Development of magnetic nanoparticle assemblies with selectable size and tunable properties

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Magnetic nanoparticles are an important component of a wide range of functional materials due to their size-dependent magnetic properties. Stable suspensions of superparamagnetic iron oxide nanoparticles, in particular, have important applications in biomedicine as drug delivery platforms, mediators for hyperthermia, and as contrast agents for magnetic resonance imaging (MRI). Control of nanoparticle size, and of the emergent size-dependent magnetic properties, is critical to the performance of magnetic materials and is also of fundamental scientific interest.

The controlled assembly of individual nanoparticles into larger clusters provides a route to novel materials with tunable collective properties, while still maintaining the size-dependent magnetic properties of the individual nanoparticles. The development of iron oxide nanoparticle clusters for biomedical applications is critically dependent on the ability to control cluster size, architecture, and surface composition, as these properties are known to regulate biodistribution and the extent of MRI contrast enhancement.

A new method for the assembly of size-selectable iron oxide nanoparticle clusters through competitive stabilizer desorption will be presented. The unique feature of this approach is that previously stable suspensions of monodisperse nanoparticles are perturbed by the introduction of a tertiary phase that competes for the stabilizer. Due to solvophilic conditions, this effect induces slow formation of monodisperse clusters with a size that can be precisely controlled over the range of 15 – 200 nm. Field-cycling ^{1}H NMR relaxation measurements of the cluster suspensions allows the analysis of the superparamagnetic relaxation rate enhancement as a function of cluster size, and the evaluation of their potential MRI contrast enhancement. Finally, the iron oxide clusters can be further surface functionalized to produce hybrid nanocomposite materials, providing new opportunities for the integration of multiple desired functionalities onto the magnetic cluster core.