

Optimization of the Synthesis of Au@SiO₂ Core-Shell Nanostructures, And Their Modification

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Extended Abstract

Core-shell nanoparticles are interesting due to their small size and their hybrid composition. The core of these materials is usually made of metallic nanoparticles (nanosilver, nanogold) because they have plasmonic or antimicrobial properties [1]. In turn, the shell is most often a chemically neutral material such as silica. The task of this material is to reduce the toxicity of nanoparticles contained in the core, ensures colloidal stability and thus prevents agglomeration of metallic nanoparticles, and eliminating the effect of quenching the fluorescence emission [1], [2]. However, one of the most important steps in working with core-shell nanomaterials is their synthesis. By selecting the appropriate conditions for its execution, it is possible to control the shape, size, as well as the thickness of the coating and the degree of agglomeration.

It is generally known that the most durable connections are covalent bonds, which also applies to the core-shell structures with the properties-modifying molecule. Before this happens, chains ending with an amine (-NH₂), thiol (-SH), or carboxyl (-COOH) group are needed to functionalize the shell [3]. Apart from selective bonds, these groups are responsible for the appropriate distance from the structure's core. In this type of modification, an important aspect of the work is the determination of the number of active groups on the surface of the coating. For this purpose, a useful method in terms of using a small amount of sample and good repeatability is to use a method known from peptide chemistry described in [3].

The aim of the research was to obtain and modify core-shell nanostructures with the structure of nanogold coated with silica (Au@SiO₂). To confirm the success of the syntheses carried out, the characteristics of the obtained nanomaterials were made using the following methods: Transmission Electron Microscopy (TEM), UV-Vis Spectroscopy, and Fourier Transform Infrared Spectroscopy (FT-IR). Many syntheses have been carried out for various amounts of stabilizing agent (surfactant), reducing agent and silica coating precursor. The modification of nanostructures with amine and thiol groups was also performed. Moreover, the number of active groups on the silica surface was determined for them.

The obtained results allowed to obtain important information on the synthesis of nanostructures. First, that as the added amount of surfactant increases, the tendency of the nanostructures to form larger agglomerates decreases. The effect of reducing the amount of hydrazine as a reducing agent is to obtain a nanostructure with a more uniform shape, as well as to increase their sphericity. Finally, reducing the amount of tetraethoxysilane added results in a thinner silica shell around the gold core. The obtained nanostructures were successfully attached i.a. amine groups that have been estimated to amount to about 5-8 μmol/g on the surface of the silica depending on the various molar absorption coefficients available in the literature.

References

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