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

Chemistry of Material Reaction: Designing Chemical Reactions for Materials

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Project Information	Project Number : 26B205 Keywords : Polymers, Chemical Reaction, Material Degradation, Material Transformation, Recycling	Project Period (FY) : 2026-2028

Purpose and Background of the Research

● Outline of the Research

—Toward Comprehensive Principles of Chemical Reactions for Materials—

By harnessing various chemical reactions, such as organic, inorganic, catalytic, enzymatic, and electrochemical reactions, humanity has created diverse materials. The well-developed reactions enable sophisticated transformations of substrates via cleavage and formation of chemical bonds, which are indispensable to both academia and industry. In contrast, the resulting materials are highly stable, making their use as starting substrates for further chemical transformations inherently challenging. However, in response to growing demand for material degradation and the circular economy, materials are no longer regarded as end products but as valuable feedstocks. This shift calls for a new paradigm beyond conventional solution-phase chemical reactions, toward comprehensive principles of chemical reactions that proceed within materials—referred to as material reaction chemistry. In this transformative research area, we establish new paradigm of highly efficient chemical transformations for materials—“MATEReactions”. By exploiting the interplay across micro-, meso-, macro-, and interfacial scales in polymer materials, we will develop novel reactions for materials, through cooperative, accelerated, and chain reactions, thereby opening new frontiers in materials science.

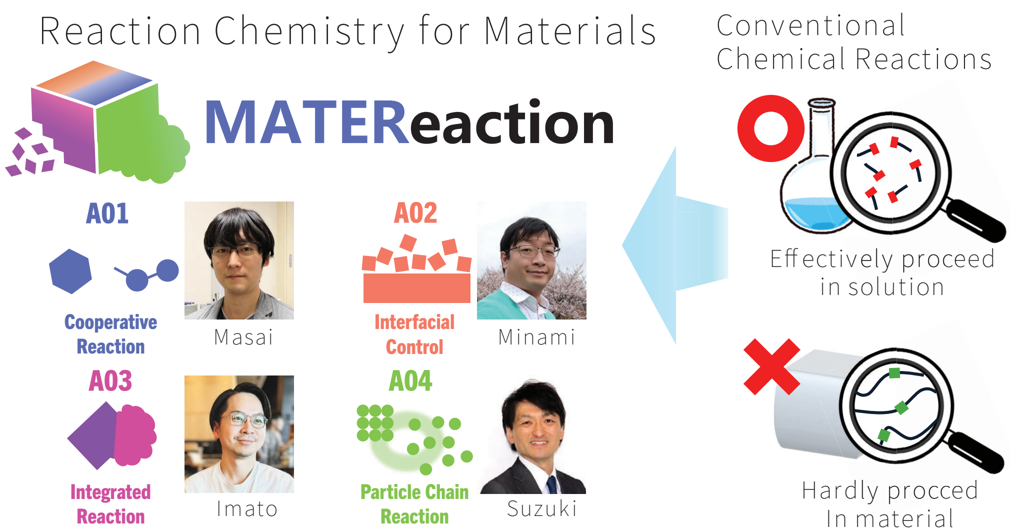


Figure 1. Overview of research project

Expected Research Achievements

● Strategy

To achieve efficient chemical reactions in stable materials, new principles are required to precisely understand and control chemical reactivity across multiple scales, including micro-, meso-, macro-, and interfacial regimes. This transformative research area brings together four experts developing distinctive methodologies for material transformation. This research area will systematize novel reaction principles formaterials, including cooperative, accelerated, and chain reactions, thereby establishing fundamental principles of material reaction (MATEReaction).

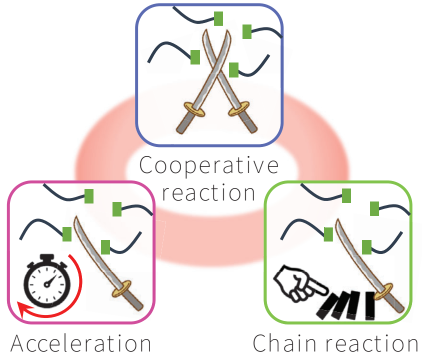
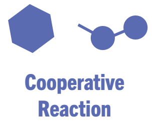


Figure 2. Strategy of research

● Project Organization

A01　Hiroshi Masai　(The University of Tokyo)



A01 focuses on the principles and mechanisms to achieve high reactivity in stable chemical bonds in polymer materials. Harnessing ubiquitous stimuli, practical and efficient reaction systems will be achieved by using multiple stimuli acting cooperatively.

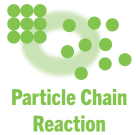
A02　Yasunori Minami　(AIST)

A02 designs reaction systems from the standpoint of interface, that enable the efficient cleavage of robust chemical bonds in highly durable materials. The group will achieve the decomposition of super engineering plastics, and establish chemical recycling based on the regenerated feedstocks.

A03班　Keiichi Imato（Hiroshima University)

A03 elucidates the principles and mechanisms that enable high reactivity in materials, from the perspective of mesoscale control in polymer materials. Mesoscale structural changes on crystalline polymers will be induced by light to accelerate chemical reactions in the material.

A04班　Daisuke Suzuki（Co-I：Yuichiro Nishizawa）　(Okayama University)



A04 establishes design principles for realizing high reactivity in materials, focusing on microparticles. Using large specific surface area of particulate materials, efficient transformation will be achieved through the cleavage of interparticle bonding induced by external stimuli or chemical reactions.

● Expected impact

By exploiting long-overlooked phenomena in reaction chemistry, such as the cooperative effects of multiple stimuli and non-equilibrium changes in materials, this research will establish new technologies for the versatile transformation of materials through chemical reactions. The research will contribute to materials recycling and the circular economy, while providing theoretical foundations for reaction chemistry, making transformative contributions to fundamental and applied materials science.

Website(s)	Under construction