Supramolecular Assemblies on Curved Surfaces: the case of Nanoparticles

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Abstract:

It is know that specific molecules can spontaneously arrange on various surfaces forming two-dimensional poly-crystalline mono-molecular layers called self-assembled monolayers (SAMs). These organic coatings are used to impart targeted optical, electronic and biological properties to surfaces. Very often SAMs composed of more than one type of molecule (mixed-SAMs) are used to simultaneously impart multiple properties. Scanning tunneling microscopy (STM) studies have shown that, in mixed SAMs, molecules phase-separate in domains of random shape and size.

We will show that when mixed SAMs are formed on surfaces with a radius of curvature smaller than 20 nm they spontaneously phase-separate in highly ordered phases of unprecedented size. The reason for this supramolecular phenomenon is purely topological and can be rationalized through the "hairy ball theorem". In the specific case of mixed SAMs formed on the surface of gold nanoparticles, the molecular ligands separate into 5 Å wide phases of alternating composition that encircle or spiral around the particle metallic core. This new family of nano-structured nano-materials[1] shows new properties solely due to this novel and unique morphology. For example, the particles' solubility starts to depend on the ratio between the dimensions of the phases and that of the solvent molecules. More importantly, due to the ordered alternation of 5 Å wide hydrophobic and hydrophilic regions, surfaces coated with these particles show the ability of suppressing protein nonspecific adsorption, outperforming poly-ethylene glycol (PEG) the golden standard in this field.