STRIKING NANO-ONION NANOPARTICLES WITH CORE (γ-Fe) / DOUBLE SHELL (α-Fe/ Fe-oxide): SYNTHESIS, MICROSTRUCTURE AND MAGNETISM

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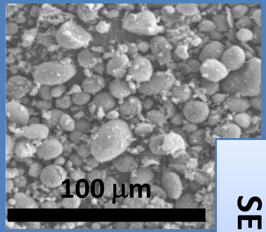
STATE OF THE ART

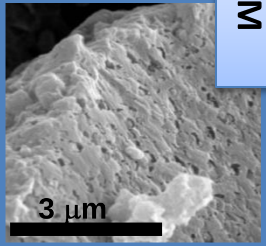
- Biomedical applications and magnetic separation
- Stabilization and protection of Fe-NPs with Fe-oxide layer
- Magnetic properties of Fe core/shell NPs at the nanoscale
- γ-Fe nanomagnetism:
  - In bulk form, only stablished above 1183 K
  - Stabilized on thin films, CNTs and Fe-NPs
  - Contradictory T_N results

a (Å)	Magnetic ordering
> 3.6	FM
< 3.6	AFM

CHEMICAL PREPARATION

- Simple, unexpensive, massive (grames) technique
- Diameter of the porous
- Amorphous carbon filled with Fe nitrate solution
- Pyrolisis at the interconnections of porous carbon at 1173 K (α-Fe to γ-Fe bulk transition)
- 17 wt.% Fe
- Fe-NPs catalyze the phase conversion from amorphous carbon to graphite (2700 K → 1100 K)

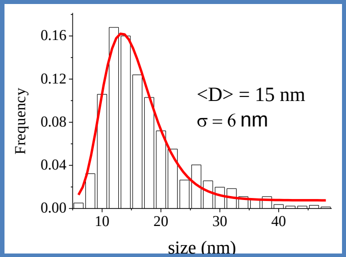




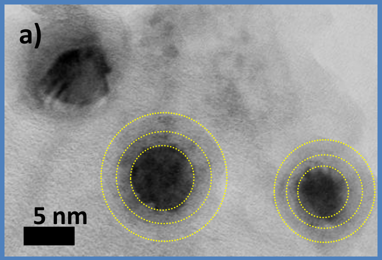
SEM

A.B.Fuertes et al. *Chem.Mater.* **18,** (2006)
M.Sevilla et al. *Carbon* **44,** 468 (2006)

MICROSTRUCTURE AND CRYSTAL STRUCTURE



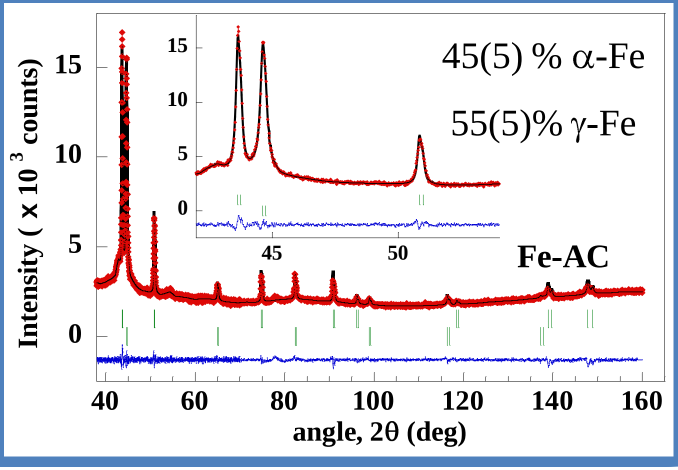
TEM

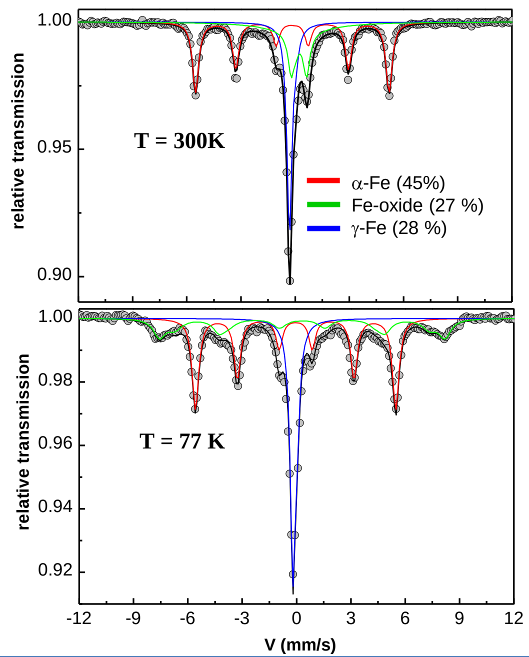


- Fe-NPs randomly dispersed
- Fe-NPs deposited at the interconnections of the porous carbon
- Thin Fe-oxide shell among the NPs under coherence length of XRD to be detected

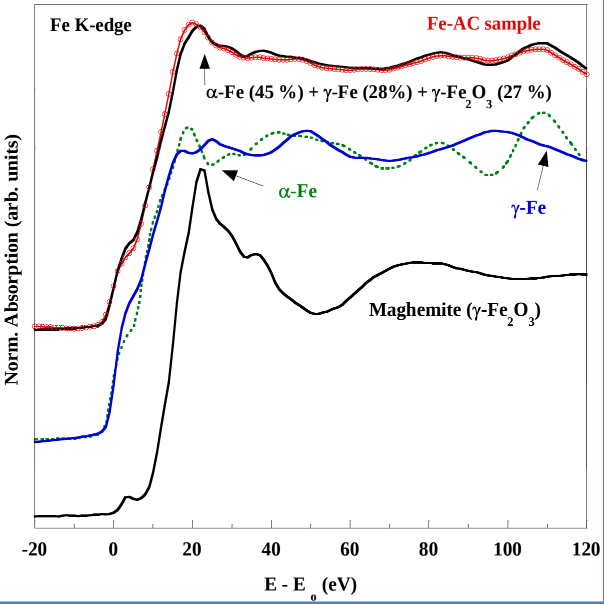
•Unknown AC crystalline structure
•a_{BCC} = 2.867 (1) Å
•a_{FCC} = 3.587 (1) Å < 3.6 Å !

XRD @300 K





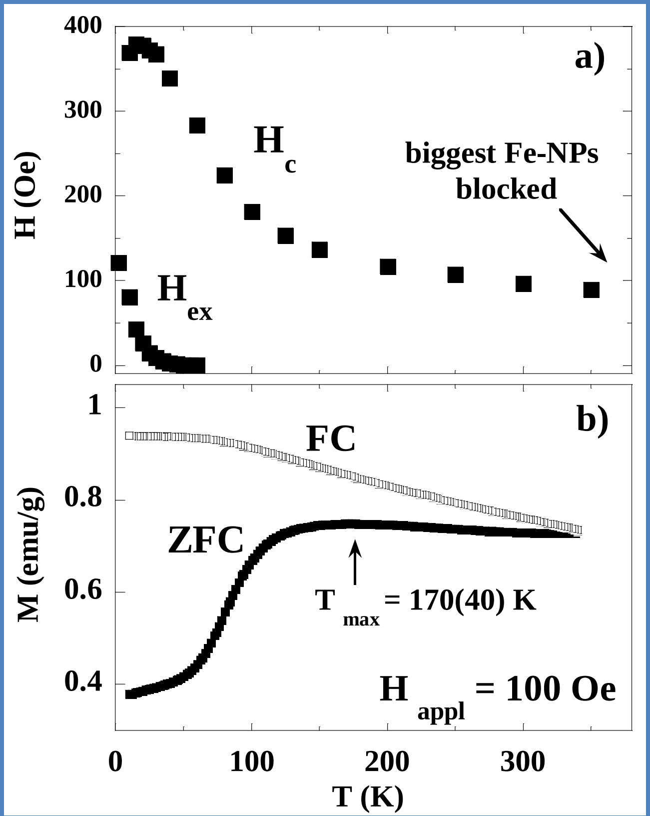
MÖSSBAUER SPECTROSCOPY



XANES

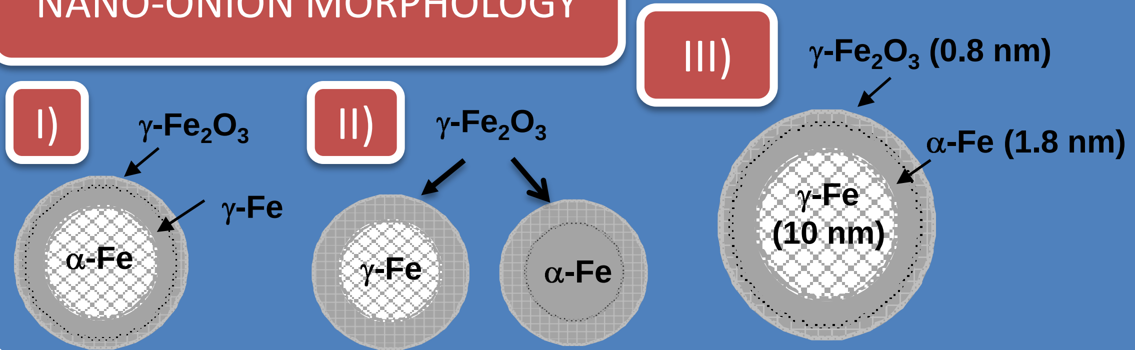
MAGNETISM

- Broad distribution of Fe-NPs sizes → $T_B \approx 170(40)$ K
- Not complete SPM behaviour at 300 K
    - biggest NPs remain blocked
    - coercivity at room temperature
    - Irrversible behavour between ZFC-FC curves
- Interface and surface progressively freeze into a low temperature spin-glass-like creating:
    - Exchange bias effect below 50 K
    - "Plateau-like" in low temperature ZFC-FC curves
    - *M(H)* cycles not completely saturated at low temperature
- EB effect created by magnetic coupling between :
    - FIM Fe-oxide / FM α-Fe / possible AFM γ-Fe



NANO-ONION MORPHOLOGY

M. P. Fernández-García et al. *Phys. Rev. B* 81, 094418 (2010)



- 3 possible microstructures
- III) is the most probable due to magnetic properties (α-Fe cores not SPM at 300 K)
- Medium relative dimensions of nano-onion NPs estimated within this structural and magnetic combined study.