TOYOTA CRDL, INC. NEWS

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Toyota Central R&D Labs., Inc.

# A big leap for artificial photosynthesis

## ---Direct synthesis of organic compounds from water, carbon dioxide and solar light---

Toyota Central Research and Development Laboratories, Inc., President, Dr. Takashi Saito, which belongs to the TOYOTA group, succeeded in the artificial photosynthesis that generates organic compounds from water and carbon dioxide using solar light without external energy and/or material sources, for the first time.

Artificial photosynthesis has been one of the key issues to solve energy problems, including global warming and the shortage of fossil fuel. However, the existing technologies of "artificial photosynthesis" do work only with external energy/material sources such as:

- Organic chemicals called "sacrificial reagent"
- UV light illumination that is not available from the solar light
- Electrochemically applied voltage

Our demonstration is the breakthrough that makes the artificial photosynthesis much closer to the natural photosynthesis. This new technology generates organic compounds from $H_2O$, $CO_2$ and solar light without external help.

Our artificial photosynthesis is a combination of two chemical reactions driven by solar energy, which are (1) extraction of electrons by $H_2O$ oxidation and (2) reduction of $CO_2$ to convert it into organic compounds. The reaction (1) donates electrons to the reaction (2) as shown in Figure 1. In the reaction (2), we have developed a new concept for the photocatalyst of $CO_2$ reduction, which was composed of a semiconductor and metal complexes (Figure 2). The photocatalyst was connected with another semiconductor, which is capable of $H_2O$ oxidation. The two systems were immersed in a $CO_2$-bubbled aqueous solution in a photoreactor, but were separated by a proton-exchange membrane. Under simulated solar irradiation, the whole system could generate formic acid, which is an organic compound that is useful as industrial raw material. Our technology made a big leap for artificial photosynthesis, and it would be one of the key technologies for future carbon-neutral society.

There still remain challenges and problems for putting forward the current basic technology to a practical use. We are making efforts to increase the conversion efficiency of solar energy to chemical energy, which is currently 0.04%, equivalent to only one-fifth of that of plant photosynthesis. We are also searching and examining new chemical reactions to generate more valuable organic compounds as a final product such as methanol.

The present research was published in an electronic version of Journal of the American Chemical Society on 7th September 2011.

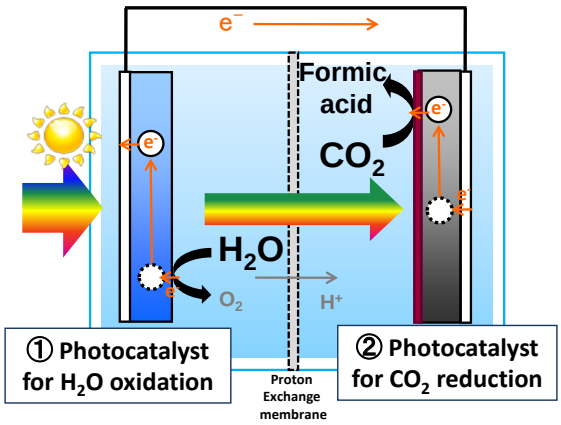


Figure 1. Schematic illustration of the artificial photosynthesis.

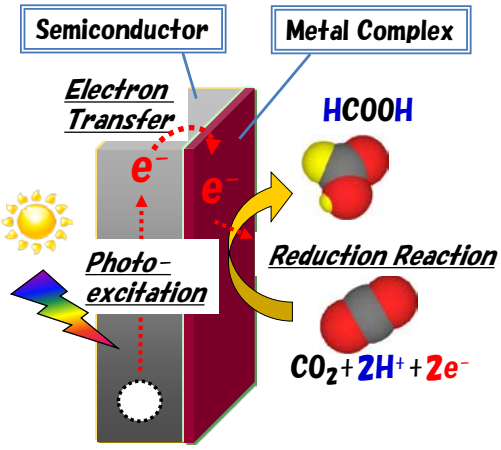


Figure 2. Reaction mechanism over $CO_2$ reduction photocatalyst.

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