【Grant-in-Aid for Transformative Research Areas（B）】

Concerto Photocatalysis: Innovation and Concert of Molecular Catalyst, Reaction Field, and Mechanistic Analysis for Light-Driven Multiple-Electron Reduction of CO_2

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Research Area Information	Number of Research Area : 23B208　Project Period (FY) : 2023-2025 Keywords : Photocatalytic CO_2 reduction, Molecular catalyst, Reaction field, Reaction analysis

Purpose and Background of the Research

●Outline of the Research

Carbon dioxide (CO_2) conversion by using solar energy is a great challenge toward carbon neutral. In most conventional photocatalytic CO_2 reduction systems, only two-electron reduction of CO_2 proceeds, producing carbon monoxide (CO) and formic acid. On the other hand, it is necessary to constantly acquire not only CO but also various carbon compounds to sustainably support various industries. Formation of these compounds requires multi-electron reduction of 6 or more electrons (methanol: 6 electrons, methane: 8 electrons) or C-C bond formation of CO_2. Therefore, innovative breakthroughs to obtain such diverse CO_2 reduction products are the most important challenges in the research field of artificial photosynthesis.

To achieve the highly difficult CO_2 photoconversion, it is necessary to (1) accurately understand the properties and reactivity of the numerous intermediates, (2) modulate the structure at the molecular orbital level, and (3) control the electron/proton supplying rates and the distance between the intermediates. This is an extremely complex and interconnected issue that cannot be achieved unless catalyst creation, reaction field design, and reaction analysis are all carried out simultaneously at a high level, and is the main reason why this goal has not been achieved for a long time. In this research area, we will carry out "technological innovation" in three directions: catalyst creation, reaction field design, and innovative reaction analysis, and link them in a cooperative manner. The aim is to establish the principles of artificial photosynthesis that will lead to the realization of highly difficult CO_2 photoconversion.

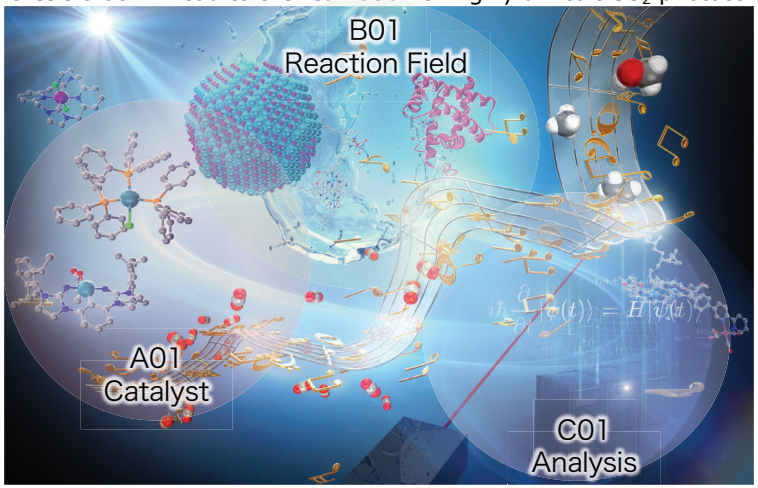

Figure 1. An image of this research area “Concerto Photocatalysis”

Expected Research Achievements

We aim to create and concert three innovative technologies: (1) development of catalyst that can convert CO_2 into hydrocarbons (A01), (2) reaction field design that dramatically increases catalyst performance (B01), and (3) novel reaction analysis technology that enables tracking of multi-photon/multi-electron reactions. (C01).

●A01 Molecular photocatalyst for CO_2 conversion into hydrocarbons

Leader :	**Kei Murata**	**The University of Tokyo**
Co-investigator :	**Kosei Yamauchi**	**Kyushu University**
Co-investigator :	**Ryo Nakano**	**Nagoya University**

We aim to create a catalyst that captures and activates "CO_2 reduction intermediates" to selectively provide hydrocarbons.

●B01 Hybrid photoreaction field for multielectron CO_2 conversion

Leader :	**Akinobu Nakada**	**Kyoto University**
Co-investigator :	**Yasuomi Yamazaki**	**The University of Tokyo**
Co-investigator :	**Koji Oohora**	**Osaka University**

We aim to create a new concept “designing a photoreaction field'' that brings out the abilities of catalysts.

●C01 Multi-excitation transient spectroscopy for multielectron CO_2 conversion

Leader :	**Kiyoshi Miyata**	**Kyushu University**
Co-investigator :	**Yusuke Kuramochi**	**Tokyo University of Science**
Co-investigator :	**Takeshi Iwasa**	**Hokkaido University**

We aim to create “innovative analytical methods” to elucidate multiphoton/ multielectron reactions which are essentially impossible by the conventional method.

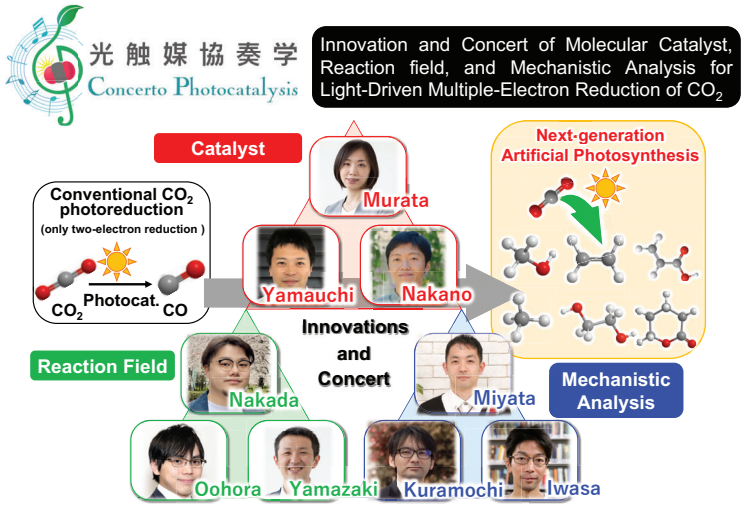

Figure 2. Organization of this research area “Concerto Photocatalysis”

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