Mangetic Nanoparticles as Vehicles for Multidisciplinary Medicine

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The idea of having a "doctor" inside a body is a good metaphor for the use of nanoparticles in multidisciplinary medicine. Indeed, the ability to carry out diagnosis and therapy simultaneously (termed as theranostics) opens new options in medicine. Magnetic nanoparticles (MNPs) are protagonists in multiple bioapplications, one of them being excellent T_2 imaging agents in MRI. Additionally, MNPs based drug delivery has been proposed as a suitable vehicle for overcoming pharmacokinetic limitations associated with conventional drug formulations. Considering also the heterogeneity of enhanced permeability and retention effect, magnetic targeting could boost the accumulation of MNPs in the diseased area. The prerequisites for using MNPs in bio-applications are multifaceted and include specific physicochemical characteristics (size, shape, structure and surface chemistry) and enhanced magnetic properties, which would lead the way to a desirable biodistribution, image contrast, target selectivity and sustained drug release. The successful preparation of primary MNPs with desired characteristics is the preliminary step to move forward to the new generation of secondary nanomaterials, which can be designed via appropriate post-synthetic functionalization of the primary MNPs. The strength point of these secondary nanoplatforms is the combination of the magnetic properties of the core with the versatility of an organic coating able to impart new and specific functionalities.

We have undertaken a study where we focus on synthetic parameters to control the size, composition, magnetization and colloidal stability of biocompatible coated ferrites, MFe_2O_4 (M=Mn, Co, Zn) as well as secondary magnetic nanoplatforms. Microwave assisted or conventional heating solvothermal and hydrothermal routes were employed for the synthesis of the inorganic nanocrystals while polyethylene glycol (PEG), octadecylamine (ODA), oleic acid (OA) and oleylamine (OAm) where utilized to tailor the organic surface. In that manner hydrophilic (PEG), hydrophobic (OAm), amine group functionalized (ODA) and carboxylate group functionalized (OA) ferrite MNPs were fabricated. PEGylated MNPs where evaluated solely as imaging agents while $–NH_2$ and –COOH functionalized MNPs were also converted to nanocarriers by the conjugation of anti-inflammatory and Alzheimer's disease drugs via amide bond coupling (Fig. 1). Shifting from the synthesis and functionalization, complex architectures were prepared with combined functions. In specific, magnetic colloidal superparticles (MSPs) of the same and/or different hydrophopic (OAm coated) MNPs were prepared. Multi-responsive water-soluble graft copolymers, prepared also by us, and or Sodium dodecyl sulfate (SDS) were used to serve as multifunctional polymeric platforms for the encapsulation of MNPs into the hydrophobic cores of the micellar structures. All MNPs, magnetic nanocarriers and nanoplatforms were thoroughly characterized and evaluated for their theranostic potential.

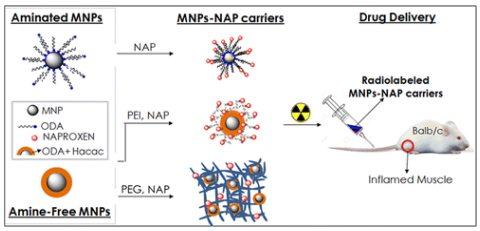

Fig. 1. Conjugation of anti-inflammatory drug on $–NH_2$ functionalized MNPs.

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