Experimental report

02/02/2024

Proposal: 5-42-576 **Council:** 4/2023

Title: Magnetic Core-Shell Morphology in Cobalt-Doped Iron Oxide Nanoparticles of Different Sizes

Research area: Chemistry

This proposal is a new proposal

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Samples: Co-doped iron oxide nanoparticles

Instrument	Requested days	Allocated days	From	To
D33	3	3	13/09/2023	16/09/2023

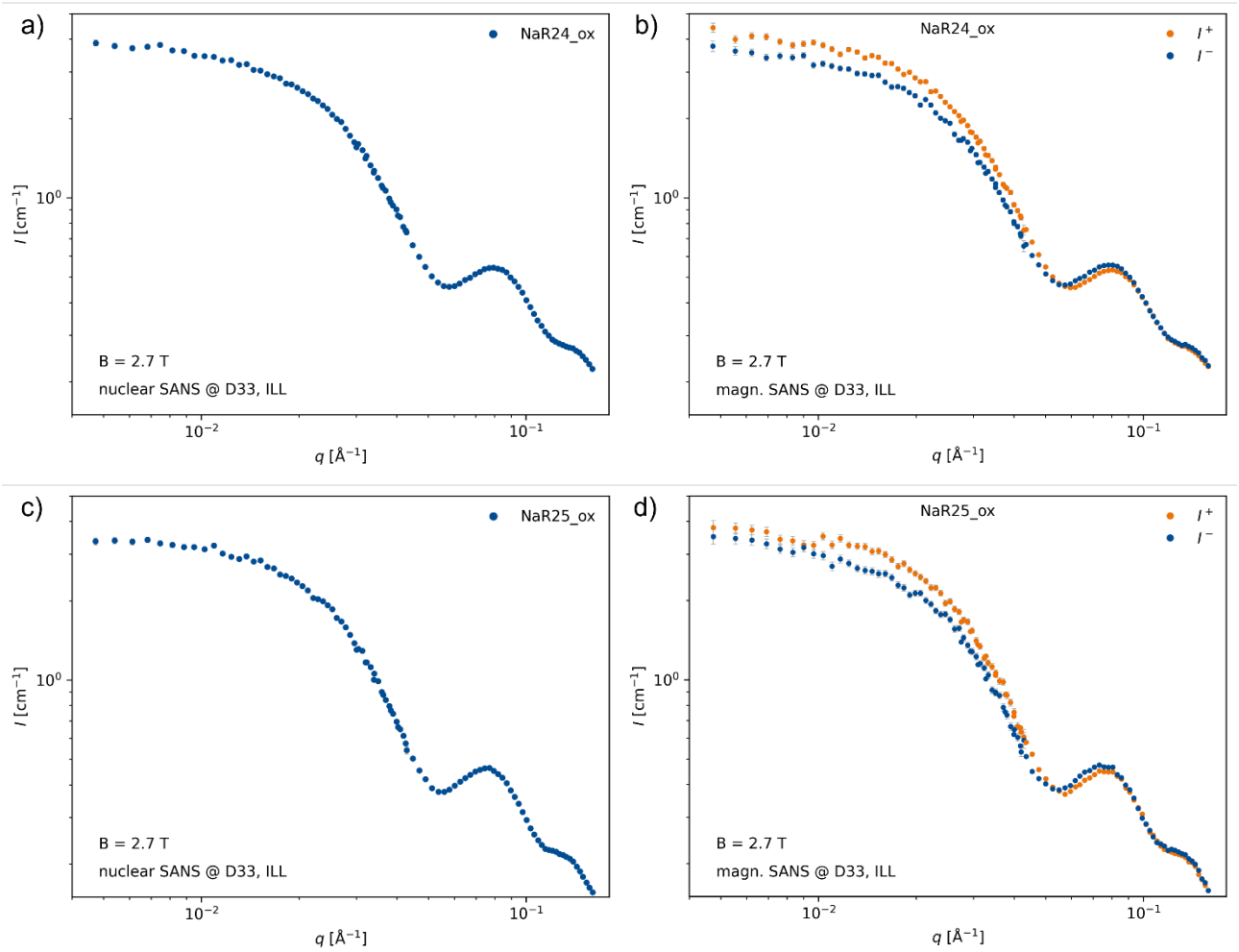
Abstract:

The objective of this proposal is to investigate the spatial resolved magnetization behavior in cobalt-doped iron oxide NPs during oxidation. The samples of this proposal were synthesized out of a mixed iron-cobalt-oleate precursor following a thermal decomposition route. The particle size is precisely controlled by variation of heating rates. For this synthesis pathway, formation of a core-shell morphology is known, consisting of a wustite core which topotaxially oxidizes to maghemite near the particle surface. We want to analyze these highly interesting materials after partly the oxidation process takes place by using magnetic SANS to elucidate the quantitative magnetization independently in particle core and shell to compare with the same samples, which were measured in the early stage of topotaxial oxidation at ISIS facility in February.

Experimental Report: Magnetic Core-Shell Morphology in Cobalt-Doped Iron Oxide Nanoparticles of Different Sizes

The aim of this experiment was to investigate (using SANSPOL) the magnetic morphology in core-shell ferrite nanoparticles of varying particle size. These nanoparticles are known to consist of a wuestite-type core and a cobalt-doped iron oxide shell. We study these highly interesting materials during the slow topotaxial oxidation process to elucidate the evolution of quantitative magnetization independently in particle core and shell in comparison to the same samples measured at an earlier stage of oxidation several months ago.
A series of samples were investigated using SANSPOL at the D33 instrument at two detector distances of 2.0 and 7.8 m, with collimations of 2.8 m and 7.8 m, respectively. The samples were measured at applied magnetic fields between 0.049 T and 2.7 T. The data was reduced using GRASP, taking into account standard monitor calibration, direct beam and background correction, a flipper polarization correction of 0.99716, and a supermirror polarization correction of 0.948.

Fig.1 shows the purely nuclear and nuclear-magnetic SANS cross sections of the three samples NaR24_ox, NaR25_ox and NaR27_ox at the highest applied field of 2.7 T.



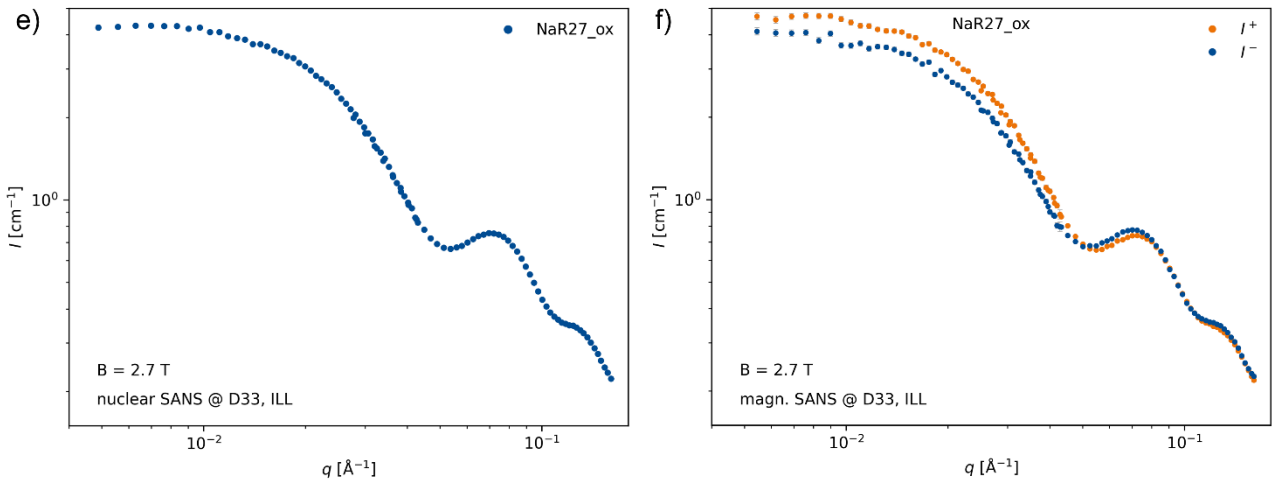


Fig. 1: SANS and SANSPOL of a-b) NaR24_ox, c-d) NaR25_ox, and e-f) NaR27_ox.

We clearly observe the form factor minima in the nuclear SANS cross section, as well as a magnetic contrast in the I^+ and I^- channels. The data will be analyzed within the particle-matrix framework to give quantitative insight into the chemical morphology and magnetization profile of the nanoparticles.

The 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 NaR27_ox at four different fields.

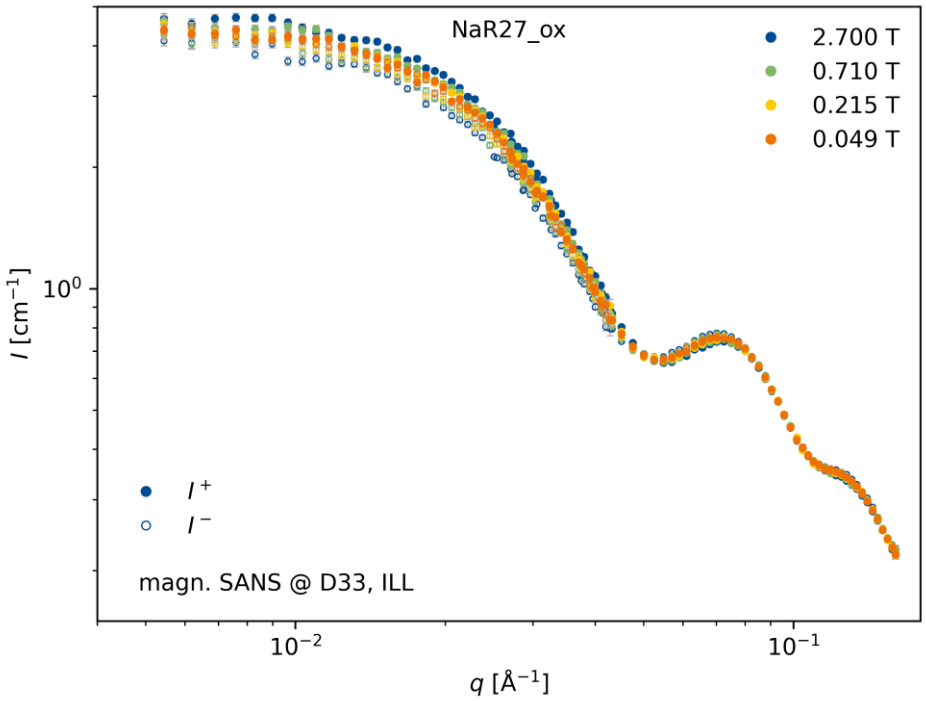


Fig. 2: SANSPOL of NaR27_ox at four different fields.