Report for Interdisciplinary research startup

1. Name of project leader： **Kunpeng Cui**
2. Project title: **Understanding of physical properties at the atomic level of supramolecular bonding network** (超分子結合ネットワークの 原子レベルで物性理解)
3. Report

Recently, we synthesized novel polyampholyte hydrogels (PA gels) form hierarchical structure, which show high toughness, high fatigue resistance, and self-healing. PA gels consist of reversible ionic bonds at the 1-nm scale, a cross-linked polymer network at the 10-nm scale, and bicontinuous hard/soft phase networks at the 100-nm scale. Such hierarchical structures are found strongly depend on the chemical structure of the monomers, and it is essential for the high toughness and fatigue resistance of PA gels. Here we studied how the hierarchical structure forms and how it influences the mechanical properties of PA gels. With real time X-ray scattering, we revealed the structure formation process of PA gels. By using an osmotic stress method, we established the correlation between the relative strength of soft and hard phase, and the viscoelastic property, toughness and self-recovery behavior of PA gels. In addition, we also studied the effect of phase-separated structure on fatigue behavior of PA gels and highlight the role of multiscale structure on fatigue resistance.

The phase separation data may lead to future fusion research of "phase separation behavior of tough and self-healing polyampholyte hydrogels". Furthermore, my experimental conditions have been largely improved by the start-up funding. I purchased some equipment such as temperature-controlled oven, electronic balance and so on. My office condition was also improved by the start-up funding, such as I purchased a monitor for my paperwork.

4. Research achievement

(i) Kunpeng Cui, Ya Nan Ye, Tao Lin Sun, Liang Chen, Xueyu Li, Takayuki Kurokawa, Tasuku Nakajima, Takayuki Nonoyama, and Jian Ping Gong*, Effect of Structure Heterogeneity on Mechanical Performance of Physical Polyampholytes Hydrogels, ***Macromolecules,*** 2019, 52, 19, 7369–7378;

(ii) Xueyu Li, Kunpeng Cui, Tao Lin Sun, Lingpu Meng, Chengtao Yu, Liangbin Li, Costantino Creton, Takayuki Kurokawa, and Jian Ping Gong*, Mesoscale bicontinuous networks in self-healing hydrogels delay fatigue fracture, ***PNAS***, 2020 117 (14) 7606-7612;

(iii) Kunpeng Cui, Ya Nan Ye, Tao Lin Sun, Chengtao Yu, Xueyu Li, Takayuki Kurokawa, Jian Ping Gong*, Phase Separation Behavior in Tough and Self-Healing Polyampholyte Hydrogels, ***Macromolecules,*** 2020, Accepted.