Harnessing photochemistry to turn light energy into mechanical work

Most mechanical devices rely on electrons or chemical fuels as energy sources that converted into mechanical motion by some type of “engine”. Photons represent an alternative way to transport energy, but there is a lack of “engines” that can use photons as a fuel. One way to transform light into mechanical work is to utilize photochemical reactions. Crystals organize photoreactive molecules and coordinate their motions, leading to photoinduced deformations like expansion, bending, twisting, peeling and coiling. This class of materials provides a path to photomechanical actuators that can be scaled down to micro- or nanoscale dimensions, but along the way several challenges must be addressed: 1) optimization of the molecular structure to control the rate and mechanism of reversibility (photon versus thermal activation); 2) control of crystal morphology to generate actuating structures with a variety of shapes and sizes; and 3) the hierarchical organization of nano-scale and micro-scale crystals into a macroscopic actuator structure, usually by templated growth and organization. Recent progress in all three areas have led to the development of composite organic-inorganic structures with unprecedented power-to-weight ratios: under light illumination, less than 1 mg of material can move a 100 g mass.

Bio

Prof. Bardeen received his B.S. in chemistry from Yale University in 1989 and a Ph. D. in chemistry from UC Berkeley in 1995 under Charles V. Shank. After a post-doc with Kent Wilson at UC San Diego, he became an assistant professor at U. Illinois, Urbana-Champaign in 1998 and moved to the Chemistry Department at UC Riverside in 2005. He uses laser spectroscopy and microscopy to study light-induced dynamics in solid-state organic materials. One area of interest is excited state dynamics in organic photovoltaic materials, including exciton fission and fusion. He has also studied the kinetics of photochemical reactions in molecular crystals, and how these reactions can generate larger scale mechanical deformations and motions. His awards include the Camille and Henry Dreyfus New Faculty Award, the 3M Non-Tenured Faculty Award, the Research Corporation Research Innovation Award, the National Science Foundation CAREER Award, and a Sloan Research Fellowship.

Prof. Bardeen received his B.S. in chemistry from Yale University in 1989 and a Ph. D. in chemistry from U. C. Berkeley in 1995 under C. V. Shank. After a post-doc with K. Wilson at U. C. San Diego, he became an assistant professor at U. Illinois, Urbana-Champaign and moved to the Chemistry Department at U. C. Riverside in 2005. His research interests include the experimental study of exciton dynamics in organic photovoltaic materials, as well as the application of photoreactive molecular crystals as mechanical actuators.