UT biosolar breakthrough promises cheap, easy green electricity

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Barry D. Bruce, professor of biochemistry, cellular and molecular biology, at the University of Tennessee, Knoxville, is turning the term "power plant" on its head. The biochemist and a team of researchers have developed a system that taps into photosynthetic processes to produce efficient and inexpensive energy.

Bruce collaborated with researchers from the Massachusetts Institute of Technology and Ecole Polytechnique Federale in Switzerland to develop a process that improves the efficiency of generating electric power using molecular structures extracted from plants. The biosolar breakthrough has the potential to make "green" electricity dramatically cheaper and easier.

"This system is a preferred method of sustainable energy because it is clean and it is potentially very efficient," said Bruce, who was named one of "Ten Revolutionaries that May Change the World" by Forbes magazine in 2007 for his early work, which first demonstated biosolar electricity generation. "As opposed to conventional photovoltaic solar power systems, we are using renewable biological materials rather than toxic chemicals to generate energy. Likewise, our system will require less time, land, water and input of fossil fuels to produce energy than most biofuels."

Their findings are in the current issue of *Nature: Scientific Reports.*

To produce the energy, the scientists harnessed the power of a key component of photosynthesis known as photosystem-I (PSI) from blue-green algae. This complex was then bioengineered to specifically interact with a semi-conductor so that, when illuminated, the process of photosynthesis produced electricity. Because of the engineered properties, the system self-assembles and is much easier to re-create than his earlier work. In fact, the approach is simple enough that it can be replicated in most labs—allowing others around the world to work toward further optimization.

"Because the system is so cheap and simple, my hope is that this system will develop with additional improvements to lead to a green, sustainable energy source," said Bruce, noting that today's fossil fuels were once, millions of years ago, energy-rich plant matter whose growth also was supported by the sun via the process of photosynthesis.

This green solar cell is a marriage of non-biological and biological materials. It consists of small tubes made of zinc oxide—this is the non-biological material. These tiny tubes are bioengineered to attract PSI particles and quickly become coated with them—that's the biological part. Done correctly, the two materials intimately intermingle on the metal oxide interface, which when illuminated by sunlight, excites PSI to produce an electron which "jumps" into the zinc oxide semiconductor, producing an electric current.

The mechanism is orders of magnitude more efficient than Bruce's earlier work for producing bio-electricity thanks to the interfacing of PS-I with the large surface provided by the nanostructured conductive zinc oxide; however it still needs to improve manifold to become useful. Still, the researchers are optimistic and expect rapid progress.

Bruce's ability to extract the photosynthetic complexes from algae was key to the new biosolar process. His lab at UT isolated and bioengineered usable quantities of the PSI for the research.

Andreas Mershin, the lead author of the paper and a research scientist at MIT, conceptualized and created the nanoscale wires and platform. He credits his design to observing the way needles on pine trees are placed to maximize exposure to sunlight.

Mohammad Khaja Nazeeruddin in the lab of Michael Graetzel, a professor at the Ecole Polytechnique Federale in Lausanne, Switzerland, did the complex testing needed to determine that the new mechanism actually performed as expected. Graetzel is a pioneer in energy and electron transfer reactions and their application in solar energy conversion.

Michael Vaughn, once an undergraduate in Bruce's lab and now a National Science Foundation (NSF) predoctoral fellow at Arizona State University, also collaborated on the paper.

"This is a real scientific breakthrough that could become a significant part of our renewable energy strategy in the future," said Lee Riedinger, interim vice chancellor for research. "This success shows that the major energy challenges facing us require clever interdisciplinary solutions, which is what we are trying to achieve in our energy science and engineering PhD program at the Bredesen Center for Interdisciplinary Research and Graduate Education of which Dr. Bruce is one of the leading faculty."

Provided by University of Tennessee at Knoxville