4aa Synthesis and Controlled Clustering of Magnetic Nanoparticle Suspensions

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The dynamic response of composite structures incorporating magnetic nanoparticles can be exploited in a wide range of applications including microfluidics and high energy absorption scenarios. The interactions between individual magnetic nanoparticles in a suspension are negligible even under applied magnetic fields. However, when they are incorporated into composite structures they act in concert to provide a desired magnetic response. In my dissertation I have investigated two different magnetically-responsive composite structures. In the first approach, I created rigid and flexible magnetic chains composed of polystyrene beads coated with magnetic nanoparticles, prepared using the layer by layer technique. These magnetic polystyrene beads were aligned within a microchannel by an external magnetic field and linked together using sol gel chemistry to yield rigid superparamagnetic chains. Linking these magnetic beads with a flexible linker molecule resulted in flexible superparamagnetic chains. The dynamic response of rigid and flexible chains under a fixed and rotating magnetic field was modeled. Microcontact printing was exploited to tether the magnetic chains to a glass surface. These structures can have potential applications in micro fluidics where they can be used as micro mixers, pumps, magnetic actuators and filters. In the second approach, magnetic nanoparticles were suspended in a polymer solution which was then electrospun into magnetically-responsive polymeric fibers. Different size monodisperse magnetic nanoparticles, synthesized via an organic route synthesis, allowed the investigation of the effect of size on the relaxation behavior of the fixed magnetic nanoparticles. Theoretical analysis suggests that incorporating magnetic nanoparticles with high relaxation time in a fiber can drastically improve the fiber strength under an external magnetic field. My research has exposed me to variety of characterization techniques which include Scanning Electron Microscopy, Transmission Electron Microscopy, X-ray diffraction, Light Scattering, Zeta potential measurement, Magnetization measurement (SQUID and VSM) and Fluorescent microscopy. I have been a teaching assistant for an undergraduate course in thermodynamics for which I held regular office hours and taught recitation sections. I was awarded “Edward W. Merrill Award for Outstanding Teaching Assistant” by the Chemical Engineering Department at MIT and AICHE. As an assistant professor I would like to continue my work in the field of magnetic nanoparticles and magnetic colloids. I would like to study the effect of shape, size and material on the dynamic response of magnetic nanostructures under an applied magnetic field. Also, I would like to explore the applications of magnetic nanoparticles and magnetic colloids in the areas of bioseparations and microfluidics.