Influence of metal doping on the magnetic and hyperthermic properties of ferrite nanoparticles

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Spinel ferrites (MFe_2O_4) nanoparticles (NPs) have an enormous potential in many applications, from data storage to electronics, energy conversion, and biomedicine. Depending on the nature of the divalent transition metal M, the magnetic, catalytic, electric, and optical properties of the ferrite can differ considerably. Among the different potential applications of ferrite NPs, one of the most promising is their use as heat mediators for Magnetic Fluid Hyperthermia, a thermal cancer treatment that exploits the heat released by NPs when exposed to alternating magnetic field.[1] The most studied ferrites in this field are iron oxides (magnetite, Fe_3O_4, and maghemite, γ-Fe_2O_3), thanks to their good biocompatibility and suitable magnetic properties. However, cobalt ferrite ($CoFe_2O_4$) presents better hyperthermic performances, thanks to its high magnetic anisotropy, but its use is hampered by the potential toxicity of Co.

Within this framework, we attempted to obtain cobalt ferrite-based NPs that exhibit reduced toxicity, while retaining their unique magnetic properties, through two different strategies: i) the reduction of Co-content, through the preparation of non-stoichiometric cobalt ferrite NPs ($Co_xFe_{3-x}O_4$); ii) the doping of cobalt ferrite NPs with divalent Zn ($Co_xZn_yFe_{3-x-y}O_4$). In this contribution, we present the investigation of the magnetic and hyperthermic properties of highly monodisperse cobalt- and cobalt-zinc ferrite NPs as a function of the amount of both Co and Zn content. We focus on the dependence of the hyperthermic efficacy on the magnetic and structural properties and we analyse the role of magnetic anisotropy in increasing the heat release capability. The obtained results indicate that the maximum of hyperthermic efficiency and of magnetic anisotropy is reached for intermediate Co content,[2,3] and that a small amount of Zn significantly improves hyperthermic performances by increasing the saturation magnetization. Finally, the Co-doping strategy was found to be extremely efficient in reducing the melanoma cells viability in *in vitro* hyperthermic tests using ferrite NPs mineralized inside the internal cavity of the ferritin protein.[4]

References

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