ABSTRACT FOR Particles Workshop

“Supersusceptible Nanoclusters: The Synthesis and Applications Highly Responsive Magnetic Particles”

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One of the most important properties of soft magnetic materials is their susceptibility to external magnetic fields. It governs their performance in diverse technologies that seek to image, move, or heat particles and describes how applied fields, ideally small in magnitude, induce material magnetization. Conventional approaches to forming more field-sensitive nanoparticles alter their composition, which increases the toxicity and cost of particles for only modest susceptibility gains. Here we show that magnetic susceptibility exhibits striking size-dependence in clustered particles containing safe and earth-abundant iron oxide nanocrystals. Libraries of particles with independently controlled particle diameters and primary particle sizes were formed using hydrothermal method and their magnetization in very low applied fields shows a striking size dependence. For particle dimensions of approximately 40 nm, the initial magnetic susceptibility is an order of magnitude larger than smaller clusters as well as bulk iron oxides. We term these systems “supersusceptible”. A similar size-dependence was observed for isolated iron oxide nanocrystals although the optimized susceptibility was much lower and peaked at smaller dimensions. Susceptibility falls in both systems as particle dimensions increase and materials become blocked single domain magnets. Micromagnetic simulations of these aggregates illustrate the importance of moderate exchange coupling between primary particles in clustered materials; because of this interaction these aggregates remain superparamagnetic up to a larger volume than isolated nanocrystals yielding larger susceptibilities. These supersusceptible nanoparticles have superior properties in both magnetic capture, magnetic particle imaging as well as for magnetic heating applications. Their high sensitivity to applied fields makes it possible to apply portable, battery-operated devices to the inductive heating of biological materials as well as inexpensive refrigerator magnets to the capture of live cells containing the particles. Environmental applications also become possible as efficient magnetic heating permits the destruction of persistent drinking water contaminants.