

Organic single crystal gains elastic flexibility

Organic fibrous materials, such as polymers, have attracted great attention due to their flexibility. On the other hand, organic single crystals are contrasting materials with less flexibility. Semiconducting films and fibers based on π -conjugated polymers have exhibited attractive elastic (reversible) or plastic (irreversible) bendability, which are valuable for future photonic and electronic applications, but these low crystallinity materials present amorphous domains that increase charge traps, cause loss of anisotropy and decrease refractive index. Thus, crystallinity of the materials is key to develop the photonic and electronic devices. On the other hand, densely packed and anisotropic molecular assemblies of π -conjugated molecule, such as semiconducting organic crystals, display exceptional intermolecular charge transport ability that would lead to high-performance optical and electronic devices, but these high crystallinity materials are not mechanically robust and are susceptible to breakage under applied stress. To harness the advantages of both of polymeric and crystal materials, mechanically bendable crystals based on π -conjugated molecules would be an ideal material. In particular, elastic π -conjugated molecular crystals would lead to the next generation semiconducting materials. To pioneer the creation of flexible densely packed and anisotropic molecular assemblies of π -conjugated molecule, we considered the fibrous crystal design based on stacked molecular wires of a π -conjugated molecule as a new category of materials.

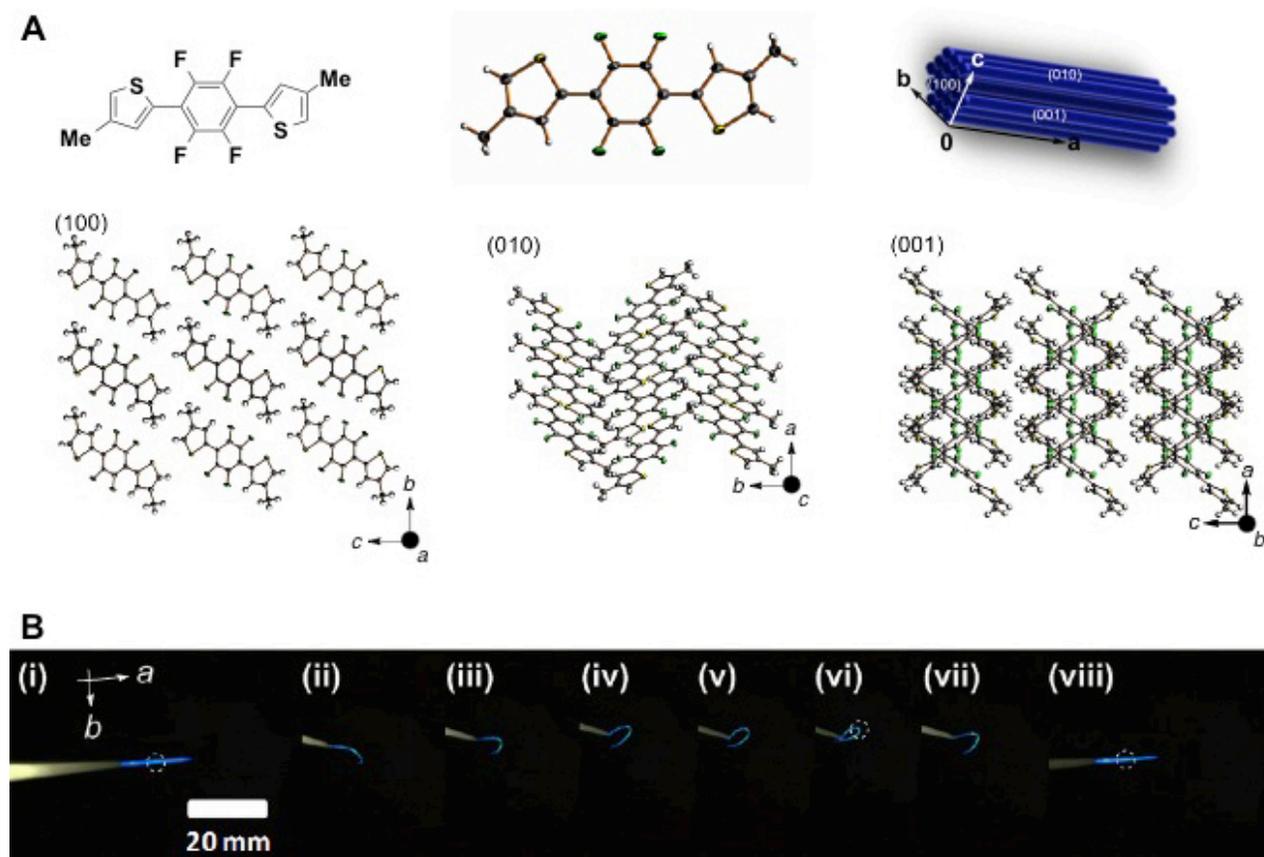


Fig. 1. (A) Molecular structure and crystal morphology. (B) Elastic bending motion of the crystal. (i)-(vi) Bending. (vi)-(viii) relaxation.

We have realized an elastic π -conjugated molecular single crystal with bending flexibility. The centimeter-scale organic single crystal (up to 60 mm length) was assembled from slip-stacked molecular wires composed of the planar π -conjugated molecule, 1,4-bis[2-(4-methylthienyl)]-2,3,5,6-tetrafluorobenzene (Fig. 1A). Unlike common organic crystals, the straight crystal bent under applied stress and quickly recovered its original shape upon relaxing. The crystal was capable of bending more than 180° (Fig. 2B). Interestingly, the fluorescence quantum yield of the molecule in crystal increased about 2 times compared to that of the THF solution, which is an evidence for aggregation-induced enhanced emission. The single crystal showed unique mechanofluorochromic abilities caused by mechanical bending–relaxing motions.

The fibrous single crystal of a π -conjugated molecule is a new category of materials, which possess characters of both of polymers and crystals. Large-scale and flexible (elastic) organic single crystal based on π -conjugated molecule will be offered a potential for various optoelectronics.

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Publication

[Elastic Organic Crystals of a Fluorescent \$\pi\$ -Conjugated Molecule.](#)

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Angew Chem Int Ed Engl. 2016 Feb