BIOENERGY NEWS

January 2006

FEATURE ARTICLE:
Use Of Nanomaterials in Organic Photovoltaic Devices

Background

The ability to create high-efficiency solar cells is a key strategy to meeting growing world energy needs. Nanotechnology is currently enabling the production of high-efficiency organic photovoltaics (OPVs) to help meet this challenge.

Organic photovoltaics are nanostructured thin-films composed of layers of semi conducting organic materials (polymers or oligomers) that absorb photons from the solar spectrum. These devices will revolutionise solar energy capture because they can be manufactured via solution-based methods, such as ink-jet or screen printing, enabling rapid mass-production and driving down cost.

OPVs – Organic Photovoltaic Devices

OPVs currently lag behind their "inorganic" counterparts because of low solar energy conversion efficiencies, of approximately 1-3%. Several research groups are addressing conversion efficiency by employing a combination of nanomaterials and unique nano-scale architectures. These hybrid organic-inorganic photovoltaics consist of light absorbing polymers in contact with semiconductor nano-crystals, fullerenes or nano-structured metals. The nanomaterials affect electro-optical properties of the conducting polymer, which include assisting in absorption of red and near-infra-red photons, a significant portion of the solar spectrum.

Examples of OPVs designs employing nanomaterials include Polymer-Fullerene Heterojunctions, Organic-Nanocrystal Solar Cells, Dye-sensitized Cells, Tandem Cells.

Polymer-Fullerene Heterojunctions

Cells where chemically modified C60 like PCBM, acting as an electron acceptor, is in close physical contact with a polymeric organic electron donor or P3HT. This contact improves efficiency by allowing charge transfer to take place at the sub 10-nanometre scale, on the order of the diffusion length of an exciton generated from organic semiconductors. The most recent cells exhibit conversion efficiencies of ~ 5%.

Organic-Nanocrystal Solar Cells

Blends of semi-conducting polymers and semi-conducting quantum dots or nanorods (CdSe or CdTe) are mixed in a manner similar to the polymer-fullerene blends. The polymers are modified to give rise to chemical bonding between the nano-crystal and polymer. The nano-crystals can be tailored to a wide variety of optical band gaps, which depend on the size of the nano-crystal (or the diameter of the nanorod.)

Dye-sensitised Cells

These cells employ complex dye molecules attached to the surface of nano-structured oxides like TiO2 or Nb2O5. The dyes exhibit broad light absorption profiles and rapid photo-induced charge transfer of electrons to the nano-crystals. These cells show solar conversion efficiencies of ~ 4%.

Tandem Cells

The tandem cell harvests photons from the complete visible spectrum. These cells employ layers of C60 as a strong blue light absorber and CuPc (copper-phthalocyanine) as a red-yellow absorber. Nano-sized silver particles are used to act as a charge conduit between the cells but do not absorb photons travelling through the cell because of their nano-sized dimensions. These cells have achieved conversion efficiencies of ~ 6%. (Figure 1).

Efficiency Challenges

Significant challenges exist to achieving OPV devices that can be mass-produced and these

issues all affect the device efficiency. Nanotechnology will assist in meeting the technical challenges of this rapidly evolving field.

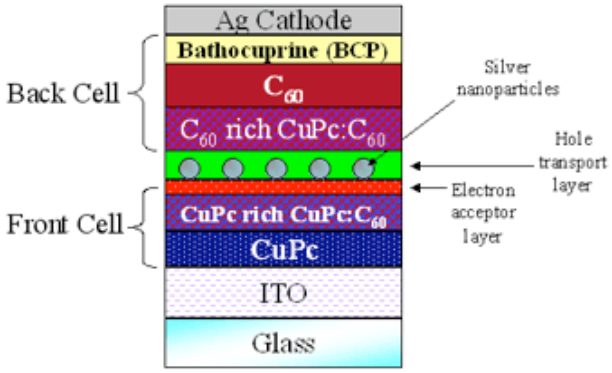

Figure 1. Schematic of a Tandem Organic Photovoltaic

Primary author: Dr. Sean Dingman

Source: "Nanomaterials in Organic Photovoltaic Devices", Sigma-Aldrich.

NEWS BRIEFS:

EU Plan

In December the EU Commission adopted an "**Action Plan for the Promotion of Biomass Energy**". The action plan sets out 20 measures for the development and improvement of Biomass technology, and as a result, enable a better use of biomass to produce energy, in particular heat. For the year 2006, the Commission has already announced a bill designed to promote the market for cooling and heating from renewable energy sources. The European Parliament estimates a probable percentage of renewable heating and cooling of 25% by 2020.

Converting Gasoline Pumps to Ethanol

VeraSun Energy Corporation, the USA's second largest ethanol producer, announced that it will work with Ford Motor Company in 2006 to convert gasoline pumps in the Midwest to E85, a blend of 85 percent ethanol with 15 percent gasoline. The companies will also launch a consumer awareness campaign to promote the benefits and use of E85, and Ford will ask local dealerships to participate in the campaign. Currently, of the more than 180,000 fuel stations in the United States, only about 500 offer E85. Flexible fuel vehicles can run on either E85 or gasoline, and Ford is offering four new models with the flexible fuel technology option for 2006: the Ford F-150, Ford Crown Victoria, Mercury Grand Marquis and Lincoln Town Car.

The U.S ethanol fuel industry continues to grow rapidly. In the first week of November alone, construction started on four new ethanol plants in Indiana, Minnesota, Missouri, and Nebraska, and a new plant in Iowa started production. Currently, 92 ethanol plants have the capacity to produce more than four billion gallons annually. Another 23 ethanol plants and seven expansions are under construction, and will add more than a billion gallons in annual production capacity. Meanwhile, Panda Energy, which made news in May by announcing plans to build an ethanol plant in Texas powered by cow manure, has since announced plans to build similar plants in Colorado and Kansas.

Co-firing and Efficiency Increase with Boilers

Improving the efficiency of boilers used in coal-fired power stations reduces carbon dioxide emissions because less coal is needed to generate the heat energy that turns the steam turbines powering the electricity generators.

Current systems, called advanced supercritical boilers, have an efficiency level of around 42%. By replacing an old-style boiler, operating at about 30% efficiency with one of the new systems can cut CO2 emissions by 23%.

The latest boilers also allow biomass to be added to the fuel mix. Industry figures show that this can reduce emissions by a further 20%. By increasing the efficiency of a plant and combine it with biomass/coal firing then you get the emissions down to similar levels as a gas-fired power plant.

Gasification plants and advanced supercritical boilers both have advantages that advocates of each are quick to highlight. Boilers are available commercially and can be "retrofitted" to existing coal-fired plants. This means the operator can improve efficiency while keeping capital costs down by using the existing infrastructure at the site.

Gasification systems, such as Integrated Gasification Combined Cycle (IGCC), can be used for "poly-generation". This allows the gas (hydrogen) to be used either to power a gas turbine or to be piped elsewhere, for example in transport or in the chemical industry.

This approach could become a key component role in a future hydrogen economy.

BIGCC

The advent of solid-fuel gasifiers that liberate combustible gases from solid fuel can allow

certain types of internal-combustion gas turbine engines to be fueled by biomass. Many gasifier combustors have a feature that continually transfers ash into an ash pan during engine operation, allowing only the combustible gases to be burned in the combustion chambers. The main drawback of this system is that single-shaft non-reheat turbine engines only deliver peak efficiency at maximum engine speed and at maximum power output. The turbine may be used to generate power at stationary locations while its hot exhaust partly energises a bottom-cycle steam engine.

Solid fuel gasifiers may be applied to intercooled/reheat turbine engines, one design of which is known as a complex-cycle engine. It is an internal combustion 3-shaft gas turbine that delivers a competitive efficiency when operating at over 20% of its maximum power output. The high-pressure compressor and turbine are located on one turboshaft, the intermediate-pressure power turbine that drives the load is on a second shaft while the low-pressure compressor and turbine are located on the third turboshaft. Fuel combustors are located upstream of both the high and intermediate pressure turbines. There would ideally sufficient oxygen in the high-pressure turbine exhaust to support combustion to reheat gas entering the power turbine. Historically, the complex cycle turbine was a temperamental and problematic engine.

Modern computerised engine control technology using exhaust-system oxygen-sensors can regulate the combustion in both the high-pressure and low-pressure combustors and alleviate the operation problems of the 3-shaft complex turbine engine. In this engine, an intercooler is located between the low and high-pressure compressors while exhaust recouperators would be located downstream of the high-pressure compressor and ahead of the primary combustor. Biomass may be the main solid fuels being gasified in this type of engine. Dell-Point Energy (Montreal) has developed a line of solid fuel biomass gasifiers that can be upscaled and adapted for use with turbine engines. Auger mechanisms would remove ash produced by the gasifier during engine operation to reduce carbon deposit formation on turbine blades.

Bioenergy Feedstock Information Network

Oak Ridge National Laboratory (ORNL) recently redesigned its Bioenergy Feedstock Information Network (BFIN). The U.S. DOE's Bioenergy Information Network (BIN), housed at ORNL, had become a central location for information related to biomass and in particular feedstocks.

Information available at the site includes:

Reports, Fact sheets, Databases, Presentations, Images, Links, News, Events, Contacts.

The site has been updated now with a variety of new information. Biomass feedstock types with information featured on the site includes:

Agricultural residue, Forestry residue, Herbaceous crops, Municipal/Urban residues, Oil crops, Short-rotation woody crops.

The industry segments help to partially structure the site's content into five distinct supply system:

Processes, Harvesting, Storage, Pre-processing, Transportation and System integration.

The BFIN home page features the new Interactive BFIN supply system search tool. This tool allows users to search quickly to gain access to a multitude of information. Users select a desired biomass feedstock type and a specific process stage and what is returned is information including fact sheets, reports, links, and presentations.

The site's menu structure categorises every file into either a top-menu technical category or left-menu file-type category. Most files appear in both menus and are intuitively organised for quick access. Drop-down/sub menus allow users to further refine their search as seen in the screen shot below. Most of the top menu-items are completely new. The Biomass Basic, Environment and Economic menus are geared to the layperson and first time visitors to the site. The Biomass Resources and Supply System menus appeal to researchers and scientists looking for the latest R&D on biomass Feedstocks. Using these menus users can create refined search results for R&D information, links and images based on specific feedstock types or stages in the supply chain. The R&D Portfolio menu communicates work being conducting by ORNL pertaining specifically to biomass feedstocks.

The new website is now available publicly at http://bioenergy.ornl.gov

BioOil in Production

DynaMotive Corporation has started commercial production of BioOil at its new production facility

in West Lorne, Ontario, near Lake Erie. The company sent out its first shipment of the biomass-derived fuel on 22 November under a contract with a U.S. company. The contract will last for 5 years and calls for monthly deliveries of BioOil starting at 22 tons per month and increasing to 275 tons per month at its peak (3,300 tons per year). At its peak, the shipments will represent 15 percent of the plant's annual production of BioOil.

DynaMotive converts biomass into BioOil using a patented fast pyrolysis process, which involves heating the biomass to high temperatures in the absence of oxygen. The facility is designed to convert 100 tons per day of wood residue into 70 tons of BioOil, 20 tons of char, and 10 tons of gases. Erie Flooring and Wood Products supplies the wood residue, and DynaMotive plans to burn about 50 tons of BioOil each day in a gas turbine to produce 2.5 MW of electricity, which powers the Erie Flooring plant. The gas turbine will also generate steam for the plant. The company began producing power at the facility in late June. DynaMotive is currently scaling up its process for a plant that would produce 220 tons of BioOil per day.

EECA

nature's flame
Renewable fuel from Solid Energy

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EVENTS CALENDAR:

Biofuels Conference, Brussels, 15-17 February

Website:
www.greenpowerconferences.com/events/biofuelsmarkets.htm

European Pellets Forum, Wels, Austria, 1-3 March

Forum is part of the World Sustainable Energy Days 2006 conference. This is the largest annual conference in the field of sustainable energy use in Europe and will also include:

- European Energy Efficiency Conference
- Conference "Renewable Heating and Cooling"
- Conference "Green electricity for Europe's regions"

NZ Forest Industries, Rotorua, 8-11 March

Website: www.forestevents.co.nz

National Bioenergy Conference II, Denver, 14-16 March

Agenda includes presentations by bioenergy experts from across the nation, and sessions exploring policy, technology and markets, innovations and successes. Opportunities are provided for regional breakout sessions. Three field review options are set for both prior to and after the conference.

Website: www.nationalbiomassconference.org/

Central Biofuels Conference & Expo, Panama City, 21-23 March

Website: www.centralbiofuels.com

World Bioenergy 2006, Jönköping, Sweden, 30 May-1 June

Website: www.worldbioenergy.se

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