Title of Project : Construction of High-Performance Photomobile Polymer Materials by Means of Interfacial Control

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Research Area : Chemistry
Keyword : Functional Polymer

【Purpose and Background of the Research】

As light is a good energy source that can be controlled remotely, instantly, and precisely, light-driven soft actuators could play an important role for novel applications in wide-ranging industrial and medical fields. Liquid-crystalline elastomers (LCEs) are unique materials having both properties of liquid crystals (LCs) and elastomers, and a large deformation can be generated in LCEs, such as reversible contraction and expansion, and even bending, by incorporating photochromic molecules, such as an azobenzene, with the aid of photochemical reactions of these chromophores. Recent studies revealed that various motions could be induced in laminated films, while their detailed mechanism at the interface has not been made clear. We propose new sophisticated photomobile polymer materials by means of the interfacial control.

【Research Methods】

It is well known that when azobenzene derivatives are incorporated into LCs, the LC-isotropic (I) phase transition can be induced isothermally by irradiation with UV light to cause trans-cis photoisomerization, and the I-LC reverse-phase transition by irradiation with visible light to cause cis–trans back-isomerization. However, the extinction coefficient of the azobenzene moieties at around 360 nm is large and thus the incident light is absorbed only at a surface. In the LCE films, the decrease in nematic order occurs only in the surface region facing the incident light, but in the bulk of the film, the trans-azobenzene moieties remain unchanged. As a result, the volume contraction is generated only in the surface layer, thus causing the film to bend toward the irradiation source (Fig. 1). This process includes the dynamic conversion from the nanoscopic change in the molecular structure to the macroscopic motion of the film, while the details have not been clarified yet. Furthermore, the interface between the LCE and substrate layers plays an important role in the photomobile behavior. To develop high-performance photomobile polymer materials, we implement the following programs.

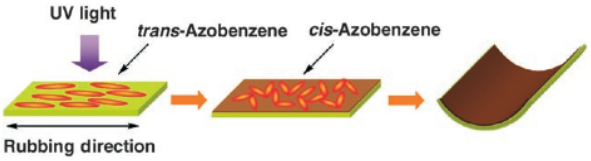

Figure 1. Mechanism of photoinduced motion.

(1) Investigation of the photomobile mechanism
(2) Control of the interface by various irradiation techniques
(3) Construction of sophisticated photomobile polymer materials

【Expected Research Achievements and Scientific Significance】

Photomobile polymer materials enable direct conversion of light energy into mechanical work without the aid of batteries, electric wires, or gears. Since the size of the samples is not in principle material-limited, numerous applications even on the nanoscale are possible, especially where efficient power supply to mechanical system is battery-free and noncontact.

【Publications Relevant to the Project】

- Y. Yu, M. Nakano and T. Ikeda
  Directed Bending of a Polymer Film by Light
  Nature, 425, 145 (2003).
- M. Yamada, M. Kondo, J. Mamiya, Y. Yu, M. Kinoshita, C. J. Barrett and T. Ikeda
  Photomobile Polymer Materials - Towards Light-Driven Plastic Motors
  Angew. Chem. Int. Ed., 47, 4986-4988 (2008).

【Term of Project】 FY2009-2013

【Budget Allocation】 163,300 Thousand Yen

【 Homepage Address and Other Contact Information】

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