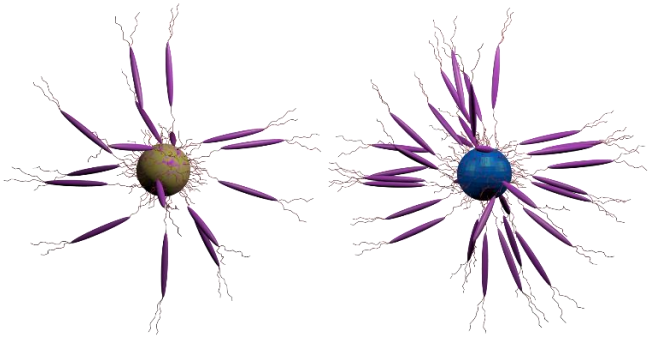
Goal

The goal of the project is to create new types of materials that exhibit the possibility to modulate light that shines on it, i.e. that can change IR light (not visible) into a visible light, by the means of upconversion* process (changing energy of photons, UC). These new materials will be built of very small parts of matter – nanoparticles. In our research we will prepare materials exhibiting UC that will have either the quality of emitting polarized light (can be compared to one direction emission) or of which internal structure (thus properties) will be switchable with the temperature changes. Both these qualities are required to fully exploit applicative potential of the UC materials.
Nanoparticles that exhibit UCare not the only interesting materials in the nano-world. For example solutions of fine grained gold have either red or blue colors. Physical effects that stand behind these colors will also be used in our work. By adding metal nanoparticles to UC nanoparticles we will enhance light emission. Importantly, magnitude of the emission strongly depends on the distance between different (metallic and UC) constituents of the structure, thus in our approach we will try to control this parameter. Of course it is not possible to manually control single nanoparticles thus we will achieve our goal by modifying the surface of the nanoparticles by organic compounds.

Description of the research

In the first stage we will prepare precursors of the materials that we need for further work. These will be both spherical and rod-like nanoparticles made of silver, gold and nanoparticles that exhibit UC. At the second stage we will obtain organic molecules, which have innate tendency to form liquid-crystalline phases and are temperature-responsive. The next stage will be devoted to the attachment of organic molecules to the surface of nanoparticle via specific anchoring groups. This way we will obtain hybrid materials – inorganic nanoparticles covered with organic coating (Fig. 1, stage 3). Hybrid particles with rod-like shape will be then used to prepare materials in which they all point to one direction (stage 4). We will then focus on the possibility of controlling spatial distribution of particles by using temperature (stage 5) to finally investigate optical and electronic properties of these materials to analyze their performance.



Rysunek 1. Schematic illustration of hybrid structures made of inorganic nanoparticles (spherical cores) and organic ligands (which have the possibility of forming liquid-crystalline phases) attached to their surface. The change of ligands spatial distribution causes changes of interparticle distances.

Reasons for choosing the research topic

For materials which we intend to investigate a number of applications is foreseen, e.g. in high-efficiency photovoltaic and photocatalytic cells, soft actuators, security inks or single-molecule microscopy. However, to maximally exploit their potential we need to resolve problem of their low efficiency, e.g. by ‘precise’ mixing of upconverting and metal nanoparticles. This ‘precision’ refers to control over interparticle distances. In our project it will be possible to dynamically switch the distances, which will allow to optimize parameters of the material. The achieved tunability will also be used to better understand working mechanism of similar materials. Finally, positive results should open the way to various applications of the obtained materials – specifically we will try to use them to enhance solar cells.

* upconversion proces relies on a non-linear absorption of two or more photons and emission of a photon of higher Energy than the one absorber