Photosynthesis re-wired: Chemists use nanowires to power photosynthesis

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Harnessing the power of the sun has inspired scientists and engineers to look for ways to turn sunlight into clean energy to heat houses, fuel factories and power devices. While a majority of this research focuses on energy production, some researchers are looking at the potential uses of these novel solar technologies in other areas.

Boston College Assistant Professor of Chemistry Dunwei Wang's work with silicon nanowires and his related construct, Nanonets, has shown these stable, tiny wire-like structures can be used in processes ranging from energy collection to hydrogen-generating water-splitting.

Teaming up with fellow Boston College Assistant Professor of Chemistry Kian L. Tan, the researchers have taken aim at a role for nanowires in photosynthesis.

Their work has produced a process that closely resembles photosynthesis, employing silicon nanowires to collect light energy to power reactions capable of synthesizing the basic compounds of two popular pain-killing, anti-inflammatory drugs, they report in the current edition of Angewandte Chemie, the journal of the German Chemical Society.

The reaction sequence offers an approach that differs from earlier attempts to sequester carbon dioxide with sunlight and solves the vexing problem of carbon's low selectivity, which so far has limited earlier methods to the production of fuels. Tan and Wang report their process offers the selectivity required to produce complex organic intermediaries capable of developing pharmaceuticals and high-value chemicals.

The process succeeds in taming stubborn carbon, which structurally resists most efforts to harness it for a single chemical product. Typically, refined forms of carbon molecules must first be produced to produce the necessary results.

"If we can start to use carbon dioxide and light to power reactions in organic chemistry, there's a huge benefit to that. It allows you to bypass the middle man of fossil fuels by using light to drive the chemical reaction," said Tan. "The key is the interaction of two fields – materials and synthetic chemistry. Separately, these fields may not have accomplished this on their own. But together, we combined our knowledge to make it work."

During photosynthesis, plants capture sunlight and use this solar energy and carbon dioxide to fuel chemical reactions.

Tan and Wang used silicon nanowires as a photocathode, exploiting the wire's efficient means of converting solar energy to electrical energy. Electrons released from the atoms in the nanowires are then transferred to organic molecules to trigger chemical reactions.

In this case, the researchers used aromatic ketones, which when struck by electrons become active and attack and bind carbon dioxide. Further steps produced an acid that allowed the team to create the precursors to ibuprofen and naproxen with high selectivity and high yield, the team reports.

Tan and Wang were joined in the research by Research Assistant Guangbi Yuan, PhD '12, graduate student Rui Liu, doctoral student Candice L. Joe, and former doctoral student Thomas E. Lightburn, PhD

'11.

Tan said it is no accident that the process so closely resembles natural photosynthesis, as chemists are constantly drawing inspiration from nature in their work.

"Researchers in my field are always drawing inspiration from nature," said Tan. "You take the basic lessons and you try to do it in an artificial way. In this work, we're trying to learn lessons from nature, although we can't copy nature directly."

Provided by Boston College

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