Switchable supramolecular motors with surface chirality

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Surface-supported molecular motors are nanomechanical devices of particular interest in terms of future nanoscale applications [1-3] However, the molecular motors realized so far consist of covalently-bonded groups that cannot be reconfigured without undergoing a chemical reaction. Here we demonstrate that a supramolecule can be used to realize a rotary molecular motor capable of *in-situ* directional switching through variation of surface chirality [4]. A platinum-porphyrin-based supramolecularly-assembled dimer was fabricated by sublimation of the molecules onto Au(111) in vacuum. It was found that dimer species were trapped preferentially at an atomic defect in the herringbone structure. The dimer could be rotated with high directionality by exciting only the molecule-motor part of the dimer using the tunneling current of STM. The ''axle'' of the molecular-rotor moiety of this dimer is defined by the atomic defect and the center of the molecule, which in this case is the Pt atom of the metalloporphyrin. Rotational direction of the molecule-motor is determined solely by the surface chirality of the dimer. Notably, the chirality and hence the rotational direction can be inverted, through a process involving an intra-dimer rearrangement, by selecting an appropriate applied bias voltage. In view of biological motors made of supramolecules, our finding promises construction of complex molecular machineries resembling biological systems at a smaller scale and on a solid surface.

References

[1] T. Kudernac et al., Nature, 479 (2011) 208.
[2] H.L. Tierney et al., Nat. Nanotech., 6 (2011) 625.
[3] U.G.E. Perera et al., Nat. Nanotech., 8 (2013) 46.
[4] P. Mishra et al., Nano Lett., 15 (2015) 4793.

Figures

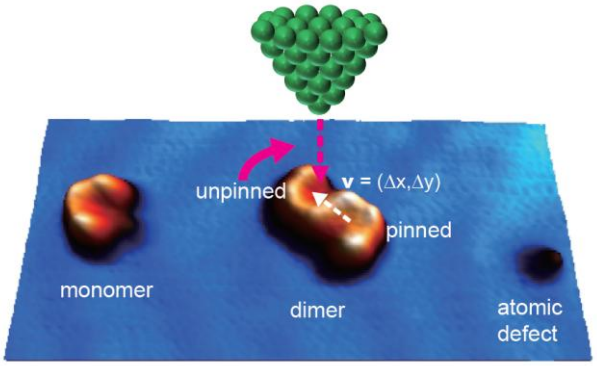

Figure 1. Three-dimensional presentation of an STM image of a Pt-MTBPP dimer molecule taken at 5 K. A monomer and an atomic defect are also visible nearby. Tunneling current injection from STM tip at the center of the unpinned molecule is schematically illustrated.

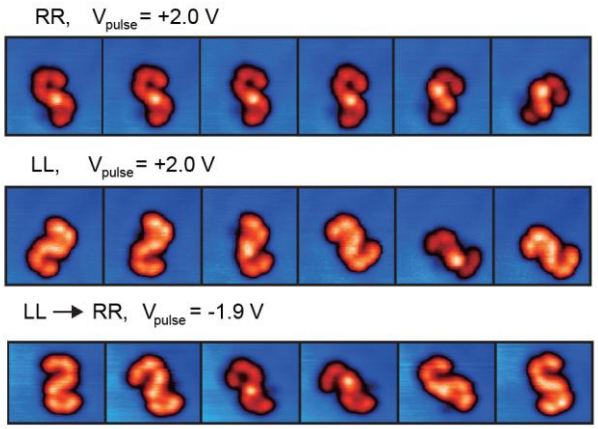

Figure 2. (top) Series of STM images of a dimer undertaking directional rotations at V_{pulse} = +2.0 V. The chirality of the dimer is RR. (middle) Series of STM images of a dimer with a chirality of LL. (bottom) Series of STM images of a dimer undergoing chirality change induced at V_{pulse} = -1.9 V.