Investigation of finite size effects in self-assembly of magnetic nanoparticles

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Self-assembly of magnetic nanoparticles, in general, is of interest due to the broad range of applications in material science and biomedical engineering[1-2]. Parameters that affect self-assembly in nanoparticles include particle size, external magnetic field, the thickness of surfactant, concentration and synthesis routines[3]. Superparamagnetic iron oxide nanoparticles (NP's) of 20nm and 27nm were investigated using Small Angle Neutron Scattering (SANS) at room temperature in 2.2T field which revealed a profound size effect on the observed self-assembly (Fig 1.a and 1.b). In the case of 20nm NPs there was no indication of self-assembly even at high concentration (1% vol) and a maximum field of 2.2T, while 27nm NP's start self-assembling into linear chains even in low concentrations (0.42%) and zero field (fig1.c). The SAXS and SANS data of 27 nm are best described by the linear pearl model. The particle size distribution and the core diameter were determined with transmission electron microscopy (TEM) and small angle x-ray scattering (SAXS). Macroscopic magnetization measurements reveal a different magnetic behavior in dilute and concentrated samples indicating the influence of interactions in both NPs. The structural and form factors are obtained by sector analysis of the 2-D pattern of SANS with field variation. The half-polarized neutron scattering was used to separate the nuclear and weak magnetic scattering for both NPs. This study will open new perspectives and understanding of the control and manipulation of self-assembly in complex nanoparticles with additional physical parameters.

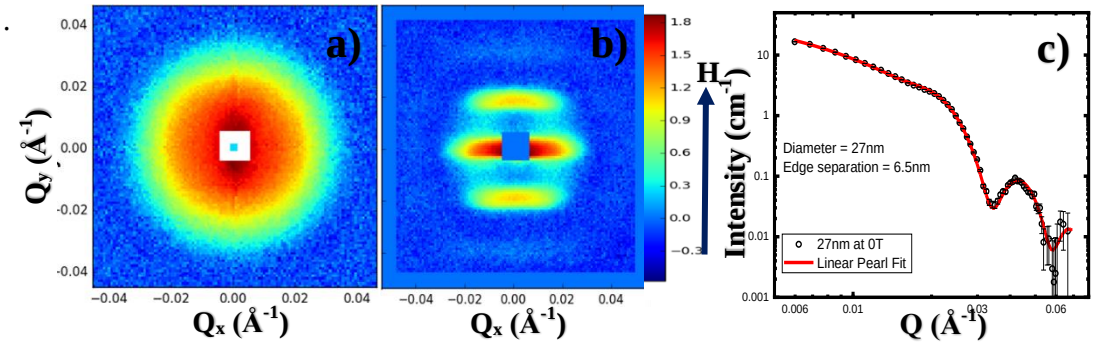

Figure 1: SANS pattern at room temperature in H=2.2T (similar concentration) of a) 20nm b) 27nm NP (colour bar in logscale) c) Radially averaged SANS of 27nm NP's in 0T at room temperature (red line linear pearl model fit)

References

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