Structure of Assemblies of Nanospheres Confined in Smectic Liquid Crystal Defects

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ABSTRACT

Smectic liquid crystal 8CB, assembled on a rubbed polyvinyl alcohol (PVA) substrate, forms smectic layers curved into hemicylinders. Within these periodic flattened hemicylinders, ribbonlike grain-boundary topological defects are created. These defects can confine nanoparticles (NPs), such as gold or semiconductor nanospheres. At sufficiently high NP concentrations, the confined particles self-assemble into ribbon-like monolayers with hexagonal ordering 1 . GISAXS measurements reveal two symmetric intensity maxima on the upper part of the scattering ring, demonstrating that the central smectic layers of the hemicylinders are not strictly flat. Instead, two symmetric regions of straight but tilted smectic layers form, producing a central chevron of width W that joins the straight and tilted layers with a characteristic dihedral angle 2 . This inclination is transmitted to the NP assembly, leading to a corresponding tilt of the NP monolayer. Recent experiments on the SIXS beamline show that when NPs exceed a threshold diameter of approximately 4 nm, they form ordered hexagonal monolayers aligned with the hemicylinder axis. In contrast, smaller NPs form an average disordered hexagonal lattice. This size-dependent behaviour arises because larger NPs protrude partially from the defect core, inducing elastic distortions in the surrounding liquid crystal that impose orientational constraints. Smaller NPs remain fully trapped within the defect core and do not perturb the neighbouring liquid crystal, allowing the hexagonal lattice to rotate freely and lose long-range orientation. Within liquid-crystal defects, the interparticle spacing is reduced relative to pure NP monolayers and decreases further with increasing NP concentration, indicating compression of the smectic environment. We will continue to use GISAXS and TSAXS to quantify NP arrangements and interparticle distances. Future work will focus on synthesising a broader range of chemical ligands and exploring the assembly behaviour of diverse nanoparticles within liquid-crystal topological defects.

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