

UNIVERSITY ALEXANDRU IOAN CUZA IN IASI, ROMANIA

PHYSICS FACULTY

Habilitation thesis

*Contributions to the study of metallic nanoparticles with
applications in life sciences*

Prof. univ. dr. Dorina-Emilia CREANGA

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Summary

In this thesis are presented the main results in the study of some metallic nanoparticles that we have synthesized and characterized from the viewpoint of physical-chemical features aiming to evidence their interaction with various biological structures. The approach of this domain is related to some actual trends of the science of nanostructured materials to ensure the efficacy of their utilization in biomedical sciences with simultaneous diminution of side effects in humans, as well as of the environmental pollution risks.

In the first Chapter are described the laboratory methods applied for the synthesis of magnetic nanoparticles based on iron oxides and mixed iron and other metals oxides - such as cobalt and zinc. Details are given on the experimental variants of magnetic nanoparticle chemical co-precipitation resulting in colloidal suspensions in hydrocarbons but mostly in aqueous fluids, by coating metallic cores with various organical molecules to balance the agglomeration and sedimentation tendencies.

For colloidal suspensions of nanoparticles composed by iron oxides coated with oleic acid for their stabilization in liquid hydrocarbons, there were taken into account the samples provided by co-precipitation of ferric and ferrous ions in alkali reaction medium in comparison with the products of the wet-milling technology - that processes micrometric particles in the presence of simultaneously supplied oleic acid and liquid hydrocarbons.

The genotoxicity of such nanoparticle oily suspensions was studied on widely cultivated plants, considering final delivery in the environment of nanoparticles following their utilization in various technical applications.

Then, comparative analysis was presented with focus on iron oxide nanoparticles stabilized in aqueous suspensions with citric acid, by varying acidity, stirring procedure, precursor iron salts. By using other organic molecules as ingredients for the stabilization of iron oxide nanoparticles in aqueous medium, new series of colloidal suspensions were synthesized and analyzed in this thesis.

Parallel study was carried out on colloidal suspensions of nanoparticles of magnetite, cobalt ferrite and zinc ferrite - all being stabilized in water by adding sodium oleate - the best hydrophilic substitute of oleic acid, known to develop strong interactions with metal ions at the surface of magnetic grains.

The samples characterization was focused on microstructural features investigated through electron microscopy, X-ray diffraction, small angle X-ray scattering or neutron scattering, as well as on their magnetic properties, since these are essential for the product stability and availability for utilization in biomedicine: either for contrast agents in magnetic resonance imaging or as vectors in targeting drug molecules or in the experimental cancer therapy through tumor hyperthermia.

Some cytogenetic effects were evidenced in vegetal embryos of widely cultivated agroindustrial plant species.

Coating with silica of magnetite/maghemite nanoparticles capped with citrate or oleate ions was studied aiming to increase their surface reactivity for further grafting of some biomolecules of interest in biomedicine.

In Chapter II we presented the results of magnetic nanoparticle supply in various biological materials: blood, bacterial and fungal cell cultures, and animal cells.

In each situation specific tests and analyses were carried out to evidence the interaction of magnetic nanoparticles with every type of cells considered for the investigation of possible effects in the body or in the environment.

In Chapter III we have investigated non-magnetic metallic nanoparticles such as gold nanoparticles coated in citrate or chitosan as they resulted during synthesis by reduction of gold salts with sodium citrate or by synthesis in the chitosan polymer presence. We studied the influence of stabilizing agents added in the reaction media or/and the influence of sample exposure to light beam, on the structural features and stability of colloidal gold suspensions.

Some bioeffects were evidenced by analyzing the impact of citrate/gold nanoparticles on microorganisms from environment as well as by the experimental investigation of chitosan/gold nanoparticles interactions with animal tissues. At the end of this chapter are mentioned several complementary research directions in biomagnetism such as the study of some bioeffects of electromagnetic fields but also the analysis of bioelectromagnetic activity of cardiac and visual systems; also experimental studies that were initiated in radiobiology field are mentioned.

In Chapter IV the teaching activity is presented: new courses introduced during the development of biophysics and medical physics sections, books published to support some of these courses and the practical application lessons; we mentioned the results of young people involving in research activity with underlying of their participation to traditional events in our

faculty as well as to national and international scientific conferences, and also the papers published with students in journals with ISI impact factor.

In Chapter V we have presented the plans for the continuation of the previously developed research directions by new technological approaches of preparing nanoparticles and multilayered nanocomposites based on mixed oxides of iron and other ions with magnetic or non-magnetic features.

For teaching, the focus will be the continuous improvement of communication with students, either undergraduate or master students, to prepare them properly for further doctoral studies. Through the intensification of international collaboration relationships larger number of students could be involved in Erasmus program mobilities, for example, for the benefit of our Physics Faculty as well as of Alexandru Ioan Cuza University in Iasi - since the international image and prestige of our affiliation institution is of greatest interest for all of us.