Research area in Strategic Objective *“Recycling technology using a material conversion system pioneered through “Convergence of Knowledge””*

Development of Basic Material Conversion Science for global environment

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Overview

In this research area, we aim at the research and development of material conversion and the creation of basic science related to this material conversion, where objective high-value materials can be obtained with high selectivity from stable molecules consisting of elements involved in material circulation. These materials are indispensable for harmonization of the human society with the global environment, reducing energy consumption and waste emission as much as possible.

Specifically, we conduct the basic research and development related to material conversion targeting elements and compounds (mainly carbon, nitrogen, oxygen, hydrogen, phosphorus, sulfur, silicon, etc. and their compounds) whose material circulation is important among those that are abundant on the surface of the earth and make up living organisms such as humans and food, or those that are utilized in human society. This means the creation of basic technology that is expected to significantly improve the energy utilization efficiency and selectivity for target products compared with current elemental material conversion technologies related to resource recycling. We aim to promote the following examples and create basic material conversion science that can be developed for social implementation through (1) research/development of catalyst materials with innovative catalytic action enabling reactions previously thought to be impossible, and electrode materials; (2) research/development of solid electrolyte materials with high-speed, selective ionic conductivity; (3) research/development of reaction processes using advanced energy control or electron transfer control with electricity or light; (4) research/development of cutting-edge analysis methods such as operando measurement and on-demand measurement for an analytical and theoretical understanding of reaction mechanisms; (5) research/development of theoretical calculations such as first-principles calculations, thermo-fluid engineering simulations, and machine learning.

Furthermore, with targeting at the ideas, themes, and results of these studies, we demonstrate the material conversion indicators that contribute to the realization of a sustainable society from the perspectives of green chemistry, economics, social sciences.

<u>Research Supervisor's Policy on Call for Application, Selection, and Management of the Research Area</u>

1. Background and Basic Policy

With the goals of a carbon-neutral environment, global conservation, and a sustainable society, the chemical industry aims to research, develop, and implement environmentally friendly synthesis processes that release almost no carbon dioxide or pollutants. Production of valuable substances necessary for our lives with minimum carbon dioxide emission requires synthesis processes that reduce the energy required, reduce the use of fossil fuels as much as possible, and use renewable energy more efficiently. To synthesize with minimal waste, it is important to develop highly selective reactions and improve the overall efficiency of the synthesis process.

For human survival, the circulation of materials related to human activity as well as other living organisms and food must be considered. In addition to carbon dioxide, we must consider the circulation of nitrogen compounds and sulfur oxides of human origin, and the circulation of silicon compounds and phosphorus compounds that are abundant on the earth's surface. If the balance of the existence, concentration, or distribution of these elements is lost, the global impact on the environment will be devastating.

In recent years, the utilization efficiency and selectivity of material synthesis have improved significantly, enabling reactions previously thought to be impossible through the use of electricity, light, plasma, and microwaves to control the movement of electrons, ions, or energy in chemical reactions. To further this research and apply it to material circulation in the real world, research and development of catalysts, electrodes, and solid electrolytes, synthetic reactions, and the control of reaction fields are important. Such efforts must be integrated with reaction engineering. In addition, in order to promote research, the study of analytical techniques such as operand measurement, understanding mechanisms through theoretical calculation, and understanding the active site structure are indispensable. Furthermore, with an eye on the future material cycle based on research proposals, evaluations, recommendations, and indicators of environmental load and economic efficiency must be presented from the perspectives of green chemistry, economics, and social science.

2. Assumed Research Fields and Policy for Call/Screening of Proposals

In this research area, we envision studies in various fields including material science, catalyst chemistry, electrochemistry, photochemistry, plasma engineering, electromagnetic wave engineering, operand measurement, theoretical calculation, and material circulation evaluation methods. In the research proposal, example study areas include (1) new catalyst/electrode materials that significantly improve energy utilization efficiency and selectivity for high-value materials, enabling new reactions that have been thought impossible by controlling electrons, ions, and energy transfer; (2) research and development of new reaction methods that significantly improve energy efficiency and the selectivity for high-value materials; (3) research of unprecedented reaction processes; (4) research of innovative analytical methods and characteristic theoretical calculations to understand reaction mechanisms and active point structures. We value originality and innovativeness above all others.

In research management, we will consider the fusion of research areas and evaluation of environmental load. Precursory Research for Embryonic Science and Technology (PRESTO) is a type of research that does not require all research and evaluation to be conducted by one person. During the research period, active exchanges between research supervisors, research area advisors, and researchers will promote fusion of research areas and deepen insight into material conversion that contributes to the realization of a sustainable society. In the research proposal, applicants must present a logical path to reach the target, the goal, superiority and originality compared with current technologies, and the expected effects and scale of reduced environmental load after the target has been reached. We also welcome research proposals on methods for evaluating material cycles based on green chemistry, economics, and sociology.

3. Research periods and research funds

The upper limit of the initial research budget is a total of ¥40 million (direct expenses) for one project. The research period is within three and a half years from the fiscal year in which the project was selected.

4. Management Policy

In this research area, research supervisors and advisors will offer support in an environment where individual researchers can engage in original research for three and a half years without focusing on short-term results. In addition, we will promote exchanges with researchers in green chemistry, economics, social sciences, and other humanities fields both within and outside of our research field, and work as a creative group with high aspirations to realize a carbon-neutral and sustainable society.