Why is ultrasonic technique important in nanoscale dispersion and synthesis?

Nanoparticles with unstabilised surface possess huge amount of energy that causes agglomerate formation to attain stable state of lower energy. Conversely, these agglomerates demand large quantity of mechanical energy to bring about spatial resolution in the form of dispersion in a continuous liquid medium. The energy needs to be supplied at the agglomerate – liquid interface and the interstices in the cluster. Ultrasound energy is a means by which energy can be conveyed to the interface site in the form of continuous 'spurts' of high intensity. This energy is in the following forms:

- Alternating impulses of very high pressure of the order of thousand atmospheres (~2000atm).
- Oscillating zones of high temperature (5000 deg C)with extremely rapid heating and cooling rates
- High velocity liquid jets up to 50 m/sec
- Cavitation resulting into formation, growth and collapse of micro-vacuum bubbles throughout the liquid

The high energy field thus created causes disbondment of the van der Waals forces which hold the agglomerate together leading to uniform distribution of the individual nanoparticles in the medium. Ultrasonic method of dispersion of pigments in the medium has been found to be more effective in achieving nanoscale dispersion compared to the conventional milling methods because of its ability to direct the energy where it is needed without the assistance of any intermediate conveyers like grinding media. Ultrasonic dispersion is claimed to be a method of choice for dispersion of carbon nanotubes in liquids.

Even in bottom-up approach of nanoparticle synthesis of metal oxides by Sol-gel method, the assistance of ultrasonic energy has been found to be useful in controlling the particle size, and more particularly, its distribution. The narrower the distribution, the better the stability of the particle size as Ostwald ripening is prevented.

Sonochemical synthesis is a distinct branch where chemical reactions, particularly involving a solid state reactant, can be manipulated employing ultrasound energy. The sonic energy refreshes the solid-liquid interface thereby enabling the reactants to access the surface. This technique is reportedly used in functionalization of nanotubes with carboxyl groups.

Different types of ultrasonic dispersers are commercially available. These differ in the following aspects:

- The principle of generation of ultrasonic waves: Mechanical, Piezoelectric or Magnetostriction
- Batch type or continuous flow cell type.
- Scale varying from lab research model to pilot and production model
- Choice of power (in watts) from few hundred to few thousand

Choice of frequency from 20 KHz to 20 MHz
