From Chains to Monolayers: Nanoparticle Assembly Driven by liquid crystal Topological Defects

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I propose to show how advanced hierarchical structures of liquid crystal topological defects can be used to sequentially transfer their geometrical features to nanoparticle (NP) organizations. We use two kinds of topological defects, 1D dislocations and 2D ribbon-like topological defects, forming organized arrays of oriented defects embedded in the same smectic films [1]. I will show their ability to confine NPs, either in 1D or in 2D for the formation of original NP organizations.

Using gold nanosphere (diameter 6nm) we show that 1D dislocations lead to formation of NP chains. The large trapping efficiency of the smectic dislocation cores surpasses the one of the 2D ribbon-like topological defects. This enables the formation of a large number of NP chains all aligned along one single direction for a given sample. When the NP concentration is large enough to entirely fill the dislocation cores, the LC confinement varies from 1D to 2D. We demonstrate using GISAXS performed at Soleil synchrotron that the 2D topological defect cores induce a confinement that leads to planar hexagonal networks of NPs. Combining GISAXS with spectrophotometric measurements we then draw the phase diagram driven by NP concentration, associated with the sequential confinements induced by these two kinds of topological defects. Owing to the excellent large-scale order of these defect cores, not only the NP chains but also the NP hexagonal networks can be oriented along the desired direction [2].

We have thus extended this work to the confinement induced-organizations of nanorods using fluorescent nanorods that are probed by fluorescent microscopy. We observe that nanorods are perfectly oriented in chains within the 1D defects [3, 4]. We also observe that nanorod ribbons can be formed, confined in the 2D topological defects. We demonstrate that even for ribbons as large as some hundreds of nanometers, the average nanorod orientation, whatever slightly less defined than for chains in 1D defects, remains well-controlled, parallel to the defect orientation. These results thus open an avenue for the creation of either 1D or 2D highly anisotropic NP networks.

[1] Coursault et al.,Soft Matter (2016)
[2] Do et al., Nano Letters (2020)
[3] Pelliser et al., Adv. Funct. Mat. (2015)
[4] Rozic et al., ACSNano (2017)