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

Science and Engineering (Chemistry)

Title of Project : Role of Liquid for Controlling Autonomy of Soft Materials Containing Ionic Liquids

Masayoshi Watanabe
(Yokohama National University, Graduate School of Engineering, Professor)

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【Purpose and Background of the Research】

Soft materials, such as polymer gels and colloids, mainly consist of liquids. This aspect generates large internal freedom of the materials, which allows them to respond properly to tiny changes in the external environment. Thus, such soft materials can be candidates for so-called "*smart materials*". However, most of the studies on soft materials have focused on polymers, and little attention has been paid to the liquid structures (the main component) and the changes in the liquid structures.

In this study, the characteristic features of soft materials, typically autonomous structure formation, fluctuation, and transition (generalized as "*autonomy*") are assumed to originate from the structure-forming properties of liquids. We have selected ionic liquids (ILs) as the structure-forming liquids for designing new soft materials. This study aims at understanding the effects of structure-forming properties and hierarchal structures of ILs on the autonomy of the resulting soft materials.

【Research Methods】

This study opens up the frontiers of new soft materials containing ILs by correlating the autonomy of the materials and the structure-forming properties of the ILs. The following studies will be conducted.

(1) Understanding of Solubility of Polymers in ILs:

A characteristic feature to determine the solubility of polymers in ILs is that the cation-anion interaction competes with the interactions between either cations or anions and polymers. This aspect is not observed in the solubility of polymers in molecular solvents. We classify possible ion-polymer interactions into several different categories and elaborate to understand the solubility.

(2) Autonomy of Soft Materials Induced by Temperature Change

The lower critical solution temperature (LCST) and upper critical solution temperature (UCST) phase transition of polymers in ILs were initially discovered by the principal investigator. These phase separation phenomena are analyzed from the standpoint that the structure-forming properties of ILs induce such phase-separation.

(3) Autonomy of Soft Materials Induced by Light

Self-assembly of polymers in ILs, such as sol-gel transition, is controlled by introducing photochromic compounds into the thermo-sensitive polymer/IL systems studied in (2). Photo-healable soft materials are to be realized.

(4) Autonomy of Soft Materials Induced by Chemical Reactions

The partner investigator, Prof. Yoshida, discovered Belouzov-Zhabotinsky (BZ) reactions in IL mixtures. These findings will be utilized to realize autonomous soft materials induced by chemical reactions in ILs.

【Expected Research Achievements and Scientific Significance】

This research will provide not only valuable fundamental knowledge on the new soft materials but also a breakthrough in functional materials. The fundamental knowledge of how the structure-forming properties of ILs affect the autonomy of the soft materials also contributes to a deeper understanding of conventional soft materials.

【Publications Relevant to the Project】

・T. Ueki, M. Watanabe, Macromolecules in Ionic Liquids: Progress, Challenges and Opportunities, *Macromolecules,* **41**, 3739-3749 (2008).

・T. Ueki, Y. Nakamura, R. Usui, Y. Kitazawa, S. So, T. P. Lodge, M. Watanabe, Photoreversible Gelation of a Triblock Copolymer in an Ionic Liquid, *Angew. Chem. Int. Ed.*, **54**, 3018-3022 (2015).

【Term of Project】 FY2015-2019

【Budget Allocation】 155,300 Thousand Yen

【Homepage Address and Other Contact Information】

http://mwatalab.xsrv.jp/
mwatanab@ynu.ac.jp