Supervisor's report

Academic year: **2022/2023**

Student: **Mgr. Tereza Sojková**

Doctoral programme: **Advanced materials and nanosciences**

Field of study**: Advanced nanotechnologies and microtechnologies**

Supervisor: **Assoc. Prof. Roman Gröger**

Name of doctoral thesis topic: **Optimization of magnetic nanoparticles for hyperthermia in viscous environments**

Tereza Sojková began her Ph.D. study in the fall semester of the academic year 2018/2019 when she has also joined my CEITEC research group Multiscale Modelling and Measurements of Physical Properties (RP1) at the Institute of Physics of Materials (IPM), Czech Academy of Sciences.

The main objective of her Ph.D. Thesis was to optimize the protocol for the synthesis of superparamagnetic iron-oxide nanocubes and investigate their properties in media of a wide range of viscosities. Her dissertation contains six chapters appended by the list of publications and references. *Chapter 1* provides the motivation for this work and sets the limits of AC magnetic field amplitudes and frequencies that are safe for human body. *Chapter 2* summarizes the objectives of this work, which are split into three topics investigated in the forthcoming text. *Chapter 3* gives a theoretical background for the present work, including the procedure for deducing the values of specific absorption rates (SAR) from measured data. *Chapter 4* gives a broad overview of the methods used to characterize the structure and physical properties of nanoparticles (NPs). The major *Chapter 5* summarizes the results obtained on dextran-coated NPs prepared by co-precipitation, NPs prepared by thermal decomposition with $Fe(acac)_3$, and core-shell NPs prepared by thermal decomposition with Fe(III) oleate. This part also contains time-resolved XRD measurements of spontaneous oxidation of NPs from wüstite to magnetite. Using two-state Master equations, the heights of the energy barriers for these NPs were shown to depend logarithmically on time (this is unlike the bulk materials, where the energy barriers are fixed). Moreover, particle size distributions measured for four different particle sizes were used to deduce the corresponding effective anisotropy constants, which are used in the extension of the Néel-Brown model of non-interacting particles. The SAR values of individual NPs were measured as functions of viscosity (mixture of water and 0-50% of glycerol) with the best results obtained for 20 nm particles. *Chapter 6* summarizes the main findings of this project. An especially interesting result is that when the NPs are used in magnetic particle imaging, they exhibit a factor of 3 better properties than the commercial tracer VivoTrax.

In her first year, Tereza was in charge of establishing a chemical laboratory at IPM dedicated for the synthesis of nanoparticles. Her help was indispensable in choosing the right equipment for the characterization of nanoparticle systems, which complemented our recently modernized Laboratory for the Preparation and Analysis of Materials (LaPAMat), and the Laboratory of Electron Microscopy. Throughout her Ph.D. program, Teresa was very focused on solving the main objectives of her work. She did not hesitate to put together a wide range of experimental techniques (much wider than I have initially intended to use) to explore the properties of her samples from the bottom up. She was self-sufficient at coordinating these measurements and required very little or no interference from my side. A part of this work has been done during the 10-month research stay of T. Sojková at IIT Genova, under the supervision of prof. Teresa Pellegrino (one of the world-leaders involved in the research of superparamagnetic nanoparticles for magnetic hyperthermia of tumors).

Our joint work on describing the kinetics of oxidation of the wüstite phase to magnetite under the presence of a minor concentration of goethite was quite enlightening on both sides as we were able to learn a lot from each other. Tereza was very instrumental in helping younger colleagues at IPM with chemistry-related problems of their projects. She has learned scanning electron microscopy quite quickly, especially the transmission mode for particle imaging of which she is now the exclusive user at IPM. The images of her NPs were used by the group of prof. Adam Herout at the Faculty of Information Technology BUT for the purpose of developing models for rapid shape recognition and characterization of particle sizes (joint TAČR project "GEFSEM" of NenoVision with IPM, CEITEC, and RCPTM Olomouc). Throughout her Ph.D. program, Teresa has made a numerous presentations for the general public, Open Days, Science Nights, Science Fairs, etc.

This work presented in the dissertation of Tereza Sojková provides a sufficient amount of new results to make her eligible for the award of the degree of the Doctor of Philosophy (Ph.D.). Upon the successful defense of her dissertation she will assume the position of a research staff at IPM.

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