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La0.80Ag0.15MnO3 Magnetic Nanoparticles for Self-Controlled Magnetic Fluid Hyperthermia

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Abstract : Current nanomaterials for use in biomedicine are based mainly on iron oxides and on present knowledge on magnetic nanostructures. Manganites can represent another material which can be used optionally. Manganites and their unique electronic properties have been extensively studied in the last decades not only due to fundamental interest but to possible applications of colossal magnetoresistance, magnetocaloric effect, and ferroelectric properties. It was found that the oxygen-reduction reaction on perovskite oxide is intimately connected with metal ion e.g., orbital occupation. The effect of oxygen deviation from the stoichiometric composition on crystal structure was studied very carefully by many authors on $LaMnO_3$. Depending on oxygen content, the crystal structure changes from orthorhombic one to rhombohedric for oxygen content 3.1. In the case of hole-doped manganites, the change from the orthorhombic crystal structure, which is typical for La1-xCaxMnO3 based manganites, to the rhombohedric crystal structure (La1-xMxMnO_3 where M = K, Ag, and Sr based materials) results in an enormous increase of the Curie temperature. In our paper, we study the effect of oxygen content on crystal structure, thermal, and magnetic properties (including magnetocaloric effect) of La1-xAgxMnO_3nano particle system. The content of oxygen in samples was tuned by heat treatment in different thermal regimes and in various environment (air, oxygen, argon). Water nanosuspensions based on La0.80Ag0.15MnO_3 magnetic particles with the Curie temperature of about 43oC were prepared by two different approaches. First, by using a laboratory circulation mill for milling of powder in the presence of sodium dodecyl sulphate (SDS) and subsequent centrifugation. Second nanosuspension was prepared using an agate bowl, etching in citric acid and HNO3, ultrasound homogeniser, centrifugation, and dextran 40 kDA or 15 kDA as surfactant. Electrostatic stabilisation obtained by the first approach did not offer long term kinetic and aggregation colloidal stability and was unable to compensate for attractive forces between particles under a magnetic field. By the second approach, we prepared suspension oversaturated by dextran 40 kDA for steric stabilisation, with evidence of the presence of superparamagnetic behaviour. Low concentration of nanoparticles and not ideal coverage of nanoparticles impacting the stability of ferrofluids was the disadvantage of this approach. Strong steric stabilisation was observable at alcaic conditions under pH = ~10. Application of dextran 15 kDA leads to relatively stable ferrofluid with pH around physiological conditions, but desegregation of powder by HNO_3 was not effective enough, and the average size of fragments was to large of about 150 nm, and we did not see any signature of superparamagnetic behaviour. The prepared ferrofluids were characterised by scanning and transition microscope method, thermogravimetry, magnetization, and AC susceptibility measurements. Specific Absorption Rate measurements were undertaken on powder as well on ferrofluids in order to estimate the potential application of $La_{0.80}Ag_{0.15}MnO_3$ magnetic particles based ferrofluid for hyperthermia. Our complex study contains an investigation of biocompatibility and potential biohazard of this material.

Keywords : manganites, magnetic nanoparticles, oxygen content, magnetic phase transition, magnetocaloric effect, ferrofluid, hyperthermia
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