Abstract of Doctoral Dissertation

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Title of Doctoral Dissertation

Study on on-demand functionalization of hydrogel surfaces by force-induced rapid microstructure growth
（力誘起急速微細構造成長によるハイドロゲル表面のオンデマンド機能化に関する研究）

Living organisms share the ability to grow various microstructures on their surface to achieve functions. In contrast, most synthetic materials are usually considered static, with no surface microstructures regeneration after the material synthesis. The purpose of this dissertation is to develop a method to facially functionalize hydrogel surfaces. In an extension of our work on mechanoresponsive self-growing hydrogels that respond to repetitive mechanical force through effective mechanochemical transduction, I presented a force stamp method to grow microstructures on the surface of hydrogels based on a force-triggered polymerization mechanism of double-network (DN) hydrogels. This method allows fast spatial modulation of the morphology and chemistry of the hydrogel surface within seconds for on-demand functions. The selective adhesion, oriented growth of cells, and directional transportation of water droplets on the engineered hydrogel surfaces are demonstrated. This force-triggered method to chemically engineer the hydrogel surfaces provides a new tool in addition to the conventional methods using light or heat, and will promote the wide application of hydrogels in various fields.

The thesis consists of 7 chapters. **Chapter 1** is a general introduction. **Chapter 2** enlightens a brief review on productive mechanochemistry in polymeric materials.

In **Chapter 3**, the synthetic procedure is included, and fundament mechanical properties of various DN hydrogels are quantified by the mechanical testing.

In **Chapter 4**, reswelling properties which reveals internal fracture of the force-triggered damage zone on DN hydrogel surfaces are systematically studied. The reswelling of the damaged zone confirms bond scission and radical production. The mechanoradical concentration is estimated as 2.9×10^{-5} M when the indentation depth is 1000 μm.

In **chapter 5**, rapid microstructure growth on DN hydrogel surfaces triggered by mechanical force is performed, and the quantitative relationship between microstructure feature height and hysteresis energy is systematically studied. It is found that the force-triggered rapid strategy is chemical species-dependent, spatially controllable, and allows fine modulation of the size and composition of microstructures.

In **Chapter 6**, various complex physical and/or chemical micropatterns on DN hydrogel surfaces are created by the force-triggered rapid microstructure growth. The results reveal that the micropatterned DN hydrogels could be used not only for directed growth and enhanced myogenesis of muscle cell but also for water droplet directional transport. It is envisioned that the force-triggered rapid microstructure growth strategy and the micropatterned hydrogels hold promise for biomedical engineering application.

In **Chapter 7,** the main findings and conclusions are summarized.