【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Chemistry)

Title of Project : New Energy Sources from Hydrogenase-Photosysnthesis Models

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Research Project Number : 26000008　Researcher Number : 60290904
Research Area : Chemistry
Keyword : Hydrogenase, Photosystems, Energy

【Purpose and Background of the Research】

A new energy system independent of fossil fuels is required in order to realize a sustainable environmentally friendly society. The extraction of electrons from H_2 and H_2O and their use in energy applications are a necessary part of this goal. H_2 and H_2O are expected to become new energy sources or energy carriers to replace fossil fuels. In natural systems, hydrogenase, an H_2-activating enzyme, catalyzes extraction of electrons from H_2, and photosystem II, an H_2O-activating enzyme, catalyzes extraction of electrons from H_2O. Such enzymes function under mild conditions but are inactivated under extreme conditions. However, enzymes contained in extremophile bacteria are robust because they have self-repairing systems to protect the active centers.

In this study, we create an innovative energy conversion technology for practical use on the basis of chemistry (coordination chemistry, biochemistry, and electrochemistry) and agriculture (applied microbiology) by elucidating the catalytic reaction mechanism using the robust enzymes.

【Research Methods】

We develop novel model catalysts for hydrogenase and photosystem II in order to extract electrons from H_2 and H_2O. Based on a biomimetic approach from nature to technology, we conduct research with the following themes to achieve a practical application of the catalysts.

Theme 1: Search for new hydrogenases. We look for unknown robust hydrogenases under extreme conditions, investigate the catalytic mechanism for H_2-activation, and analyze the genome.

Theme 2: Synthesis of hydrogenase models. By mimicking the structure and function of the active center of hydrogenase, we develop novel model catalysts to activate H_2.

Theme 3: Development of electrode catalysts for a fuel cell. We apply the hydrogenase model catalysts to the electrodes of fuel cells and investigate the performance of the catalysts.

Theme 4: Search for new photosystem II enzymes. We look for unknown robust photosystem II enzymes under extreme conditions to investigate the catalytic mechanism for H_2O-activation.

Theme 5: Synthesis of a photosystem II model. We produce novel biomimetic catalysts to activate H_2O based on photosystem II.

Theme6: Development of an artificial photosynthesis catalyst. We apply the photosystem II model catalysts to an artificial photosynthesis system and investigate the performance.

【Expected Research Achievements and Scientific Significance】

The achievements of this project will have a great impact on human society with regard to energy, resources, and environmental problems. In this project, we focus on activation of H_2 and H_2O by hydrogenase and photosystem II, respectively, to develop artificial catalysts for practical use on the basis of agriculture (applied microbiology), chemistry (coordination chemistry, biochemistry, and electrochemistry), and practical engineering. The results to be obtained from this project are significant in the field of basic science, and will also a have high impact in the chemical industry. The achievements will be transferable to industrial technologies.

【Publications Relevant to the Project】

・S. Ogo, K. Ichikawa, T. Kishima, T. Matsumoto, H. Nakai, K. Kusaka, T. Ohhara, *Science* **2013**, *339*, 682–684.
・S. Ogo, R. Kabe, K. Uehara, B. Kure, T. Nishimura, S. C. Menon, R. Harada, S. Fukuzumi, Y. Higuchi, T. Ohhara, T. Tamada, R. Kuroki, *Science* **2007**, *316*, 585–587.

【Term of Project】

FY2014–2018

【Budget Allocation】

437,900 Thousand Yen

【Homepage Address and Other Contact Information】

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