IMPACT OF PARTICLE SIZE AND SUBSTRATE AFFINITY ON COBALT NANOPARTICLES SELF-ASSEMBLY

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INTRODUCTION

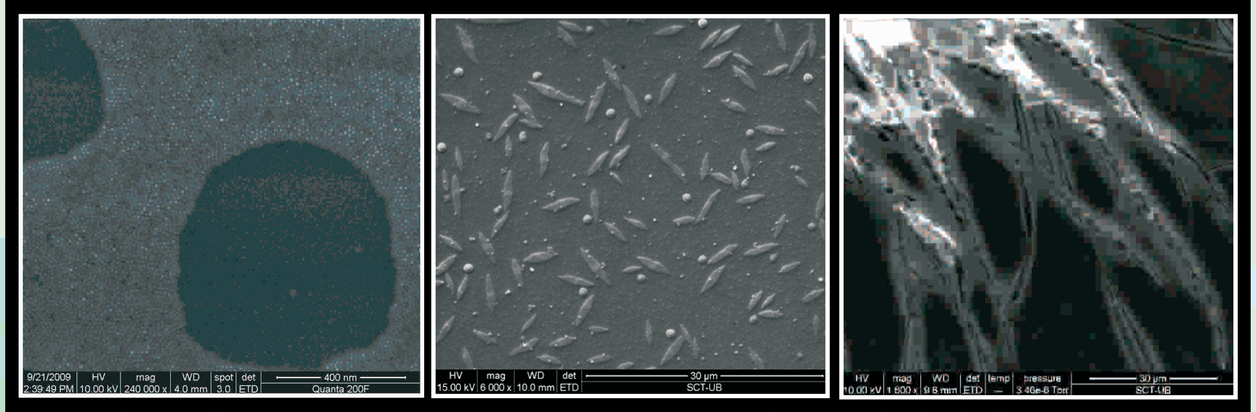
Colloidal dispersed nanoparticles (NPs) self assemble into complex structures when segregated from the solvent either by evaporation or precipitation. Thus, different micro and macroscopic structures like opals, fractals, anisotropic structures and others formed by NPs are observed as a result of the balance between electrostatic forces, surface tension, entropy, topography, substrate affinity, among others, and evidently, the size, shape and concentration of the particles. In the case of magnetic NPs, the magnetic properties arise from the competition between short and long-range interactions. These competing interactions favour parallel alignment of distant spins, forming magnetic domains in 'bulk' magnets. In addition, the dipolar magnetic interactions, add a new term in the interactions balance.

The self-assembly (SA) process and mechanisms that control it are not well understood. Its technological interest is evident but up to now the most remarkable results have achieved in amorphous carbon membranes and only in some case on technological substrates which its repercussion is expected to be of great relevance in an immediate future. In this complex context, the study of the self-assembly processes of cobalt NPs onto different substrates gives the opportunity to deeply study the balance between NP-NP and NP-substrate interactions.

We observed different spontaneous self-assembled structures formed by Co NPs depending of the size of the particles, in fact depending on their superparamagnetic behavior, onto Highly Ordered Pyrolytic Graphite (HOPG).

Thus, large monolayer areas of cobalt NPs and different micro and macroscopic structures, resulted from the evaporation of a solution of Co NPs, were observed [1,2].

Particle Size

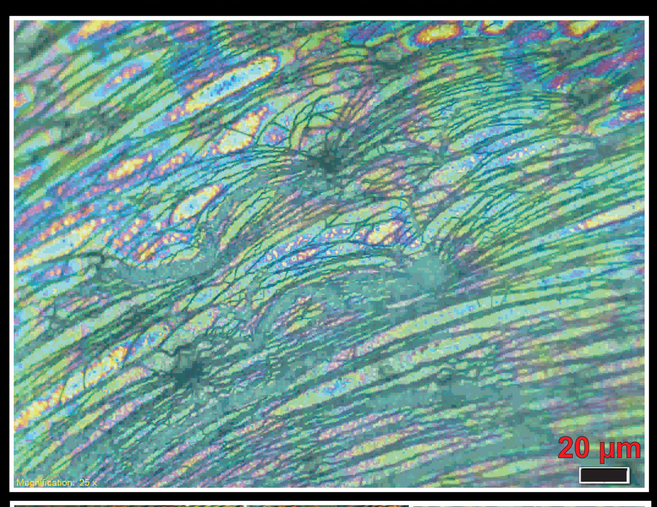


Scanning Electron Microscope images of self-assembled structures formed by Co NPs of different size.

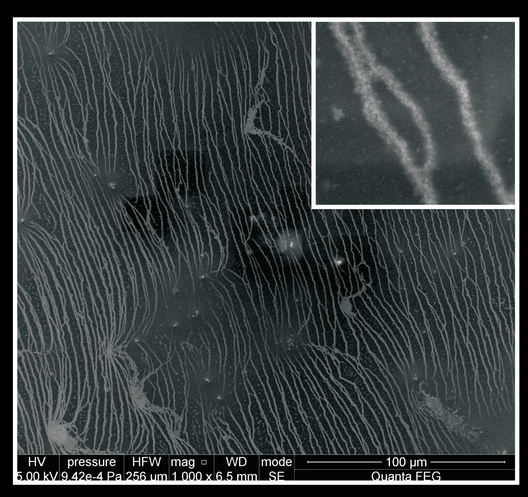
This process can be modulated by different parameters. In our case, we modulate the contribution of dipolar magnetic interactions to the SA process by using Co NPs of different sizes onto HOPG .

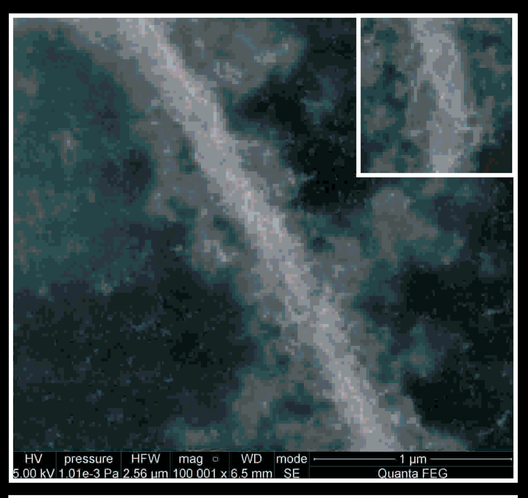
TEM

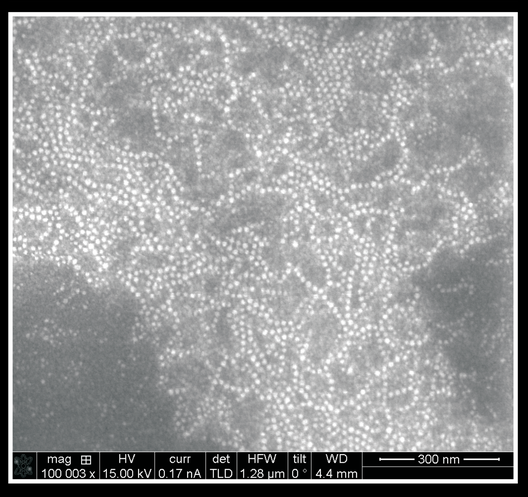
OPTICAL MICROSCOPE



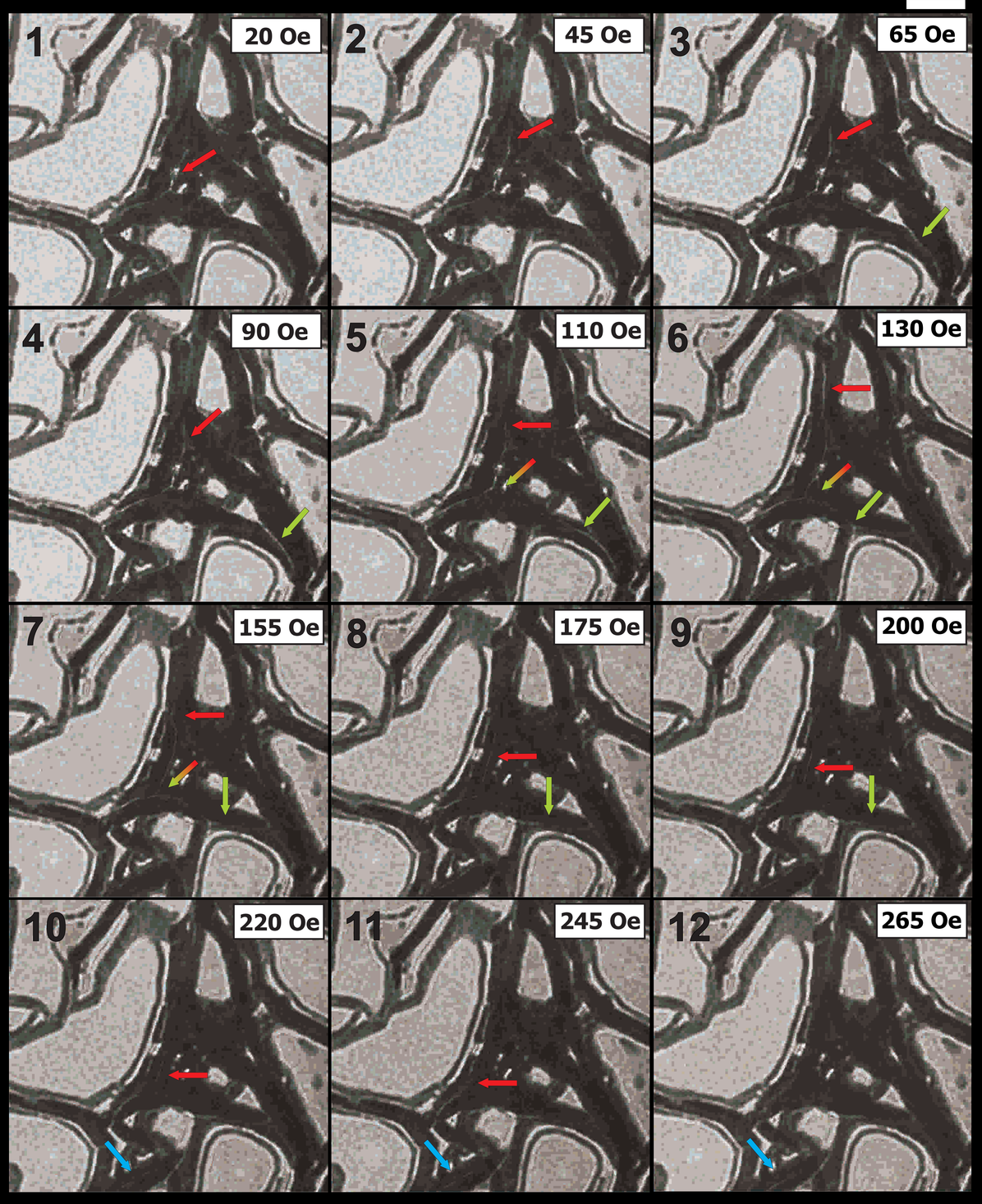
SEM







LORENTZ MICROSCOPY



The deposition of colloidal ε-Co particles on graphite through evaporation leads to formation of NP wires of thickness of 200-300 nm and lengths of up to hundreds of microns.

Scanning electron microscopy shows that the wires consist of loose bundles of single-particle chains, where neighboring chains touch each other forming a compact structure.

FOLLOW THE MOVEMENT OF THE DOMAIN WALLS LOOKING AT THE COLOURED ARROWS

Lorentz microscopy indicates that the collective magnetic behavior of the NPs is FERROMAGNETIC (dipolar ferromagnetism), showing the movement of some domain walls when the direction of the applied magnetic field is reversed *in situ* by changing the value of the objective lens.

The dipole magnetizations and domain walls are preferentially oriented along the length of the wires.

[1] M. Varon, L. Pena, L. Balcells, V. Skumryev, B. Martinez and V. Puntes, Dipolar driven spontaneous self assembly of superparamagnetic Co nanoparticles into micrometric rice-grain like structures, Langmuir, 2010, 26(1), 109-116.
[2] Luis Peña, Miriam Varón, Zorica Konstantinovic, Lluis Balcells, Benjamín Martínez and Víctor Puntes, Large 2D self-assembled domains of cobalt nanoparticles onto silicon wafers, J. Mater. Chem., 2011, Advance Article, DOI: 10.1039/C1JM11647A

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