Plasmonic agents for bioimaging and photothermal therapy with red and NIR lasers

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Lasers play a significant role in modern medicine as they are used in many medical and surgical procedures. Among photoactivated agents, noble metals nanoparticles with pronounced plasmonic properties have extremely high potential, which allows them to effectively convert light into thermal energy, as well as enhance the optical response of reporter molecules. We represent here the study of a wide range of combinations of morphologically different gold nanoparticles and various molecular probes (fluorophores or Raman reporters). The agents under study have a core-shell structure consisting of a gold nanoparticle and a biocompatible polymer where molecular reporters are incorporated into a polymer shell.

Keywords — gold nanoparticles; bioimaging; tag; PTT

I. Introduction

Lasers play a significant role in modern medicine as they are used in many medical and surgical procedures. The accelerated development of agents for bioimaging, photodynamic (PTD) and photothermal (PTT) therapies activated by electromagnetic irradiation, contributes to the even greater entry of laser technologies into medicine. Among the photoactivated agents, noble metals nanoparticles with pronounced plasmonic properties, which allow them to effectively convert light into thermal energy, as well as enhance the optical response of reporter molecules, have extremely high potential [1]. Based on these nanoparticles, molecular-plasmonic structures optimized for a complex effect can be obtained, when a spectral detection of targeted cells is carried out along with a thermal treatment.

Anisotropic gold nanoparticles are considered to be one of the most effective as their plasmon resonance occurs in the first window of tissue transparency in the spectral range from 650 to 950 nm [2]. This work is addressed to the development of hybrid systems which are considered as new means of imaging and therapy of malignant neoplasms. We represent here the study of a wide range of combinations of morphologically different gold nanoparticles and various molecular probes (fluorophores or Raman reporters).

II. Methods and Results

A. General conception of developed plasmonic agents

The agents under study have a core-shell structure consisting of a gold nanoparticle and a biocompatible polymer. Molecular reporters are incorporated into a polymer shell. The design and optical concept of the developed plasmonic agents are presented in Fig. 1.

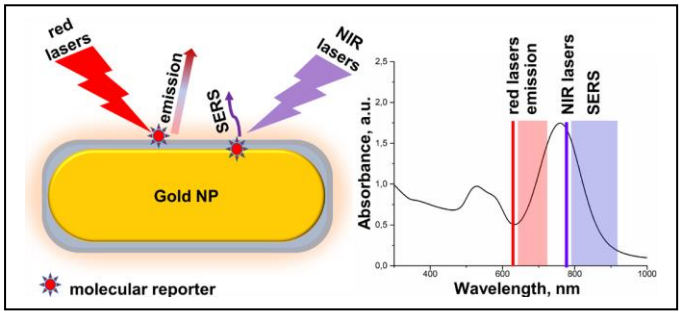

Fig.1. A) General structure of plasmonic agents for bioimaging and PTT; B) Optical conception of plasmonic agents.

B. Results and discussion

Obtained structures were subjected to wide spectral studies, mainly using absorption spectroscopy, Raman scattering, and fluorescence microscopy.

The plasmonic hybrids with the highest optical response underwent cell testing for bioimaging by fluorescence microscopy and Raman mapping, and primary tests for cytotoxicity were also performed for them. Concentrated suspensions of hybrid systems were tested on laboratory mices in fluorescence and computed tomography modes. For the agents under study, data on natural biodistribution upon their introduction into the bloodstream were obtained, and initial dose-dependent measurements were carried out. The test results showed that the studied agents are potentially biocompatible, and a dose of 23.7 mg/mL of atomic gold is sufficient for contrast imaging through the skin barrier.

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