On-Surface Synthesis and Manipulation of Functional Molecules

Leonhard Grill

Department of Physical Chemistry, University of Graz, Austria (www.nanograz.com)
leonhard.grill@uni-graz.at

To construct molecular wires from the bottom-up in a highly controlled fashion, specifically designed molecular building blocks can be connected by “on-surface synthesis” [1]. This method turns out to be very versatile as the final nanostructure is precisely defined by the chemical structure of the initial precursor [2]. It allows the controlled creation of molecular wires, for instance with alternating donor and acceptor groups that are identified via their electronic fingerprint [3].

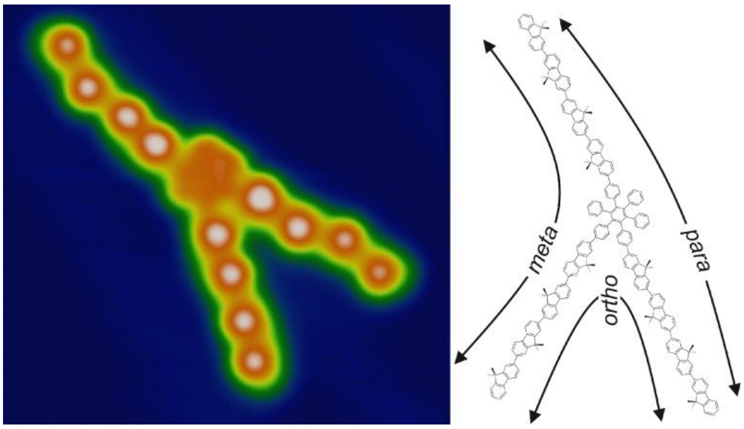

Figure 1: STM image and scheme of a single non-symmetric molecular node [4].

When pulling with the tip of a scanning tunneling microscope (STM), not only the electric current through a single molecular wire can be measured but also various charge transport channels – with different chemical conjugations – are identified in non-symmetrical molecular nodes (see Fig.1) [4]. The mechanical and electrical properties of single wires can be correlated by using not only STM but also atomic force microscopy (AFM) in such pulling experiments.

An important issue for any molecular function is the role of the direct environment. It will be shown for molecular switches (based on isomerization or tautomerization) how their atomic scale surroundings determine their function, leading to strongly enhanced switching for azobenzene derivatives on an insulator [5] and control over the switching by only *one* atom in the vicinity of a porphycene molecule [6].

In order to achieve lateral motion of molecules, STM manipulation can be employed where fast motion could be achieved by specific molecular side groups and an improved manipulation protocol [7]. On the other hand, enhanced translation of molecular machines is achieved by light on a metal surface [8]. The effect vanishes if an incompatible photon energy is used or if the motor unit is removed from the molecule, revealing that the enhanced motion is due to the presence of the wavelength-sensitive motor in each molecule.

References:

[1] L. Grill, M. Dyer et al., Nature Nanotech. **2**, 687 (2007).
[2] L. Lafferentz, V. Eberhardt et al., Nature Chem. **4**, 215 (2012).
[3] C. Nacci, F. Ample et al., Nature Comm. **6**, 7397 (2015).
[4] C. Nacci, A. Viertel et al., Angew. Chem. Int. Ed. **55**, 13724 (2016).
[5] S. Jaekel, A. Richter et al., ACS Nano **12**, 1821 (2018).
[6] T. Kumagai, F. Hanke et al., Nature Chem. **6**, 41 (2014).
[7] G. J. Simpson, V. Garcia-Lopez et al., Nature Nanotech. **12**, 604 (2017).
[8] A. Saywell, A. Bakker et al., ACS Nano **10**, 10945 (2016).