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# High-performance polymers for flexible OPV raise cell efficiencies

## The pitch

Thin-film photovoltaics (PVs) offer an affordable alternative to silicon photovoltaics. However, thin-film technologies face many challenges including concerns about toxicity as is the case with cadmium telluride (CdTe)-based PV and difficulties in scale-up as evidenced by copper indium gallium diselinide based PV. Organic photovoltaic (OPV) cells printed on flexible substrates are free of toxic materials and cost competitive since they can be manufactured by roll-to-roll processes. In addition, OPVs have improved performance in low light, can be transparent and colorful, and are more flexible and lower in weight than current PV.

OPV technology has grown during the past decade with cell efficiencies quadrupling. To date, the highest NREL-certified number for OPV cells is 8.6% as reported by the University of California–Los Angeles. Solarmer Energy, a developer of OPV, has been at the forefront of this technology and has demonstrated four world record efficiencies in the last two years.

With the recent growth of mobile devices, tablets, and e-readers, the prospect of having conveniently accessible portable power has rapidly progressed into a much sought-after commodity. Because of its light weight and flexibility, OPV can be integrated into portable electronic devices with minimal increase in weight. OPV opens new markets for products that were not possible for traditional PV. For example, in the outdoor products market, gear for hiking and camping can be redesigned to incorporate electrical power generation.

## The technology

In an OPV cell, various functional layers are deposited in a stacked structure, which upon light absorption produces electrical power. The heart of this stack is the active layer comprised of donor and acceptor materials with energy levels that must be properly matched in order to maximize the power conversion efficiency (PCE). Low-bandgap polymers with absorption extending into the infrared region are optimal for increasing PCE. In addition, the energy levels are tuned to increase the open-circuit voltage ($V_{OC}$) without sacrificing the current density and fill factor (ratio of actual maximum obtainable power to theoretical power). Solarmer currently has a portfolio of more than 50 polymers with efficiencies ranging from 6% to more than 8.5% in a wide range of voltages, colors, and transparencies.

Many research groups are targeting the design and synthesis of ideal donors with optimal characteristics. This involves carefully positioning the highest occupied molecular orbital level to achieve high $V_{OC}$ while maintaining an ideal bandgap of 1.5 eV for efficient charge transfer. The polymer must also have an optimal molecular weight and adequate solubility in organic solvents. Slight modifications to the conjugated polymer backbone such as addition of alkyl chains (containing C and H atoms) have been shown to improve polymer solubility. In the last three years, Solarmer has consistently improved the OPV cell efficiency. The efficiency of laboratory-scale cells has increased from around 5% in 2008 to more than 8% currently, and is expected to break the 10% mark by 2012. This is expected to enable OPV to directly compete with other thin-film PV cells for affordable and portable energy generation.

In addition to materials development, Solarmer is focusing on production technology development to bridge the gap between laboratory-scale and production grade efficiency for OPV. A pilot line to develop roll-to-roll processes for producing OPV has been built (shown in the figure). The process shares many similarities with traditional printing and coating. However, low viscosity of inks, low film thicknesses, precise edge alignment of all the functional layers, and high film uniformity make the roll-to-roll process for OPV challenging. The company anticipates small-scale production of its OPV for initial applications in portable power to begin by the second half of 2012.

Solarmer's roll-to-roll pilot production line for the manufacture of organic photovoltaic modules.

## Opportunities

Solarmer understands the importance of collaboration as a key strategy for accelerating the development of OPV and therefore welcomes co-development opportunities. The company's mission is to commercialize a low-cost and clean source of energy with OPV. It is evaluating opportunities for collaboration in module development as well as in manufacturing, and anticipates manufacturing OPV modules jointly with a partner. The company anticipates OPV module production to begin in 2012.

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