Doctoral Dissertation Evaluation Review

Degree requested Doctor of Life Science Applicant's name LIANG CHEN

Examiner :

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Title of Doctoral Dissertation

Facile Synthesis of Novel Elastomers with Tunable Dynamics for Toughness, Self-healing and Adhesion
(高分子ダイナミックスの制御による高靭性、自己修復性および接着性を有する新規エラストマーの合成)

Results of Evaluation of the Doctoral Dissertation

Elastomers, known for their softness and stretchability, are extensively used as structural materials where load-dispersing and shock-absorbing abilities are required. Although natural rubbers have demonstrated excellent mechanical performance, many synthetic substitutes have been developed due to the inherent limitations of natural resources. However, there are limitations to the synthetic elastomers. One is that the synthetic elastomers are often stretchable but lack toughness, breaking easily along a notch. The other is that the approaches used for synthesizing elastomers are usually through multi-step, organic-solvent involved synthesis processes, which greatly limits their industrial applicability. Developing tough elastomers with simple one-step synthesis without using organic solvents will have a great impact.

In this study, the author synthesized a series of elastomers by one-step free radical random copolymerization without using any solvents. A diverse acrylate monomer pairs were chosen based on the linear rheological behaviors of their individual homopolymers to tune the characteristic relaxation time of the elastomers. These elastomers exhibit maximum energy dissipation around the ductile-brittle transition, reaching a work of extension at fracture of ~ 25 MJ/m^3 and a fracture energy of 20 kJ/m^2, which is comparable to natural rubbers and is among the highest ever reported. Furthermore, these elastomers possess 100% self-recovery, and a relatively high self-healing efficiency (37%-70%) of cutting samples at room temperature even for relatively rigid samples, and strong adhesive strength on glass and polymethylmethacrylate (PMMA) substrates. In addition, the author systematically studied the relationship between linear rheology and mechanical properties, and a universal tough-brittle transition behavior has been revealed. Using these novel elastomers, extra-ordinarily tough fiber-reinforced polymer composites have been developed recently.

This work not only developed novel elastomers that brings ground breaking achievement of polymer composites, but also gives guide to design novel advanced elastomers with excellent mechanical properties based on the dynamics of linear rheology. Therefore, we acknowledge that the author is qualified to be granted the Doctorate of Life Science from Hokkaido University.