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Organic solar cell – A Renewable Energy Resource

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ABSTRACT

This new photovoltaic energy technology can contribute to environmentally friendly, renewable energy production, and the reduction of the carbon dioxide emission associated with fossil fuels and biomass. In this regard organic solar cells have attracted considerable attention in the past few years owing to their potential of providing environmentally safe, flexible, light weight and inexpensive as efficient energy resource.

Solar cells constructed of organic materials are becoming increasingly efficient due to the discovery of the bulk heterojunction concept. This paper provides an overview of such organic solar cells.

INTRODUCTION

Fossil fuels, however, are running out and are held responsible for the increased concentration of carbon dioxide in the earth's atmosphere. Developing environmentally friendly, renewable energy is one of the challenges to the society in the present century. It is expected that the global energy demand will double within the coming years. One of the renewable energy technologies is photovoltaic (PV), the technology that directly converts daylight into electricity. PV is one of the fastest growing of all the renewable energy technologies; in fact, it is one of the fastest growing industries at present.

Photovoltaic's is the field of technology related to production of electricity from light. Cells can be described as photovoltaic even when the light source is not necessarily sunlight (lamplight, artificial light, etc.).

The operation of a photovoltaic (PV) cell requires 3 basic attributes:

1. The absorption of light, generating either electron-hole pairs or excitons.
2. The separation of charge carriers of opposite types.
3. The separate extraction of those carriers to an external circuit.

At present, the active materials used for the fabrication of solar cells are mainly inorganic materials, such as silicon (Si), gallium-arsenide (GaAs), cadmium-telluride (CdTe), and cadmium-indium-selenide (CIS). The power conversion efficiency for these varies from 8 to 29%. However a large production cost is required for the silicon solar cells, which is one of the major obstacles. Even when the production costs could be reduced, large-scale production of the current silicon solar cells would be limited by the scarcity of some elements required, e.g. solar-grade silicon.

Photovoltaic cell configurations based on organic materials differ from those based on inorganic semiconductors, because the physical properties of inorganic and organic semiconductors are significantly different. Organic or plastic solar cells use organic materials (carbon-compound based) mostly in the form of small molecules, dendrimers and polymers, to convert solar energy into electric energy. These semi conductive organic molecules have the ability to absorb light and induce the transport of electrical charges between the conduction bands of the absorber to the conduction band of the acceptor molecule. There are various types of organic photovoltaic cells (OPVs), including single layered and multilayered structured cells. Both types are currently used in research and small area applications.

Organic solar cells commonly utilize two different materials that differ in electron donating and accepting properties. In general, for a successful organic photovoltaic cell four important processes have to be optimized to obtain a high conversion efficiency of solar energy into electrical energy.
A- Light absorption
B- Charge transfer and separation of the opposite charges
C- Transportation of charge
D- Collection of charge

There are different types of plastic solar cells some of which are list below:

1. Dye-sensitized solar cells
2. Double layer cells
3. Bulk heterojunction cells

EFFICIENT BULK HETEROJUNCTION CELLS

The bulk hetero junction is presently the most widely used photoactive layer. The name bulk-hetero junction solar cell has been chosen, because the interface (hetero junction) between both components is all over the bulk (Figure), in contrast to the classical (bilayer-) hetero junction. As a result of the intimate mixing, the interface where charge transfer can occur has increased enormously. Subsequently, the photo generated charges are transported and collected at the electrodes. Polymer-fullerene solar cells were among the first to utilize this bulk-hetero junction principle. When such a bulk-hetero junction is deposited on an ITO substrate and capped with a metal back electrode, working photovoltaic cells can be obtained (Figure).

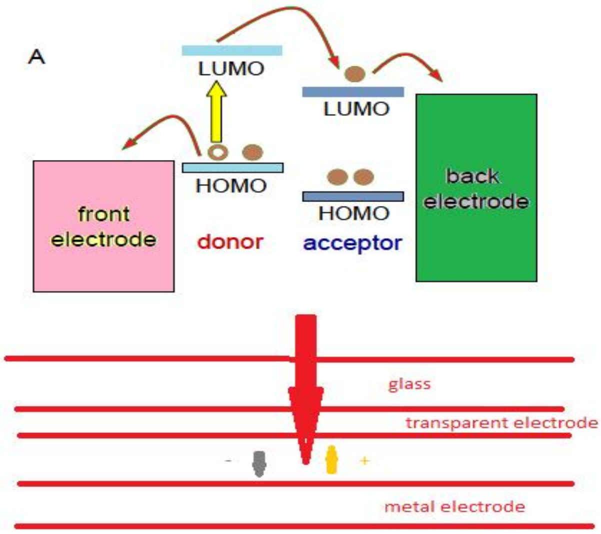

Figure : The bulk-heterojunction concept

STABILITY OF ORGANIC SOLAR CELLS

Polymer-based solar cells must be protected from ambient air to prevent degradation of the active layer and electrode materials by the effects of water and oxygen. Even with proper protection there are several degradation processes that need to be eliminated to ensure stability. Apart from device integrity, the materials must be photo chemically stable and the nano scale bi continuous donor-acceptor in the active layer should preserve.

Upon cooling to operating temperatures, it may be expected that no further changes occur in the morphology. Nevertheless, creation of nano scale bulk hetero junction morphologies that are stable in time and with temperature is one of the challenges that must be met before polymer photovoltaic can be applied successfully.

SCOPE TO IMPROVE EFFICIENCY

Efficiency can be improved by improving three factors these are: open-circuit voltage, the short circuit voltage and the fill-factor. New combinations of materials that are being developed in various laboratories focus on improving the three parameters that determine the energy conversion efficiency of a solar cell, *i.e.* the open-circuit voltage, the short-circuit current, and the fill factor that represents the curvature of the current density-voltage characteristic.

For ohmic contacts the open-circuit voltage of bulk-hetero junction polymer photovoltaic cells is governed by the energy levels of the highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO) of donor and acceptor, respectively.

One of the crucial parameters for increasing the photo current is the absorption of more photons. This may be achieved by increasing the layer thickness and by shifting the absorption spectrum of the active layer to longer wavelengths. Hence, a gain in efficiency can be expected when using low-band gap polymers.

A high fill factor is advantageous and indicates that fairly strong photocurrents can be extracted close to the open-circuit voltage. In this range, the internal field in the device that assists in charge separation and transport is fairly small. Consequently a high fill factor can be obtained when the charge mobility of both charges is high.

COST

An extensive use of organic solar cells could contribute to the increased use of solar power globally and make renewable energy sources friendlier to the average consumer. Organic solar cells can be easily manufactured compared to silicon based cells, and this is due to the molecular nature of the materials used. Molecules are easier to work with and can be used with thin film substrates that are 1,000 times thinner than silicon cells (order of a few hundred nanometers). This fact by itself can reduce the cost production significantly.

Since organic materials are highly compatible with a wide range of substrates, they present versatility in their production methods, which have low energy and temperature demands compared to conventional semi conductive cells and can reduce cost by a factor of 10 or 20.

CONCLUSION

Organic Solar cells have certain disadvantages including their low efficiency (only 5% efficiency compared to the 15% of silicon cells) and short lifetime. Nonetheless, their numerous benefits can justify the current international investment and research in developing new polymeric materials, new combinations, and structures to enhance efficiency and achieve low-cost and large-scale production within the next coming years. A commercially viable organic solar cell production is the target of the next decade and so much is still going on in this regard.

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