Crystal locomotion driven by photo-triggered phase transition

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Mechanical crystals are expected to be applicable for actuators and soft robots [1]. Before the past decade, we have developed many mechanical crystals based on photoisomerization [2], and some based on phase transition [3] and photothermal effect [4]. In 2019, we have found a new kind of phase transitions, referred to as the photo-triggered phase transition [5]. The photochromic crystal exhibiting a thermal, reversible single-crystal-to-single-crystal phase transition upon heating and cooling, transform to the identical phase upon light irradiation at temperatures lower than thermal phase transition temperature. A chiral salicylidnephenylethylamine [enol-(*S*)-**1**] crystal is known to undergo photoisomerization (Fig. 1a) [6], and thermal phase transition [7]. We have found that the enol-(*S*)-**1** crystal exhibited the photo-triggered phase transition.

Upon heating, the enol-(*S*)-**1** crystal in the a-phase ($P2_1$) transformed to the b-phase ($P2_12_12_1$) with the discontinuous b-angle change to 90° at 0 °C due to thermal phase transition from monoclinic to orthorhombic crystal system (yellow circles, Fig. 1b). Under UV light (365 nm) irradiation, the a-phase changed to the b-phase even at -30 °C (orange circles, Fig. 1b). The mechanism was revealed that the photo-triggered phase transition is driven by the strain near the irradiated surface produced by the photoisomerization. A thick crystal in the a-phase deformed by the photo-triggered phase transition to the b-phase upon UV light irradiation; the surface temperature did not reach the thermal phase transition temperature. Furthermore, the thin plate-like crystal exhibited two-step bending motion by the photo-triggered phase transition and then the photoisomerization (Fig. 1c). Finally, by alternate irradiation of UV and visible light (488 nm) from the left, the plate-like crystal on the glass surface locomoted in the lower right direction (Fig. 1d). This finding leads to generalize the photo-triggered phase transition phenomenon and indicates that the photo-triggered phase transition enables to create various motions of crystals such as locomotion.

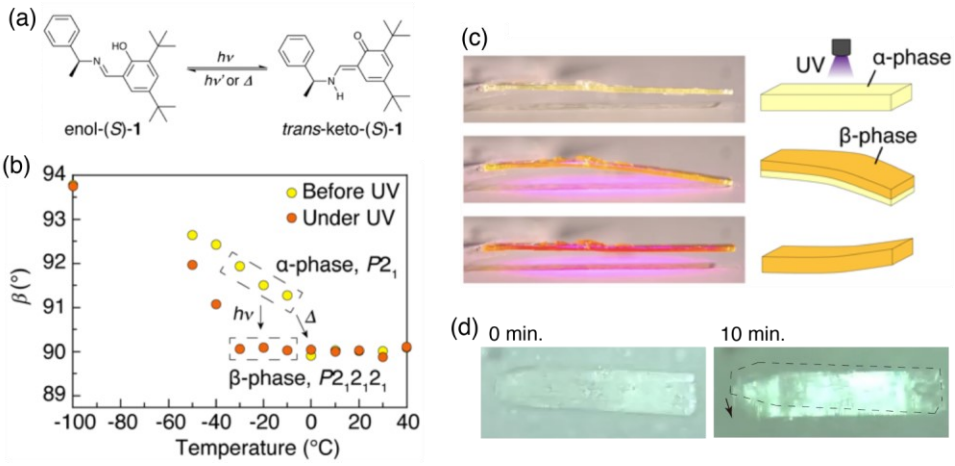

Figure 1 (a) Photoisomerization of enol-(*S*)-**1**. (b) Temperature dependence of the b-angle before and under UV light irradiation. (c) Two-step bending of the thin-plate crystal. (d) Locomotion of the crystal on the glass plate.

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