Title of Project : Multiscale Interfacial Molecular Science for Innovative Functional Materials

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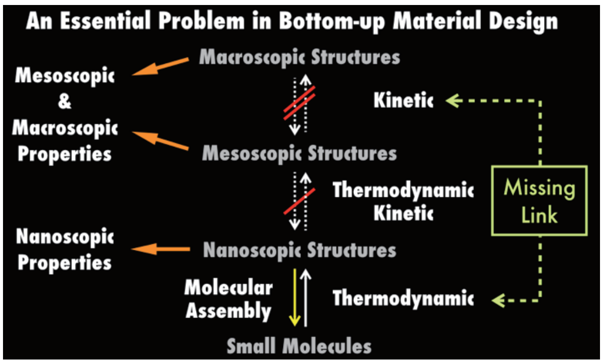
【Purpose and Background of the Research】

A remarkable progress in supramolecular chemistry in the last two decades now allows us to design and tailor a variety of desired nanostructures by optimizing a thermodynamic control. However, there still remains an essential missing link between molecular/nano structures and those with meso/macroscopic size regimes. This is mainly because the assembling events from "nanoscale size regimes" toward "upper hierarchical levels" suffer from an irreversible interference by numerous kinetic traps, leading to the formation of ill-defined macroscopic structures. On the other hand, in living system, many biological events rely on certain macroscopic structural anisotropies of biomaterials. Those anisotropic structures are constructed under physical perturbations such as electrical potentials, ion/fluid fluxes, osmotic pressures, and sheer forces.

Having a lesson from biological assembling events, we are taking up the challenge of filling the above-mentioned "missing link" by applying physical perturbations to our highly reputed assembled motifs.



【Research Methods】

In this project, we will mainly focus attention on utilization of three chemical motifs (1)–(3), all of which require a certain structural anisotropy up to a macroscopic length scale for their practical applications. Motif (1) is the first self-repairable polymer glass. Motif (2) is ionic liquid-based polyelectrolites showing extra-large capacitance. Motif (3) is a non-spherical polyelectolyte such as titanate nanosheets with orientaion properties in a magnetic field.

【Expected Research Achievements and Scientific Significance】

This project will cause a big paradigm shift in industrial technologies as well as basic sciences. (1) Development of self-repairing polymer glass is important for application to various types of self-repairing plastics, leading to a major step toward achieving sustainable development goals (SDGs). (2) Large capacitance of polyelectrolytes leads to practical applications as large-capacity electricity storage devices. (3) Anomalous behaviors of non-spherical polyelectrolytes are utilized for the development of "anisotropic colloid science", which will open up a new field of material science and will pave the way for a full-fledged artificial muscles and cartilages. We apply a variety of physical perturbations to control kinetic events of the assembly of large-dimension nanostructures and achieve structural anisotropies.

【Publications Relevant to the Project】

- Y. Yanagisawa *et al.* Mechanically robust, readily repairable polymers via tailored noncovalent cross-linking, *Science* **359**, 72–76 (2018).
- M. Matsumoto *et al.* Ultrahigh-throughput exfoliation of graphite into pristine 'single-layer' graphene using microwaves and molecularly engineered ionic liquids, *Nature Chem.* **7**, 730–736 (2015).
- M. Liu *et al.* An anisotropic hydrogel with electrostatic repulsion between cofacially aligned nanosheets, *Nature* **517**, 68–72 (2015).

【Term of Project】 FY2018-2022

【Budget Allocation】 148,800 Thousand Yen

【Homepage Address and Other Contact Information】

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