

What is the potential of 'Self-assembly' in designing new coatings?

Conventional methods of synthesis involve formation of covalent, electrovalent or metallic bonds. Polymethyl methacrylate is synthesized from methyl methacrylate by formation of covalent bonds. Zinc oxide is formed by partly covalent and ionic bonds between zinc and oxygen. Metals are formed by association of atoms through metallic bonds.

Concept of 'Self-assembly' has provided scientists with a new strategy for synthesizing materials. The short range interactions governing self-assembly did always exist in bulk materials; but was not used as a deliberate strategy for creating ordered structures from nanoparticles and macromolecules. Thus chemical synthesis, synergistically combined with self –assembly, is emerging as a powerful tool for fabrication of new materials with novel properties.

There are two important principles that govern the use of self-assembly for synthesis of ordered materials:

- Architecture of the super structure is governed by the characteristics of the individual units. Hence, the ability to tailor-make self assembled structures is dependent upon the degree of control on the basic synthesis of nanoparticles and macromolecules. These basic units have to be so designed that their self-assembly builds up the desired structure.
- Architecture of the superstructure can be altered by changing the environment in which the process of self assembly takes place. This is called as 'Directed self-assembly'. This change in the environment can be of different types. Surface on which the self assembly happens may physically constrict the space or energetically exert a strong influence on the self assembling units. In such situations, the self-assembly is called as 'Templated Self-assembly'.

Similarly, other aspects of the environment like electric or magnetic field, temperature and nature of solvent can significantly influence the configuration of the self assembled structures.

Both these principles of 'Tailoring individual units' and 'Directed self assembly' can be applied to coatings. The coating films consist of inorganic particles dispersed in a polymeric matrix. Consider a coating composition consisting of diblock copolymer, pigment nanoparticles and a solvent blend. Films cast from this composition can be made to self-assemble as explained below:

Block copolymers are excellent candidates for self assembly. Diblock polymers can be tailor-made with a pair of monomers differing in hardness (T_g), polarity, hydrophobicity, adhesion, solvency and cross linking sites. Modern techniques of controlled radical polymerization (CRP) enable excellent control over molecular weight and polydispersity.

Further, during film formation, the process of self-assembly can be directed through a blend of solvents with differing polarities and evaporation rates. The individual molecules will self assemble on the surface with one type of block anchored on the substrate and the other block orienting outwards and open to the environment. These polymer blocks can also act as templates for self-assembly of pigment nanoparticles depending upon their affinity for individual blocks. Accordingly, these nanoparticles can be made to self-assemble either in the top or the bottom layer of the film depending on the desired function.

This approach has immense potential to yield following types of coatings

1. Coatings with simultaneously contradicting properties like good adhesion to low energy surfaces with good cohesive strength.
2. Thermoplastic coatings with improved solvent resistant as the outer blocks repel solvent.
3. Waterborne coatings with improved water resistance with hydrophobic outer blocks.
4. Self healing coatings which regain the self assembly to repair disturbance caused by external impact.
5. Introducing cross-linkability only in the outer layer of the film with inner layer remaining thermoplastic to provide impact resistance and dirt pick-up resistance
6. Placing the pigment particles deeper in the film to improve the gloss

7. Placing the UV absorbing and scratch resistant particles in the top layer

