Plastic Solar Cells
Cheap energy device for tomorrow
Conventional Solar Cells

- A solar cell is a device that converts the light energy into electrical energy. Usually light from the sun is used to generate electricity from such a device hence the name solar cell.
- Conventional Solar cells are built from semiconductors.
- Usually mono-crystalline or poly-crystalline materials are needed for higher efficiency.

**Advantage:** High efficiency - up to 30% has been reached. Normally 10% for commercial product.

**Disadvantage:** Elaborate and very expensive method required to produce the material.
Working Principle
A p-n junction.

• When p-doped and n-doped semiconductors are brought together, a depletion layer is formed.

• The depletion layer sets up an electric field.

• Any charge in the field experiences a force that sweeps it to the end of the depletion layer.
Action of Photons

• A photon excites an electron from the valence band to the conduction band creating an electron-hole pair.

• The excited electrons in the depletion layer move towards the n-type end while the holes move to the p-type end.

• This flow of charge drives the external load.

\[ E = mc^2 \]
Uses

• Generating electricity for space vehicles.

• Alternative energy source for household purpose where normal electricity is not feasible.

• Power for facilities like repeater stations for tv, radio etc. in remote locations.

• Power source for small devices like pocket calculators.
Motivation:
A Burning Necessity

- Dwindling fossil fuels.
- Environmental hazards from other energy sources.
- Reliable energy source for remote places.
- Demand for portable energy source.
Promising Alternative
Plastic Solar Cells

Advantages:

• Low production cost.
• Easy manufacturing technique
• Can be built on various substrates
Device Architectures

- Simplest design uses organic semiconductor, metal-insulator-metal (MIM) tunnel diode.

- The insulator typically is a conjugated polymer.

- A more complicated design uses two conducting polymers differing in electron affinities forming hetero-junction.
Working Principle
(MIM Tunnel Diode)

• Conjugated polymers are analogous to inorganic semiconductors.

• The overlap of atomic pi orbitals gives rise to delocalized bonding and antibonding pi orbitals analogous to the valence band and the conduction band.

• Energy gap between the bands is typically 1.5 – 3 eV which lies in the range of the visible light.
Working Principle …

• Like in the semiconductors the electrons are excited by the photons creating electron-hole pair

• Unlike in the semiconductors the electrons and the holes are not free to move. They form excitons and move together.
Working Principle …

• The paired charges are splitted at the interface using electrodes of suitable workfunctions.

• Holes get collected at the high work function electrode and the electrons get collected at the low work function electrode.

**Drawbacks:**

• Splitting is not efficient.

• Impurities like oxygen trap the excitons.

• Very low electron mobility, typically below $10^{-4}$ cm$^2$ V$^{-1}$s$^{-1}$
Working Principle
Heterojunction Diode

- An interface is created between conducting polymers with different electron affinities.
- Such junctions are very effective in splitting the excitons.

**Limitation:**
- Life time of the excitons. Only the excitons formed within ~10 nm of the junction can reach it.
- Interpenetrating networks of electron-accepting and electron-donating polymers.
A Production Technique

Preparation of ITO surface

Coating of hole conduction layer PDOT:PSS

Coating of active layer

Evaporation of top contact

Sealing against oxygen and water

Device testing
Achievements

• Power conversion efficiency upto 3% has been reported using bulk heterojunction.

• Scientists from … have reported an efficiency of 5%. They hope to reach an efficiency of 15% within next 6 years!

• Very recently scientists from … reported an efficiency of 6%. They believe they can reach an efficiency of 15% within next 3 years!
A Bright Future With Clean, Green And Free Energy