Citric Acid-Coated Magnetite Nanoparticles. Previous Fundamental Studies to Biomedical Applications

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Abstract
Line to the objectives of the scientific initiation program at UNICAMP, in this work we present partially results of an interdisciplinary and larger project that involves the synthesis, characterization and basic studies of magnetite nanoparticles, as well as cytotoxicity and drug delivery studies on rats. Specifically, citric acid-coated magnetite nanoparticles (Fe$_3$O$_4$) were synthesized by the co-precipitation method. Citric acid shell was employed with three central objectives: to avoid the nanoparticle aggregation, to ensure a stable dispersion in water, and to guarantee the biocompatibility of the magnetite nanoparticles. Citric acid-coated magnetite nanoparticles (Fe$_3$O$_4$) of mean diameter of 7.2 nm and a standard deviation of σ = 0.25 were synthesized by the co-precipitation method. Citric acid shell was employed with three central objectives: to avoid the nanoparticle aggregation, to ensure a stable dispersion in water, and to guarantee the biocompatibility of the magnetite nanoparticles. Structural properties of the obtained nanoparticles were characterized by X-diffraction, small angle X-ray scattering and transmission electron microscopy techniques. Magnetic behavior was studied by means of magnetization vs. magnetic field and ZFC-FC curves. Size-dependent magnetic parameters such as anisotropy, magnetic moment per particle, blocking temperature, and dipolar interaction energy were inferred using basic phenomenological approaches. Magnetic and structural results indicate the presence of non-compact cluster and the overall magnetic response is near to the superparamagnetic state.

Key words:
Magnetism, nanoparticles, biomedicine.

Introduction
The common use of magnetism is recent. Nowadays, the society uses magnetism in all kinds of daily activities and the research about the subject is massive. One of the lines of research is the study of magnetism in nanoparticles (the materials have different properties in relation of the equivalent in macroscopic scale). In this category, when the ultimate goal is applications in organic, more careful is necessary to guarantee that the nanoparticles will not prejudice the animal. So, to achieve this, the nanoparticles are recovered with organic shells. The hope is that this research, in a near future, help the medicine to solucinate various deseases that actualy have no good medications, same as cancer.

Results and Discussion
The aproach of this scientific initiation was more closer than usual of the research of the lab where it was made. In it was made the synthesis of the sample, taked measurements and made characterizations. All main results of research are so wide to explain in a single page, then, a exemple is the Image 1 below, that shows the magnetization as a function of the applied field at room temperature. The saturation magnetization (obtained from Langevin formalism) was 42 emu/g. As a first approximation, one can say that the experimental curves seem to be typical of systems with single domain nanoparticles, showing a coercive field of zero, which is in accordance to a system in thermodynamic equilibrium.

Conclusions
This scientific initiation allowed a closely aproach with the methods, theory and applications of this research. Participating in activities in that is possible to do for an undergraduate student, provided a real perspective of the subject beyond the learning of important concepts of the research in magnetic nanoparticles.

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