Research Introduction

Light-Driven Actuators Based on Photochromic Organic Crystals

profile
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He received Ph.D. degree from OCU in 1996. He engaged as postdoctoral researcher and research associate at Kyushu University. He moved to OCU as associate professor in 2004, and was promoted to professor in 2011. He received the CSJ Award for Young Chemists in 2002, the APA Prize for Young Scientist in 2010, and the JPA Award in 2014.

When a molecular structure changes reversibly by some external stimuli, the properties of the materials consisting of the molecule can change reversibly. Such molecules will possess the switching function. A phenomenon that exhibits a reversible color change by photoirradiation is called photochromism. The photogenerated colored state is thermally unstable or stable depending on the photochromic compounds. In many cases, photochromic reactions take place even in solid states as well as in the solution. However, compounds that exhibit photochromism in the crystalline state are very rare.

Color change of photochromic diarylethene crystals is shown in Figure. Due to the different in the molecular structure of diarylethenes, the crystal color changes to yellow, red, blue, and green by irradiation with ultraviolet (UV) light. The colored crystal is thermally stable and returns to the original colorless one by visible light irradiation. This is due to the reversible change in the molecular structure. The photogenerated colored isomer can be directly observed as a disorder structure by single crystal X-ray crystallographic analysis. The cell length is slightly changed by the photochromic reaction. This indicates that the shape of the bulk crystal may be changed by the photochromic reaction.

In 2007, a reversible crystal shape change accompanied with a molecular structure change of a small-sized photochromic single crystal was reported for the first time. [1] The corner angle of the thin crystal changed and the rod-like crystal exhibited bending by the photochromic reaction. Because such a photomechanical phenomenon can change photon energy to mechanical energy without any direct contact and electrical wire, it is expected as a photoactuator for application. However, photoinduced crystal shape changes are limited to contraction, expansion, and bending, and thus creation of the more complicated photomechanical function is required. [2-5]

Photoinduced reversible twisting was found for a diarylethene crystal. [6] There is a right-handed twisting or a left-handed twisting depending on the crystal faces irradiated with UV light. The twisting of the crystal requires both a gradient of photocyclization conversion in the thickness direction and the contraction and expansion of the crystal in the diagonal direction. The crystal can be protected by coating the crystal using thin metal film and thin polymer film. Gold-coated diarylethene crystals exhibited photoreversible bending upon alternating irradiation with UV and visible light. It can be used as an actual electrical circuit ON/OFF photoswitching. [7]

These findings bring about not only a new strategy to design for photomechanical actuators but also a new practical use of photomechanical crystals.

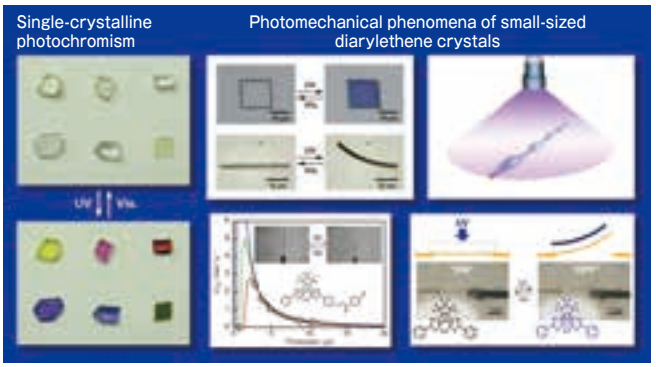

Figure. Examples of studies on photochromism and photomechanical phenomena of diarylethene crystals.

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3) D. Kitagawa, S. Kobatake, *Photochem. Photobiol. Sci.,* 13, 764-769 (2014).
4) D. Kitagawa, R. Tanaka, S. Kobatake, *Phys. Chem. Chem: Phys.,* 17, 27300-27305 (2015).
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6) D. Kitagawa, H. Nishi, S. Kobatake, *Angew. Chem., Int. Ed.,* 52, 9320-9322 (2013).
7) D. Kitagawa, S. Kobatake, *Chem. Commun.,* 51, 4421-4424 (2015).