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„Gold nano- and microparticles: synthesis, deposition and their assembly into 2D structures"

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Abstract

Nanotechnology is a scientific area on the boundary of chemistry, physics, and material engineering. Its essential aspects are design, synthesis, and analysis of nano- and microobjects, as well as their organization into complex and ordered systems. Interestingly, despite years of intense research, our understanding of the processes occurring at the nanoscale is not complete. Usually we fail to predict the properties of new nanomaterials, and designing their synthesis is still a process of trial and error.

Unusual features of nanoparticles make them interesting objects of scientific research. Moreover, nanostructures, having uncommon optical, electrical, and magnetic properties have enormous application potential. They are used, for example, in medicine, the chemical industry, electronic and optical devices, but also in everyday consumer goods like cosmetics and household chemicals. The range of applications is constantly growing, so new types of nanomaterials and methods for their synthesis and manipulation are still needed.

In this dissertation I present the results of my research in the field of nanotechnology. The studied nanostructures are presented in order from the smallest to the biggest objects. First, the results on the organization of gold nanoparticles having 5 nm in diameter and functionalized with organic ligands are described. A new method for their immobilization on solid substrates is introduced, and a way of controlling the density of the deposit is presented. The described gold nanoparticles attach to the solid surface und undergo morphological changes: Their spherical shape flattens and the extent of this deformation depends on the composition of the organic protecting shell on the nanoparticle. Interestingly, I found that after cleaning such deposited nanostructures using oxygen plasma treatment, the particles partially restore their spherical shape. They become, however, larger and their arrangement on the substrate differs from the initial one. The reason is that during the plasma treatment the AuNPs behave like droplets of a non-wetting liquid, exhibiting an ability to move and merge. Experimental evidence suggests that the process of the re-formation of these small gold clusters

orders their crystallographic structure, as a result changing their catalytic properties. This conclusion follows from the analysis of morphologies of the plasma-treated nanoparticles after their autocatalytic growth in various growth solutions. The obtained new shapes differ from those observed for nanoparticles prepared without plasma treatment.

The abovementioned findings are described in the first four sections of the Results chapter (4.1 - 4.4). The last two sections, namely 4.5 and 4.6, present microscopic gold structures called microflowers (AuMFs). The AuMFs are branched particles of ~2 μm in diameter and originate in the reaction of two reagents in an aqueous solution. I show that the morphology of these microstructures can be easily tailored by a proper composition of the reaction mixture as well as by the reaction time. In section 4.5, the kinetics of their synthesis is described and stages of their formation are analyzed. Also, the mechanism of the morphological changes of the AuMFs in time is proposed. In section 4.6 an exemplary application of the AuMFs is described. I demonstrate that the AuMFs form stable deposits on solid substrates and exhibit high enhancement of the Raman scattering. These features make them useful in fabricating analytical platforms for surface enhanced Raman spectroscopy (SERS). In this section a method for fabrication of a sensitive and repeatable new SERS platform, with several possible modifications, is described.