学 位 論 文 審 査 の 要 旨
Doctoral Dissertation Evaluation Review

博士の専攻分野の名称　博士（生命科学）　　氏　名　　黄　以万

Degree requested: Doctor of （Life Science）　　Name: Yiwan Huang

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学 位 論 文 題 名
Title of Doctoral Dissertation

Developing Extremely Tough Fiber Reinforced Soft Composites
（超強靭な繊維強化ソフト複合材料の開発）

博士学位論文審査等の結果について（報告）
Results of Evaluation of the Doctoral Dissertation (Report)

As a vital class of soft materials, tough hydrogels have shown strong potential as structural biomaterials. These hydrogels alone, however, still possess limited mechanical properties (such as low modulus) when compared to some load-bearing tissues, e.g. ligaments and tendons. Developing both strong and tough hydrogel-based materials similar to soft load-bearing tissues is strongly desirable but still challenging. To overcome this obstacle, a novel soft composite concept was recently initiated successfully by combining a new class of tough polyampholyte (PA) hydrogels with negatively charged woven glass fiber fabric to create fiber reinforced soft composites (FRSCs). The new FRSCs exhibit extremely high toughness and tensile properties, far superior to the simple combination of the individual components, indicating a synergistic reinforcement. However, the structure of FRSCs is to be optimized and the synergistic toughening mechanism of the FRSCs is not understood.

In this study, the author performed systematic research on development of the extremely tough FRSCs and on revealing the synergistic toughening mechanism of the FRSCs. In details, the size effect of the fabric, the roles of the energy dissipation of the matrix, and the interfacial interaction between the fiber and hydrogel on the mechanical behaviors of the FRSCs were studied. A theoretical model was developed that provides a satisfactory explanation of the synergistic toughening of the FRSCs.

Based on the results of this Doctoral Dissertation, extraordinarily energy-dissipative soft composites have been developed. The fracture energy of the FRSCs reaches extra-ordinarily high value of ~1,000 kJ $m^{-2}$, which is comparable to some metals and alloys.

In conclusion, the author has made significant progresses not only on developing extremely tough fiber reinforced soft composites, but also on understanding of the synergistic toughening mechanism of the novel soft composite materials. This work provides a good guide toward the design of soft and wet materials with extraordinary fracture resistance.

Therefore, we acknowledge that the author is qualified to be granted the Doctorate of Life Science from Hokkaido University.