Scientists unravel the mechanism of the functioning of a new type of solar cell

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Swiss scientists have uncovered the mechanism by which novel, revolutionary solar cells based on lead iodide perovskite light-absorbing semiconductor transfer electrons along their surface. The finding shows these devices constitute a new type of solar cells and open the way to the design of photovoltaic converters with improved efficiency.

Photovoltaic energy conversion offers one of the best means for the future of renewable energy in the world. The efficiency of solar cells depends heavily upon the light-absorbing materials they use. Photovoltaic systems based on lead halide perovskite are a new, revolutionary type of device with efficiencies currently exceeding 16%. However, a detailed description of how these solar cells turn light into electrical current is still lacking. Publishing in *Nature Photonics*, scientists from EPFL have investigated how the generated electrical charge travels across the perovskite surface of solar cells built with different architectures.

Lead halide perovskites are materials that have recently attracted an immense interest, as solar cells based on these semiconductors demonstrate very high conversion efficiencies and an unsurpassed cell voltage of more than 1 V. However, it is not entirely clear how they work. A better understanding of their functioning mechanisms would help improve them in the future or even open up novel technologies with increased efficiency.

The groups of Michael Grätzel and Jaques E. Moser at EPFL, working with the Institute for Solar Fuels in Berlin, have used time-resolved spectroscopy techniques to determine how charges move across perovskite surfaces. The researchers worked on various cell architectures, using either semiconducting titanium dioxide or insulating aluminum trioxide films. Both porous films were impregnated with lead iodide perovskite ($CH_3NH_3PbI_3$) and an organic "hole-transporting material", which helps extracting positive charges following light absorption. The time-resolved techniques included ultrafast laser spectroscopy and microwave photoconductivity.

The results showed two main dynamics. First, that charge separation, the flow of electrical charges after sunlight reaches the perovskite light-absorber, takes place through electron transfer at both junctions with titanium dioxide and the hole-transporting material on a sub-picosecond timescale. Secondly, the researchers found that charge recombination was significantly slower for titanium oxide films rather than aluminum ones. Charge recombination is a detrimental process wasting the converted energy into heat and thus reducing the overall efficiency of the solar cell.

The authors state that lead halide perovskites constitute unique semiconductor materials in solar cells, allowing ultrafast transfer of electrons and positive charges at two junctions simultaneously and transporting both types of charge carriers quite efficiently. In addition, their findings show a clear advantage of the architecture based on titanium dioxide films and hole-transporting materials.

More information: Arianna Marchioro, Joël Teuscher, Dennis Friedrich, Marinus Kunst, Roel van de Krol, Thomas Moehl, Michael Grätzel and Jacques-E. Moser. 2014 Unraveling the mechanism of photoinduced charge transfer processes in lead iodide perovskite solar cells. *Nature Photonics* DOI: 10.1038/nphoton.2013.374

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