Artificial molecular muscle acting in nanoscale

Supported by the National Natural Science Foundation of China, the research group led by Prof. Qu DaHui (曲大辉) at the East China University of Science and Technology, realized the artificial molecular muscle in nanoscale, which was published in *Chem* (2018, 4: 2670—2684).

Muscle acts as a key tissue in the animal body to transform bio-chemical energy into mechanical work by linear contraction/extension motion. To mimic this vital functionality of muscle tissue, synthetic chemists have constructed molecule-scale muscles by organic synthesis, which can perform muscle-like linear contraction/extension motion driven by the external chemical stimuli. Although some efforts have been made in macroscopic molecular muscle polymers, the functional application of molecular muscle in nanoscale remains unexplored. The realization of this concept is of great significance for the evolution of artificial molecular muscles and machines towards single molecule devices and materials.

In their previous exploration, Qu's group had investigated some supramolecular host-guest chemistry on the surface of TiO_2 and gold nanoparticles (NPs), controlling the aqueous reversible self-assembly and the catalytic properties of NPs. The related researches were published in the journal of *Angewandte Chemie* and *Advanced Materials*. These early explorations confirmed the good performance of supramolecular systems on inorganic NPs, also providing important experience for the fabrication of more complex and precise hybrid systems.

In the current study, they successfully constructed a linear molecular muscle based on daisy chain rotaxane, which bears mechanically interlocked structure and performs stimuli-responsive contraction/extension motion. Au NPs were selected as the inorganic objects due to their distance-dependent optical properties. With an effective interaction between Au and thiol group, the artificial molecular muscles were connected between the gap of gold NPs dimer after a stepwise surface immobilization route. Importantly, they used the integrable feature of optical signal to overcome the natural single-molecule thermal noise of molecular muscle. Hence, they can collect the linear molecular motion of the interparticle molecular muscles as a real-time optical signal at the single-particle scale. Excitingly, the molecular muscles were found to be able to actuate in the gap of gold NPs dimer reversibly in at least four cycles under the stimuli of acid/base. This proof-of-concept study published in *Chem* paper pushes the evolution of artificial molecular machines towards the functionality in nanoworld, which might open a conceptually novel single molecule device based on artificial molecular machines acting on surfaces.

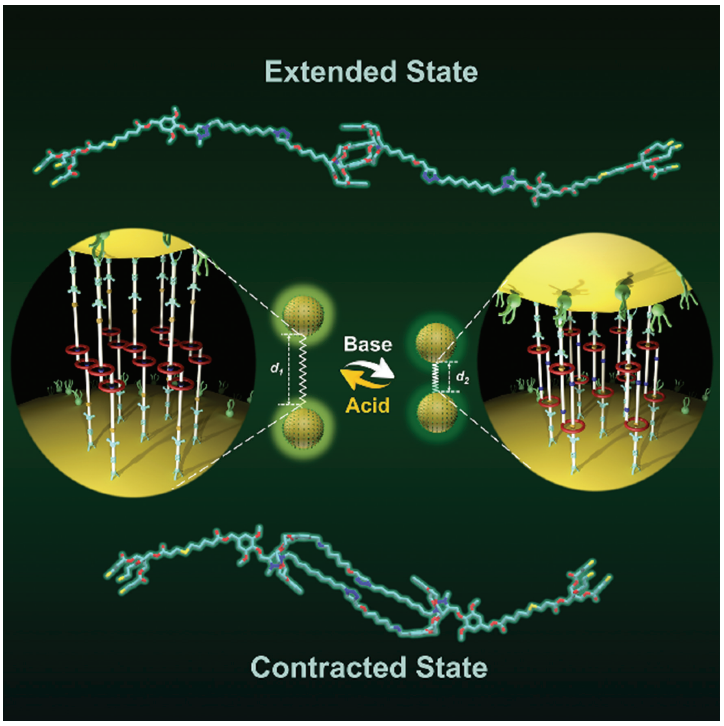

Figure Schematic representation for the operation mode of the daisy chain-based muscle-like molecular actuator for the Au NPs.