Special Materials Organic Colloquium

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“Crystal Adaptronics: Dynamic and Soft-Matter-Like Properties of Molecular Crystals”

Abstract: Elastic materials that are capable of stimuli-induced mechanical reconfiguration are indispensable for fabrication of mechanically tunable elements for actuation, including flexible electronics, artificial muscles, and microfluidics parts. The advanced materials that will qualify for these applications in the future must fulfill an extended list of requirements including reversible, rapid and controllable response that is proportional to the applied stimulus, and fatigueless operation over prolonged periods of time.

Despite that elasticity is counterintuitive for crystals, there is an increasing number of reports of serendipitous observations of molecular single crystals that can hop, leap, bend, curl, crawl, expand, contract, twist, spin, explode, split, roll, or respond otherwise to external stimuli akin to soft, mesophasic materials. These dynamic crystals provide extreme and visually impressive demonstrations of the mechanical strain that can accumulate in the interior of molecular crystals and be released as mechanical energy. Mechanically reconfigurable molecular crystals—ordered materials that can adapt to variable operating and environmental conditions by deformation, whereby they attain motility or perform work—are quickly shaping up a new research direction in materials science, crystal adaptronics. Properties such as elasticity, superelasticity and ferroelasticity that are normally related to inorganic materials, and phenomena such as shape-memory and self-healing effects which are well established for soft materials, are now being reported for molecular crystals, yet their mechanism, quantification, and relation to the crystal structure are not immediately intelligible to the wider materials science research community. At the current stage of the understanding of their mechanical properties, the type of mechanical response from these materials remains hardly predictable, although it almost always is a result of the interplay between disintegrative and restorative factors.

This lecture will provide a condensed overview of the dynamic and self-healing single crystals, emerging new classes of materials that bridge the gap between the soft matter and inorganic materials. The occurrence and detection of their unconventional properties, and the underlying structural features of the related molecular materials will be discussed and highlighted together with prominent recent examples.

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