学 位 論 文 の 要 約

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学 位 論 文 題 名

Fabrication of Multiple Responsive Photonic Hydrogels
Based on Lamellar Bilayer Structure
(ラメラ二分子膜を用いた多重応答性構造色ゲルの創製)

Photonic crystals are materials baring stop-bands in visible range of light. The periodic microstructure of a photonic crystal intensifies the reflection at a particular wavelength satisfying the Bragg condition and results in a brilliant coloration. Photonic crystals based on soft materials, that is, polymers and hydrogels, have attracted great attention due to their tunable stop-bands through deformation. Moreover, photonic hydrogels have additional potential advantages as active chromatic materials through swelling/deswelling in responsive to environmental stimuli, such as pH, salt, temperature. This kind of chromatic stimuli-response behavior in water medium resembles the structural coloration widely found in aquatic animals for camouflage, signalling, and mimicry. As stimuli-responsive materials, many polymer scientists have been concentrated on the developing of hydrogels that possess structural coloration for sensing of chemical or physical change of their environment. Recently, Haque et al (Adv. Mat., 2010) have developed an anisotropic photonic hydrogel based on 1D crystal structure. This hydrogel consists of uni-domain lamellar bilayers (polydodecyl glyceryl itaconate: PDGI) as 1D crystal structure in the polymer matrix of polyacrylamide (PAAm). The PDGI bilayers (thickness ~ 4.7 nm) are rigid and non-swellable while the PAAm layers of several hundred nm thickness are soft and swellable in water.

In this dissertation, a lamellar photonic hydrogel (PDGI/PAAm-PAAc) with high toughness, exhibiting ternary stimuli-responsive structural color to various external stimuli including temperature, pH, and stress/strain has been synthesized (Yue et al, Adv. Mat. 2013). Due to the association and dissociation of hydrogen bonds between PAAm and PAAc in the soft layer, the gel exhibits *positive* thermochromatic behavior. Furthermore, an ultrafast full-color display actuated by stress distribution of elastic photonic hydrogels (PDGI/PAAcNa) has been developed. The reflective flat-panel display technology is based on the pressure actuation of elastic photonic hydrogels. These hydrogels display magnificent structural color, reflecting narrow bands of wavelengths by decreasing of the photonic-crystal lattice. The hydrogel is inherently bright in high-light environments, has mechanical stability, low operational pressure value, ultrafast response time. Thus, it can be integrated onto flexible

substrates or free-moving. Also, an electroactive lamellar photonic gel with unique color tuning behaviors has been developed. By applying electric field vertical or parallel to the layer structure, the gel exhibits homogenous color tuning or rainbow-like color tuning behavior. In summary, 1D photonic hydrogels with interesting color tunability over the entire visible wavelength by the external stimuli, such as, temperature, pH, mechanical stress, and electric field have been developed. These photonic hydrogels can undergo significant shape change in response to changes in their chemical environment, and these chemical or physical stimuli can have major effects on the swelling behavior of the gel, as is the case in color changing iridophores in nature. It is believed that this research will open a new class of soft photonic sensors, bio-compatible materials, and displays.