organic solar cells (heterocyclic bilayer OSCs (Fig. 1), containing acceptor and donor materials (copper as the donor (D) and perylene tetracarboxylic derivative as acceptor (A)) were created, Tang (Tanget al.,1986) presented a major breakthrough in the field of organic solar cell fabrication (OSCs). Copper-phthalocyanine and tetracarboxylpyrene act as active layers in this heterostructure bilayer device, resulting in a 1% increase in PCE. However, its effectiveness is limited a cinar. To put organic solar cells to use, they must have three layers: a donor layer, a passive layer, and an active layer that stimulates the exciton pair (gap - electron) to work. In 1995, Heeger and his research team invented these links (BHJ), which are depicted in Fig. 1. (4., 5), There has been remarkable progress in the field of organic solar cells in recent years (OSCs). Existing research indicates that the efficiency of organic solar cells (OSCs) is greater than 10%, if not 20%. (6). This advancement can be attributed to the discovery of new materials with excellent photosensitivity, such as MDMO-PPV and P3HT as donors and fullerene derivatives as acceptors, which were popular in the field's early days (7). Hundreds of more complex donor and acceptor layer materials have been presented that improve photovoltaic properties, have good light absorption, charge generation, and excitonic generation (electron-hole pairs), and significant progress has also been made in other components that do not. Organic solar cells (OSCs) are embedded with electrodes and interlayers Furthermore, new device structures such as ternary and tandem organic solar cells (OSCs) have gained popularity (8).

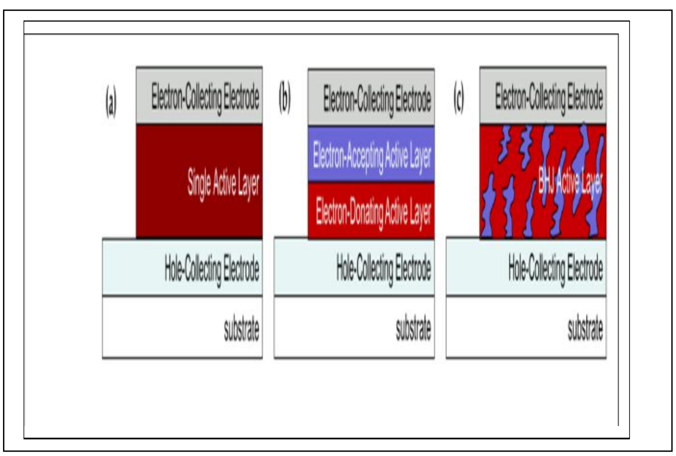

Fig. 1. Organic Solar Cell

2. Organic solar cell advancements

There are three types of organic solar cells ,Organic monocrystalline solar cells ,Organic bilayer solar cells Fig. 2,Heterogeneous solar cells in bulk.

Because they are made up of a single layer of organic materials, monolayer organic solar cells (OSCs) are the simplest structure of organic solar cells. It is made up of a conjugated polymer layer sandwiched between two conducting electrodes. The main requirement for device fabrication is an absorbing medium film thickness of 10-20 nm (9). Bilayer organic solar cells (OSC) have two separate organic layers that are confined together. Between the electron and hole assembly layers, conductive electrodes are placed. At the interface between acceptor and donor, the basic structure of the device exciton separation occurs. The purpose of modifying electrodes to form better ohmic contacts with electron and hole collecting layers is to improve electron affinity and ionization potentials. The donor layer absorbs the incoming photon, and electrons in the donor material move from the highest occupied molecular orbital (HOMO) level to the lowest unoccupied molecular orbital (LUMO), forming excitons. At long last Organic solar cells (OSC) are heterogeneous on a photovoltaic (absorbent) layer composed of a polymer mixture. Typically, the mixture is created by combining electron donor and acceptor polymers and then inserting it between electrodes. (10,11).

3. Organic solar cell stability

Because organic solar cells (OSCs) are highly sophisticated devices, their stability cannot be controlled even in the absence of external degradation factors. The inherent instability occurs due to two factors: morphology changes in the active layer and carrier diffusion, transport layer, and electrical materials in the active layer. The active layer the most critical component of heterojunction OSCs (BHJ) solar cells has a bi-domain nan morphology with a doped donor and acceptor material. The active layer morphology must be in an ideal state to achieve the best acceptor and donor mixing performance. It is accomplished through efficient exciton dissociation and charge carriers, Concurrently, the transfer process and the freight recombination process are reduced. The optimum, however, is not always the thermodynamic steady state at equilibrium. As the best morphology emerges, it will gradually evolve towards equilibrium, causing changes in the active layer. (12,13) because of the high mobility of donor and acceptor material and, in some cases, a structural mismatch between donor and acceptor, (14) investigated the role of phase separation from the molecular aggregation point and the aggregation field and found that phase separation had a significant negative impact on the charge generation, transport, and extraction processes in the active layer. They pointed out that the mixed system can have a high degree of stability due to its perfect mixing, and that the optimal morphology is initially thermodynamically and creates an equilibrium state, just a few examples of donor and acceptor materials, widely used electrodes, aluminum (Al) and indium tin oxide (ITO), Even in the absence of external factors, it can cause diffusion from Al and In atoms to the carrier and active layer. (15,16) extensively use poly(3,4-ethylenedioxythiophene)-poly(styrenesulfo nate) as a carrier transport layer), It has the potential to spread in the active layer. (17) It is possible to argue that the diffusion of transport layers and carrier electrodes can change the energy levels of each layer and cause traps in the active layer, which accelerates non-radioactive charge recombination. The transport layer and electrical materials in the active layer So does the effect of light. (photo oxidation) The changing composition of donors and acceptors degrades their photovoltaic properties, resulting in reduced light absorption and charge generation in organic solar cells (OSCs) (18), Because solar cells operate under continuous illumination, a relatively high working temperature with constant heating is unavoidable. Unfortunately, many organic solar cells (OSCs) suffer from thermal instability. In addition, most organic solar cells face air instability (OSCs). The ratio of surrounding oxygen and water may be detrimental to device performance, and the diffusion of oxygen and water around the cells causes severe physical and chemical deterioration in the electrodes, carrier layers, and active layers (19).

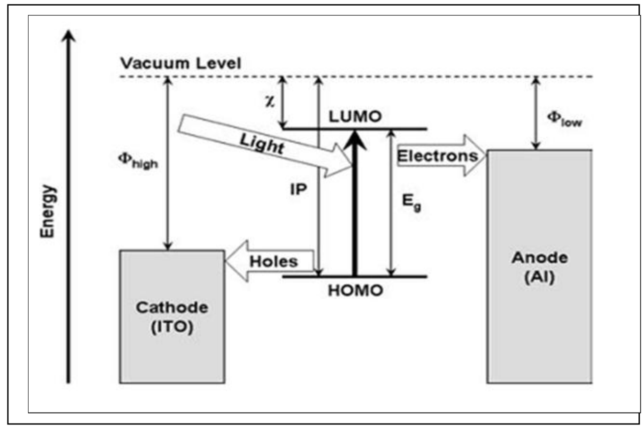

Fig. 2. Solar cell mechanics

Organic solar cell material compositions.

Acceptors and donors are the materials used. The donors contain small molecules that are part of the material's structure, such as the polymer molecular structure in polymeric organic solar cells (PSCs). Donors are typically D-A polymers: electron acceptors: electron donor units (20) Fig. 3 shows that the donor polymer used in organic solar cells (OSCs), such as PC61BM and PC71BM, has always been in first place due to its isotropic transfer and high electron affinity (21).

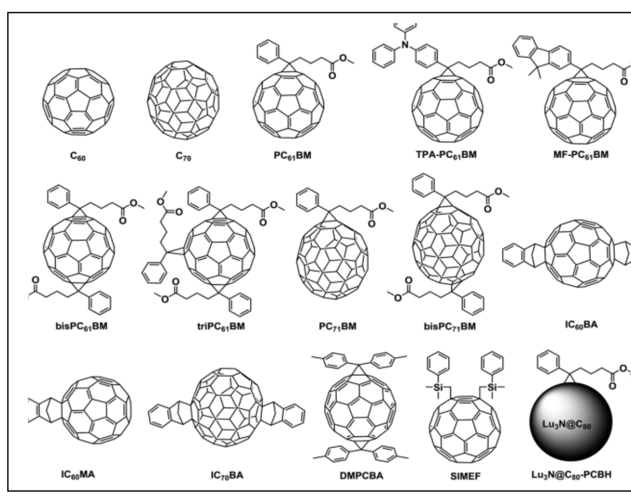

Fig. 3. Organic solar cell material compositions

Organic solar cell's operation could be summarized in the following step:-

Absorption of Photons Light, Excitons, and Diffusion Excitons Charge Separations, Pair Accumulation (Electron, Hole) Collection of Charges Because of the molecular structure of the conjugate organic materials (22) used, the excitation process leads to the generation of the pair after the photon absorption of the incident light by the active layer in the cell structure, (Electron - gap) This causes pair spread in the active layer and electron separation if the electron moves towards the negative pole and the gap moves towards the positive pole, and the separation efficiency of the pairs must be high (23),

Organic solar cell advancements over the last ten years

There is a pressing need for all polymeric organic solar cells (APOSCs) to improve their efficiency.

In 2012, researcher Seong-Kyujang and his colleagues used P3HT:PCBM as an active layer in solar cells in a 50:50 ratio, and the cell efficiency was 2.9%. Deng Zhen and his colleagues investigated the use of PEDOT:PSS in solar cells the same year, and discovered that it had a high efficiency of 3.34%(24). Due to its high conductivity, PEDOT:PSS polymer was discovered to be one of the most commonly used materials in solar cells in 2014, and the researcher compared the cell Layered solar panels ITO/PEDOT:PSS/P3HT:PCBM/AL, with other cells of the same composition and by adding other materials, it was discovered that the efficiency of the first is 3.07%, while the efficiency of the other is about 1.87%(25). In 2015, the researcher Abdullah a.Hussen created a solar cell using gold nanoparticles that had an efficiency of up to 3.7% and were layered . ITO:PEDOT:PSS: AuNps:P3HT:PCPM/AL.

In the same year, Furkan.K of the University of Technology, Baghdad, investigated the effect of lasers on the efficiency of a solar cell with the composition ITO/PEDOT:PSS/Polymini + TIO2 + AL2O3 using the spin coating method, and it had a 3.7% efficiency(26). Fatima Hameed, a researcher, built a solar cell in 2016 with the following composition: ITO/PEDOT:PSS/P3HT:Orange G/AL and different doping ratios for the dye used, with the best result when doping 5% (27). a ternary system in 2017 that consists of two morphologically compatible polymers with distinct chemical structures and can achieve a high PCE of 9.0% with a mass ratio of 1:1. Significantly more than triple. We attribute this to the system's high conformational compatibility, equilibrium electron and hole mobility, and reduced recombination.In 2018, ternary organic solar cells were created using a donor polymer PBT1-C, an integrated-ring amorphous electron acceptor ITIC-2Cl, and a two-channel amorphous indene-C60 fullerene derivative (ICBA). It was discovered that Ekpa can disrupt the interactions of ITIC-2Cl crystal molecules in ternary syntheses, resulting in a more uniform conformation. As a result of incorporating 20% EkPA into the PBT1-C:ITIC-2Cl blend, efficient charge dissociation, negligible molecular recombination, and balanced charge-carrier transitions are possible. With a high fill factor (FF) of 76.8%, an impressive power conversion efficiency (PCE) of 13.4% was achieved, representing one of the highest PCEs reported to date for organic solar cells (28).

In 2020, researcher Haitham Ahmed and colleagues created a high-efficiency polymeric solar cell of type P,n based on carbon nanotubes (29). Tao Liu et al. improved the efficiency of an organic solar cell to 16% in 2021 by incorporating a small amount of BN-T, an N-type polymer acceptor, which results in enhanced exciton formation and charge transfer (30).

Conclusion.

Organic solar cells (OSCs) have significant advantages in terms of achieving low production costs while maintaining high efficiency. OSCs provide advantages such as the ability to tune chemical properties, light weight, and ease of fabrication. Although solar cells based on inorganic molecules have demonstrated higher energy conversion efficiency and environmental stability, high performance OSCs can be obtained by using highly absorbent materials. Polymers are commonly used as absorbent layers to induce light absorption efficiency and device performance. To achieve highly effective OSC, new polymers with a narrow bandgap and appropriate energy level arrangement must be designed.

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