Researchers discover "zombie solar cells" that generate power even after electrolyte evaporation

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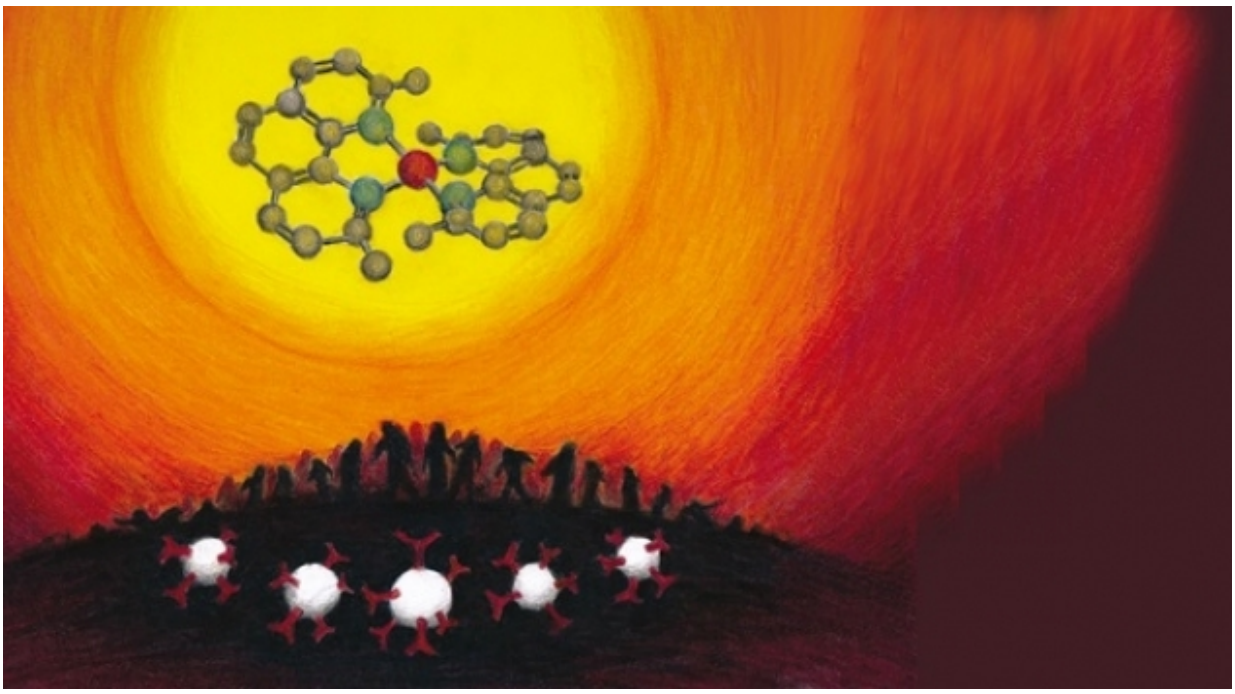

Credit: Gerrit Boschloo and The Royal Society of Chemistry

A group of researchers at Uppsala University has discovered a "zombie solar cell" that continues to generate electricity with unexpected effectiveness although the liquid transferring charges between the electrodes has dried out. The results were recently published in the

journal *Energy and Environmental Science*.

The discovery was made by Gerrit Boschloo's group at the Department of Chemistry-Ångström Laboratory, Division of Physical Chemistry. When the researchers tested old dye-sensitized solar cells, also known as Grätzel cells, these were still active, despite the fact that the electrolyte conducting electricity between the minus and plus poles had evaporated.

"The dried-out solar cells worked in some cases even better than when they were liquid-filled and alive. The power conversion efficiency of specific cells had increased to 8 percent, which is a record for dye-sensitized solar cells with a solid hole conductor. Our post-doc Marina Freitag who produced and studied the solar cells named them 'zombie solar cells' since they were alive although they should be dead," laughs Gerrit Boschloo.

In a Grätzel cell, an electrically conductive liquid facilitates a flow of electrons with the use of substances that can give away or take up electrons, a so called redox couple. But when this liquid dried out in "zombie solar cell", a solid hole conducting structure was created, continuing to transport positive charge.

However, this only occurs with certain copper based redox couples. Gerrit Boschloo also points out that dye-sensitized solar cells with solid hole conductors have been developed before, but that the high efficiency of this "zombie cell" had taken the researchers by surprise. To ensure the result, the project was repeated under controlled conditions.

"But it turned out to be quite difficult to produce the cell in the way we usually produce solid state solar cells. The best option was to instead make a liquid-based cell and letting it dry out slowly in order to achieve the right structure."

The advantage of a solar cell without liquid is that it hopefully becomes more stable. When the solar cell is in a solid state, it is much easier and cheaper to seal. This reduces the risk for the cell to leak and corrode the surrounding material.

"Several companies have said that if it would only seal properly, they'd invest in liquid-based solar cells. If we would be able to seal these "zombie cells" so that they would last for years, it would be very interesting," says Gerrit Boschloo and adds:

"Right now we have 'zombies' that've been left for several months and have dried out, and they work. But there's one thing to keep them in the lab in the dark and test them. We also need to test the cells in the sunlight for a long period of time to see if they work in the long run."

Gerrit Boschloo's research group is collaborating with two chemistry groups at KTH since 2005. They are responsible for the custom-made dye which is part of the Grätzel solar cell. The collaboration also involves physicists from Uppsala University and experts in the field of industrial manufacturing from Swerea IVF. After the discovery just over a year ago, the researchers filed a patent application for the "zombie solar cell" through their own company Dyenamo.

What areas of application do you envisage for the "zombie solar cell"?

"The final purpose is of course energy production in the form of solar cells on the roof. We know this works for solid state photovoltaics. Grätzel solar cells work very well even if the light source is not optimal - you can acquire kilowatt hours even if it's cloudy."

"To get there is however a long road, it takes a lot more research. But if we can make these 'zombie solar cells' very affordable, you can imagine them almost anywhere, for example charging mobiles or running

computers."

More information: Marina Freitag et al. "High-efficiency dye-sensitized solar cells with molecular copper phenanthroline as solid hole conductor," *Energy Environ. Sci.* (2015). DOI: 10.1039/C5EE01204J

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