Freie Universität Berlin

Magnetism and Lateral Ordering Phenomena of Switchable Molecules on Surfaces

or: What B3 of SFB 658 is doing

Lorenz Drescher

May 30th 2013

Outline

Methods of measurement

- XPS
- XAS
  - NEXAFS
  - XMCD

Studied Systems and Molecules

- Conformational Switches
- Spin-Crossover Switches
- Chemical Switching of Magnetic Properties

Outlook

- Magnetic Properties of Adsorbed Metal Complexes
- Molecular Switches on Magnetic Surface-Structures

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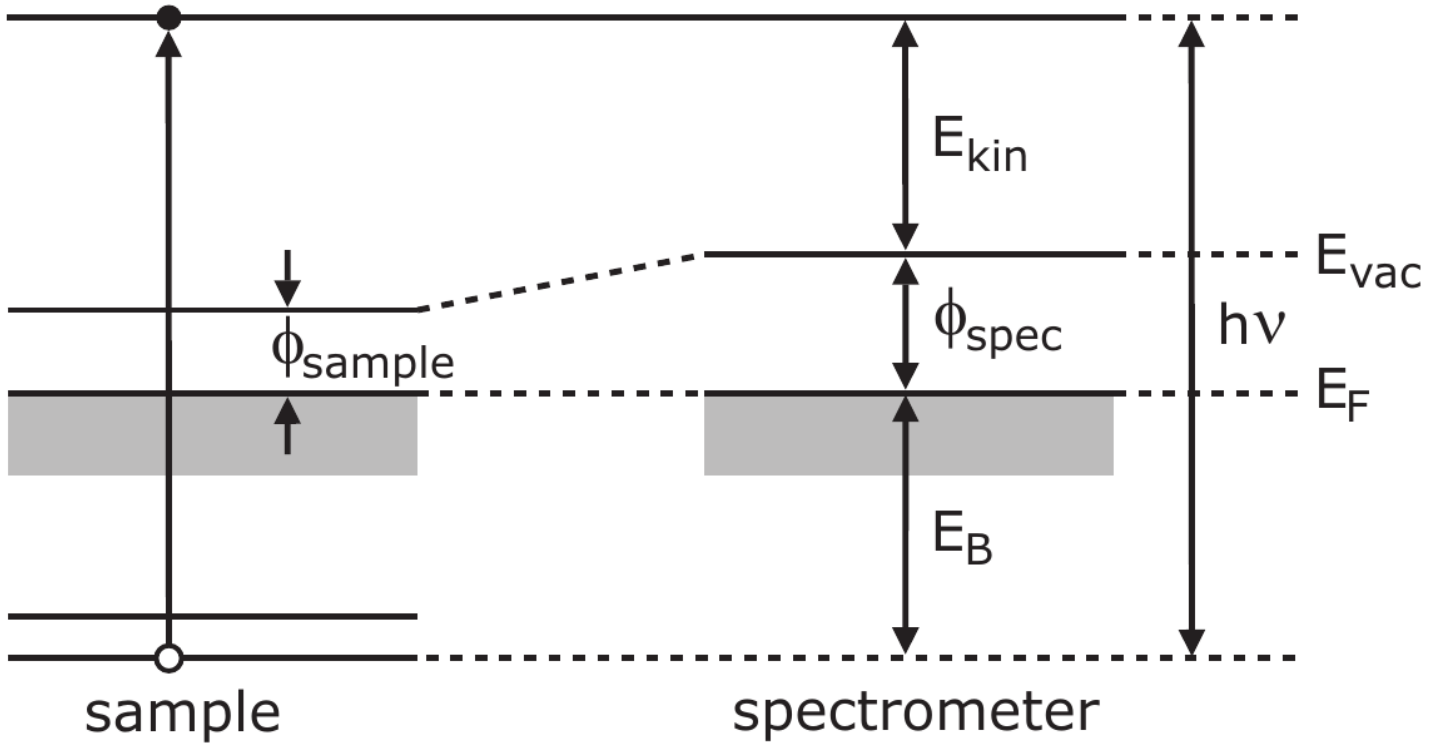
X-Ray Photoelectron Spectroscopy (XPS)

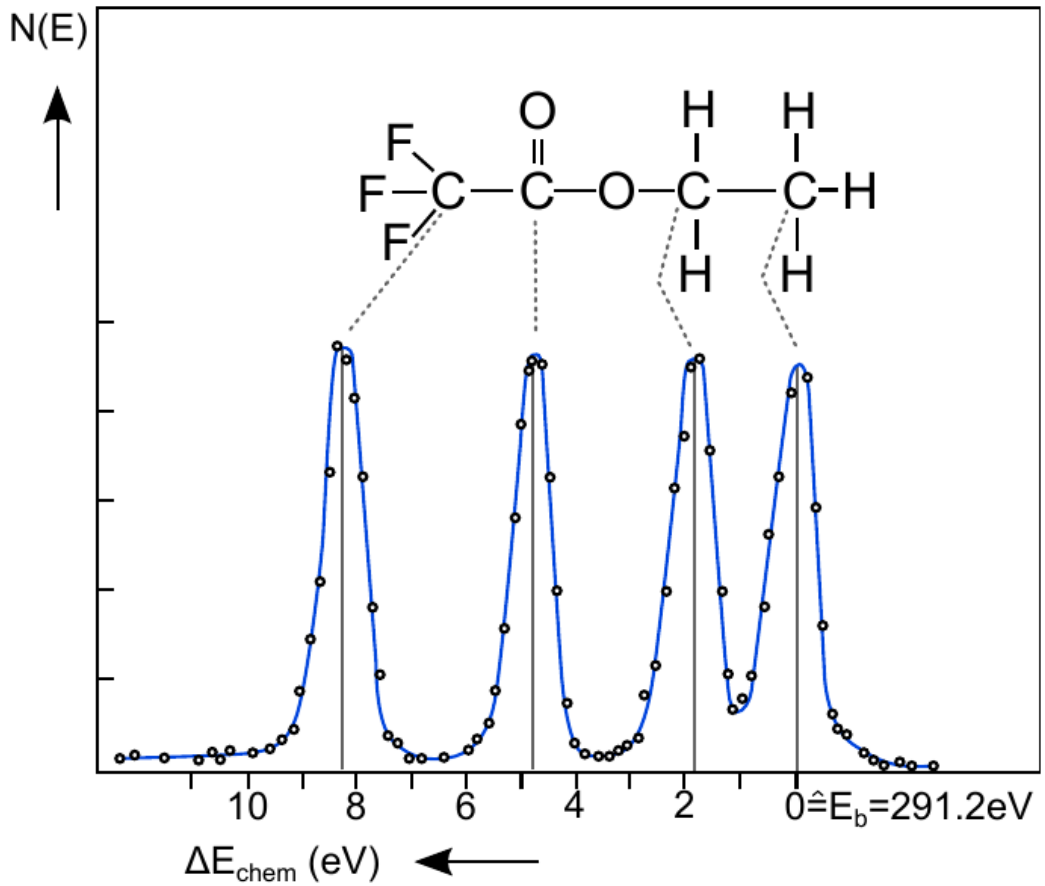
- Excitation of core-level electron over ionization barrier



from M. Bernien, X-Ray Absorption Spectroscopy of FE Complexes on Surfaces: Electronic Interactions and Tailoring of the Magnetic Coupling, FU-Berlin Diss. (2009)

X-Ray Photoelectron Spectroscopy (XPS)

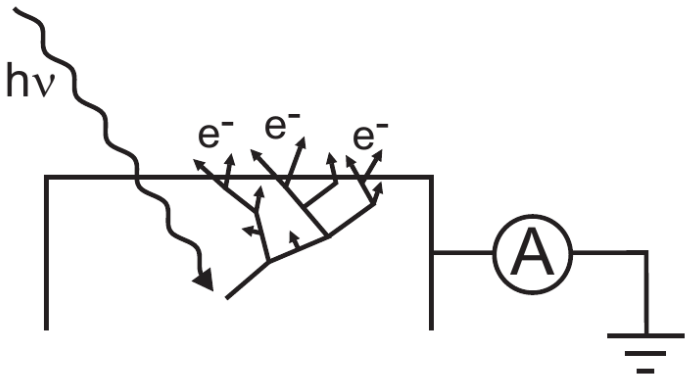
- Binding energy depends on charge density
  - Chemical Shift



from Henzler & Göpel: Oberflächenphysik des Festkörpers, Teubner (1994)

X-Ray Absorption Spectroscopy (XAS)

- Excitation of core-level electron in unoccupied state close to the ionization barrier
- Density of empty states
  - Spin-state, oxidation, ligand-field
- Requires tunable X-ray source
  - Synchrotron



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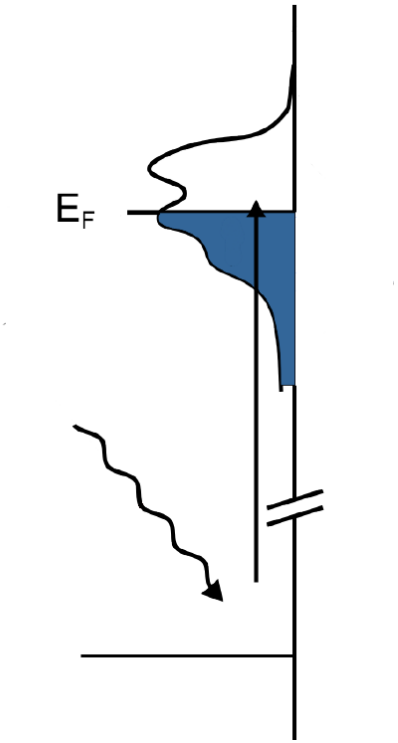
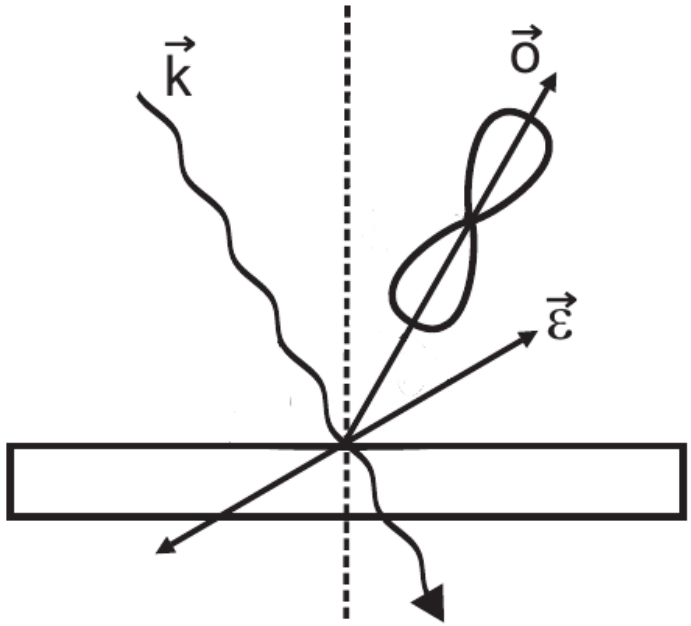


based on M. Bernien, Promotionsvortrag (2009)

Near Edge X-Ray Absorption Fine-Structure (NEXAFS)

- Element specific
- Probes unoccupied molecular orbitals
  - Chemical information
  - Orientation of orbitals
- Theoretical model via DFT



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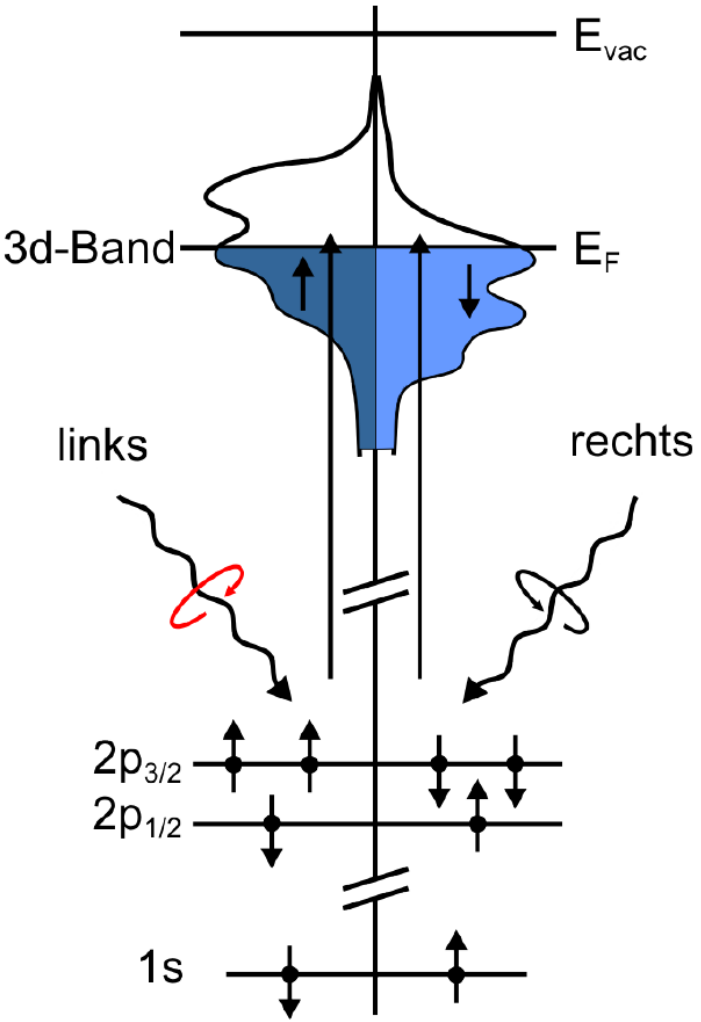
X-Ray Magnetic Circular Dichroism (XMCD)

- Element specific magnetic moments and magnetization



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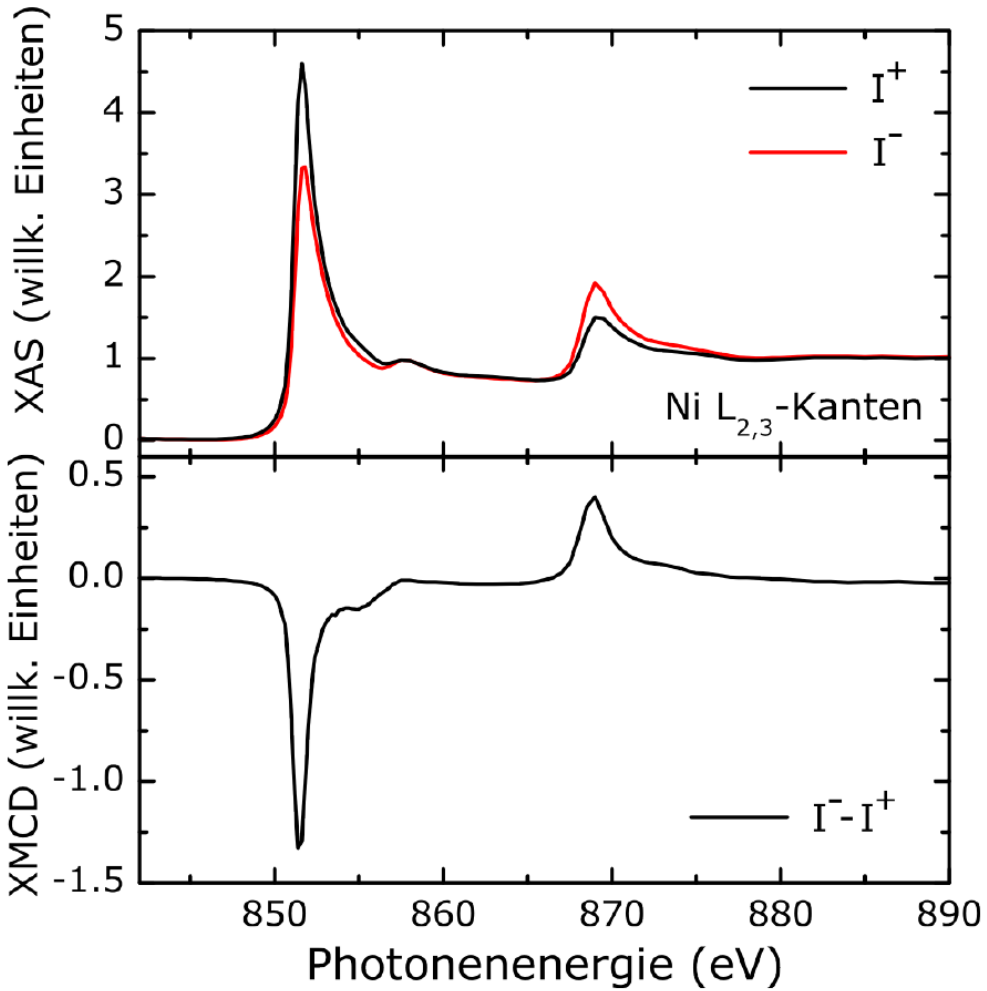

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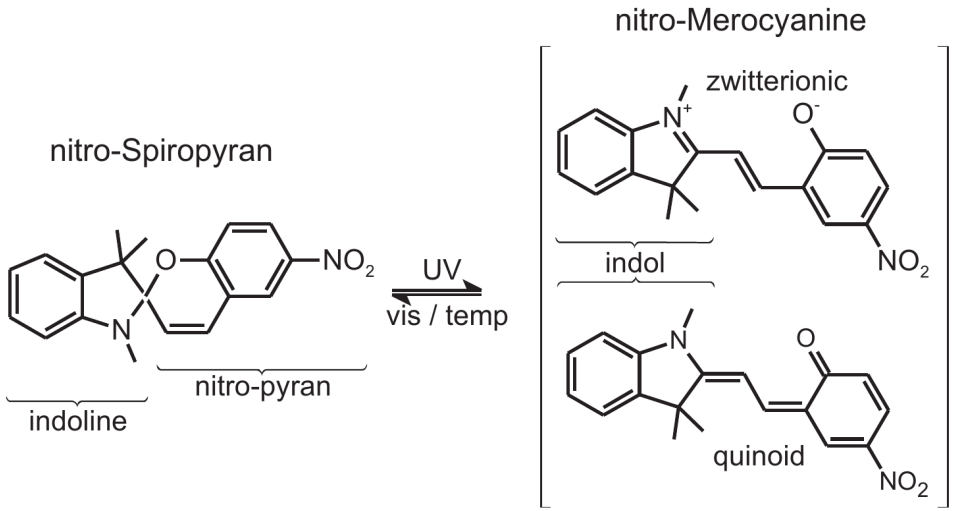
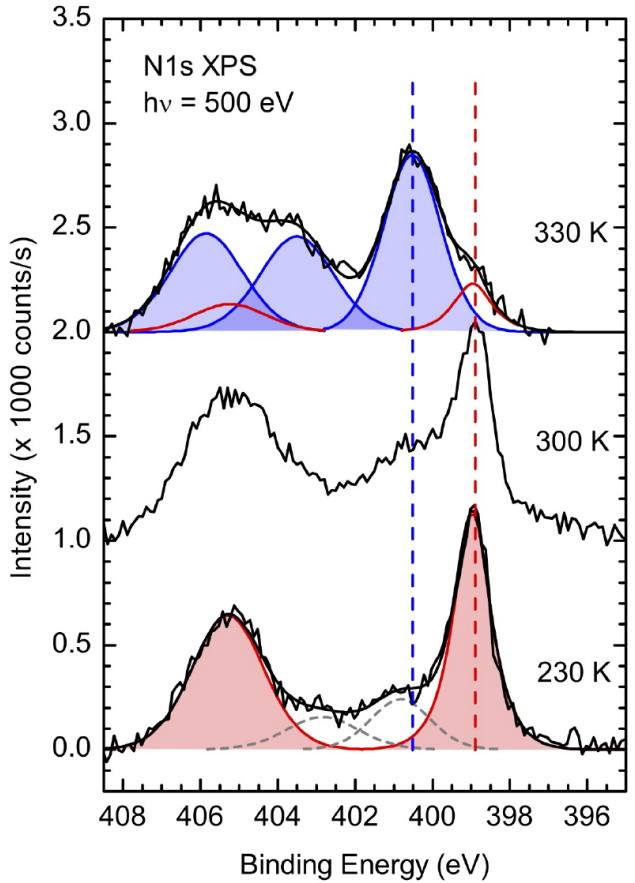
Outline

Conformational and Ring-Opening/-Closing Switches



- Spiropyran ring opening
- Orientation of adsorbed molecules via NEXAFS
- Inhibiting interaction with surface



N 1s-XP spectra of Spiropyran/Au(111) during heating. Both fig. from M. Piantek, FU-Berlin Diss (2009)

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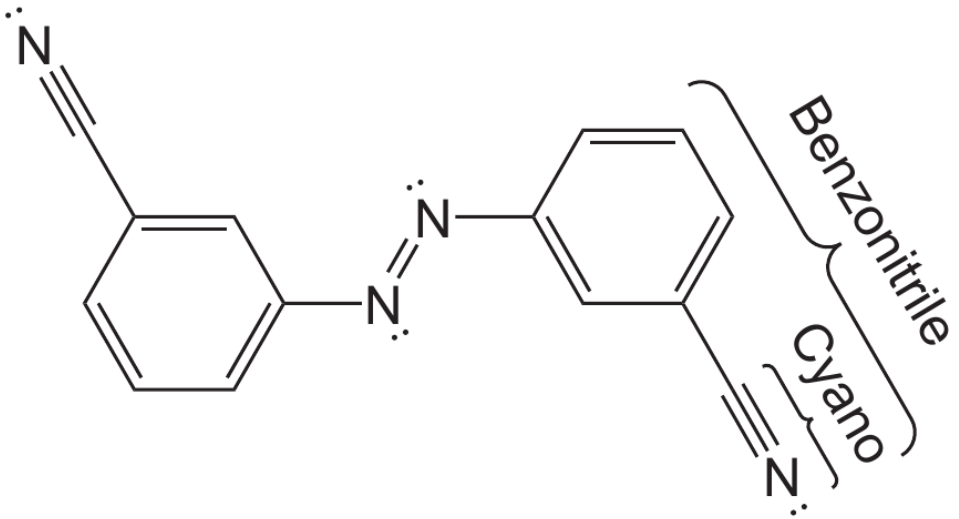

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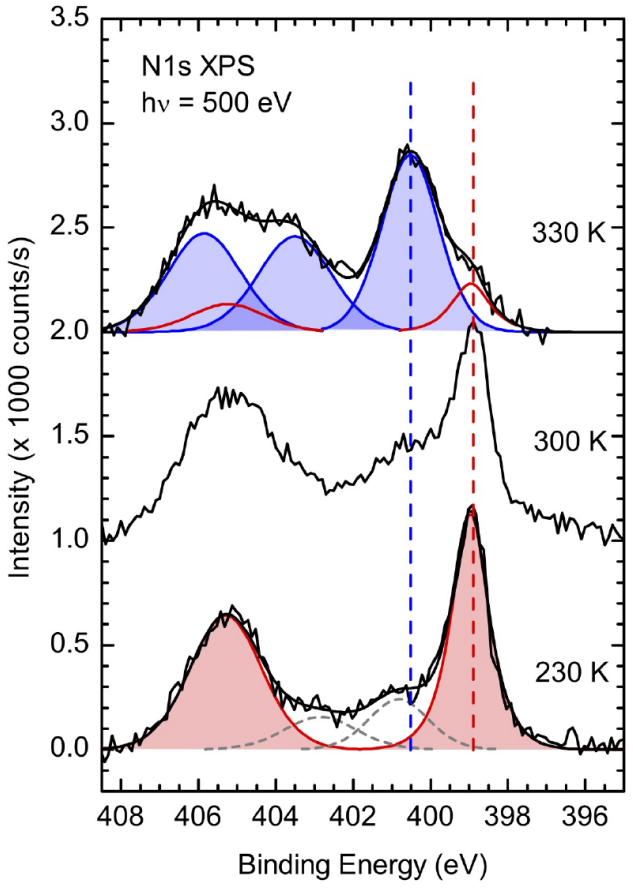

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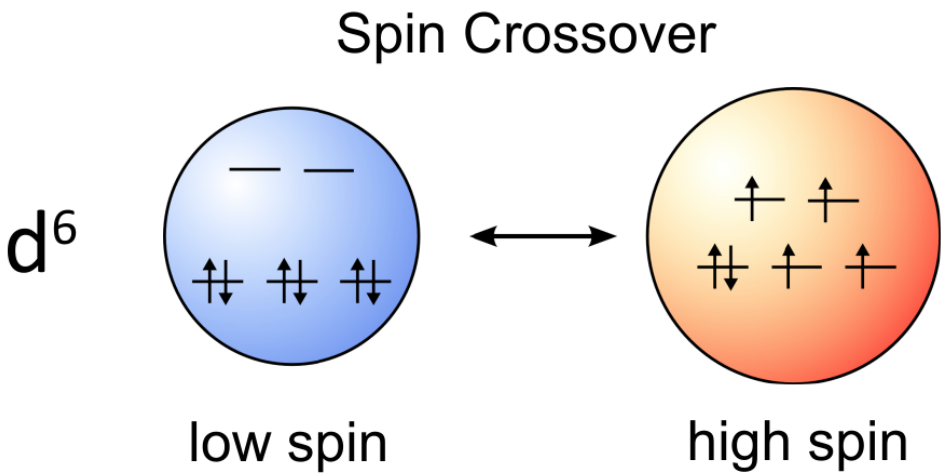
Adsorbed Spin-Crossover Switches

- Two metastable spin-states (low-spin and high-spin).
- Switchable by temperature, light, ...

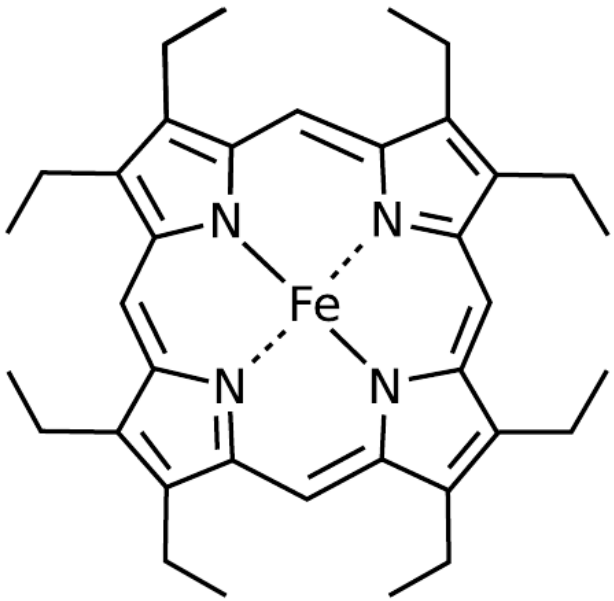


from M. Bernien: Spin Crossover in a Vacuum-Deposited Submonolayer of a Molecular Iron(II) Complex, DPG-Talk 2013

- Other talk

Reversible Switching of Magnetic Properties by Ad- & Desorption of NO.

- Planar molecules (metalo-porphyrins) allow for manipulation of metallic ion
- Adsorption of NO-molecule switches magnetic properties
- Reversible by desorption



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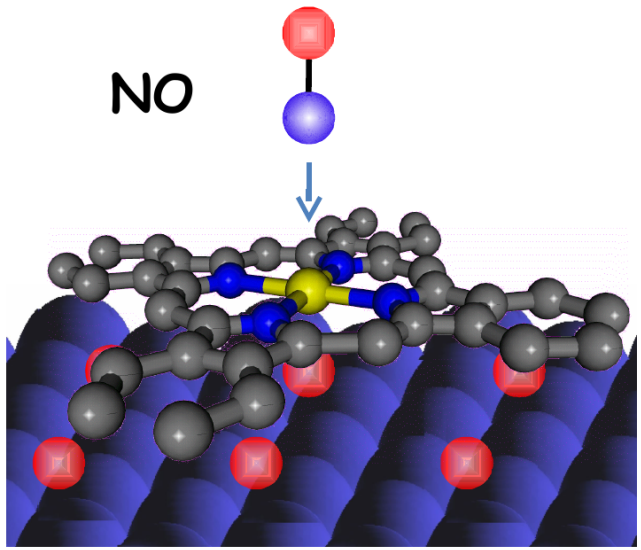
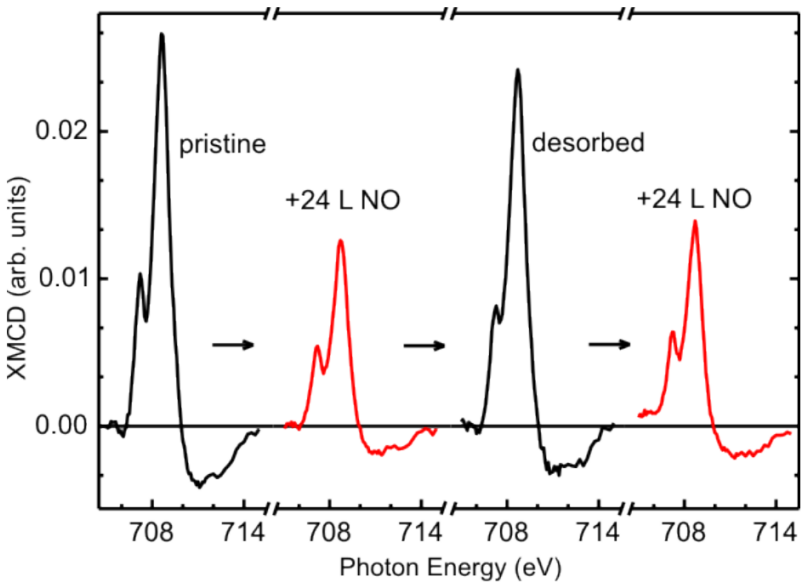
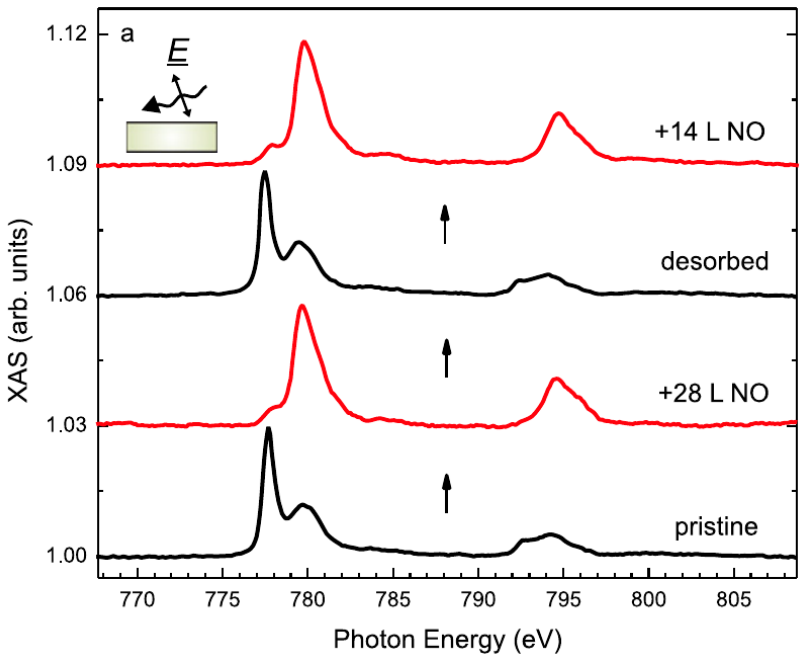


from W. Kuch, et al., “Magnetismus und laterale Ordnungsphänomene von schaltbaren Molekülen auf Oberflächen”, Poster

Reversible Switching of Magnetic Properties by Ad- & Desorption of NO.



Fe-L_3 XMCD spectra of Fe-OEP on O-Co/Cu(001) at 120K. From J. Miguel, et al., J. Phys. Chem. Lett. 2, 1455 (2011)



CoOEP on O-Ni/Cu(001) measured with p-linear polarized light at an angle of 20° at 130K. Desorption was ensured by heating to 350K. Spectra are shifted vertically. From C.F. Hermanns, et al., J. Phys.: Condens. Matter 24 394008 (2012)

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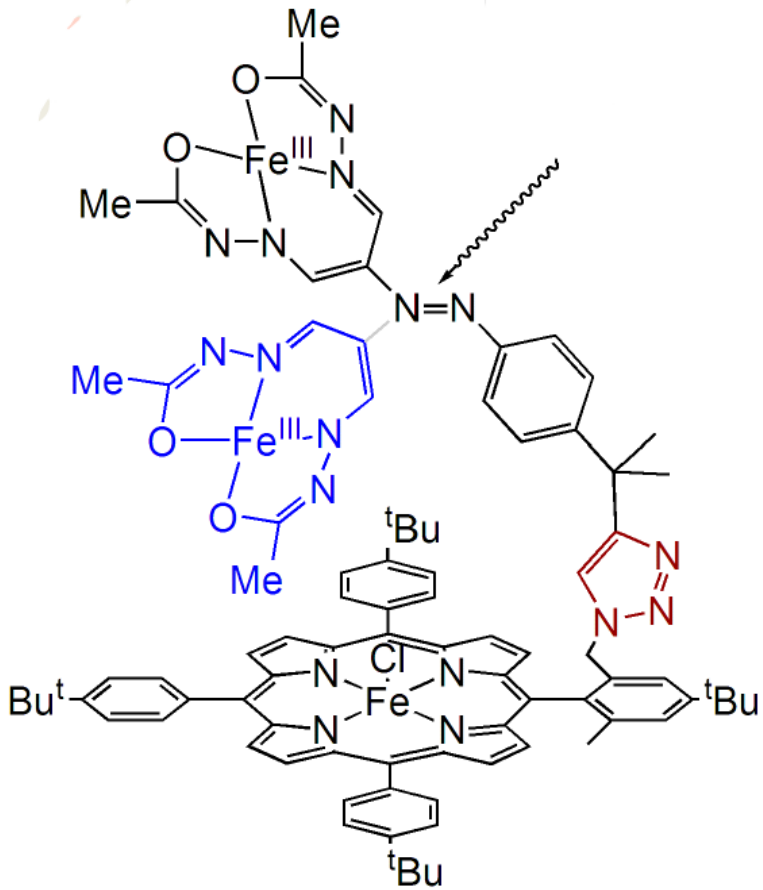
Outlook: Magnetic Properties of Adsorbed Metal Complexes

- Study influence of substrates to spin-cross-over switches
- Coupling surface - substrate of porphyrine & phtalocyanine
- Dual-core metal-complexes
  - Intramolecular coupling
  - Possible switching?



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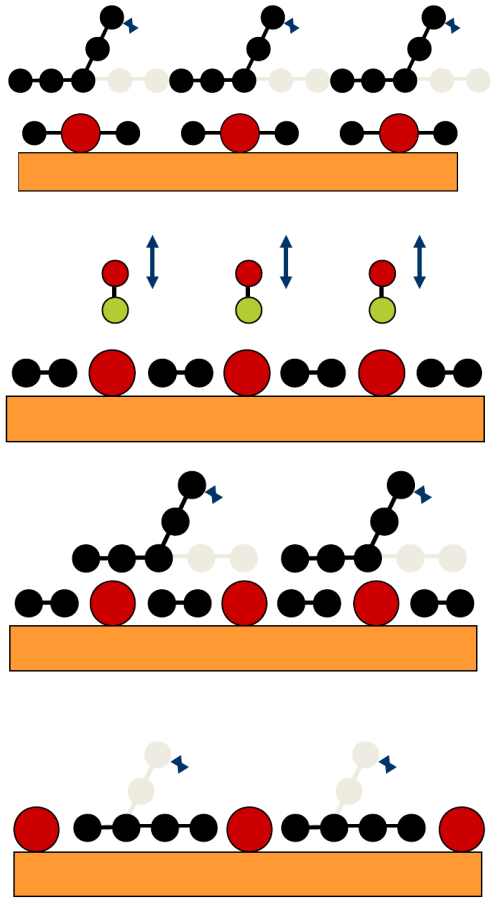
Outlook: Molecular Switches on Magnetic Surface-Structures

- De-couple switches from substrate
- Influences to magnetic properties of substrates
- Self-assembled networks
  - lateral coupling of molecules



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Q&A

- Questions?