Investigating self-assembly of Au-Fe_3O_4 dumbbell nanoparticles using advanced scattering techniques

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We investigated parameters that affect self-assembly of magnetic dumbbell nanoparticles (DBNPs) in solution. The dumbbells consist of epitaxially grown magnetic Fe_3O_4 nanoparticles on the surface of spherical Au nanoparticles. Their structural, optical and magnetic properties are useful for variety of applications such as dual probes for drug delivery [1-2], catalysis [3], sensing [4], optics [5] and electronics [6]. However, fundamental understanding of mechanisms and parameters involved in self-assembly of DBNPs in solution is still missing. We studied several DBNPs coated with a mixture of oleic acid and oleylamine of different sizes: A13F14, A11F8, A10F14, A10F12, A9F11, where numbers indicate the diameters of Au (A) and Fe_3O_4 (F), respectively. Field-dependent DC magnetization reveals different shapes of hysteresis loops for our samples, which is presumably due to a Au/Fe_3O_4 interface and modification of magnetization profile of Fe_3O_4 [7-8]. Small-angle neutron scattering in applied magnetic field showed self-assembly of DBNPs in solutions, in contrast to zero-field measurements. We observed the onset of order beginning at 0.2 T for A10F14, A9F11 and at 1T for A13F14 (Figure 1). Surprisingly, we found no self-assembly for A10F12 and A11F8 even at 3T. We also performed a polarized SANS at 1T and 3T to separate nuclear and weak magnetic scattering.

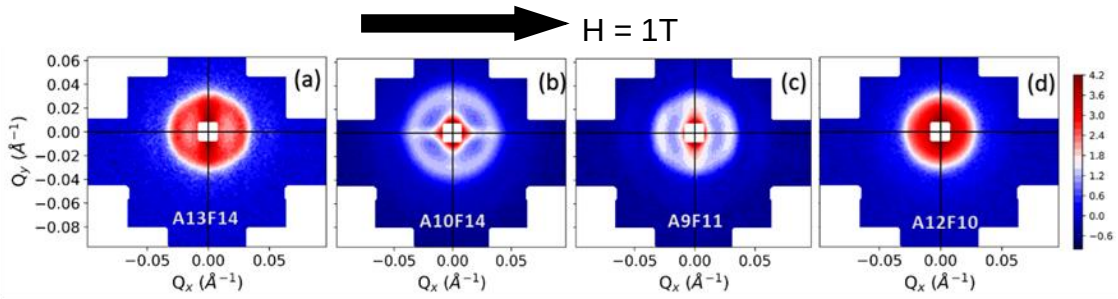

Figure 1: 2D SANS pattern of a) A13F14 b) A10F14 c) A9F11 d) A12F10

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