SOL-GEL METHOD:

- The sol-gel method is a wet chemical method or chemical solution deposition method.
- This method is used to (generate) produce nanoparticles & nanopowder in the form of oxide material such as TiO_2, ZnO, Al_2O_3 and various rare earth oxides.
- A given material is converted into colloids & dissolved in water/alcohol/acids, then form a solution.
- A colloid suspended in a liquid is called "sol" and a suspension that keeps its shape is called "Gel" (Gelatin).

Principle:

- The basic principle of the sol-gel method is “the formation of a hydroxide through Hydrolysis and Polycondensation reactions of a molecular precursor in a liquid”.

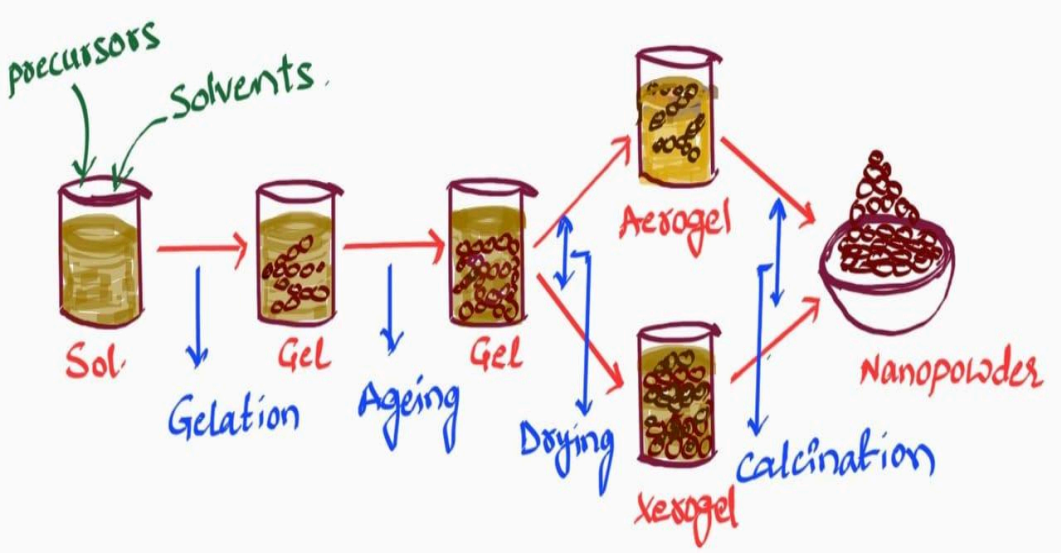
Steps involved in precipitation method:

(i) Formation of Sol. (ii) Gelation (iii) Aging of Gel

(iv) Drying of Gel (v) Calcination

- **The schematic representation of Sol-Gel Method as follows:**

Precursor → Sol→ Gel → Aerogel or Xero Gel → Final product



(**i) Formation Sol :** Take precursors(raw material) like metal alkoxide or metal salts and dissolved in water or alcohol or other solvents.

- It forms a colloidal suspension known as a solution simply "sol".

(ii) Gelation: Gelation can be induced by various methods such as hydrolysis and condensation reactions.

- During **hydrolysis**, the metal alkoxide precursors react with water to form metal hydroxides, while **condensation** reactions lead to the formation of bonds between the nanoparticles, resulting in the formation of a “gel”.

(iii) Aging of Gel: After gelation, the gel is typically allowed to age at a controlled **temperature** and **humidity** for a certain **time period.**

- Aging promotes **polycondensation** reactions and allows the gel structure to mature, leading to the formation of solid mass along with contraction of the gel network.

(iv) Drying of Gel: Drying can be carried out through evaporation, freeze-drying, or supercritical fluid extraction to remove the solvents (water and other liquids) from the gel.

- If the rapid drying under **supercritical conditions** results in the formation of aerogel while **thermal evaporation** results in the formation of a xerogel.

(v) Calcination: Calcination is a final step used to transform a dry gel into the desired final material, typically an oxide or ceramic powder

NOTE: Spinning also used to deposit a thin, uniform film of dry gel material onto a substrate.

Advantages:

1. Cheap and low-temperature technique.
2. To prepare mono-sized nanoparticles.
3. Obtain very high purity material.
4. Easy control of the rate of reaction.

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5.Even small quantities of dopants can be introduced.

Disadvantages:

1.Controlling the growth of particles is difficult.

2.Issue with shrinkage and cracking during drying.

3.Issue the potential cost of precursors.

Applications:

1.It can be used for ceramics, thin film manufacturing.

2.These derived materials have applications in optics, electronics, energy, and space.

3.These derived materials also have applications in bio-sensors, medicine, etc.

4.It is used to carry out zeolite synthesis.

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