Integration of Molecular Machines in Active Polymer Materials

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Abstract: Making molecular machines that can be useful in the macroscopic world is a challenging long-term goal of nanoscience. Inspired by the protein machinery found in biological systems, and based on the theoretical understanding of the physics of motion at the nanoscale, organic chemists have developed a number of molecules that can produce work when triggered by various external chemical or physical stimuli. In particular, basic molecular switches that commute between at least two thermodynamic minima and more advanced molecular motors that behave as dissipative units working far from equilibrium when fueled with external energy have been reported. However, the ultimate challenge of coordinating individual molecular motors in a continuous mechanical process that can have a measurable effect at the macroscale has remained elusive until very recently. We will discuss advances developed by our group on artificial molecular machines and involving their mechanical coupling within dynamic polymer systems. We will show that it is now possible to amplify their individual motions to achieve macroscopic functions in materials. In particular, we will present a dual-light controlled system operating fully out-of-equilibrium, and in which the integrated motions of two types of mechanically active units can be tuned by modulation of frequencies.

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