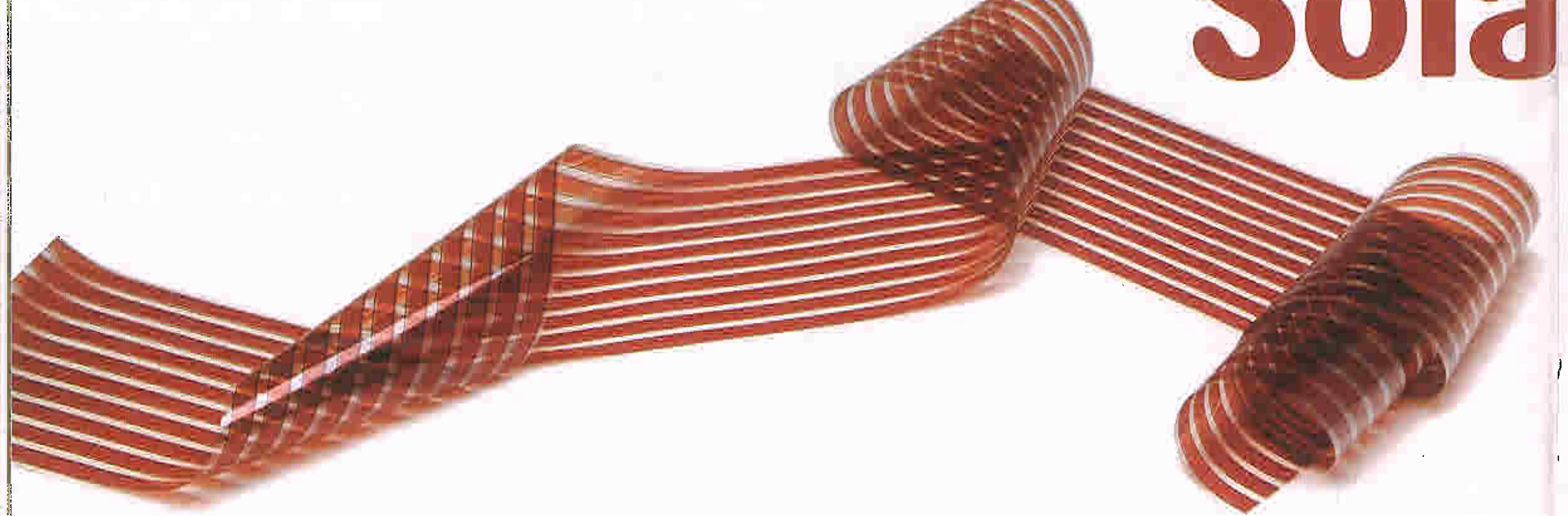


Solar energy without subsidies?

With climate change at the top of the agenda, renewable energies have gained unprecedented attention. Aafko Schanssema, Consumer and Environmental Affairs Manager at PlasticsEurope, Belgium, considers a possible role for plastics.

The EU aims to meet 20% of its energy needs from renewable sources by 2020. But many of these sources remain expensive and are not cost efficient. Although the price of fossil fuel is rising, it is still far below that for harvesting the sun's energy.

Research has sought technologies to solve this problem. One of the more promising avenues is organic photovoltaics (PV) – solar cells made from plastics. They take the form of a flexible, light film that can be easily attached to other materials and adapted to different colours and designs.

This has led to potential commercial applications in the construction industry, where plastic cells could be used as a thin film on roofs, windows and facades (see main image). Moreover, they could feature in foldable chargers for mobile phones and other gadgets, on car roofs, or in clothes.

Plastic PV cells rely on the properties of organic semiconductors that were discovered by Alan Heeger, Alan MacDiarmid and Hideki Shirakawa – an achievement for which they received the 2000 Nobel Prize in Chemistry. The conductivity of these semiconductors can be increased several times by 'doping' them, either positively or negatively. P-doped organic semiconductors include polyaniline (PAn), polypyrrole (PPy), polythiophenes (PTh) and Poly (p-phenylenevinylenes). Less effort has gone into synthesising n-doped organic conductors (see image below, left).

Main image: Thin film, courtesy of Konarka. Right: Synthesising n-doped organic conductors, courtesy of Merck

Photo centre

The PV effect for conventional inorganic semiconductors (mostly silicone) is well established. Incoming sunlight excites an electron into a higher energetic state so that it moves from the valence band to the conduction band of the atom. This produces two charge carriers – a free electron in the conduction band and an electron hole in the valence band, which behaves like an independent carrier of positive charge. Thus, a chain reaction of moving electrons and holes is set in motion, which amounts to an electric current.

For organic solar cells, the process is more complex. Conjugated polymers can host electrons at different energy levels. Sunlight can excite an electron into a higher energy band, but, unlike in inorganic semiconductors, the resulting electron and hole are bound into an exciton and cannot move separately. This prevents a current from emerging. However, the exciton can be split into an electron and a hole at an interface to create a current. To facilitate this, researchers have developed heterojunction cells, made of both electron-donating and electron-accepting conductors jumbled together. The multiplicity of interfaces between them generates more possibilities for excitons to split and for a stronger current to emerge.

A number of material combinations are possible for organic PV cells. Some plastic solar cells combine polymer conductors with pure carbon molecules (fullerenes). Hybrid cells use both organic and inorganic substances, for example, researchers at the University of California, Berkley, USA, use nanorods made from cadmium selenide and embed them in a polymer environment.

To produce the active layer of a heterojunction cell, both the donor and acceptor materials are mixed together in a solvent, which is then printed or sprayed onto a substrate. Molecule layers can also be vacuum-deposited by vacuum thermal evaporation. This active layer may be framed by semiconducting transport layers, either inorganic (such as transparent titanium dioxide) or organic semiconductors, such as triarylamine. Two thin electrodes enclose the cell. Typically, one consists of a transparent conducting oxide (such as indium tin oxide) while the other is metal.

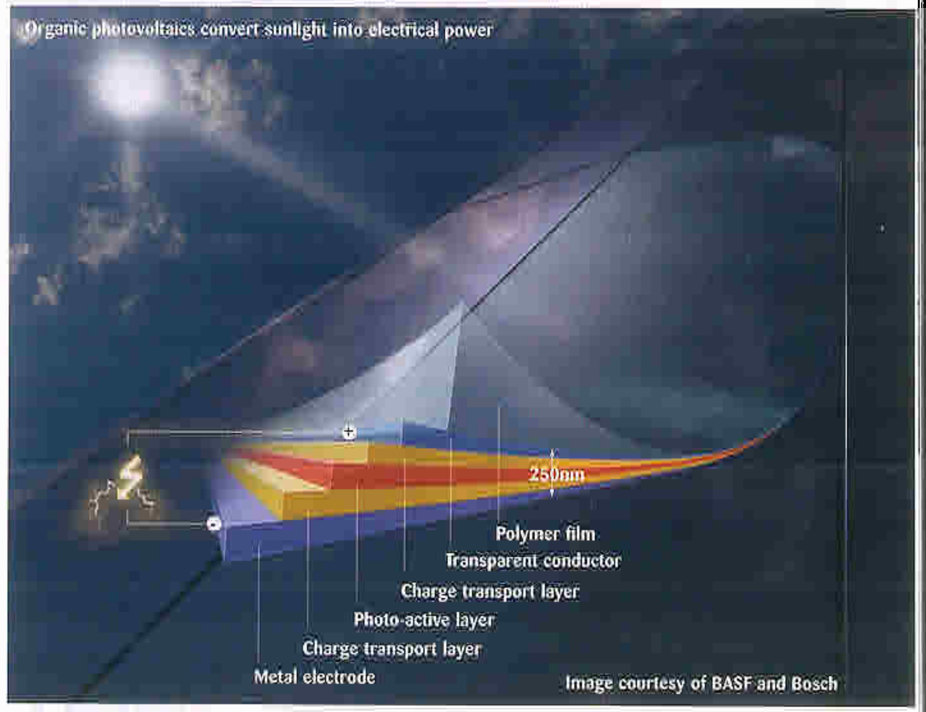
For a wholly see-through cell, transparent conducting oxides can be used for both electrodes. A plastic film covers the solar cell to protect it from contact with water and oxygen. For heterojunction cells, the film is no thicker than 250nm (see image right).

Photo production

The rather 'dirty' printing process for plastic solar cells lends itself to mass production of PV films. According to US-based solar technology company Konarka, plastic solar cells cost only a fifth of the price of traditional PV cells, which have to be manufactured under specific conditions in a clean room and baked in a vacuum chamber.

Current silicone technology means that the electricity produced costs around three euros/watt peak. Watt peak measures the DC watts output of a solar molecule under a standardised light test. Researchers working on polymer PV cells are aiming for a cost of less than one euro/watt peak. The production of plastic solar cells also consumes less energy than traditional PV cells, reducing the energy payback time.

Organic PVs need to develop further to achieve the same efficiency as traditional solar cells. Their conversion rate, demonstrating how much sun energy they convert into electricity, stands at five per cent, while traditional cells achieve around 15%.



Researchers believe that plastic solar cells can reach this level and in order to achieve this, they seek to widen the spectrum of sunlight absorbed to include infrared and UV.

Last summer, Nobel laureate Heeger presented a tandem solar cell that can achieve efficiencies of 6.5%. It combines two cells with different light absorption capacities, separated by a layer of transparent titanium oxide. Adjusting the energy levels of the active substances and conducting layers facilitates the splitting of excitons and helps to generate a stronger current.

Commercial applications of plastic solar cells are expected to reach the market this year, starting with chargers for consumer electronics.

Further information

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