INTRODUCTION TO CERAMICS, GLASS AND REFRACTORIES

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5) Ceramic Powders
Ceramic Powder Preparation

Preparation methods

Mechanical Method
- Natural Minerals
  - Crushing (to 5 mm)
  - Grinding (to 1 mm)
  - Ball Milling (to 0.5 – 10 µm)
  - Attrition Milling (to 0.1 – 5 µm)

Chemical Method
- Sol-gel Processing
  - 1) Control on Particle Morphology
  - 2) Purity
  - 3) ≤ 0.1µ

Vapour Phase
- Materials Evaporation-Condensation
  - 1) Very Expensive
  - 2) High Purity
  - 3) Nano-Particle (10^-9 m)

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**Types of Particles**: It is important to be able to distinguish between different types of particles.

- **Primary Particle**: discrete low porosity unit (0.1 – 1.0 µ) it may be a single crystal, a multi-phase polycrystalline, a multi phase polycrystalline, amorphous or a glass. The pores are isolated from each other.
- **Agglomerate**: small mass of bonded primary particles having a network of interconnected pores.
  - **Hard agglomerate**: solid bridges between particles due to sintering, fusion or chemical reaction.
  - **Soft Agglomerate**: Particles are connected by surface force such as electrostatic.
- **Particle**: Measured by particle size measuring techniques, can be primary, agglomerate or a mixture.
- **Granule**: Large soft agglomerate for example the product from a spray drier.
- **Colloid**: Small particle less than 1µ dispersed in a fluid and maintained in suspension by Brownian motion.
- **Floc**: Clumped of colloidal particles in liquid suspension.

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Powder requirements for high quality ceramic microstructure:

- **Mean size:** Less than 10µ; less than 0.5µ better to control sintering rate since; \(\Delta L/L\) proportional to \(d^{-n}\) where \(\Delta L/L\) is the linear shrinkage (sintering), \(d\) grain size and \(n\) is a factor

- **Particle size distribution:** Determine packing density and sintering behaviour. Mostly large particles and sufficiently small particles to fill in the interspaces will result in compact of high green density.

  - **Shape:** Shape of particles such as elongated or spherical influence packing density & powder flowability

  - **Homogeneity:** Agglomerates may result in non homogenised microstructure

  - **Purity:** Impurities may cause a precipitation of another phase at grain boundaries which reduce strength and decrease creep resistance. Inclusions act as a flaw and for different thermal expansion cause microcracking.

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Preconsolidation and Additives

The desired powder is compacted into final shape by various forming techniques such as pressing, slip casting, injection moulding, extrusion and then strongly bonded and densified. A uniform compact having uniform properties and no distortion is required. Depending on specific forming method the powder requires special treatments or processing and various additives prior to compaction and densification.

**Binders**: are added to provide enough strength in the "green" body to permit handling and machining.

**Dispersing agents**: To control pH of slurries and provide particle surface charge and particle-particle repulsion.

**Plasticizers**: Rheological aid, improve flexibility of binder film, allow plastic deformation of granules.

**Wetting agents**: reducing of surface tension

**Lubricants**: To decrease particle-particle and particle-tool friction during compaction

**Sintering aids**: To aid densification