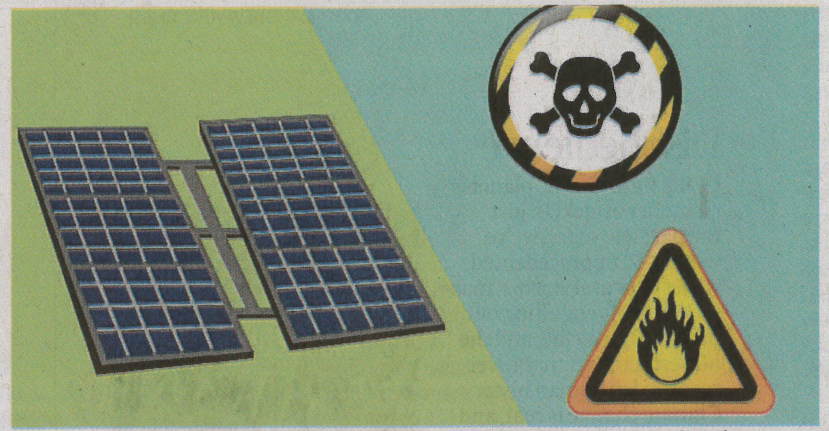
‘Organic’ material set to make solar energy better

Scientists believe that inorganic semiconductors used in making solar cells may have hit the efficiency ceiling besides being an environment hazard. “In my opinion, silicon technology has reached a sort of limit regarding efficiency. It is around 20% efficient right now, but it hasn’t seen a huge leap in efficiency in a long time. Production of electronic grade silicon pollutes the environment significantly and manufacturing silicon wafers indigenously on a large scale is still a challenge,” says Professor Sandeep Kumar, Raman Research Institute, Bengaluru, who specialises in soft condensed matter.



IMPROVED CHARGE MOBILITY **Researchers used discotic liquid crystals to increase the efficiency of solar cells.** ILLUSTRATION BY PURABI DESHPANDE/ GUBBI LABS

Increasing solar efficiency

Going ‘organic’ is the alternative, says Sandeep, who along with his team of researchers, is studying the use of organic materials like polymers or carbon fullerenes in solar cells. “Organic photovoltaic (OPV) research has received a good momentum in the past decade as OPVs have emerged as promising sources of alternative energy due to their low cost, ease of fabrication, roll-to-roll processing and flexibility,” he says. Traditionally, inorganic semiconductors like silicon have been used in making solar cells due to their appropriate electrical properties and wide availability. In addition to being an environmental hazard, some scientists believe that silicon-based solar cells may have also hit the efficiency ceiling. “The power conversion efficiency of OPVs has crossed the 10% mark and is increasing by the day,” explains Sandeep. In a recent study, in collaboration with researchers at the Centre of Material Sciences, University of Allahabad, and National Physical Laboratory, New Delhi, Sandeep has used indigenously developed discotic liquid crystals (DLC) to build effective organic solar cells. This could become an eco-friendly alternative to conventional solar cells.

This study was funded by the Department of Electronics and Information Technology and published in the journal, *Liquid Crystals*. “DLCs are of fundamental importance not only as models for the study of energy and charge migration in self-organised systems but also as functional materials for device applications such as one-dimensional conductors, photoconductors, light emitting diodes, photovoltaic solar cells, field-effect transistors and gas sensors,” remarks Sandeep.

DLCs are made of stacks of disc-like molecules in a state of matter that lies between those of a liquid and a solid crystal, like powdered sugar, which is made of solid crystals, but collectively behaves like a liquid taking the shape of the vessel in which it is stored. Earlier studies have shown that DLCs efficiently conduct electricity along their length with very little loss. In this study, the researchers have used DLCs in solar cells to increase their efficiency.

The world is witnessing a shift in its primary energy sources, with fossil fuels giving way to renewable sources like solar and wind. India is well along this line of transformation with 10 GW of electricity currently produced from solar energy, compared to just 2.6 GW in 2014. This shift to solar energy across the world has revived the solar cell (also known as photovoltaic cells) industry. As a result, there is an increase in the number of investments in the sector.

A solar cell, in principle, converts the energy of light falling on it into electricity. The light conversion in OPV cells is based on charge generation at the interface between two different organic semiconductors, followed by their separation and migration towards opposite electrodes.

The researchers of the study sandwiched a layer of DLC between an active layer (PCDTBT and PCBM) and a molybdenum trioxide buffer layer. “We have explored the use of DLC as an additive in classical organic photovoltaic cells and observed significant improvement in conversion efficiency from 1.24% to 5.14%. The enhancement is attributed to the better charge mobility in the ordered system due to the presence of columnar phase of the DLC,” explains Sandeep.

Although solar is hailed as a green energy source, the mining and manufacturing process associated with silicon-based solar cells releases large amounts of pollutants, overshadowing the eco-friendly status of solar power. Organic solar cells, on the other hand, overcome these shortcomings and with studies like this, they may soon surpass the efficiency of silicon-based cells, finally providing us a true green source of power.

Dennis C Joy

(The author is with Gubbi Labs, a Bengaluru-based research collective)