Experimental report

02/02/2024

Proposal: 5-42-575 **Council:** 4/2023

Title: Magnetization Distribution and Spin Disorder in Sequentially Grown Manganese Ferrite Nanoparticles

Research area: Chemistry

This proposal is a resubmission of 5-32-942

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Samples: Manganese Ferrite Nanoparticles

Instrument	Requested days	Allocated days	From	To
D33	3	3	07/11/2023	10/11/2023

Abstract:

The objective of this proposal is to investigate the magnetization distribution in spherical manganese ferrite nanoparticles to disclose the impact of sequential particle growth on the surface-near and intraparticle spin disorder. Structural defects and the associated spin disorder have recently been suggested to be beneficial for biomedial applications such as in intracellular magnetic hyperthermia. The samples of this proposal were sequentally grown from 5 - 8 nm via thermal decomposition. We are particularly interested to clear up how the local spin disorder changes, e.g. when the surface of the initial seed nanoparticle becomes the interior of the grown particle. Depending on the outcome of our study, the sequential growth technique might be considered as a promising strategy to engineer nanoparticles with a tunable surface spin disorder thickness.

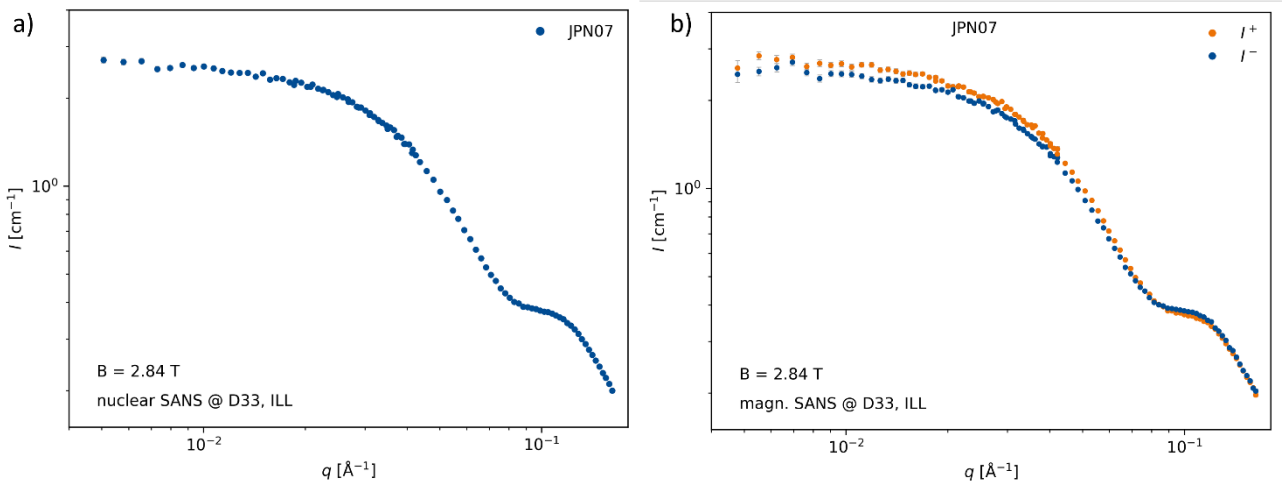
Experimental Report: Magnetization Distribution and Spin Disorder in Sequentially Grown Manganese Ferrite Nanoparticles

The aim of this experiment was to investigate (using SANSPOL) the intraparticle distribution of magnetization and spin disorder in sequentially grown ferrite nanoparticles. The samples consist of spherical manganese ferrite nanoparticles, which were grown to larger nanoparticles with either a manganese ferrite (Mn@Mn) or cobalt ferrite shell (Mn@Co). We are particularly interested to clear up how the local spin disorder changes, e.g. when the surface of the initial seed nanoparticle becomes the interior of the grown particle. A series of sequentially grown cobalt ferrite nanoparticles was already measured at ISIS facility in May 2022.

A series of samples were investigated using SANSPOL at the D33 instrument at two detector distances of 2.0 and 7.8 m, with a collimation distance of 2.8 m and 7.8 m, respectively. Polarized SANS was measured in a varying applied magnetic field of up to 2.84 T. The data was reduced using GRASP, taking into account the standard monitor calibration, direct beam and background correction, a flipper polarization correction of 0.99716, and a supermirror polarization correction of 0.948.

During the data evaluation it was found that the scattering cross-sections measured at different two detector distances do not coincide in intensity. It was found out that here was a problem with the attenuators. Therefore, a scaling factor based on the relatives of the two attenuators was used.

Fig.1 shows the purely nuclear and nuclear-magnetic SANS cross sections of the manganese ferrite seed sample JPN07 and the grown sample NaR31 (Mn@Mn) at the highest field of 2.84 T.



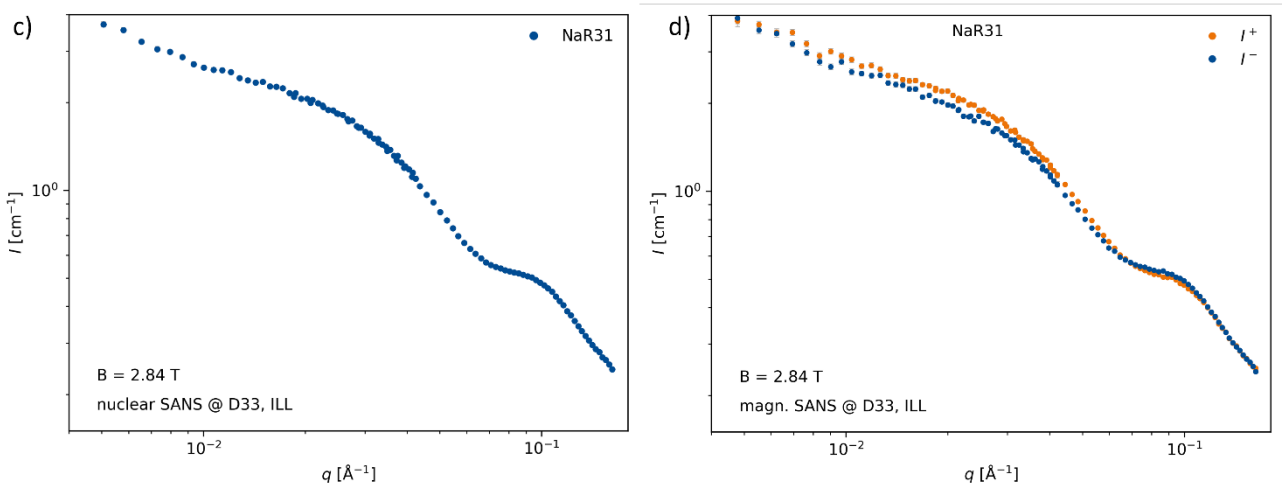


Fig. 1: SANS and SANSPOL of a-b) JPN07 and c-d) NaR31

We clearly observe the form factor minima in the nuclear SANS cross section, as well as a magnetic contrast in the I^+ and I^- scattering cross sections. The grown particles NaR31 also show a structure factor in low q. The data will be analyzed within the particle-matrix framework to give more detailed insight into the chemical morphology and magnetization profile of the nanoparticles.

A wide field range was chosen to asses the similarities and differences in the field dependent magnetization of core and shell. Fig. 2 shows the sample JPN11 (Mn@Co) at three different fields.

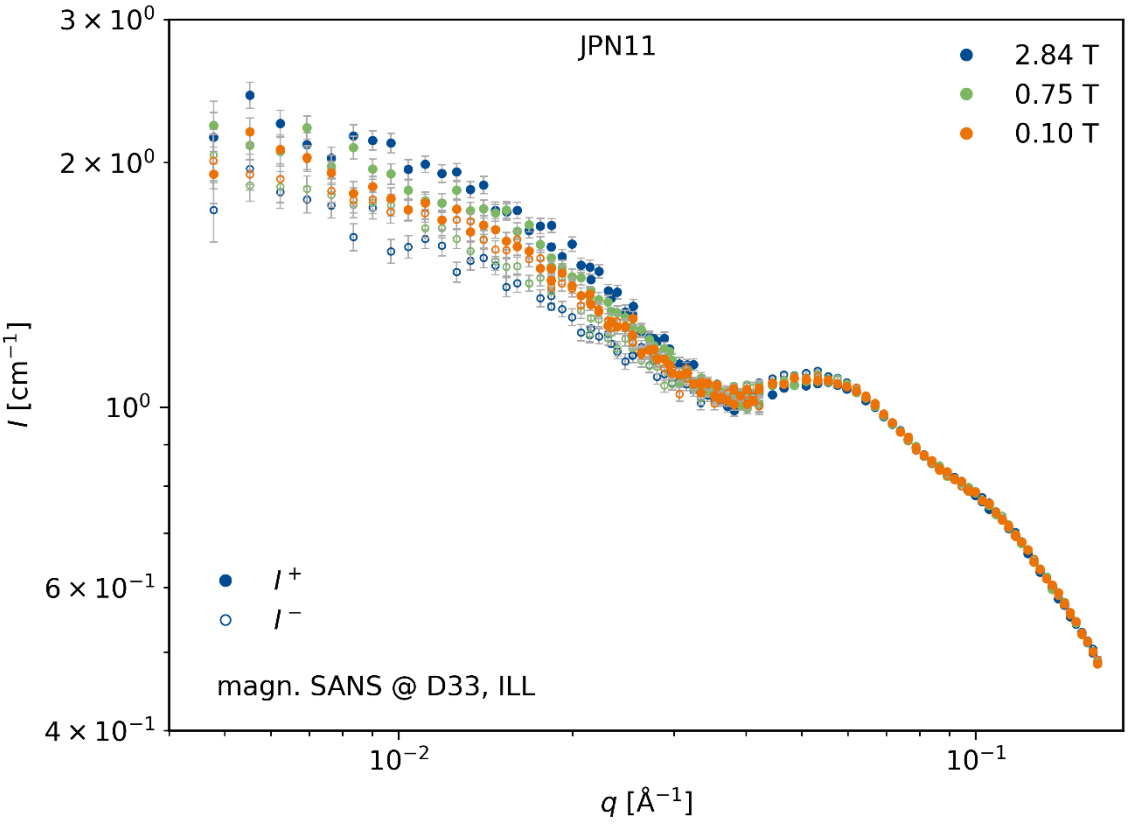


Fig. 2: SANSPOL of JPN11 at three different fields.