【Grant-in-Aid for Scientific Research(S)】

Science and Engineering (Interdisciplinary science and engineering)

Title of Project： Creation of Mass Transport Membrane Using Slide-Ring Molecular Structure

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Research Area： Polymeric Materials, Supramolecular Chemistry, Soft Matter Physics

Keyword： Polymer Structure and Properties, Supramolecular Chemistry, Nano Materials

【Purpose and Background of the Research】

We have developed slide-ring materials with freely movable cross-links, and investigated the peculiar physical properties arising from the mobility of ring components and their various applications. Very recently, we found an obvious on-off behavior of the pressure dependence of solvent permeability in slide-ring gel membrane. Such a reversible on-off behavior has never been observed in usual chemical and physical gel membranes. This anomaly seems to arise from the homogeneous-inhomogeneous transition in the slide-ring network: The slide-ring gel forms homogeneous network hindering solvent flow in the lower pressure region while a strong hydrodynamic field creates some inhomogeneous solvent flow channels, aggregating free movable rings in the higher region. In this research project, we investigate the molecular mechanism of the on-off behavior based on the peculiar structure of the slide-ring membrane and create a digital mass transport membrane system by the molecular design controlling the distribution entropy of rings.

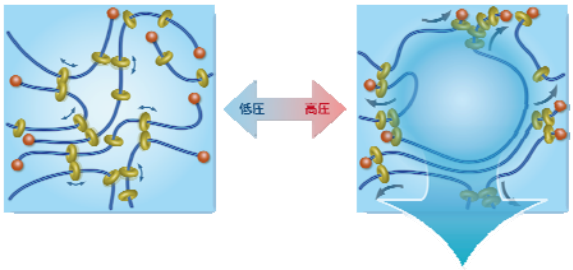

Figure 1. Pressure induced homogeneous- inhomogeneous transition of the slide-ring gel membrane. Reversible solvent flow channels are formed by pressure gradient.

【Research Methods】

To achieve the purpose of the project, we develop a new measurement system for small angle scatterings under pressure or concentration gradient. The meso-scale structural analysis leads to the elucidation of the molecular mechanism of the on-off behavior in the slide-ring gel membrane. And we synthesize a new polyrotaxane based on the molecular design controlling the ring entropy. Moreover, we systematize the on-off behavior of the slide-ring membrane by creating digital mass transport membrane system. For example, the encapsulation of usual drag delivery system (DDS) by a slide-ring gel membrane can release a drug digitally with controllable delivery rate and amount.

【Expected Research Achievements and Scientific Significance】

This project is expected to bring a paradigm shift from analog to digital in the field of mass transport membrane. And it will create a new research area of the ring entropy in the polymer science. In addition, we can contribute to a dramatic development of polymer science and supramolecular chemistry through establishing a new theoretical model based on the ring entropy and finding novel dynamic phenomena and peculiar meso-scale structures. On the other hand, the on-off behavior can be applied to DDS and separation membrane, which leads to innovation in medical science, chemical engineering and so on.

【Publications Relevant to the Project】

・K. Kato and K. Ito, “Dynamic transition between rubber and sliding state attributed to slidable cross-links”, Soft Matter, **7**, 8737 (2011).

・A. Konda, K. Mayumi, K. Urayama, T. Takigawa, and K. Ito, “Influence of structural characteristics on stretching-driven swelling of polyrotaxane gels with movable cross links”, Macromolecules, **45**, 6733 (2012).

・K. Kato, T. Yasuda, and K. Ito, “Viscoelastic properties of slide-ring gels reflecting sliding dynamics of partial chains and entropy of ring components”, Macromolecules, **46**, 310 (2013).

【Term of Project】 FY2013-2017

【Budget Allocation】 160,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.molle.k.u-tokyo.ac.jp