The MOF family of compounds base on metal-organic frameworks, in which small anions (in most cases formate ions) form a stable framework with metal ions. Small organic cations compensate the negative charge of framework and are located in created cavities. Great number and diversity of metal ions as well as organic cations let to combine them to form a different type of frameworks and adjust the expected properties of synthesized materials. MOF-type compounds have recently received a lot of attention due to their unique properties and potential applications. MOFs are called multifunctional materials, since often a few interesting physical phenomena are observed in the same phase. The most important are magnetic and electric ordering, structural, dielectric and luminescence properties. In recent years MOFs are extensively studied as a materials for use in catalysis, detection and storage of gases and bioimaging.

In presented project, two new families of luminescent MOFs were selected for studies. All compounds will be synthesized using solvothermal, diffusion and crystallization methods.

First family of studied MOFs is pure and chromium(III)-doped [cat][$M^{I}_{0.5}Al_{0.5}(HCOO)_3$], where M^{I} = K(I), Na(I), cat denotes various organic cations, such as ammonium, ethylammonium, hydrazinum, imidazolium etc. Our first trials show that these compounds have very promising and interesting structural and dielectric properties. Second family of studied compounds is pure and Er(III)/Eu(III)-doped [cat]$Ln(HCOO)_4$, where Ln denotes trivalent lanthanide ion, i.e. Er(III), Lu(III) and Y(III). Very few reports on materials belonging to this family showed they crystallized usually in chiral structures (without center of symmetry) thus may exhibit not only the efficient luminescence but also nonlinear optical properties or magnetoelectric ordering. We hope that structural phase transitions will be also present in studied MOFs and the combination of various sized organic cations with different metal ions will help us with determining the dependence between functionality, properties and structure. The main role in stability of structure play hydrogen bonds.

The main aim of the presented project is specifying of structural, optical, dielectric and phonon properties of new MOF compounds. All samples will be studied by selected methods of the solid state physics. First, using X-ray diffraction all structures will be solved and their purity will be checked. Second, the DSC measurements will be performed to find a structural phase transitions in broad temperature range. For samples, for which phase transition will occur, the structure of low- and high-temperature phases will be determined using X-ray techniques. Then, the dielectric and spectroscopic measurements will be performed. Raman and IR spectra will be measured at room temperature, then for samples with occurring phase transitions, temperature-dependent measurements will be performed to understand the mechanisms of the transition. For monocrystals polarized Raman and IR reflection spectra will be measured to better understand their properties. Excitation, luminescence and absorption spectra as well as lifetimes will be also measured and analyzed. For most interesting samples, high-pressure Raman experiments will be performed. We hope, that for some synthesized materials nonlinear optical or multiferroic behavior will be find.

There are also very few reports on lanthanide-based MOFs exhibiting up-conversion but such compounds are of great interest for their potential application in lasers, display and bioimaging. Our study will be significant contribution also in the field of up-conversion lanthanide MOFs.