Imaging and directed rotation of single molecules by non-contact force microscopy

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Non-contact force microscopy has demonstrated true atomic resolution on metals, semiconductors and insulators. The application of AFM to single molecules is a challenge because of relatively weak bonding to the substrate, which often leads to high diffusion rates of the molecules. We will present molecules, which were designed to interact with specific sites on insulating surfaces. Molecular wires of porphyrin molecules on ionic crystal surfaces are observed [1,2]. A complete immobilization at kink sites of KBr(001) is observed for single truxene molecules at room temperature [3]. Recently, intramolecular resolution is studied on a variety of molecules [4]. A further challenge is the manipulation of molecules on surfaces, including the controlled rotation, which means that the direction of rotation of the molecule can be chosen by the experimentalist [5]. The control of the probing tip is of central importance for a quantitative understanding of nc-AFM imaging and force spectroscopy. Progress has been made by a variety of preparation procedures: sputtering, indentation or pick-up of molecules, such as CO. The attachement of a single molecule to the end of the tip is shown for the case of a functionalized porphyrin, which can used as a stable probing tip for imaging in the attractive as well as the repulsive regime.

[1] Th. Glatzel, L. Zimmerli, S. Koch, S. Kawai, E. Meyer, Molecular assemblies grown between metallic contacts on insulating surfaces, Appl. Phys. Lett., 94, (2009), 3

[2] Th. Glatzel, L. Zimmerli, S. Kawai, E. Meyer, L.-A. Fendt and F. Diederich, Oriented growth of porphyrin-based molecular wires on ionic crystals analysed by nc-AFM , Beilstein J. Nanotechnol. 2, 34-39, (2011)., 2, (2011), 34-39

[3] B. Such, T. Trevethan, Th. Glatzel, S. Kawai, L. Zimmerli, E. Meyer, A. L. Shluger, C. H. M. Amijs, P. de Mendoza, and A. M. Echavarren , Functionalized Truxenes: Adsorption and Diffusion of Single Molecules on the KBr(001) Surface ACS Nano, 4, (6), (2010), 3429

[4] R. Pawlak, S. Kawai, S. Fremy, T. Glatzel and E. Meyer, Atomic-scale mechanical properties of orientated C60 molecules revealed by noncontact atomic force microscopy, ACS Nano, 5, (8), (2011), :6349-54

[5] R. Pawlak, S. Fremy, S. Kawai, T. Glatzel, H. Fang, L.-A. Fendt, F. Diederich, and E. Meyer , Directed rotations of single porphyrin molecules controlled by localized force spectroscopy, ACS Nano, 6, (2012), 6318–6324