Nanotech-nology

New mechanical stress sensing rubbers from paper materials

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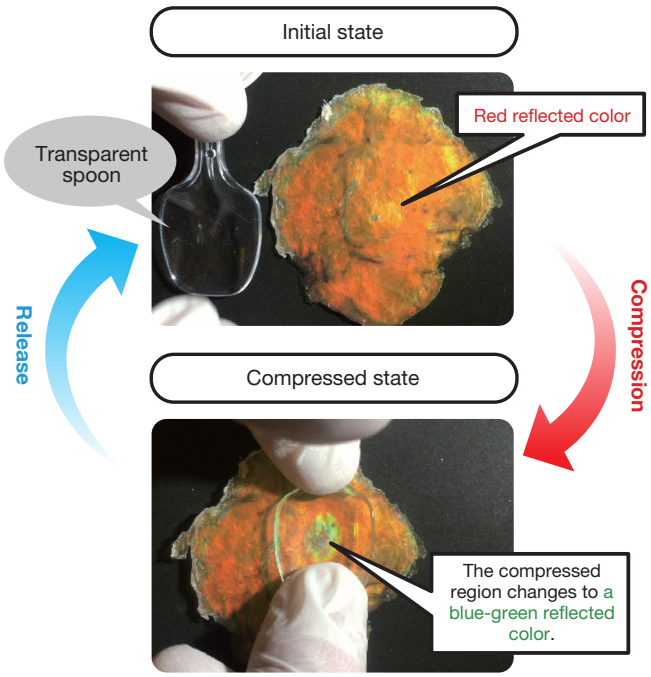
Purpose of Research

Cellulose, the main component of paper, cotton and wood, is a natural polymer in which glucose is polymerized as a straight chain, and it has long been a familiar material in our daily lives. In this study, we synthesized a new cross-linking cellulose derivative into which a functional group has been introduced that has an unsaturated bond in the lateral chain; through this means we succeeded in producing a cellulose liquid crystal elastomer film that has both special visible light reflection properties and rubber elasticity. Furthermore, we also discovered that this can be used for strain sensors capable of sensing mechanical pressure in real time.

Summary of Research

In this study, we have developed a new rubber material (elastomer) that can sense mechanical pressure through reflected color, and which uses cellulose—the main component of paper—as its raw material. Focusing on the features of low cost cellulose, which is friendly both to the environment and human body, we have created a new cellulose liquid crystal elastomer film that—due to its unique molecular design—exhibits Bragg reflection throughout the whole visible wavelength range, and also possess rubber elasticity. For example, when mechanical compressive force is applied to this cellulose liquid crystal elastomer film, one of its characteristics is that reflected color changes reversibly from red to blue-green in the compressed region only, allowing verification of the visualization of stress sensing.



Comparison with Conventional or Competitive Technology

- Conventional: Exhibits reflection characteristics derived from cholesteric crystals.
- This study: Achieved rubber elasticity in addition to reflection characteristics.
- Conventional liquid crystal elastomer: Manufactured mainly by chemical synthesis performed on materials derived from petroleum.
- Liquid crystal elastomer in this study: Can be created using cellulose, a natural polymer, as the raw material.

Expected Applications

- Sensors for social infrastructure capable of detecting distortion, such as in concrete.
- Wearable sensors that can be affixed to human skin.
- Inexpensive reflective displays with a low burden on the environment.

Challenges in Implementation

- Quantitative evaluation of interrelation between rubber elasticity and reflection characteristics of cellulose liquid crystal elastomer film.
- Optimization of cellulose liquid crystal elastomer film conditions such that it exhibits excellent rubber elasticity.

What We Expect from Companies

- We are hoping to conduct collaborative research with private companies specializing in chemistry, precision instruments, architecture, and medical care.

Points

- **Raw material is cellulose, which is abundant on earth, and is friendly to the human body and environment**
- **The cellulose liquid crystal elastomer film, with its special reflection characteristics and rubber elasticity, can be prepared using a simple chemical reaction**
- **It can be used not only in displays and as a coloring material, but also as a distortion sensor**

Future Developments

In cooperation with various private companies, we aim not only to research and develop new cross-linking cellulose derivatives but also use them in sensors and displays.

- Associated System: Grant-in-Aid for Scientific Research, Basic Research (B), JST Adaptable and Seamless Technology Transfer Program through Target-driven R&D (A-STEP)
- Intellectual Property: Japanese Unexamined patent Application Publication No. 2018-048289 Japanese Patent Application No. 2018-014066, Japanese Patent Application No. 2018-063259
- Prototype: Available
- Sample: Available
- Awards: 12th Funai Academic Award, 2nd IMRA JAPAN Award, and 10 others