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New opportunities for an old material: Magnetite at the nanoscale

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Magnetite (Fe_3O_4) nanoparticles are objects of intense research activities due to their broad range of applications covering technological, medical, and environmental applications. They are used e.g. for rotary shaft sealing, oscillation damping, position sensing, magnetic inks for jet printing, as contrast agents in magnetic resonance imaging, and to remove heavy metals from wastewater. In addition, magnetite is a half-metal with a predicted negative spin polarisation making magnetite interesting for spintronics.

For all applications, a high quality of magnetite is crucial to obtain the desired properties. In this work, we studied the quality of magnetite nanoparticles of 6 nm diameter by monitoring the Verwey transition [1] by means of x-ray absorption spectroscopy and its associated x-ray magnetic circular dichroism (XMCD). The Verwey transition is a phase transition that occurs in magnetite only and is extremely sensitive e.g. to changes in the stoichiometry by ageing effects like further oxidation. We show that a hydrogen plasma treatment of "old" magnetite nanoparticles can reverse unwanted ageing effects of magnetite and the properties of plasma treated magnetite nanoparticles can even outperform the ones of freshly prepared batches [2].

References

[1] D. Schmitz et al.: The dipole moment of the spin density as a local indicator for phase transitions, Scientific Reports 4, 5760 (2014)

[2] C. Schmitz-Antoniak et al.: Reversed ageing of Fe_3O_4 nanoparticles by hydrogen plasma, Scientific Reports 6, Article number: 20897 (2016)