Organic Photovoltaic Technology

Background

Conventional solar cells convert light energy into electricity through the photovoltaic effect on semiconductor material like crystalline silicon. Though effective, this methodology of harnessing solar energy has its drawbacks in the form of high manufacturing costs and prices, decreasing availability of sufficient amounts of silicon, module assembly costs, rigidity of panels etc.

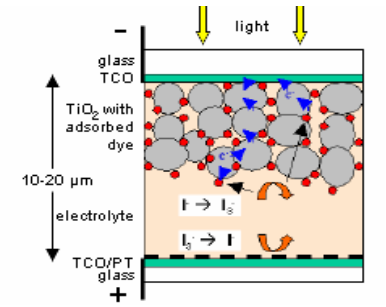
To counter these factors, new technologies have emerged that make use of technologies that use cost-effective raw materials and processes. These technologies, collectively termed "Third generation technologies" primarily include Organic technology, Nanotechnology and Spheral technology.

Research on developing organic-based solar cells started in the 1970s. Organic solar cells are a potentially cost-effective option for utilizing solar energy. The technology itself is in the process of development, and shows promise because of its ease of use, diversity of applications and manufacturing process.

Organic Technology

Organic technology solar cells are essentially based on the photosynthesis process in plants. The absorption of light in organic cells is done by the 'dye' which substitutes for the silicon in conventional cells. This light causes the dye molecules to get excited and release electrons that are converted to electrical energy.

The use of use of chemicals called dyes for the conversion process has led to organic cells also being known as "dye-sensitized solar cells."



Courtesy: European Institute for Energy Research

The absorption of light occurs in dye molecules that are in a highly porous film of Titanium dioxide (TiO_2). This causes the electron to be injected into TiO_2 and is conducted to the transparent conductive oxide layer (TCO).

Main Features

Cost

Organic solar cells can reduce the overall cost of power generation using photovoltaic technology by lowering material and manufacturing/assembly costs.

The exclusion of crystalline silicon material presents substantial savings in raw material and manufacturing/assembly costs.

Costs are limited through the use of titanium dioxide, which is relatively inexpensive and technology that does not require assembly of cells into modules.

The costs however become higher due to lower efficiency and durability levels of organic solar cells. At present, research and development efforts are underway to bring down overall costs of manufacturing and set price levels at $1/Watt.

Flexibility and Versatility

Organic technology solar cells have been developed for use in a variety of indoor and outdoor applications. The substrates used for manufacture can range from glass to plastics, and the method of application of the dye results in highly flexible solar panels that dispense with the problems faced in use of more fragile conventional solar modules[i].

Organic-based solar modules have been manufactured by various agencies, like those developed by the U.S. Air Force Research Laboratories that can be sewn into tents and other material to provide local energy solutions in remote camps (read article). This technology has also been used in photovoltaic clothing that can provide power for small electronic equipment. Research is also underway to develop 'self-assembling' organic thin-films, which are able to self-organize from liquid into efficient cell coatings[ii].

Efficiency

The Organic solar cells developed in the 1970s demonstrated efficiencies of about 1%. Through research and development of technology, efficiency levels have increased to roughly 3-5%, and up to 15% in laboratories.

Though many researchers aim for theoretical efficiencies of 33%, current levels remain around 5% for commercial cell production.

Various experiments are presently underway that make use of alternate materials, like Pentacene (at Georgia Institute of Technology: read article), that have the potential of increasing efficiencies while keeping costs level.

Use of nanotechnology in combination with organic is also being tested in order to improve the energy conversion levels of organic solar cells.

Lifetime

One of the main problems with organic technology is the short life-span of the solar cells. Because of the nature of the dyes and other chemical compounds used, the cells are prone to degrade relatively quickly at working temperatures and common weather conditions. Opting for higher efficiencies can further decrease the lifetime of the solar cells.

However, recent research and development of technology has led to the possibility of manufacturing organic solar cells that have a projected lifetime of about 10 years[iii].

Integration in manufacturing process

Due to the unique nature of the components used in manufacturing organic cells, the technology cannot be suitably integrated with other existing cell production lines for silicon based solar cells.

Reliable mass production also requires that the organic solvents used in the cells have a certain degree of durability and are able to withstand mechanical stress at working temperatures.

Market share

The organic technology growth is presently nascent, with most companies starting pilot production lines. The collective production capacity for this technology is expected to grow with an increase in the efficiency levels, durability and lifetime of the cells.

Research Organizations

Georgia Institute of Technology, USA

Location: Georgia, USA (weblink)

Research highlights: The Center for Organic Photonics and Electronics (COPE) in the School of Electrical and Computer Engineering at Georgia Tech does research on improving efficiencies and design structures of light-weight organic solar cells. This Center works with the University Center for Excellence in Photovoltaics (UCEP) for improving conventional silicon and organic solar cells. Led by Bernard Kippelen, COPE has designed cells using crystalline organic film called Pentacene that results in more efficient and light-weight solar cells.

Global Photonic Energy Corporation

Location: New Jersey, USA (weblink)

Research highlights: Global Photonics is a renewable energy technology development company. It has carried out research on developing technologies for producing organic solar cells. The company targets designers and product innovators to accelerate the development of this technology.

Korea Institute of Energy Research

Location: Daejeon, South Korea (weblink)

Research highlights: The Institute specializes in energy research and works on developing new technologies supporting energy policies. It has carried out research on improving organic solar cell technology with TiO_2, and integrating this with other solar based technologies.

Center for Photonics and Optoelectronic Materials (POEM), Princeton University

Location: New Jersey, USA (weblink)

Research highlights: This Center, affiliated with the department of electrical engineering, does research on technologies for making organic solar cells more efficient and cheaper. The Center has recently developed techniques for manufacturing organic solar cells at higher efficiencies of about 5% (read article).

GE Global Research

Location: GE offices worldwide (weblink)

Research highlights: The research unit at GE works on developing flexible substrates without silicon and optimized organic cells for energy conversion. The focus is on making use of technology and OLED device architecture in photovoltaic technology; also, developing roll-to-roll organic plastic sheets that can substitute conventional silicon panels and be used in a variety of applications.

Toshiba Research Europe Limited (TREL)

Location: Cambridge, UK (weblink)
Research highlights: Toshiba's research center works on developing organic solar cells, and has developed technologies that generate organic solar cells with efficiencies of around 7%, with higher lifetimes. The center has produced a technique for manufacturing plastic-based cells using dyes suitable for a variety of applications.

Siemens Research & Development

Location: Germany, (weblink)
Research highlights: The Siemens research group works on developing efficient printed organic solar cells that can be scaled up for commercial use. The efficiencies of the cells developed exceed 5%, more than regular levels of commercial cell production (read report) and are lightweight and flexible. This technology has been sold to companies like Konarka.

AIXTRON AG

Location: Aachen, Germany (weblink)
Research Highlights: AIXTRON is a manufacturer and supplier of equipment for compound semiconductor devices. In continuation of its Organic Vapor Phase Deposition (OVPD) business, the company has expanded research on organic solar cells in association with other companies, and is sponsored by the German Hahn-Meitner-Institute (HMI)[iv].

Companies producing Organic Solar Cells

Sustainable Technologies International

Location: Queanbeyan, NSW, Australia (weblink)
Highlights: Sustainable Technologies International (STI) was the world's first company to start commercial production of dye-sensitized solar cells which are based on organic cell technology, and also produces photovoltaic components made using nanotechnology. The company started its pilot production line in 2001 and had an annual production capacity of 0.5MW for organic solar cells by 2003. The company is owned by Tulloch Management Pty. Ltd, which also owns other organizations focusing on organic solar cell research.

Konarka Technologies, Inc.

Location: Lowell, Massachusetts. USA (weblink)
Highlights: Konarka Technologies has worked on developing technologies for commercial production of low-cost cells on flexible material, with a focus on combining organic and nano technologies and polymer electronics. The company has had $32 million financing by various investor agencies since 2001[v], and acquired the organic solar cells research group at Siemens in September 2004. Pilot-scale production of organic solar cells began in 2004 and production is expected to scale up to commercial levels in 2005. The company has diversified into manufacturing photovoltaic material adaptable for various applications, like spray-on plastic photovoltaic panels, solar fabric that generate power, etc.

Air Force Research Laboratory

Location: Ohio, USA (weblink)
Highlights: The scientists and researchers at the Materials and Manufacturing Directorate have been involved in developing advanced, flexible organic-based solar cells. The research has focused on all-polymer and organic material approach and dye-sensitized organic and inorganic material hybrid approach. This research is expected to yield versatile uses of PV, especially for military operations. Present studies have resulted in efficiencies of over 10%.

SolarAMP LLC

Location: Raleigh, NC, USA (weblink)
Highlights: SolarAMP focuses on research and development of renewable technologies, and organic photovoltaic components. As part of a recent joint effort with BP (read article), the start-up company has started to conduct tests for developing commercially viable organic molecular-based without using dye-sensitized solar cells with efficiencies targeted at 10-15% with lifetimes of 25 years.

Greatcell

Location: Lausanne, Switzerland (weblink)
Highlights: The organization focuses on dye-sensitized solar cells using organic technology. It was bought by Tulloch Management Pty. Ltd., which also owns Sustainable Technologies International (STI) in March 2003, but carried out research on organic solar cells, and assembles STI's outdoor façade modules.

[ii] Live Science, December 2004 (read article)
[ii] UniSci Int. Science News, August 2001 (read article)
[iii] Going Organic, OLE Magazine, November 2000
[iv] Press release, June 2004 (read article)
[v] Company press release, June 2004