Crystalline organic porous polymers upconverting light energy

The upconversion is a process usable for transformation of low into high energy radiation. The cost of a such transformation is the number of emitted light quants, which is at most two times less, that number of absorbed quants. Among potential applications of the TTA-UP, one may mention the diagnostic fluorescent imaging. For this purpose, the so called "optical window" of living tissues, corresponding to the red color of light radiation is used. As a consequence of the red light illumination, the emission of different and blue-shifted color is observed. This approach increases the selectivity of imaging, since only imaging agents are excited and no emission originating from surrounding tissues is observed. The other important field for the upconversion application is photovoltaics. The one of the most important parameters governing the single junction solar cells performance is the band gap of the absorbers. Usually, it is tuned to efficiently harvest the sun radiation energy allowing for its conversion with maximal efficiency of 33%. The sun energy exciding the band gap of applied absorber is transformed into heat. On the other hand, the sun energy lower than the band gap is not absorbed by the photovoltaic device at all. Thanks to the upconversion, it is possible to transform low energetic radiation into higher and usable radiation energies, that can be absorbed by the photovoltaic cell. The upconversion can increase the maximal theoretical efficiency of solar cells up to approximately 50%, simply by tunning the spectrum of incident radiation, and without the need for interference with the cell architecture.

So far, upconversion processes have been investigated using model systems based on solutions of photoactive substances or utilizing soft-matter, easily susceptible to temperature and other external factors. Such systems are not suitable for practical applications which require high stability of the materials used. The few reports of solid state converters show problem associated with low conversion. At the same time, these systems are poorly defined and it is impossible to properly determine the causes of low efficiency and thus take attempts to improve it.

The objective of this project is development and photophysical characterization of new type of self-assembled microcrystalline upconverting materials based on Covalent Organic Frameworks. The most essential feature of the target crystalline materials is their well-defined structure. It will consist of units absorbing low-energy radiation, units emitting high-energy radiation, and elements ensuring appropriate distances between them. Such proposed converter architecture is part of the novelty of the project. The target systems will allow to determine the relationship between the structure and physicochemical properties. The research will provide answers to questions about the influence of mutual orientation, distance and concentration of photoactive components on the upconversion efficiency. The obtained organic converters will be tested using a number of techniques allowing to determine their morphology, and spectroscopic techniques, providing insight into the nature of interactions between photoactive components.

As a result of the project implementation, processes disturbing energy conversion will be identified and rational methods of designing stable converters will be proposed. The direct effect of the project will be a new group of compounds, stable and allowing energy conversion with an efficiency of about 20%. Thus, conditions will be obtained in which the conversion process is not limited by the properties of the solid and crystalline matrix, but only by the properties of the photoactive units themselves. It is expected that the conducted synthetic work, optimization, and research on the physicochemistry of new converters will allow for the first time to obtain stable and well-defined converters with high application potential.