Analytical Seminar

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Room 1315
Chemistry

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Discovery of Optimally Tuned Solvent Blends for CNTs, Graphene, Metal Oxides & Chalcogenides
or
Oops! Better Modify those Solubility Rules

Nanotubes, nanographite and other macromolecules like nanocellulose have always been considered insoluble in solvents due to their size and rigidity (low entropy of solution). Insolubility and the resultant clumping have greatly hindered commercial development and for years, nanomaterials have been full of promise but have not lived up to their potential.

Nanoparticle solutions in true thermodynamic equilibrium should enable the possibility of:

1) chromatographic nanoparticle separation
2) synthetic homogeneous phase nanoparticle chemistry and
3) coatings and composites with exfoliated nanoparticles that might finally harness the super properties of individual particles like CNTs.

Recently, we published definitive evidence of spontaneous exfoliation and the establishment of chemical equilibrium of single-walled carbon nanotubes on dilution of nanotube dispersions in a common solvent, N-methyl-pyrrolidone.[1] To accomplish this work, we built custom ultrasensitive instrumentation and performed second virial light-scattering and many other measurements to show that both the enthalpy and the free-energy of mixing are negative, confirming true solubility and the existence of thermodynamic equilibrium in solution. Further work in our labs led to the discovery of a sharp resonance in experimental solvent/solute surface energy that enables determination of optimum solvent/solute interaction energies and enabled us to be able to predict and increase the SWNT solubility tenfold over our previous work and to develop a general process for solubility determination of nanoparticles like functionalized and unfunctionalized CNT's, nanographene and nanocellulose. We have since extended this into a new general principle in materials science that many of the quintessentially insoluble layered materials such as MoS_2, ITO, CdS, BaTiO3, and TiO_2 in what seem to be true solutions.