

High-speed and high-efficient actuation of molecular crystals by photothermally induced natural vibration

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Recent discovery of molecular crystals that deform flexibly without deterioration upon light irradiation shake the common perception of molecular crystals as brittle, inflexible, and unresponsive to external stimuli. These light-driven mechanical crystals (*photomechanical crystals*) have attracted much attention in both basic research and applications to light-fueled actuators and soft robotics [1]. We have developed many light-driven mechanical crystals over the past decade, mainly based on photoisomerization [2,3]. Recently, we reported high-speed (~25 Hz) bending induced by the photothermal effect [4]. The photothermal effect is a phenomenon by which thermal energy (heat) is produced by nonradiative deactivation of the photoexcited state during a photophysical process. We then elucidated the bending mechanism that a nonsteady temperature gradient in the thickness direction triggers photothermally driven crystal actuation, ultimately achieving 500 Hz high-speed bending [5]. Very recently, we discovered high-speed bending of an enol-1 crystal (Figure 1a) by natural vibration induced by the photothermal effect.

When the enol-1 crystal was irradiated with ultraviolet (UV) light irradiation for 0.1 s (Figure 1b), the crystal underwent fast and small bending due to natural vibration of 773 Hz, which was accompanied by the large photothermal bending (Figure 1c). The crystal was then exposed to a pulsed UV light of the same frequency as its natural frequency; the bend angle was greatly amplified to 7.2° by resonance, achieving high-speed (773 Hz) as well as the high energy conversion efficiency of 0.22% (Figure 1d). Any light-absorbing crystal can be actuated by photothermally induced and resonated natural vibration, which gives a versatile actuation methodology.

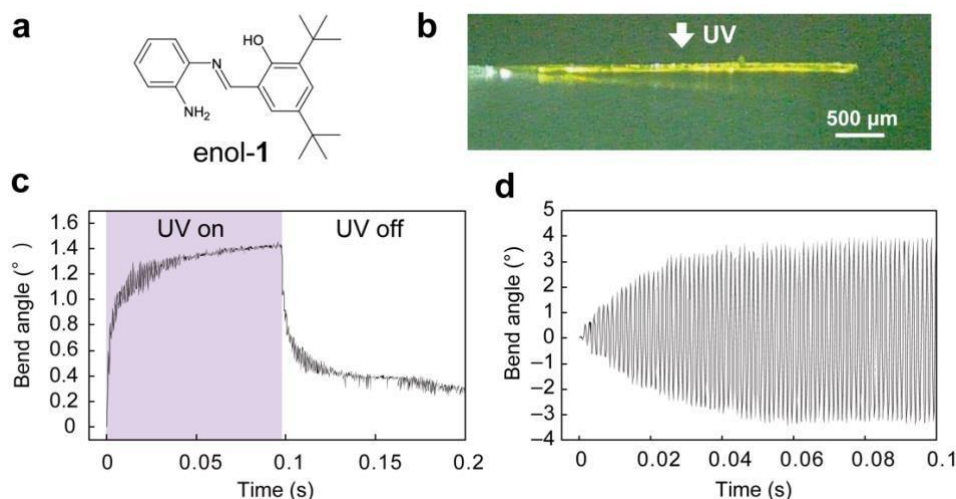


Figure 1. (a) Molecular structure of enol-1. (b) Photograph of a plate-like enol-1 crystal viewed from the side face. (c) Large photothermally driven bending and small, repetitive natural vibration upon UV irradiation for 0.1 s. (d) Amplification of 773-Hz natural vibration by resonance upon pulsed UV irradiation.

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