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Biomimetic Synthesis of Magnetosomes for MRI Application

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Extended Abstract

The application of nano-scale vesicles for drug delivery in biomedicine has accelerated in recent years and they are now extensively used in patient treatment (Abra, Bankert et al. 2002, Ren, Liu et al. 2012). Encapsulation of drugs and state of the art chemical engineering of the vesicle membranes (Ganta, Devalapally et al. 2008), to release payloads at predetermined locations (in response to specific stimuli), has resulted in increased efficiency in treatment targeting and vastly reduced patient side effects. Magnetic nanoparticles (MNPs) are used to significantly improve the targeting potential of vesicles, in the presence of a magnetic field. In addition the MNPs have properties which can be exploited for enhanced diagnostics (with Magnetic Resonance Imaging) and therapeutics (magnetic hyperthermia induction). Successful application of such treatments demands high levels of monodispersity and reproducibility with respect to the MNPs which in turn ensures a reliable and consistent magnetic response on application. Achieving monodisperse, reproducible MNPs within a vesicle synthetically is a difficult process and generally requires post-loading of MNPs produced via high temperatures and harsh chemical environments.

In the current study, to address monodispersity, we mimic the processes obvserved in magnetotactic bacteria, to create magnetic nanovesicles which are both biocompatible and fully functionalisable for precisely targeted biomedical application. Magnetotactic bacteria are organisms that have optimised the production of monodisperse, reproducible MNPs via biomineralisation within internal vesicles; termed magnetosomes. The magnetosome contains a single MNP which has been biomineralised within a lipid membrane. This process is governed by specific proteins which control the formation of vesicles; accumulation; and loading of iron ions; maintenance of the internal vesicle pH; and nucleation and formation of the MNP. (Tanaka, Mazuyama et al. 2011). Here we demonstrate the synthetic creation of both lipid and polymer vesicles via high throughput engineering techniques which are then used as nanoreactors for the precipitation of MNPs in a process analogous to that observedin magnetotactic bacteria – but offering easier isolation more suited for biomedical application and functionalisation.

We investigated the potential for these magnetic nanovesicles for both their diagnostic/contrast agent capability in MRI; and their therapeutic capability as seen in magnetic hyperthermia to treat tumours (Pankhurst, Connolly et al. 2003, Pankhurst, Thanh et al. 2009). The magnetic nanovesicles have the potential to be further functionalised for the simulataneous delivery of therapeutics.

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