What is the potential of nanotechnology in coatings?

Since the framework of rigorous rules is yet to be established for nanophase materials, it is very difficult to estimate the scope of application to coatings. What we currently do possess is the empirical information regarding properties of nanomaterials in various industries. Sampling of such information is given below to serve as clues for the coatings researcher.

- Optical properties: These depend upon two phenomena viz. scattering and absorption of light. Nanoparticles show Raleigh scattering which is an elastic form of scattering wherein no change in wavelength of radiation takes place. Therefore true nanomaterials do not exhibit phenomena like haze, mattening and translucency. These may show angle-dependent blue frost effect similar to sky appearing blue due to scattering by nanoparticles. The absorption of light by nanosize particles of metals and their oxides is significantly different than their macroscopic counterparts with the absorption bands showing significant shifts. The famous example is that of nano gold particles of 20nm showing red color instead of yellow color of the bulk gold. Another example is quantum dots, which are 5 ~10 nm particles of inorganic materials like cadmium selenide or zinc sulfide which show bright colors due to fluorescence in UV light caused by three dimensional quantum confinement. These have potential to act as intense colorants.
- Electrical properties: Some nano materials like carbon nanotubes show sharp increase in electrical conductivity which could be gainfully utilized in coatings to make them conductive for plastics applications. Certain other materials like semiconductor metal oxides show reduction in conductivity due to increased band gap at nanoscale.
- Mechanical properties: While sudden changes in the mechanical properties like hardness, elongation, elasticity and ductility are observed in the nano region, there is no general trend. Nanoscale copper is highly elastic at room temperature with 5000% elongation at breakpoint. Carbon nanotubes show much higher strength than steel while being six times lighter. Some nanophase hybrid resins show co-existence of contradictory properties like high level of hardness as well as

flexibility. Superior barrier effects of nanoparticles can be used to upgrade anticorrosive properties of coatings.

- Chemical properties: As a general trend, unstabilised nanoparticles exhibit very high chemical reactivity due to high chemical potential, e.g. at nanoscale, metallic aluminum becomes spontaneously combustible. Such enhancement in reactivity of inorganics provides an opportunity for their application in the field of catalysts, curing agents, driers and cross linkers.
- Biological properties: Nanoscale materials can enter the cell wall of organisms and interact with DNA in peculiar ways. Microbial activity of nanosize silver particle is a well known example of commercial nanoproducts. The other interesting and extremely important biological aspect of nanomaterials is their potentially high toxicity even though the parent bulk material may be benign.
