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

Green Catalysis Science for Renovating Transformation of Carbon-Based Resources

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Research Area Information	Number of Research Area : 23A206　Project Period (FY) : 2023-2027 Keywords : Catalyst, Carbon Resource, Molecular Technology, Radical

Purpose and Background of the Research

●Outline of the Research

Considering the sustainable development of society, organic synthesis must evolve into an environmentally benign technology that can efficiently convert any molecules for providing value-added organic molecules. However, in synthetic organic chemistry, the limited carbon resources can be used as substrates and there is still a lack of diversity in the structure of accessible products. Based on the establishment of catalysis science for controlling the radical reactions with light and/or electric energy, this research area transform organic synthesis into a form suitable for a sustainable society, enabling the effective utilization of ubiquitous carbon resources, molecular transformations using renewable energy, and minimization of waste.

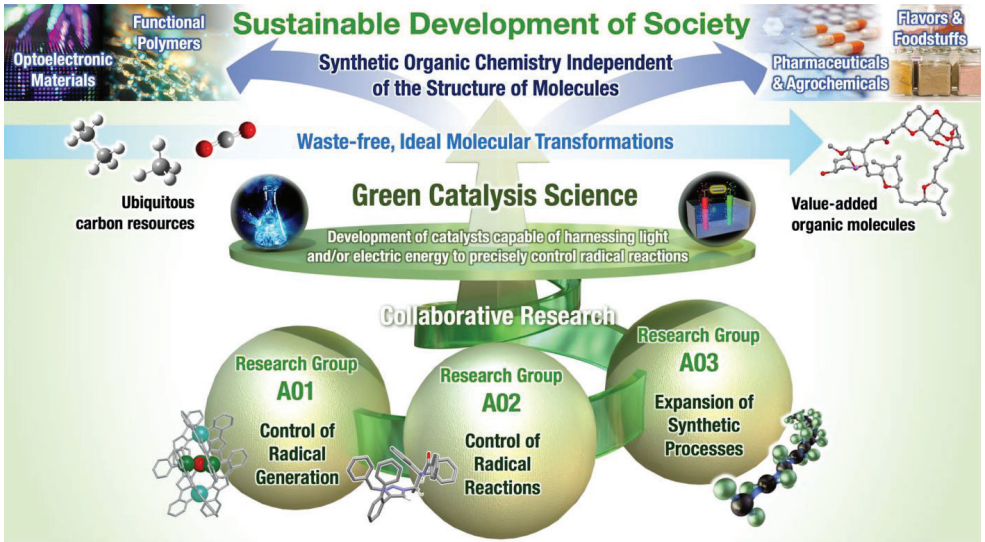

Figure 1. Overview of Research Area

●Outline of the Research

Most of the existing synthetic methods rely on ionic reactions using thermal energy, which require functional groups as a handle for executing precise transformations of starting materials. On the other hand, radical reactions are independent of functional groups and hold significant potential for realizing truly sustainable chemical synthesis with a wide range of carbon resources. However, it is very difficult to tame short-lived, highly reactive radicals, and no guiding principle has been established for the development of radical-mediated selective organic transformations.

Our challenge is to realize precise control of radical reactions by the development of catalysts capable of harnessing light and/or electric energy based on the integration of inorganic coordination chemistry, solid surface chemistry, and organic chemistry. Unlike thermal energy, light and electric energy can be used to selectively activate specific molecules depending on the physical properties of individual molecules. By exploiting newly developed catalysts, we will realize the photo- and/or electro-induced molecular transformations to assemble high value-added molecules from ubiquitous small molecules in the shortest possible steps.

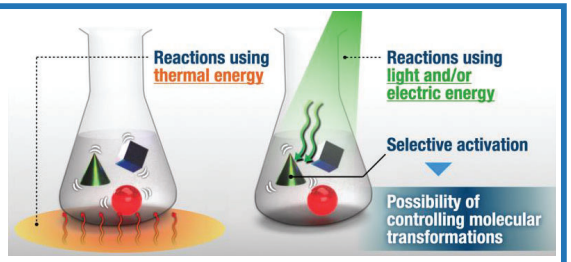

Figure 2. Reaction using light and electric energy

Expected Research Achievements

In this area, the research is conducted through the organization of three groups: Research Group A01 (Control of Radical Generation), Research Group A02 (Control of Radical Reactions), and Research Group A03 (Expansion of Synthetic Processes). To achieve the goal of the area, a fusion of a wide range of fields is essential. Particularly, collaborative research based on understanding and controlling radical species through photo- and electrochemical approaches, advanced measurement science, theoretical and computational science, and broad catalysis science creates a basis for exploring methodologies for the transformation of carbon resources.

Figure 3. Integration of a wide range of fields for "Green Catalysis Science"

Renovative organic synthesis will give the impact on a wide range of research fields and related industries that require organic molecules with well-defined structures, such as pharmaceuticals, agrochemicals, foodstuffs, and optoelectronic materials. In addition, the research achievements can contribute to SDGs, such as human health, the basis for new industry and technological infrastructure, and responsibility for consumption and production.

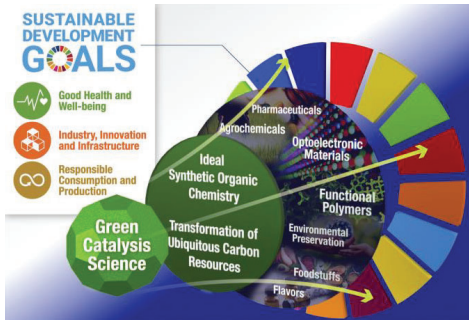

Figure 4. Goals of this research area

Homepage Address, etc.	https://greencatalysis.jp（Website） https://twitter.com/Green_Catalysis (X)