Molecular Devices for Solar-Powered Carbon Capture

CHAPEL HILL, NORTH CAROLINA, UNITED STATES, March 20, 2019 /EINPresswire.com/ -- In one approach to solar energy conversion, light-harvesting sensitizers absorb and convert photons into electron-hole pairs to drive water splitting or carbon dioxide reduction to produce fuels. Despite recent progress in photoelectrocatalytic cells, experimental realization of a high-performance photocathode for solar-driven carbon dioxide reduction has proven to be difficult.

Published at [Nature Energy on March 11](https://www.nature.com/articles/s41560-019-0345-y), new research from University of North Carolina at Chapel Hill develops a solar-cell strategy by using combined molecular and semiconductor p-n junction photocathodes for efficient and robust photo-driven carbon dioxide reduction to formate. The semiconductor p-n junction consists of highly-doped, n-type gallium nitride nanowire arrays on p-n junction silicon substrate, which was further modified with a sub-nano-thick nickel oxide for anchoring the molecular assemblies. The researchers directly synthesized a series of molecular p/n junctions on metal-oxide modified GaN nanowires by sequentially assembling an electron donating relay (phenylene diamine), a chromophore (ruthenium polypyridyl) and a molecular carbon-dioxide reduction catalyst. The resulting photoelectrodes are efficient and robust in photo-reduction of carbon dioxide to formate with stable photocurrent densities reaching -1.1 mA cm-2 during 20 hours of irradiation and a faradaic efficiency up to 64%. By varying the structures of the phenylene diamine derivatives, the researchers observed tunable photoelectrocatalytic performances and interfacial charge transfer dynamics in the integrated photocathodes.

The key insight is the electronic interplay between the molecular and the semiconductor p/n junctions where the two photosensitizing units absorb complementary light in the visible, and generate high-energy electrons for catalyst activation.

The new findings in this research provide proof-of-concept that molecular and semiconductor p/n junctions can be integrated for efficient, long-term photoelectrocatalytic CO_2 reduction, which could open the door to a new generation of chemically modified, high-performance photoelectrocatalytic cells that combine a wide range of semiconducting electrodes, chromophores and catalysts for solar fuel production.

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