Lanthanum-Strontium Manganite Nanoparticles for Magnetic Hyperthermia: Fine Tuning of Parameters by Substitutions in Lanthanum and Manganese Sublattices

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Hyperthermia (HT) is a rapidly developing technique in cancer therapy. It takes advantage of the higher sensitivity of tumor tissue to heat and typically involves heating of the affected organ to 42 – 45 °C. Magnetic nanohyperthermia [1] allows minimizing side effects by the localized heating of only desired parts of the organism. The method involves introduction of magnetic nanoparticles (MNPs) into the desired part of the organism and heating them with an alternating magnetic field (AMF).

Magnetic fluids based on nanocrystalline Fe_3O_4, stabilized by biocompatible surfactants, are typically used as HT mediators. Unfortunately, due to impossibility to control the local temperature near the particles, there is a risk of overheating and necrosis of normal tissue. This problem could be solved with MNPs of high efficiency of AMFabsorption and a Curie temperature (T_C) of 42 – 45 °C. Thus, local temperature control can be ensured even with a nonuniform distribution of mediator particles throughout the tissue, variable AMF intensity and uneven dissipation of the evolving heat.

Substituted perovskite manganites $La_{1-x}Sr_xMnO_3$ (x = 0.2 – 0.4) are of interest in this context due to easy tunable composition-dependent $T_C$and relatively large magnetic moment at room temperature [1,2].The Curie temperature of $La_{1-x}Sr_xMnO_3$strongly depends on the chemical composition: it displays a maximum at $x\approx$ 0.3 ($T_{C\max}\approx$ 370 K) and is quite sharply reduced as x deviates from 0.3. A smoother change of the Curie temperature can be reached by additional substitutions either in manganese sublattice, or in lanthanum sublattice. Such substitutions are expected to insure reliable and controllable shift of the $T_C$towards the range, which is necessary for hyperthermia treatment.

In this work, the effects of partial substitutions in lanthanum and manganesesublattices on structural, magnetic and calorimetric properties of (La,Sr)MnO_3MNPs have been studied. Fe substitution for La, as well as Nd and Sm substitutions for Mn have been usedin the experiments. The possibility of fine control of magnetic parameters has been proved experimentally. It is demonstrated that chemical substitutions may serve as anefficient tool to “softly”tune the maximal temperature achieved during the AMF-induced heating of MNPs, which is important for application of these materials as mediators of self-controlled magnetic nanohyperthermia.

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[2] O. Kaman, T. Dedourkova, J. Koktan et al., *J. Nanopart. Res.* **18** (2016) 100.