Co based magnetic nanoparticles with Pt shell: XANES and magnetic properties

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Cobalt based nanoparticles have attracted during few past decades a research interest as a subject of both fundamental understanding and application. They have been used as a ferrofluids or electronic components, solar energy transformers, as anodes for batteries, and in chemical catalysis. Co based nano-systems are top materials for preparation of high-density magnetic recording media, where the particles of small size, with narrow size distribution are required [1-3]. In this work the magnetic cobalt based nanoparticles with CoO core and Pt shell, CoO@Pt, were studied by X-ray diffraction, X-ray absorption near-edge structure (XANES).

Nanoparticles were synthesized using the reverse micelle concept [4]. This method is a very useful for preparation of particles with metal core and different coating shell. Magnetic measurements were performed on a commercial SQUID-based magnetometer (Quantum Design MPMS 5XL) over a wide range of temperatures (2-300 K) and applied *dc* fields (up to 50 kOe).

The XANES measurements were done at B1 Hasylab beamline (DESY Hamburg). The sample powder was spread between two Kapton tapes. The transmission of the sample was measured by measuring the X-ray intensity with an ionization chamber before of the sample and a photodiode after it. The energy scale was calibrated using the first inflection points of Fe, Ni, and Se foils.

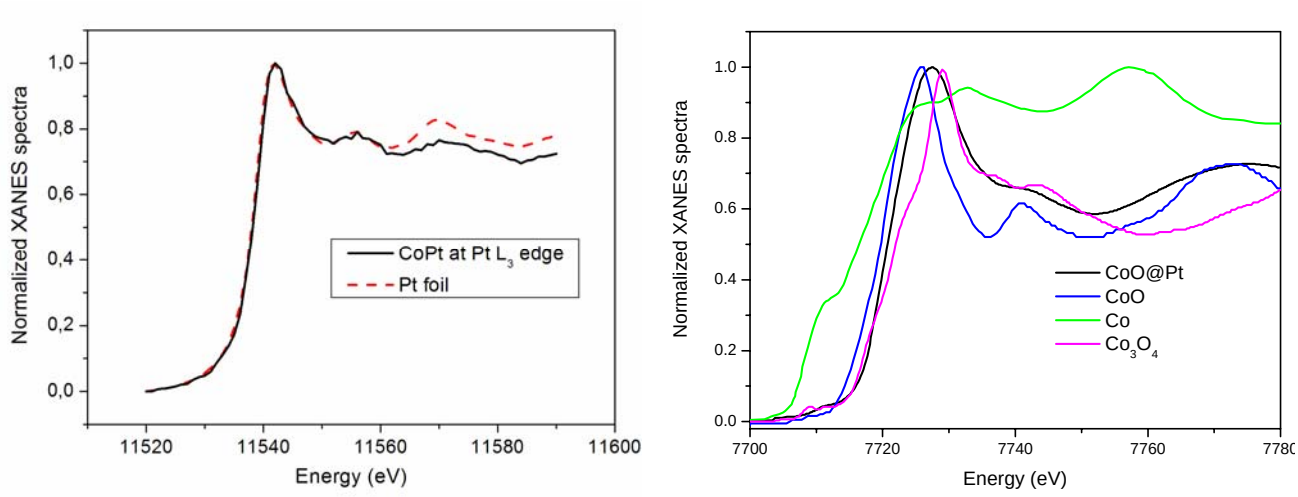

Figure 1: (a) Normalized XANES spectra of CoO@Pt magnetic nanoparticles (a) at Pt L3 edge, (b) at Co K edge.

The normalized XANES spectra of prepared nanoparticles measured at Pt *L3* edge and Co *K* edge are in the Figure 1. In the case of *Pt L3* edge (Figure 1a) it is seen that the XANES signal coming from nanoparticles is practically identical to the signal from Pt reference foil. This behaviour indicates that the platinum atoms in nanoparticles have comparable electronic configuration and the same oxidation state (exactly the same position and the shape of the absorption edge) as platinum atoms in the reference foil. The Figure 1b shows the XANES spectra of the sample at Co *K* edge. For comparison, the reference spectra of Co, CoO and Co_3O_4 are displayed. The results suggest the core of the sample is formed by CoO nanoparticles. However, small upshift of the XANES spectrum of the studied sample, with respect to CoO reference, was observed. This may indicate

that some of the cobalt atoms have different electron density and higher oxidation state (III) or, it is a consequence of existing Co/Pt interface.

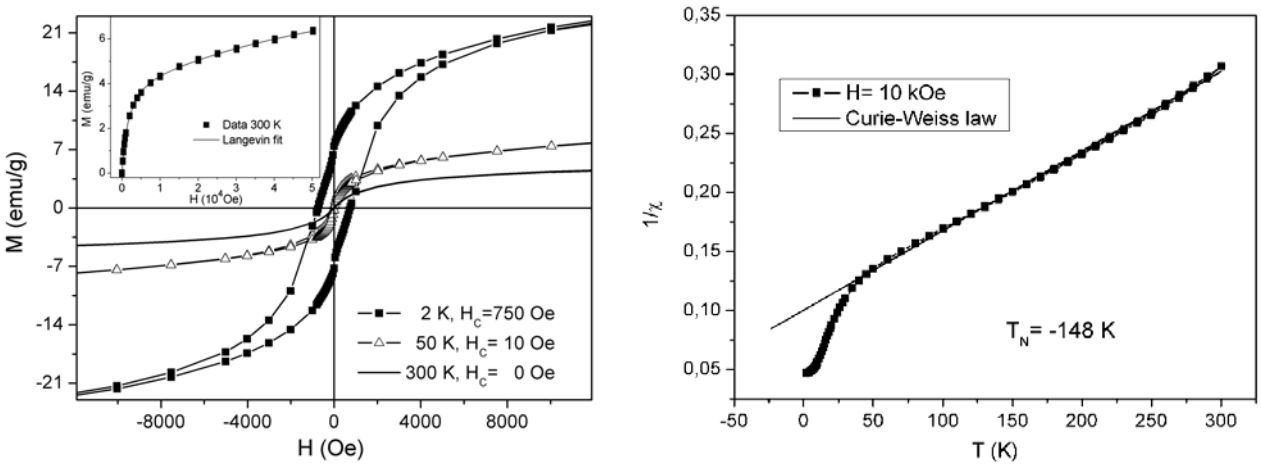

Figure 2: (a) Field dependence of the magnetization measured at 2 K, 50 K and 300 K. Inset: the measured data at 300 K (full squares) and calculated Langevin fit (solid line), (b) Temperature dependence of inverse susceptibility measure in external dc field of 10 000 Oe (full squares) and estimated Néel temperature T_N using Curie-Weiss fit.

The study of magnetic properties of prepared nanoparticles confirms the existence of superparamagnetic behaviour, see Figure 2 (a), since the synthesis of NPs was below critical size at which particles becomes a single magnetic domains. From superparamagnetic curve measured at room temperature, see Figure 2 (a) inset, we have estimated the value of magnetic moment of particles m_p = 158 μ_B using Langevin formalism [5, 6]. At low temperature the magnetic moments of particles are blocked on the external field direction and display coercivity. From the temperature dependence of magnetic susceptibility the antiferromagnetic ordering was confirmed using curie-Weiss law, what also suggests on the existence of antiferromagnetic cobalt oxide formed as a core of particles.

Acknowledgments

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