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Magnetic Nanochain Formation Studied by Small-Angle Scattering

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Self-assembly of magnetic nanoparticles is of interest due to the broad range of applications in material science and biomedical engineering. Parameters that affect self-assembly in nanoparticles include particle size, the applied magnetic field profile, concentration and synthesis routines. A range of different sizes of magnetic nanoparticles between 5 and 27 nm were investigated using polarized small-angle neutron scattering (SANS) at the KWS-1 instrument operated by the Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ) in Garching, Germany and the Quokka instrument operated by the Australian Centre for Neutron Scattering (ACNS) at ANSTO in Lucas Heights, Australia. Iron oxide nanoparticles were dispersed in toluene and measured at room temperature in applied fields between ±2.2 T. The observed self-assembly strongly depended on both nanoparticle size and applied field. For smaller particles (diameter ≤ 20 nm) there was no indication of self-assembly, while 27 nm nanoparticles assemble into linear chains even in low concentrations (0.42% v/v) and low field (4 mT).

The magnetization profile within the cores of the smaller nanoparticles could be extracted with high-resolution when using a spin-polarized incident neutron beam. For larger nanoparticle, the structural and form factors were obtained by sector analysis of the 2-D SANS patterns. The extracted structure factors suggest that the chains grow longer and straighter and align more closely with the field direction up until application of the maximum field. This is understood in terms of a minimization of the dipole energy of the nanoparticles in the presence of the applied field and neighbouring particles. Preliminary results from experiments studying self-assembly of more complex nanoparticles (including gold-iron dumbbell nanoparticles) will be discussed.

Level of Expertise

Experienced Researcher

Presenter Gender

Man

Pronouns

He/Him

Which facility did you use for your research

Australian Centre for Neutron Scattering

Students Only - Are you interested in AINSE student funding

No

Do you wish to take part in the Student Poster Slam

No

Condition of submission

Yes

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