

Controlling the magnetism of adsorbed metal-organic molecules

KUCH, W.

Institut für Experimentalphysik, Freie Universität Berlin, Germany, kuch@physik.fu-berlin.de

Organic molecules as building blocks of surface-mounted nanoscale systems have reached tremendous impact in solid state physics because they provide both reproducibility as well as structural control on the atomic level by the chemical design of the molecules. Gaining control on the size or the direction of the magnetic moment in such systems constitutes an important step towards the realization of a surface-mounted molecular spintronics.

Metalloporphyrins display a quasi-planar geometry, allowing for a two-dimensional assembly as electronic circuits or devices. In this way the central metal ion interacts with substrate electronic states, and may even magnetically couple to a ferromagnetic substrate [1–3]. Outer functional groups may play a role in defining the magnetic properties of the metal center as well. I will present data that show how a thermally induced on-surface ring-closure reaction of the outer ethyl groups of Fe and Co octaethylporphyrin (OEP) molecules adsorbed on Au(111) to form tetrabenzoporphyrin (TBP) [4] influences the electronic and magnetic properties of Fe, leading to a higher magnetic moment. In the case of CoOEP, the magnetic properties can be controlled by the choice of the substrate, while the ring-closure reaction has less influence. The magnetic moment of both CoOEP and CoTBP adsorbed on Au(111) is fully quenched. On the Cu(001) surface, in contrast, a large Co magnetic moment is present that decreases upon the reaction from CoOEP to CoTBP.

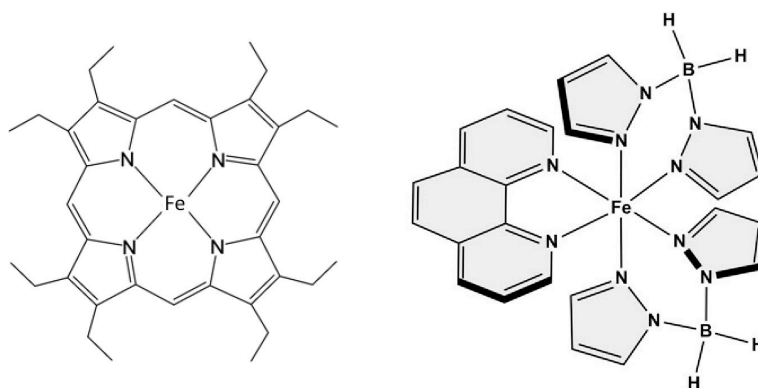


Figure 1: Chemical structure of FeOEP (left) and Fe(bpz)₂(phen) (right).

Spin-crossover complexes are another appealing species of magnetic molecules because they possess a metastable spin state that can be switched by external stimuli such as temperature or light [5]. They can thus function as tiny molecular magnetic switches that can be controlled optically. However, if these complexes are immobilized on a solid surface, the spin transition is often quenched due to the interaction with the substrate. A submonolayer of the Fe(II) spin-crossover complex Fe(bpz)₂(phen) (bpz=dihydrobis(pyrazolyl)borate, phen=1,10-phenanthroline) adsorbed on highly oriented pyrolytic graphite can undergo a reversible spin-crossover transition as a function of temperature, even though the molecules are in direct contact with a solid surface. The Fe spin can be switched from S=0 (low spin) to S=2 (high spin) using green light of 520 nm wavelength at T = 4.8 K. This light-induced switching process is highly efficient, leading to a complete spin conversion from low spin to high spin with an effective cross section of about 0.01 Å².

Acknowledgments

This work is supported by the DFG (Sfbs 658 and 677). Results were obtained together with M. Bernien, H. Naggert, L. M. Arruda, L. Kipgen, F. Nickel, Md. E. Ali, J. Miguel, C. F. Hermanns, A. Krüger, D. Krüger, T. Bißwanger, E. Schierle, E. Weschke, N. Hatter, B. W. Heinrich, F. Tuczek, K. J. Franke, and P. M. Oppeneer.

References

- [1] - Scheybal A., Ramsvik T., Bertschinger R., Putero M., Nolting F., and Jung T. A., *Chem. Phys. Lett.* **411**, 214, (2005)
- [2] - Wende H., Bernien M., Luo J., Sorg C., Ponpandian N., Kurde J., Miguel J., Piantek M., Xu X., Eckhold P., Kuch W., Baberschke K., Panchmatia P. M., Sanyal B., Oppeneer P. M., and Eriksson O., *Nat. Mater.* **6**, 516, (2007)
- [3] - Bernien M., Miguel J., Weis C., Ali M. E., Kurde J., Krumme B., Panchmatia P. M., Sanyal B., Piantek M., Srivastava P., Baberschke K., Oppeneer P. M., Eriksson O., Kuch W., and Wende H., *Phys. Rev. Lett.* **102**, 047202, (2009)
- [4] - Heinrich B. W., Ahmadi G., Müller V., Braun L., Pascual J. I., and Franke K. J., *Nano Letters* **13**, 4840, (2013)
- [5] - Gütllich P. and Goodwin H. A. *Spin Crossover in Transition Metal Compounds I*. Berlin: Springer (2004)