POLYMER PHOTOVOLTAICS

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 solar cells varies from 8 to 29%.

The large production costs for the silicon solar cells is one of the major disadvantages. Even when the production costs could be reduced, large-scale production of the current silicon solar cells is limited by the scarcity of some elements required, e.g. solar-grade silicon.

Advantages of organic photovoltaic devices over conventional solar cells:

Conjugated polymers have the immense advantage of providing environmentally safe, flexible, lightweight, inexpensive electronics.

a. Organic materials can be easily made via various synthetic pathways.

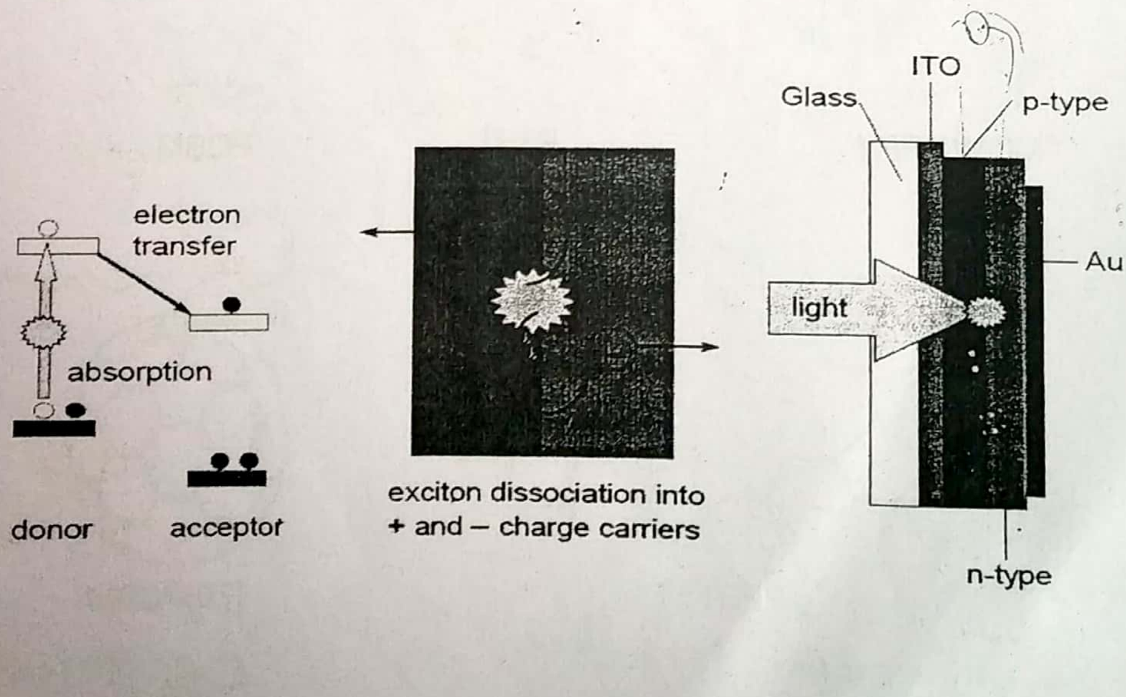
b. The band gap of organic materials can be tuned by introducing different functionalizations in their structures.

c. Most organic compounds can be dissolved in common organic solvents. They can be processed not only via vacuum evaporation/sublimation, but also by means of other low-cost manufacturing technologies, such as roll-to roll or inkjet printing, drop-casting, spin- or dip-coating, doctor-blading, and other solution casts. The ease of processing leads to cost reduction compared to inorganic PV.

d. In thin films, organic polymers have shown high absorption coefficients, which allow organic solar cells to be efficient in thin films and under low sunlight irradiation.

e. Solar cells based on organic materials are structurally flexible. Organic solar cells have a much larger application potential than conventional solar cells. They can be used not only as electricity providers on roof tops, like common inorganic solar cells, but can also be used for decoration in fashion windows, toys, and chargers for mobile phones or laptops.

Working principle of an organic photovoltaic cell.



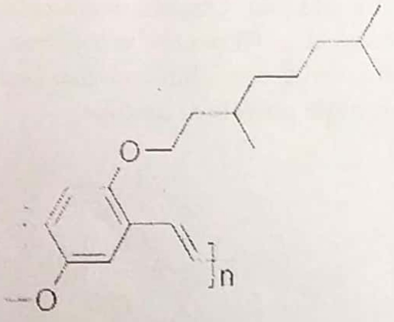
- To create a working photovoltaic cell, the photoactive material (D+A) is sandwiched between two dissimilar (metallic) electrodes (of which one is transparent), to collect the photogenerated charges.
- Ilumination of donor through a transparent electrode (ITO) results in the photoexcited state of the donor, in which an electron is promoted from the highest occupied molecular orbital (HOMO) to the lowest unoccupied molecular orbital (LUMO) of the donor. This electron-hole pair is called an exciton. Excitons diffuse towards the donor-acceptor interface.
- Subsequently, the excited electron is transferred to the LUMO of the acceptor, resulting in an extra electron on the acceptor (A^{-}) and leaving a hole at the donor (D^{+}).
- The photogenerated charges are then transported and collected at opposite electrodes with the aid of internal electric field, which generates photocurrent and photovoltage.

Difference from inorganic PV

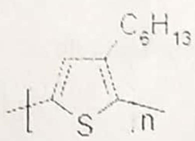
Inorganic semiconductors generally have low exciton binding energy (for GaAs the exciton binding energy is 4 meV). Hence, the thermal energy at room temperature is sufficient to dissociate the exciton created by absorption of a photon into a positive and negative charge carrier. The formed electrons and holes are easily transported as a result of the high mobility of the charge carriers and the internal field of the p-n junction.

Organic materials have higher exciton binding energy . For polydiacetylene 0.5 eV is needed to split the exciton and, hence, dissociation into free charge carriers does not occur at room temperature. To overcome this problem, organic solar cells commonly utilize two different materials that differ in electron donating and accepting properties. Charges are then created by photoinduced electron transfer between the two components.

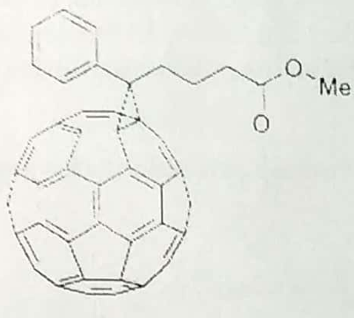
A few donor and acceptor materials are given below. One of the most promising combinations of materials is a blend of a semiconducting polymer as a donor and a fullerene, C_{60} derivative as acceptor.



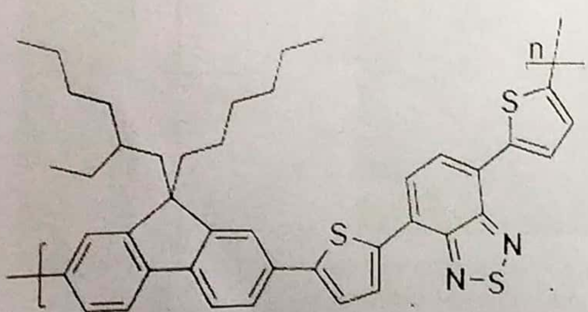
MDMO-PPV



P3HT



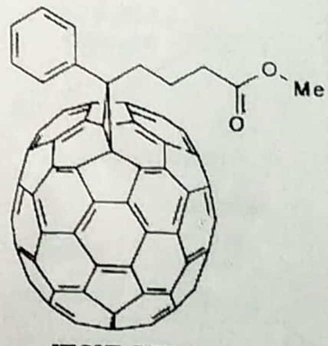
PCBM



PFDTBT

Polyfluorene derivative

DONORS



[70]PCBM

C_{70} derivative

Acceptor