Magnetic nanoparticles for effective theranostics: role of interparticle interactions

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Cancer is one of the most severe and widespread health problems faced by today's medicine. The existing techniques (such as surgery, chemotherapy and radiotherapy) have low survival rate and strong side effects. Magnetic hyperthermia is an emerging cancer therapy which can be applied on its own or in combination with chemotherapy or radiotherapy. Magnetic nanoparticles (MNPs) show promising perspectives for both therapy (magnetic hyperthermia) and diagnostics (MRI). In recent years the role of MNPs and their interaction has been discussed in terms of theranostic uses (particles capable of both therapy and diagnosis).

The application of MNPs in vivo treatment requires understanding the formation of interparticle aggregation in a biological environment and the role of such structures for theranostics. MNPs are in general produced in fluid suspension, with a coating shell to prevent aggregation. In vivo experiments have shown that, once injected into the biological environment, the particles cluster together forming agglomerates of different sizes and shapes [1]. This agglomeration process has important impacts on bio-compatibility, insertion of the particle into the tumour, on magnetic hyperthermia and on MRI.

In this work, a magnetic core-shell structure is developed, which promotes the formation of vortexlike intraparticle magnetization structures in the remanent state. This leads to reduced dipolar interactions between two neighbouring MNPs. while during an MRI scan, the presence of a DC magnetic field induces the formation of MNP chains, introducing increased local inhomogeneous dipole fields that enhance relaxivity. The core-shell MNPs also reveal an augmented anisotropy, due to exchange coupling to the high anisotropy core, which enhances the specific absorption rate. This in vivo tumour study reveals that the tumour cells can be clearly diagnosed during an MRI scan and the tumour size is substantially reduced through hyperthermia therapy by using the same FePt@iron oxide nanoparticles, realizing the concept of theranostics [2].

[1] Etheridge, Michael L., et al. "Accounting for biological aggregation in heating and imaging of magnetic nanoparticles." *Technology* 2.03 (2014): 214-228.

[2] Yang, Ming Da, et al. "Magnetic Interaction of Multifunctional Core–Shell Nanoparticles for Highly - Effective Theranostics." *Advanced Materials* 30.50 (2018): 1802444.