Study of Clusters formation/dissociation process in High-Moment Nanoparticles-based Ferrofluids

[1*] K.N. Trohidou, [1]M. Vasilakaki, [2]D. Fiorani, [2,3] D. Peddis

[1] Institute of Nanoscience and Nanotechnology,-NCSR'Demokritos', Athens Greece,
[2]Institute of Structure of Matter, National Research Council, nM2-Lab, Monterotondo Scalo 00015, Rome, Italy
[3]Department of Chemistry and Industrial Chemistry, University of Genoa
*k.trohidou@inn.demokritos.gr

Ferrofluids (FFs) based on high-moment nanoparticles emerge as an important class of smart nanomaterials, because of their fast response to low or moderate strength magnetic fields. Understanding the mechanism of cluster formation/dissociation stimulated by application/removal of an external magnetic fields, is crucial for FFs' magnetic manipulation in various applications [1]. The Diffusion Limited Cluster Aggregation (DLCA) model [2] has been used for the study of the characteristics and the optimum conditions for the formation of field-driven high-moment structures in a fluid at room temperature. Two representative cases of high-moment materials-based FFs have been investigated: 1) the ones based on $CoFe_2O_4$ multicore particles [3] and 2) the FFs based on FeCo alloy nanoparticles [4]. In both cases each particle inside the fluid is covered with an organic surfactant shell.

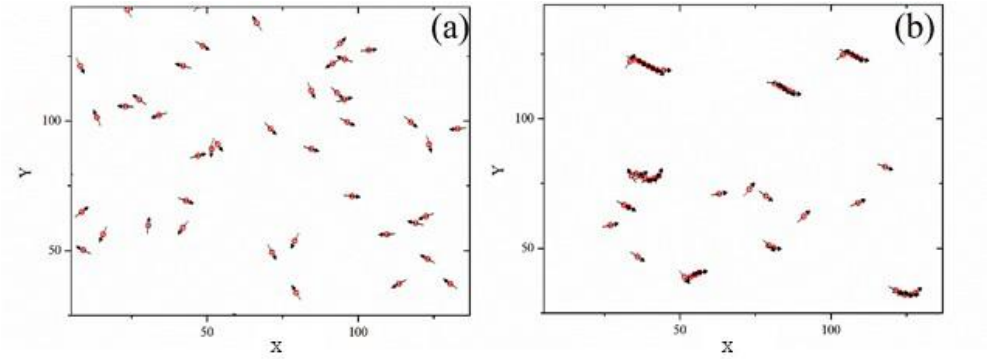

Figure 1. Snapshots of the coated CFO multicore particles configurations: at the beginning of the process t=0 when the particles are randomly placed in the fluid (a)) under a magnetic field h_X = 2.9 at the time t=10^6(in Monte Carlo steps). Black arrows show the spins orientation.

Our simulations have demonstrated [5] that: (a) a moderate magnetic field, comparable in strength to the particles' anisotropy, can create chain-like structures, (b)the dipolar interactions and the anisotropy play the most important role in the type of clusters formation and (c) reversibility of the cluster formation process, i.e. clusters dissociation when the field is switched off, resulting to reusable FFs, can only be achieved if the particles are coated with a surfactant. An important finding of our work is that the interplay between in-plane and out-of-plane field can result to a fast cluster dissociation and thus can act as a monitoring mechanism for the achievement of the preferable type of clusters inside the liquids.

References

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