An advanced thermal decomposition method for the synthesis of novel cobalt-doped core (magnetite) – shell (maghemite) iron oxide nanoparticles with ultrahigh heating efficiency for systemic magnetic hyperthermia

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Keywords

Magnetic hyperthermia, nanoparticles, ovarian cancer, LHRH peptide, AMF

Abstract

Owing to the low heating efficiency of currently available magnetic nanoparticles, it is challenging to reach therapeutic temperatures above 44 ^{0}C in tumors that are generally difficult to access after systemic delivery of nanoparticles at clinical dosage (10 mg kg^{-1}). In order to solve this problem, we have developed an advanced thermal decomposition method for the synthesis of novel cobalt-doped core (magnetite) – shell (maghemite) iron oxide nanoparticles (Co-Fe_3O_4/γ-Fe_2O_3) with an ultrahigh ILP of 48.0 nH m2 kg^{-1}. Our in vivo research shows that these nanoparticles containing a cancer-targeting peptide are biocompatible and accumulate well in ovarian cancer grafts after being administered systemically at a concentration of 4 mg kg-1. When exposed to an external AMF (420 kHz, 26.9 kA m^{-1}), the delivered nanoparticles elevate temperature in both subcutaneous and metastatic cancer tumors to 50 ^{0}C. This newly developed synthesis method can be used for the synthesis of both non-doped core-shell nanoparticles and core-shell nanoparticles doped with different metals (e.g., Ni, Co). As a result, this strategy could be extended to the development of novel nanoparticles with even greater heating performance, further advancing systemic magnetic hyperthermia for cancer treatment.