DESCRIPTION FOR THE GENERAL PUBLIC

There is an extensive worldwide interest in fabrication of photoluminescent and magnetic materials. Photoluminescence is the ability to emit light after absorption of photons. This property opens a numerous vital applications in cathode ray tubes, X-ray detectors, optical storage materials, amplification in optical communication, lighting, display devices, light-emitting diodes, elements of light conversion devices, chemical sensing, molecular thermometers and biomedicine. Photoluminescent effects were found in several group of compounds, including organic molecules or inorganic solids incorporating lanthanide ions.

On the other hand, magnetic materials which reveal spontaneous permanent magnetization, and attract other magnets, are broadly utilized in industry and everyday life. It is enough to count such applications as magnetic recording media, credit cards, microphones, compasses, magnetic resonance imaging, and electric motors. These applications are mainly assigned to classical permanent magnets made of metals, such as Fe or Co, intermetallic compounds, such as $Nd_2Fe_{14}B$, or metal oxides, such as Fe_2O_3/Fe_3O_4.

Several years ago, it was shown that magnets can be constructed of very different components, that are molecules replacing typical metals or metal oxides. Such molecule-based magnets are usually based on crystalline materials composed of paramagnetic metal complexes or organic radicals. They are combined within the crystal structure in the way that magnetic coupling between them induce magnetic ordering, and permanent magnetization below specific critical temperature. This remarkable group of materials exhibits some very uncommon physical phenomena, not achievable for classical metal- or metal oxide-based magnets. In particular, some specific molecules built of highly anisotropic magnetic metal ions, like lanthanide(3+) ions, can behave as single, independent magnets below so called blocking temperature. These molecules, named Single-Molecule Magnets (SMMs) reveal very slow relaxation of magnetization due to the strong magnetic anisotropy. As a result, they exhibit the magnetic hysteresis, similar to those observed in permanent magnets. Thus, they are considered for the future application in information storage and processing at the unprecedented level of even individual ions.

Metal complexes of f-block of periodic table were reported to be the most efficient in construction of Single-Molecule Magnets with high blocking temperatures. Moreover, they were found to be an attractive source of photoluminescence related to their specific electronic structure resulting in very weak colour but often very strong emission after irradiation by not-visible UV or near-infrared light. Therefore, coordination compounds based on lanthanides and actinides are great candidates in achieving the extraordinary materials which combine photoluminescence and magnetic anisotropy. Such multifunctional materials, which can exhibit at least two different physical properties, are now strongly desired in the aspect of growing technological demand for continuously smaller, faster, and less energy consuming devices that execute several works at the same time.

In this regards, the objective of our project is to obtain the novel molecule-based materials exhibiting both strong photoluminescence with high emission intensity at room temperature, and strong magnetic anisotropy leading to the Single-Molecule Magnet behaviour with high blocking temperatures, comparable with the current record of 60 K.

We plan to achieve this by exploration of crystalline materials based on d-f coordination networks constructed of 4f/5f metal complexes with organic ligands which are further combined with cyanide complexes of transition metal ions. We will select appropriate organic ligands, usually small organic molecules with aromatic rings, and the specific cyanide complexes in order to induce visible light photoluminescence and magnetic anisotropy of attached f-block metal ions. Moreover, our compounds will contain solvent molecules, both coordinated to metal ions, and occupying the structural pores. Therefore, we will able to post-synthetically modify our compounds by controlled thermal desolvation and further functionalization by inclusion of guest molecules. It will result in the remarkable generation of much stronger photoluminescence and magnetic anisotropy, not achievable through straightforward synthesis. We will also check the reversibility of post-synthetic treatment of the prepared materials in order to use them in such applications as chemical sensing and advanced molecular switches. We will search for correlations between optical and magnetic properties that can be helpful in better understanding of the observed physical phenomena.

Our project is expected to give new synthetic pathways towards highly efficient multifunctional materials. In addition, we plan to formulate the more general principles governing the crystal engineering of luminescent molecular magnets which will greatly contribute to the current searching for the advanced materials with applications in light emitting devices, chemical sensors, as well as nanotechnology, spintronics, and electronic devices.