Superparamagnetic magnetoferritin nanoparticles: syntheses, characterization and applications

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Ferritin is a widely existing iron-storage protein in many living organisms throughout animals, plants and bacteria. It is a cage-like protein with an external diameter of 12 nm and an inner diameter of 8 nm. The structure of mature mammalian ferritin consists of a 24-subunit protein, composed of heavy-subunits (H) and light-subunits (L). Within the ferritin protein cavity, there is a very weak magnetic hydrous ferric oxyhydroxide (ferrihydrite) mineral core. In the past few decades, great progresses have been made in synthesis of various strongly ferrimagnetic nanoparticles using ferritin proteins (e.g., Meldrum et al. 1992; Douglas et al. 1995; Kramer et al. 2004; Mann et al. 1993; Mann and Meldrum 1991; Yamashita et al. 2004). Importantly, through advancements in genetic engineering, the recombinant human H-chain ferritin (HFn) was developed and used to synthesize mono-dispersed, non-interacting ferrimagnetic magnetoferritin (M-HFn) nanoparticles. These biomimetic synthesized ferrimagnetic magnetoferritins have stoichiometric magnetite cores with nearly sphere in shape, extremely narrow size distribution, high crystallinity, and are superparamagnetic at ambient temperature (e.g., Uchida et al. 2006; Cao et al. 2010; Walls et al. 2013). Recently, we have well demonstrated that the M-HFn nanoparticles can be directly used to visualize diverse tumor tissues and in vivo imaging of microscopic tumors, due to their dual functionality of active tumor-targeting ability and inherited peroxidase-like activity (Fan et al. 2012; Cao et al. 2014; Cai et al. 2015). In this paper, we will present new results of syntheses, characterization, and biomedical applications of the M-HFn nanoparticles. It has been found that the magnetic properties, relaxivity and peroxidase-like activity of M-HFn nanoparitles are size dependent. Moreover, the cobalt-doped M-HFn nanoparticles (M-HFn-$Co_xFe_{3-x}O_4$) can enhance the peroxidase activity and tumor tissue visualization.

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