【International Leading Research】

Design of Low Entropy Polymer Network Materials for Unique Functions

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Purpose and Significance of the Research

●What is "soft matter"?

Soft Matter or soft material is a general term for soft substances and is present everywhere around us, such as gels, liquid crystals, and biological tissues. Soft Matter is indispensable for solving various modern societal challenges, including aging, environmental pollution, and resource shortages. For example, as society ages, the needs of artificial organs (such as artificial hearts and artificial joints) and reconstructive medical/nursing equipment (such as endoscopes and robots, etc.) are increasing. Traditional materials such as metals, ceramics, and plastics do not meet requirements for these biomedical purposes, as these materials, as Hard Matter, demonstrate poor mechanical compatibility with biological tissues.

●What is LeNet?

A typical gel or elastomer is a high entropy material whose network strands are in coiled state. In this high-entropy state, the intrinsic mechanical properties of materials are independent of their chemical structure, making it difficult to control their intrinsic mechanical functions from a chemical point of view. In this study, we define gels or elastomers with extremely elongated network strands as a novel soft matter "**Low entropy polymer network** (**LeNet**)" (Fig. 1). Deriving from this low-entropy state, the intrinsic mechanical properties of LeNet become highly dependent on its chemical species. In this research, we will establish synthesis methods of LeNet, elucidate mechanical properties unique to LeNet. Furthermore, we will develop various innovative functional LeNets such as tough rubber-like materials based on designed chemical structures, materials functionalized by force-induced chemical reactions, and soft composite materials with controlled microstructures(Fig. 2).

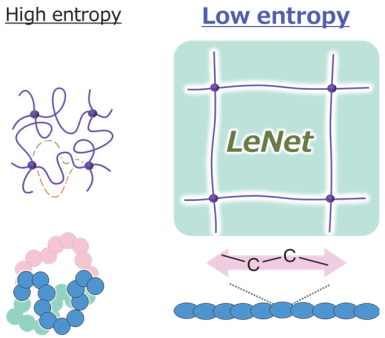

Fig.1 LeNet is defined as a polymer network with highly stretched strands

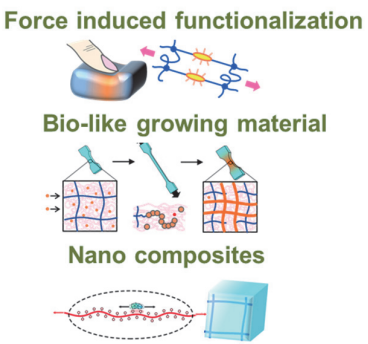

Fig.2 Examples of expected LeNet deliverables

Organization of the Project Team

The LeNet project consists of three teams, Japan team centered at Hokkaido University, US team centered at Duke University, and EU team centered at ESPCI Paris (Fig.3). The US and EU teams are led by the world frontrunner of mechanochemistry and soft matter mechanics, respectively. The Japanese team is outstanding for material design, structural analysis, and medical applications, the US team is outstanding for polymer theory and chemistry, and the EU team is outstanding for measurement and analysis of mechanical properties. The joint research will be carried out by bringing these cutting-edge knowledges of the three teams.

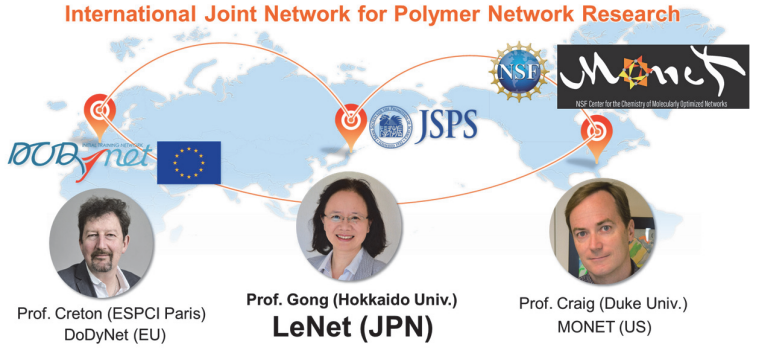

Fig.3 LeNet is a joint research project by three leading research teams.

Plan for Fostering Early-career Researchers

Taking advantage of the fact that the three partners in Japan, the United States, and Europe have different fields of expertise, we will train young researchers who comprehensively understand the synthesis, measurement, and analysis of soft matter through an interdisciplinary and cross-disciplinary system by faculty members from Japan and overseas.

A 5-year DC + PD program and a 3-year PD program will be set (Fig. 4). Overseas research destinations can be selected from 10 universities in the US and 7 universities in the EU according to characteristics and wishes of the young researchers. The dispatch period can be flexibly changed according to individual circumstances. Research guidance will be provided jointly by Japan and oversea partners, regardless of where the young researchers are staying, by actively utilizing the remote communication methods.

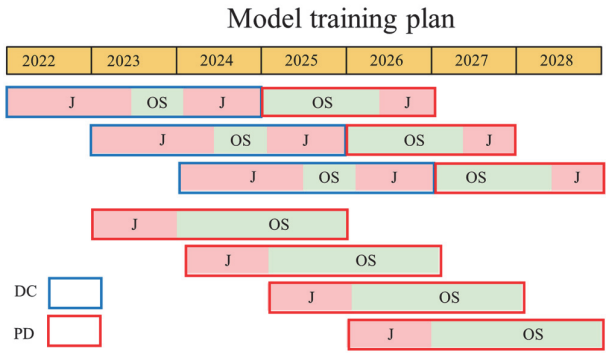

Fig.4 Model training plans for 5-year DC + PD program and 3-year PD program. J and OS mean staying in Japan and overseas, respectively.

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