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Insights into internal magnetic structure of iron oxide nanoparticles: a combined small-angle neutron scattering and magnetometry study

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This work continues our previous studies on spherical iron oxide nanoparticles 1 to systematically investigate the magnetic structure of the nanoparticles in a broad range of particle sizes (nominal iron oxide core diameter 5, 10, 12, 15 and 20 nm). The parameters of the core-shell structure (iron oxide core, oleic acid shell) were determined using small-angle neutron and X-ray scattering. A non-magnetic layer at the nanoparticle surface was determined using small-angle scattering with polarized neutrons at saturating fields. Room temperature hysteresis data was obtained using vibrating sample magnetometry and the M(H) curves were inverted to obtain the magnetic moment distribution within the nanoparticle systems.
The detailed magnetic structure of the nanoparticles is obtained by analyzing the results of the non-magnetic layer and the distribution of the size and magnetic moment. The results suggest that a particle size of 15 nm is optimal.

1 Köhler, T., Feoktystov, A., Petracic, O., Kentzinger, E., Bhatnagar-Schöffmann, T., Feygenson, M., Nandakumaran, N., Landers, J., Wende, H., Cervellino, A., Rücker, U., Kovács, A., Dunin-Borkowski, R.E., Brückel, T., 2021. Mechanism of magnetization reduction in iron oxide nanoparticles. Nanoscale 13, 6965–6976.

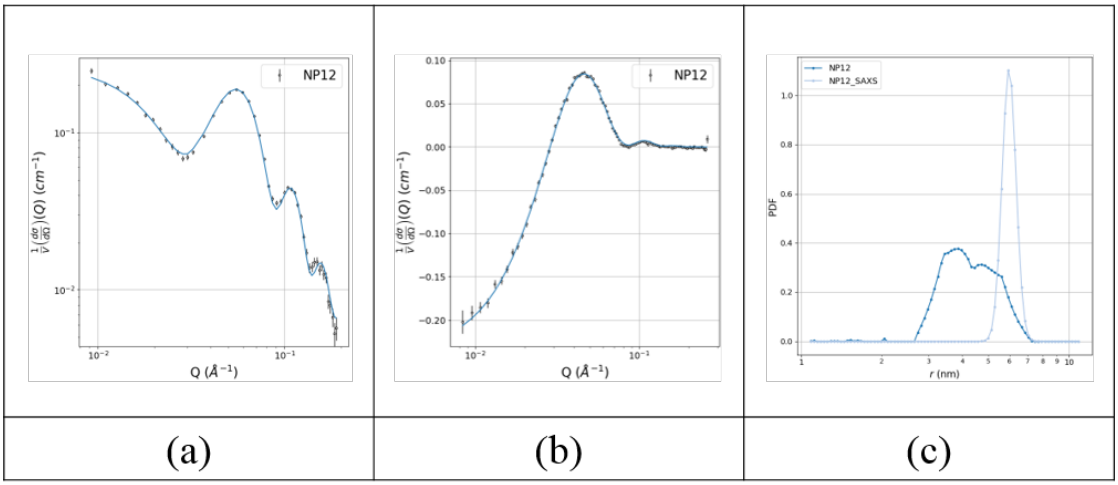

Figure 8: Exemplary results for 12 nm particles: (a) core-shell fit to determine oleic acid shell thickness, (b) fit of the nuclear-magnetic interference to determine non-magnetic shell thickness and (c) comparison of the size distribution obtained from small-angle X-ray scattering and from the inversion of M(H) hysteresis curve inferring about a reduction of the overall particle magnetic moment.

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