

Origin of the magnetic transition at 100 K in ϵ -Fe₂O₃ nanoparticles studied by X-ray absorption fine structure spectroscopy

J. López-Sánchez,^{1,2*} A. Muñoz-Noval,^{3,4} C. Castellano,⁵ A. Serrano,^{3,6} A. del Campo,⁶ M. Cabero,^{1,7} M. Varela,^{1,7} M. Abuín,^{1,8} J. de la Figuera,^{2,9} J.F. Marco,^{2,9} G. R. Castro,³ O. Rodríguez de la Fuente,^{1,2,10} N. Carmona^{1,2,10}

jesus.lopez@ucm.es

1 Departamento de Física de Materiales, Universidad Complutense de Madrid, 28040 Madrid, Spain.

2 Unidad Asociada IQFR (CSIC)-UCM, 28040 Madrid, Spain.

3 Spanish CRG, The European Synchrotron (ESRF), 38000 Grenoble, France and Instituto de Ciencia de Materiales de Madrid, ICMM-CSIC, 28049 Madrid, Spain.

4 Department of Applied Chemistry, Hiroshima University, Higashihiroshima, Hiroshima, 739-8527, Japan.

5 Dipartimento di Chimica, Università degli Studi di Milano, 20133 Milano, Italy.

6 Instituto de Cerámica y Vidrio, ICV-CSIC, 28049 Madrid, Spain.

7 Instituto Pluridisciplinar, Universidad Complutense de Madrid. 28040, Madrid. Spain

8 CEI Campus Moncloa, UCM-UPM, 28040 Madrid, Spain

9 Instituto de Química Física "Rocasolano", CSIC, 28006 Madrid, Spain.

10 Instituto de Magnetismo Aplicado, UCM-CSIC-ADIF, 28230 Las Rozas, Madrid, Spain.

ϵ -Fe₂O₃ is a collinear ferrimagnetic material which presents a Curie transition at ~500 K and an incommensurate magnetic order transition at ~100 K at the nanoscale [1]. Concerning its magnetic properties, single-domain ϵ -nanoparticles exhibit a coercive field of 20 kOe at room temperature (RT). The origin of this high value is its huge magnetocrystalline anisotropy ($K=10^5$ J/m³) originated by a nonzero orbital component of the Fe³⁺ magnetic moment and consequently, the occurrence of a strong spin-orbit coupling [1]. In this respect, a new generation of hard-magnets without rare-earth compounds based on this kind of Fe oxides seems to be feasible [2]. Furthermore, this material has the potential to be employed in high speed wireless communication technologies, since the ferromagnetic resonance frequency falls within the mTHz range [3].

The current study unveils the structural origin of the magnetic transition of the ϵ -Fe₂O₃ polymorph from incommensurate magnetic order to collinear ferrimagnetic state. The high crystallinity of the samples and the absence of other iron oxide polymorphs allow to carry out temperature-dependent X-ray absorption fine structure spectroscopy experiments out. The deformation of the structure is followed by the Debye-Waller factor for each selected Fe-O and Fe-Fe sub-shells. For nanoparticle sizes between 7 and 15 nm, the structural distortions between the Fe_{te} and Fe-D1_{oc} sites are localized in a temperature range before the magnetic transition starts out. On the contrary, the inherent interaction between the other sub-shells (named Fe-O1,2 and Fe-Fe1) provokes a cooperative magneto-structural changes in the same temperature range. This means that the magneto-elastic effects dealing with these nanoparticle sizes wherein the structural distortions are likely moderate due to surface effects and the Fe_{te} with Fe-D1_{oc} polyhedron interaction seems to be uncoupled with temperature [4].

References

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