Nano structured materials-synthesis, properties, self assembly and applications
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MODULE 2 (LECTURE 1 & 2): SOL-GEL

Problem:

1. What are the two basic approaches for synthesis of nanomaterials.
2. What is sol-gel method.
3. Advantages of sol-gel route.
4. What are the steps involved in a typical sol-gel process.
5. What is a sol.
6. What do you understand by PZC.
7. Define gel.
8. PZC depends on which parameters.
9. Define Oswald ripening.
10. Condensation process influenced by what parameters.
11. What are the different drying process of gel.
12. Difference between colloidal vs polymeric route.
13. What are the internal and external parameters affecting sol-gel process.
14. Applications of sol-gel process.
15. How to control the size of particles using sol-gel process.

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Solution:

1. Top down and bottom up approach
2. Sol-gel: process in which solid particles are dispersed in a liquid (a sol) and agglomerate together to form a continuous three dimensional network extending throughout the liquid (a gel)
3. Product morphology can be controlled, cheap and low operating temperature, shaping is simple, homogenous compound can be achieved
4. Hydrolysis, condensation, gelation, ageing, drying and densification
5. Sol: consists of a liquid with colloidal particles which are not dissolved, but do not agglomerate or sediment
6. PZC: point of zero change, pH where the particle is neutral
   PZC > pH, particle surface negatively charged
   PZC < pH, particle surface positively charged
7. Gel: dilute cross-linked system, which exhibits no flow when in the steady-state.
8. PZC depends on pH, size of particle and degree on condensation.
9. Ostwald ripening: process of ageing where small particles dissolve and add on to the large particles to grow bigger particles.
10. Condensation process influenced by type of precursor, ratio between alkoxide and water, type of catalyst, type of solvent, temperature and pH
11. Different drying process of gels: Cryogel, Aerogel and xerogel
12.

Colloidal	**polymeric**
Metal alkoxide or metal salt	Metal alkoxide
Solvent = alcohol or water	Solvent = alcohol
Precipitation [alkoxide]<<[water]	Precipitation [water]/[alkoxide] = 1-4
Gel as a result of electrostatic effects	Gel as a result of further polymerization

13. Internal parameters: nature of the metal atom and alkyl/oxide group, structure of metal precursor
    External parameters: water/alkoxide ration, catalyst(acid or base), concentration of solvent/precursor, solvent, temperature
14. Optical coatings, ceramics, thin films, fibres
15. Low temperature process advantageous for controlling particle size. Rate of hydrolysis and condensation under basic and acidic condition influences the particle size