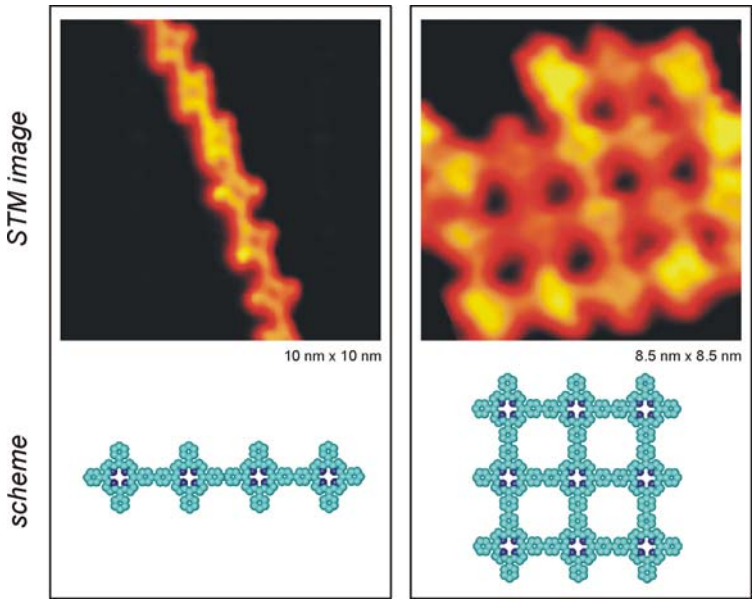
MANIPULATION OF SINGLE MOLECULES WITH THE STM: TOWARDS MOLECULAR NANOTECHNOLOGY

Leonhard Grill
Experimental Physics Department, Freie Universität Berlin
Arnimallee 14, 14195 Berlin
leonhard.grill@physik.fu-berlin.de

The idea of "molecular nanotechnology" is based on the capabilities of synthetic chemistry to functionalize molecules and to use them as electronic devices ("molecular electronics"), sensors or complex "nano-machines". Some expected advantages in future applications are the high operating speed, the small energy consumption and the chemical recognition and assembly. The scanning tunneling microscope (STM) is one of the most important instruments for the investigation of functionalized molecules, because it can image single molecules with submolecular resolution and is also capable to manipulate them by chemical/electrostatic forces or inelastic tunneling processes.
For technical applications of "molecular nanotechnology" several requirements, as for instance a stable connection between molecules or electric contacts of molecular wires to metallic electrodes, must be fulfilled. A successful approach to form such covalently bound molecular nanostructures, the "on-surface-synthesis", will be discussed [1]. It consists of two steps, the creation of reactive sites in the molecules and their connection on the surface. By choosing suitable chemical structures of the initial molecular building blocks, the nano-architectures of the formed structures can be precisely controlled. In this way, various topologies, as for instance linear molecular chains or two-dimensional networks (see figure), of porphyrin (TPP) molecules are grown and characterized.



Furthermore, a detailed understanding of the molecular motion is needed for efficient operation of nano-machines. Manipulation experiments with the STM tip will be presented, where the lateral displacement of wheel molecules on surfaces - by "hopping" or "rolling" motion - is studied [2]. A detailed investigation of the manipulation process allows the characterization of different (chemical and electrostatic) interactions between STM tip and molecule [3]. In view of "molecular electronics", molecular switches have been investigated. The results show that the azobenzene-based molecules, adsorbed on a metal surface, can be reversibly switched between *trans* and *cis* isomers by different processes [4,5]. It turns out that the chemical side groups of the molecules play a fundamental role for their switching capabilities.

[1] L. Grill et al., Nature Nanotechnology **2** (2007) 687.
[2] L. Grill et al., Nature Nanotechn. **2** (2007) 95.
[3] L. Grill et al., Nano Lett. **6** (2006) 2685.
[4] M. Alemani et al., J. Am. Chem. Soc. **128** (2006) 14446.
[5] M. Alemani et al., J. Phys. Chem. C **112** (2008) 10509.