process for large particle sizes, and certain auxiliary organics such as trimethlybenzene TMB act as pore swelling agent during synthesis. However, during nanoparticulate synthesis, pore size expansion becomes more challenging due to the presence of cosolvents such as alcohol, which is present to maintain dilute conditions. The swelling agent is dissolved preferentially in the solvent rather than utilizing surfactant micelles for solubilization. Addition of TMB 20 times compared to CTAB is quite helpful in increasing the pore size of MSNs under alkaline conditions yielding pore size up to 5.4 nm. Hydrothermal treatment is another method where dried silica/surfactant composite in the presence of surfactants with longer alkyl chains yield pore diameter in the range of 6.5 nm. Some groups have reported pore size of 13 nm, these MSNs were prepared by reverse miniemulsion technique using a dual surfactant system involving CTAB and amphiphilic block copolymer PE/B-b-PEO. However, the results under acidic conditions are quite different where MSNs having pore size 20 nm were synthesized using polymeric surfactants of the ABA-type as SDA.

During synthesis of MSNs the most challenging part is avoiding secondary aggregation of particles after nucleation and growth of primary MSN particles. In order to prevent secondary aggregation during synthesis there are two main strategies being followed:

(1) using particle growth quenchers and
(2) maintaining highly dilute conditions during synthesis.

Although synthesizing monodisperse MSNs in the laboratory under dilute conditions is very reproducible, carrying out synthesis on a large scale may become difficult. The role of growth quenchers in this aspect is a better alternative, where polymers or nonionic surfactants, triethanolomine, propanetriol, fluorocarbon (FC)-based cationic surfactants, etc. can help in achieving higher dry contents without secondary aggregation.

Another method of preparing hollow silica sphere involves depositing silica layers on colloid templates or on latex followed by removal of the hard templates by corrosion and calcinations. An alternative method is sol-gel/emulsion, in which silica growth takes place on the emulsion droplets. Various emulsion systems have been reported in the recent past such as water-oil-water, oil-in-water, water-in-oil, oil-water-oil for the synthesis of hollow mesoporous silica spheres, however uniformity in thickness of shell and size for spheres as prepared is not as satisfactory as in the case of hollow spheres obtained by hard template method. In order to achieve better results by emulsion method ethanol is used as solvent as it has good compatibility with both water and TEOS, thus it may improve stability of oil droplets. The only consideration is optimizing the amount of ethanol although it acts as stabilizer but it could also dissolve the TEOS droplets. Fig. 19.1 shows the effect of ethanol-water ratio on formation of mesoporous silica spheres.