What are the principles governing the stabilization of nanodispersions?

Stabilization of dispersions of particles is not an exact science, much less so in the case of nano-dispersions. Since the stabilization performance is system specific, it calls for series of experiments to identify the most suitable stabilizer system. However, it is important for the technologist to be aware of the following concepts so that the experimental work is well directed.

- Dynamic stabilization: Most of the commercial dispersion products work under non-equilibrium conditions. These are the conditions under which the balance between the particle and the surrounding medium is frequently disturbed due to mechanical, electrostatic and thermal stresses caused by agitation, filtration, pumping, dilution, mixing with the other ingredients, evaporation and heating-cooling cycles. Under these conditions phenomena like electroviscosity, streaming potential, interfacial viscosity and capillary action play an important role in determining the stability of the dispersed particles.
- Electrostatic stabilization: In aqueous dispersions, the particles assume either the positive or the negative charge and possess an isoelectric point or point of zero charge. This point indicates the pH at which the particle is electrically neutral. Electrostatic repulsion force between the particles can be enhanced by adjusting the pH or increasing the interfacial charge which increases the thickness of the electrical double layer on the particle. When the electrostatic repulsive force between particles is higher than van der Waals attraction, the flocculation and coagulation of the particles is prevented. This is a case of kinetic stabilization and practically useful in dilute dispersions. Re-dispersion of particles upon coagulation is extremely difficult.
- Steric stabilization: This method of stabilization makes use of high chemical potential of the particles. Non-ionic macromolecular surfactants are used as stabilizers which form a monomolecular layer on the particles through chemisorption. This provides steric hindrance among the particles thereby preventing flocculation. The dispersed

system as a whole attains a state of low free energy. Stable dispersions at higher concentration are possible by this method. Any agglomeration or settling is reversible by mild agitation. This can be a preferred route of stabilization both for aqueous and solvent based nano dispersions.

- Entropic stabilization: In this method, the polymer dissolved in the solvent, by itself acts as a stabilizing agent. Some polymer molecules along with solvent get adsorbed on the particles surface and provide steric hindrance against flocculation with other particles. The higher viscosity of the polymers solution also retards the motion of the particles and the interaction between one another. This method of the stabilization can be preferentially used in nano-dispersions as it does away the need for additional stabilizing agents which may have undesirable side effects in the ultimate product. Conventional protective colloids like carboxy methyl cellulose also function via entropic repulsion mechanism.