How is the 'reverse micelle' technique useful for the synthesis of nanoparticles?

The 'reverse micelles' can be used as templates for the synthesis of inorganic nanomaterials by precipitation technique. This technique enables nanoprecipitation of the following materials:

- Metal nanoparticles
- Semiconductor nanoparticles
- Metal oxide nanoparticles
- Insoluble salt nanoparticles

When the precipitation reaction is carried out in an aqueous medium, the rate of precipitation is too rapid to allow fine control of the particle size. Hence, we end up with coarse particles. Further, the distribution of particle size is quite wide. The particles generated by the conventional precipitation technique are generally isotropic in properties as there is no control of particle shape. Therefore, there is a need for a technique which will enable precise control of particle size, its distribution and shape. Reverse miceller colloidal precipitation fulfills this need.

The principle of reverse miceller precipitation is as follows:

- Amphiphilic surfactant molecules when present in an organic solvent form reverse micelles when the surfactant concentration exceeds a certain critical value known as the critical micelle concentration (CMC).
- Reverse micelles are self assembled nanostructures with hydrophilic heads of surfactant molecules oriented inwards and hydrophobic tails outwards in the organic solvent matrix. These micelles can be spherical, cylindrical or lamellar depending upon the type and amount of the surfactant.
- These reverse micelles permit formation of 'water-in-oil' emulsion wherein small water droplets are embedded inside the reverse micelle. The size of the droplet can be controlled by the amount of water present. ('Droplet size control')
- These water droplets undergo Brownian motion which results into their collision accompanied by the mixing and exchange of water among the droplets. The droplets of original size are reformed. (' Water exchange process')

- When two different colloidal solutions, each with an individual reactant in their reverse micelles, are mixed, the precipitation reaction occurs in the micelle. The nanoparticles thus get formed. (Figure 1)
- The size of the particle is confined by the size of the micelle which is of the order of few nanometers.

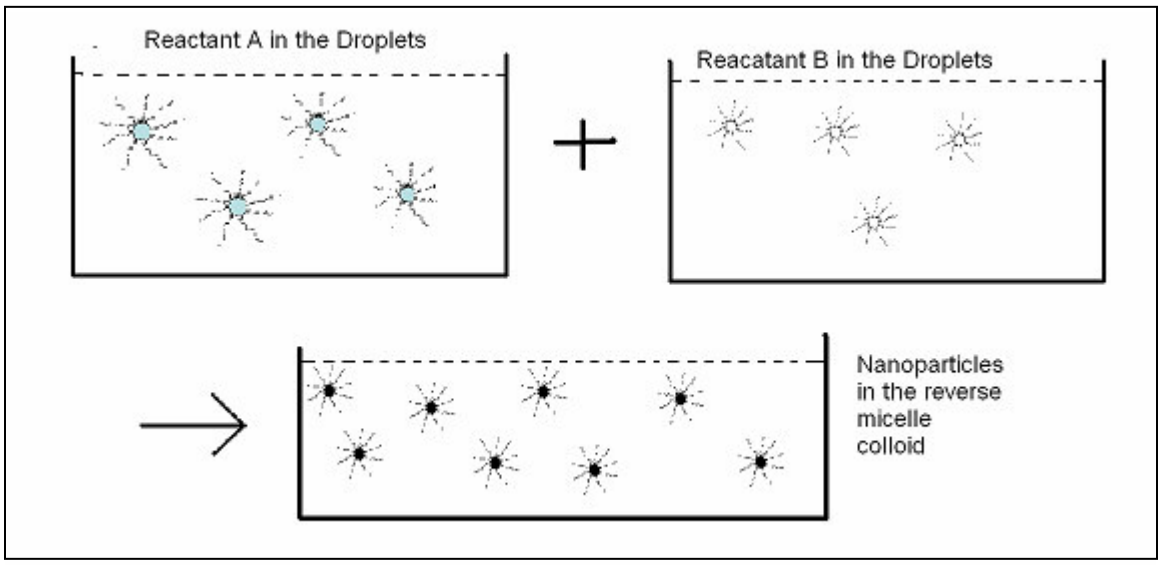

Figure 1: Nanoparticle synthesis in 'Reverse micelles'

Thus, the reverse micelle formation, droplet size control and water exchange are the three key processes in nanoparticle formation by the reverse miceller technique.

This technique can be employed for the following type of reactions:

1. Precipitation by double decomposition : Synthesis of silver halide nano particles from silver nitrate and sodium halide reverse micelles
2. Reduction: Metal nanoparticles like iron, silver, copper, zinc can be made starting with their divalent surfactants [M (AOT) 2] and a reductant like hydrazine.
3. Hydrolysis followed by condensation: Metal oxides like vanadium pentoxide can be synthesized starting with alkoxides dissolved in organic phase and hydrolysis taking place in aqueous micelle.
