What is the contribution of near- and far-field properties of gold nanoparticles to the enhancement of singlet oxygen generation in hybrid systems?

Development of qualitative models to relate the essential details of plasmon-enhanced mechanisms to the fundamental aspect of nanoparticles (NPs) in terms of their intrinsic plasmonic near- and far-fields has become increasingly popular in recent literature. However, quantitative determination of contributions of the near- and far-fields to such mechanisms is notoriously complex and hard to achieve. In the project proposed we plan to apply a novel approach to elucidate and quantify the near- and far-field contributions to the plasmon-enhanced singlet oxygen generation in the model hybrid photosensitizer-metal functionalized gold NPs. Thanks to the numerous methods of characterizing NPs, it is possible to establish their physicochemical and optical properties. The research is aimed to demonstrate how near- and far-field interactions of nanoparticles affect the enhancement of singlet oxygen generation in hybrid systems. Determining the effect of these properties will allow the design and manufacture of systems that will most efficiently generate singlet oxygen. It is expected that the planned research should be of significant potential for photomedicine applications.

The specific research aims of the project encompass the synthesis and analysis of stability of metallic nanostructures coated with silica and sensitized by an organic dye for estimation of spectral parameters and photophysical properties of investigated systems, to confirm the enhancement of their ability to generate singlet oxygen by correlation of near- and far-field contributions. Research using complementary spectroscopic and microscopic methods will determine, which of the fabrication hybrid systems will be characterized better (higher) by the ability to generate singlet oxygen or luminescence emission (which determines the phototototoxicity or diagnostic utility of the system, respectively).

The planned research aims will allow to creation hybrid systems consist of photosensitizer (chlorophyll dye) and nanoparticles (functionalized gold nanorods and nanostars). Selected systems with defined geometric dimensions (aspect ratio of length and diameter nanorod, thickness of shell, sharpness corners of nanostars) and properly selected dye will be characterized by efficient use of energy absorbed, modified by plasmon interaction with a dye, leading to enhanced desirable photophysical parameters (generation of singlet oxygen in near- and far-field contributions). The use of fabrication nontoxic nanomaterials systems (gold, SiO_2) and natural organic dyes (chlorophyll derivatives) for biomedical applications will allow to open new horizons in the research work concerning the properties of hybrid systems for selective sensitization and the destruction or imaging of pathologically changed biological structures, while low phototototoxicity with respect to normal cells.