# Switchable Spin States in the Solid State

## Researchers at the FAU developed a novel spin-crossover complex

Metal-organic spin-crossover complexes exhibit the unique possibility to switch between two distinct states with high or low total spin. They thus represent promising materials for a new generation of functional devices which take advantage of this phenomenon at the molecular scale. Scientists at the FAU (Friedrich-Alexander Universität Erlangen-Nürnberg) now published investigations on a specifically developed spin-crossover complex in the journal "Angewandte Chemie" (http://dx.doi.org/10.1002/anie.201504192). This complex is able to undergo the spin transition from a paramagnetic (*magnetic*) state in a diamagnetic (*non-magnetic*) state and reversely triggered by light irradiation at room temperature and in the solid state.

## A new generation of switchable molecules

The energetically more stable spin state of a metal complex is generally determined by the influence of its ligands. Spin-crossover complexes represent a class of materials where both spin states are energetically so similar that they can be transferred into the other state by an external stimulus ("spin crossover"). Besides variation of pressure or temperature, the reversible switching upon light irradiation is an elegant way to control the spin state  and thus the magnetic properties of the material.

Up to now, spin crossover has only been demonstrated using light irradiation at very low temperatures (< -220°C or -364°F), in solution, or triggered by a light-induced phase transition in the solid state. The iron(II) complex which was developed in the group of Dr. Khusniyarov extends the possibilities for exploiting this phenomenon significantly, as it is switchable at room temperature, in the solid state and at the molecular level – all preconditions for implementation in modern spintronic devices. The scientists achieve this by including a special ligand which can be photo-chemically closed upon irradiation with UV light ($\lambda = 282$ nm) and opened again when it is irradiated with visible light ($\lambda > 400$ nm).

## Synchrotron radiation as chemically sensitive probe for determining the spin state

After the light-induced spin crossover has already been successfully demonstrated in solution, the challenge was the exact determination and quantification of the spin state  after light irradiation in the solid state. Many methods used as standard do not meet the experimental preconditions for this purpose. The published results are the product of a close collaboration of the scientists at the FAU and their colleagues  at the synchrotron ELETTRA (Trieste, Italy). Using synchrotron radiation, the group of Prof. Fink and their Italian partners showed that the spin state can be altered upon light irradiation, and determined the fraction of switched molecules within the material experimentally.

The use of synchrotron radiation has the crucial advantage that each element can be addressed specifically due to its characteristic interaction with X-rays. The fraction of ligands with their rings closed has thus been determined using X-ray photoelectron spectroscopy probing the sulphur atoms whereas the high-spin and low-spin fractions have been quantified investigating the X-ray absorption fine structure at the L-edge of the iron centre of the complex. The combination of these methods shows that the transition of the spin states is directly triggered by the photochemical reaction in the ligands, not only in solution but also in the solid state.


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