Small zinc doped iron oxide nanoparticles for magnetic particle imaging

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Magnetic particle imaging (MPI) has garnered significant attention in biomedical imaging research due to its excellent signal intensity that is generated directly from superparamagnetic iron oxide nanoparticles (SPIONs). [1] Small nanoparticle tracers with high saturation magnetisation are crucial for MPI as they can prolong circulation, cross the blood brain barrier and enhance cellular uptake. Significant research has focused on improving magnetic properties of SPIONs of core size larger than 20 nm, because the M_{sat} value is directly related to SPION size, ie larger SPIONs have larger MPI signal intensity.[1] However, larger nanoparticle size leads to a large hydrodynamic size after coating that can compromise biological performance.[2] Previous work by our group highlighted the potential of 14 nm Fe@Fe_3O_4 NPs as small MPI tracers. The use of more highly magnetic zero-valent Fe resulted in 3x greater M_{sat} value than typical SPIONs of same size and achieved a similar MPI signal to VivoTrax.[3] There is an opportunity for the development of small tracers made of other highly magnetic materials to achieve even higher M_{sat} and improved signal intensity in MPI to surpass standard tracers. In this project, we used zinc and iron to synthesise zinc doped SPIONs to optimise the magnetic properties of magnetite. The synthesised Zn-IONPs samples achieved up to 57% and 64% enhancement in M_{sat} and MPI, respectively, compared to magnetite nanoparticles of the same size. As a result, the polymer coated Zn-IONPs with hydrodynamic size of less than 60 nm achieved 2.1- and 2.7-fold improvement in MPI signal intensity for core size of 11 nm and 15 nm, respectively, compared to commercial VivoTrax. With the small size and high MPI performance, these Zn-IONPs will be more effective MPI tracers in prolonging blood circulation time, enhancing cellular uptake and crossing the blood brain barrier, which is crucial for applications such as hyperthermia, cellular tracking, dementia and leukemia studies.

References

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