DESCRIPTION FOR THE GENERAL PUBLIC

Magnetic materials are widely applied in everyday life, medicine and industry. They are used in magnetic recording media, credit cards, compasses, microphones, electric motors and generators, or magnetic resonance imaging. Solid magnets which themselves generate a permanent magnetic field are usually made of metals (e.g. Fe, Co, Ni, Gd), intermetallic solid solutions (e.g. $Co_{17}Sm_2$, $Nd_2Fe_{14}B$), or metal oxides (e.g. CrO_2, Fe_3O_4, Fe_2O_3), and their synthesis is related to energetically demanding metallurgical processes. About 30 years ago, it was shown experimentally that permanent magnets could be completely different, built of molecules instead of metals or metal oxides. Such molecular magnets constructed from paramagnetic molecules, which can be metal complexes or organic radicals, exhibit a wide range of magnetic properties, including magnetic coupling through molecular bridges and long-range magnetic ordering below critical temperature.

An extraordinary group of molecular magnets exhibit a number of very specific physical phenomena that can not be observed in classical metallic or metal oxide-based magnets. In particular, some molecular magnets based on molecules or coordination chains behave almost like single magnets. This fascinating phenomenon observed for molecules called Single-Molecule Magnets (SMMs) is the basis for the application of molecular magnets to store information in individual ions, which would give the density of information at an unprecedented level.

Another interesting feature of selected magnetic molecular materials is the spin bistability, that is the co-existence of two different magnetic states which can be switched through external stimuli such as temperature, light, pressure, reversible dehydration, or the introduction of other molecules (guests) into the crystalline structure. There are a number of molecular switches that exhibit the bistability of both magnetic and optical properties, which is extremely promising in the context of the construction of information storage and processing devices, as well as in the construction of sensors, displays, and building blocks for molecular electronics and spintronics. Molecule-based magnets are also attractive objects for the implementation of multifunctionality, that is the synthesis of materials combining a few co-existing or interacting physical properties. This was beautifully exemplified by molecular photomagnets which magnetic properties can be switched by light irradiation. Other interesting group of chiral molecular magnets reveal the unusual magneto-optical phenomenon of magnetization-induced second harmonic generation (MSHG).

In this regards, the objective of our project is to obtain unique switchable molecular magnets. In particular, we are interested in the synthesis of magnetic molecular switches that will work at room temperature due to the fruitful use of various external stimuli. We are also interested in unique photo- and thermoswitchable molecule-based magnetic materials displaying new, unprecedented physical phenomena, and multifunctional molecular switches, combining photomagnetism, chirality, and sensitivity to reversible dehydration and level of humidity.

To achieve this, we will employ novel heterometallic coordination networks with cyanide bridges, that is the combination of various metal ions bridged by cyanide (CN^-) ligand in the crystalline solid phase. We will apply a synthetic molecular building blocks approach, whereby coordination networks can be reasonably designed and obtained by a careful selection of metal ions, organic and inorganic molecules. In our project, we will use the polycyanide complexes of transition metal ions that are combined with other metal ions, both transition metals and lanthanides, and with the additional, but very important, small organic molecules with aromatic rings. The resulting coordination networks will be the basis of new crystalline materials serving as efficient molecular switches with the desired properties, and exhibiting new, previously unknown physical phenomena. As the part of our project, we also plan to make a thorough correlation between the structures of the prepared metal assemblies, and their optical and magnetic properties under the influence of various external stimuli. This will allow us to formulate the general principles governing the crystal engineering of molecular switches, and to modify synthetic procedures to improve the functionality of switchable molecular materials, which in future will facilitate their application in nanotechnology, spintronics and electronic devices.