Warsaw, September 14, 2022

Abstract to the PhD thesis entitled: „Properties of upconverting nanoparticles and their application in photodynamic therapy"

The research presented in this dissertation pertains to upconversion phenomena in $NaYF_4$ nanoparticles doped with Yb^{3+} and Er^{3+} ions (UCNPs). These kinds of nanoparticles are capable of absorbing multiple low-energy photons which lead to high-energy photon emission. Despite the upconversion being widely investigated, there are still some aspects which require further examination. The aim of this work was to resolve three main issues concerning upconversion in lanthanide-doped $NaYF_4$ nanoparticles.

In the first part of this thesis, the influence of the magnetic field on upconverted luminescence (UCL) was explored. There are many conflicting reports on the impact of the magnetic field on the UCL. Reports have shown that magnetic field can enhance or attenuate UCL. The research presented in this work allows determining the source of these discrepancies. Namely, in different reports, a different excitation wavelength was used. The analysis of obtained results demonstrated that the magnetic field impacts the UCL by modifying the excitation efficiency. This is the consequence of Zeeman detuning in Yb^{3+} ions. Presented results revealed that the magnetic field influence on energy transfer and emission efficiency is neglected.

In the second part of this thesis, the impact of silver nanowires (AgNWs) on UCL efficiency in nanoparticles was examined. Plasmonic nanostructures are commonly used to enhance the UCL. The results presented in this work revealed that the interaction between UCNPs and AgNWs cause modification of the luminescence spectrum. Moreover, the decay luminescence measurements indicated that it is caused by an enhanced decay rate of $^4S_{3/2}$ state in Er^{3+} ions. Therefore, the efficiency of the three-photon excitation mechanism decreased.

In the last part of this dissertation, the results of upconverting nanoparticles application in photodynamic therapy (PDT) were demonstrated. To this end, the new method for Rose Bengal (organic dye) attachment to $NaYF_4$:2%Er,20%Yb surface was presented. The results of spectroscopic measurements demonstrated that obtained nanohybrids UCNPs-RB are capable of producing singlet oxygen. The experiments described in this work revealed that obtained UCNPs-RB might cause cellular damage and be an effective treatment method in deep located tissue, where the traditional PDT is not effective due to the high scattering of visible light. The *in-vitro* cell viability tests on 4T1 cancer cells showed that 250 μg/ml concentration of UCNPs-RB irradiated for 10 minutes by infrared light with 2 W/cm^2 power density reduced cell viability to about 30%. A comparison between the obtained results and other publications indicated that the nanohybrids prepared using the presented method are capable of destroying cancer cells as effectively as UCNPs-RB synthesised using other methods.

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