

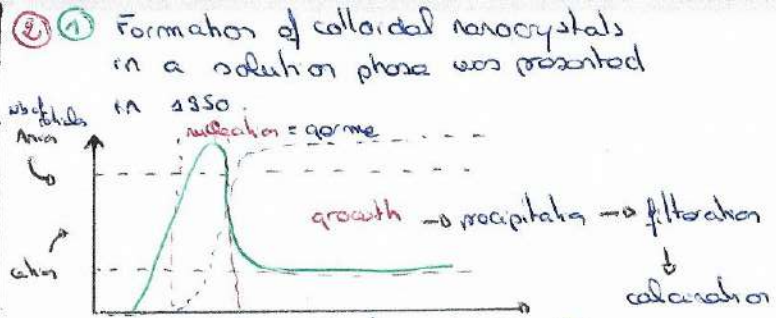
Metal oxide nanomaterials

Solid state approaches

- Selection methods ②
- co-precipitation methods ④
- Sol-gel route ②
- reverse micelle and surfactant ⑤
- templated routes ④
- hydrothermal synthesis ⑤

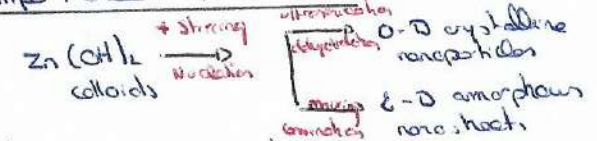
easy and effective large scale synthesis

④ High temperature of proton, low purity / poor homo. nanoscale materials hard to achieve

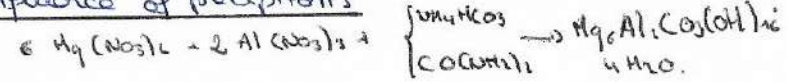


→ phénomène de vieillissement de Ostwald.
 ⚠️ table critique de stabilité: points → dissolution

Importance of treatment



Influence of precipitants

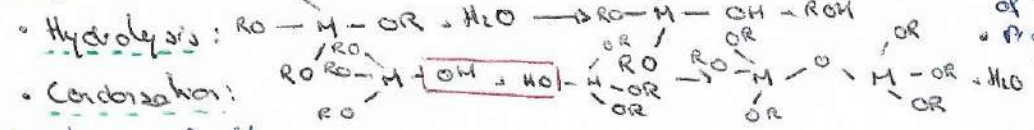


②② Sol-gel process consists in the chemical transformation of a liquid (the sol) into a gel state and with subsequent post-treatment and transition into solid oxide material.

The sol defines a colloidal solution made of solid particles, few hundred nm in diameter, suspended in a liquid phase.

The gel can be considered as a solid macromolecule immersed in a solvent.

Process for great range of elements: two main steps



Importance of pH:

- Acidic pH: - Faster hydrolysis
 - slower condensation
 - polymeric network
 - randomly branched polymer



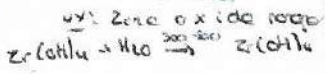
stable silica nanoparticles

- Basic pH: - slower hydrolysis
 - nucleation
 - highly branched clusters
 - colloidal suspension



strong impact on the nature of the products issued from the reactions

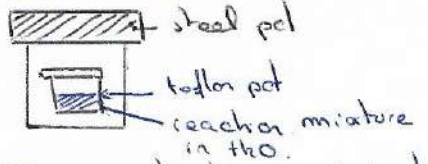
Influence of T



Pöccari process: releasing of positive ions in a solution, controlled transformation of the solution into a polymer gel, removal of the polymer matrix end up of an oxide.

②③ Self-assembly of surfactant micelles in the formation of templated mesoporous silicon. ex: ZrO₂ mesopores.

②⑤ Boms: solvent can be heated above SP.



The reactants are dissolved (or placed) in water or another solvent (solvothermal) in a closed vessel.

- solvent above boiling point (supercritical fluid)
- Usually follows a liquid nucleation model
- T > 100°C, P > 1 bar
- Modification of the chemical in a solution
- Formation of metastable structures, more complex, of lower symmetry
- Properties of the solvent are modified

① - Direct reaction of solids to form the final product.

- solids do not react with solids at room temperature even if thermodynamics is favorable.

- High temperature must be used
- Solid-solid reactions are simple to perform, starting materials are often readily available at low cost and reactions are "clean" i.e do not involve other chemical elements.



→ reaction only occurs at contact points between grains of HgO and Al₂O₃.

⚠️ Importance of the area of contact.

Two ways to increase the rate of diffusion:

- Increase T
- Introduce defects by starting with reagents that decompose prior to or during reaction, such as carbonates or nitrates.

