Engineering and production of advanced nanomaterials, become an interest research subject, recently. Undoubtedly, the reason of growing interest of nanotechnology and its products are unprecedented properties, resulting from the reduction of size of individual crystals or particles, less than 100 nm. One of the most important groups of recently investigated materials, are nanoparticles (NPs) containing lanthanide ions (Ln^{3+}) in their structure. The unique properties of NPs, such as luminescence ability are particularly interesting for bio-related applications, such as bioimaging, photodynamic therapy or drug delivery. A particularly important phenomenon is up-conversion emission of the NPs. In contrast to the classical luminescence based on down-conversion, up-conversion can convert the energy from the range of near infrared radiation to visible and ultraviolet light. Another dependency, which has been studied in materials containing Ln^{3+} ions is temperature influence on their spectroscopic properties. The knowledge about temperature impact on the luminescence properties of nanomaterials is important factor responsible for their future applications.

Therefore, the aim of the project is to synthesize and modify the surface of nanocrystals containing Ln^{3+} ions, and subsequently conjugate them with functional organic compounds. Chosen materials will be analysed as possible temperature sensors and the influence of temperature on the luminescence properties will be studied. Afterwards, the chosen NPs will be encapsulated in human erythrocytes for controlled drug loading and release. In order to estimate the impact of the NPs on human health, the cytotoxicity of the NPs will be analysed. An important part of the project will be investigation of the mechanism of the studied compounds' impact on cells. The theoretical ab-initio and semi-empirical calculations will be performed to support the understanding of the mechanism of nanostructures interactions with external environment and organic compounds bounded/adsorbed on the NPs surface.

The planned studies are interdisciplinary and concern still current and important issues connecting chemical or material sciences and biology. The performed research will result in the preparation of sophisticated nanomaterials and allow better understanding of their chemical, photophysical and biological properties. Due to the organic surface modification, the nanomaterials obtained will be bi- or multifunctional, exhibiting tuneable and multicolour luminescence. Studies of the temperature influence on the up-conversion luminescence may provide new information about mechanisms of excitation and observed emission. The theoretical calculations concerning surface energy, bond strength, structural distortions and spectroscopic properties of the nanomaterials obtained enable to design the energetically favoured products avoiding the time-consuming synthesis of numerous of nanosystems and subsequent selection of the desired ones. Essential goal of the research will be developed suitable methods of NPs encapsulation into the human erythrocytes. NPs doped with lanthanide ions are used in many fields, that's way at each stage of everyday life we meet them. Therefore, acquisition of information about their toxicity seems to be necessary. Moreover, realization of the project may contribute to protection of people directly exposed to nanomaterials' impact, e.g. engaged in their production. Obtained outcomes may contribute to a more responsible use of nanomaterials. Functionalization of inorganic NPs with luminescent properties, based on emission of the lanthanide ions could potentially increase their impact on the fundamental biomedical research and as a consequence caused significant progress in use of nanotechnology in medicine, as well in clinical practice.