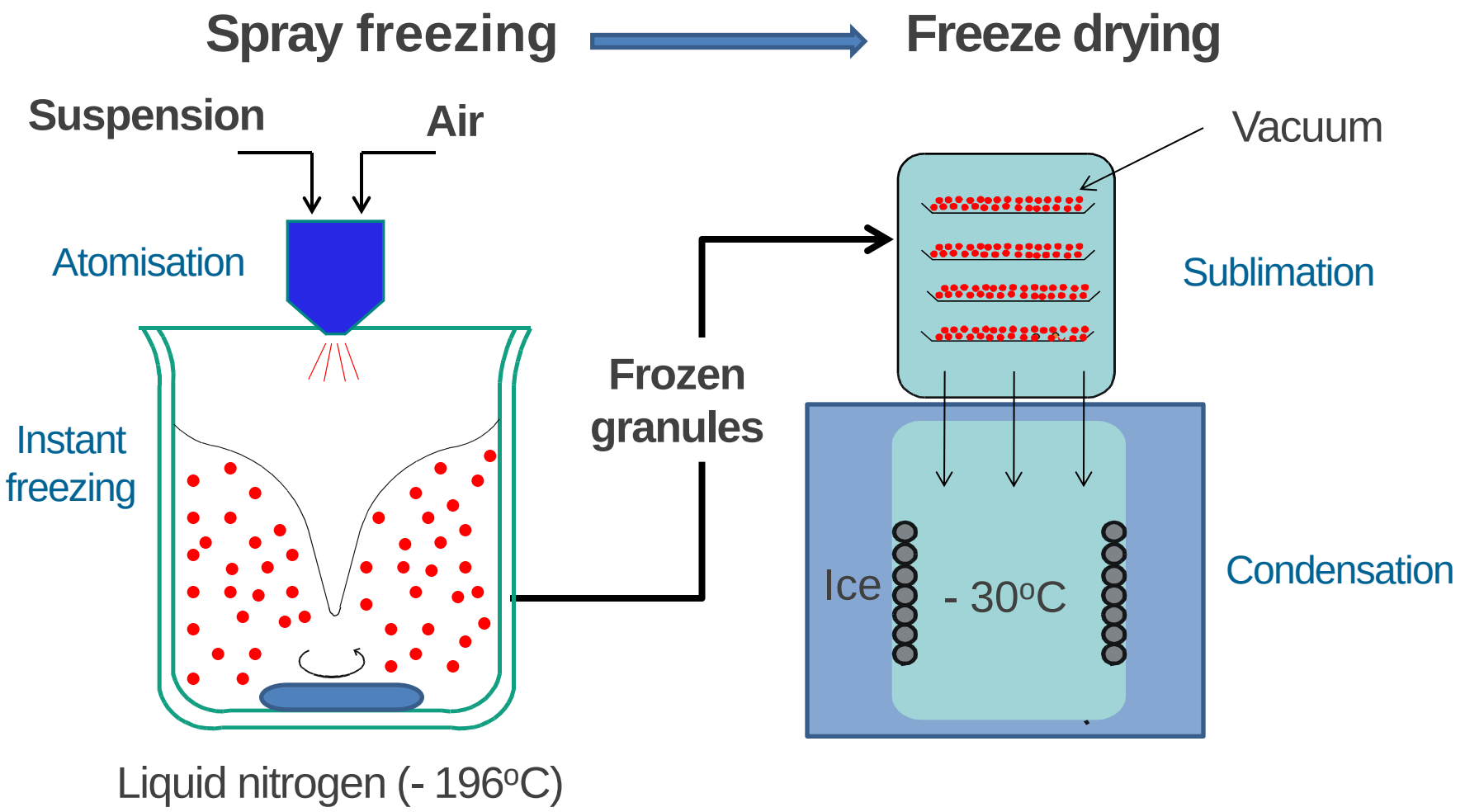
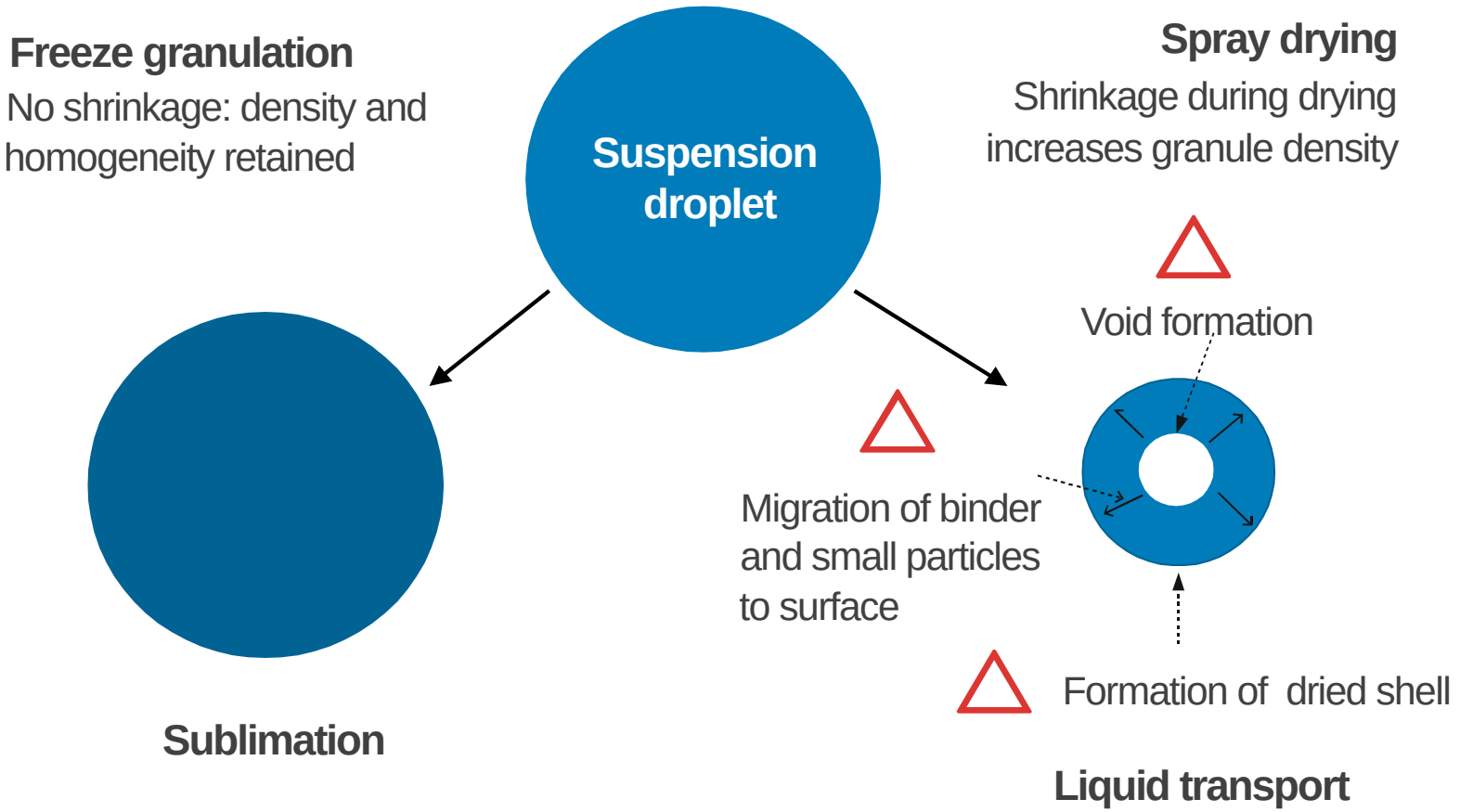
Freeze Granulation for Processing of Nano Materials

Kent Rundgren, President of PowderPro AB

Freeze Granulation Process

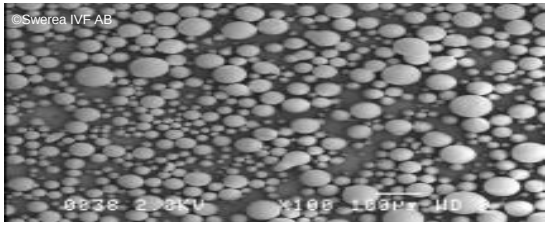


Freeze Granulation vs Spray Drying

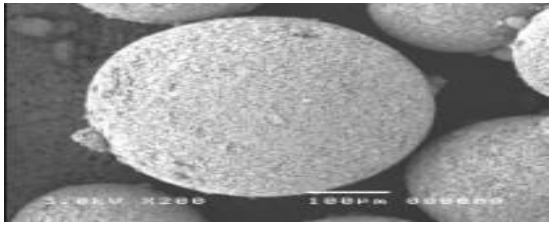


A variety of applications

Atomisation
Homogenous granules



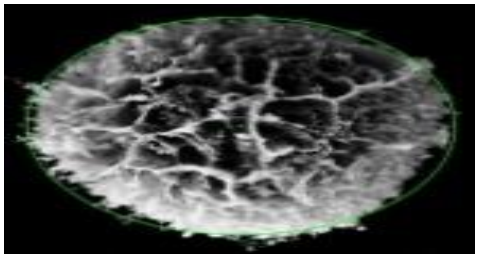
Metal powders
Explosives
Diamond tools



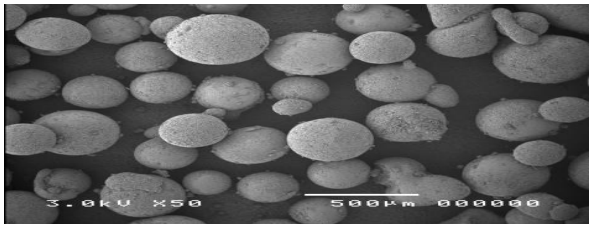
Composites
Chemical Looping
Combustion
Material synthesis

LED-Lighting materials

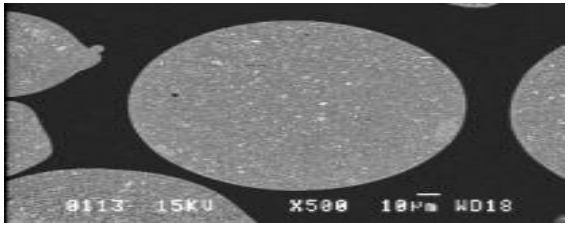
Nanopowders



Instant freezing
Spherical Free flowing

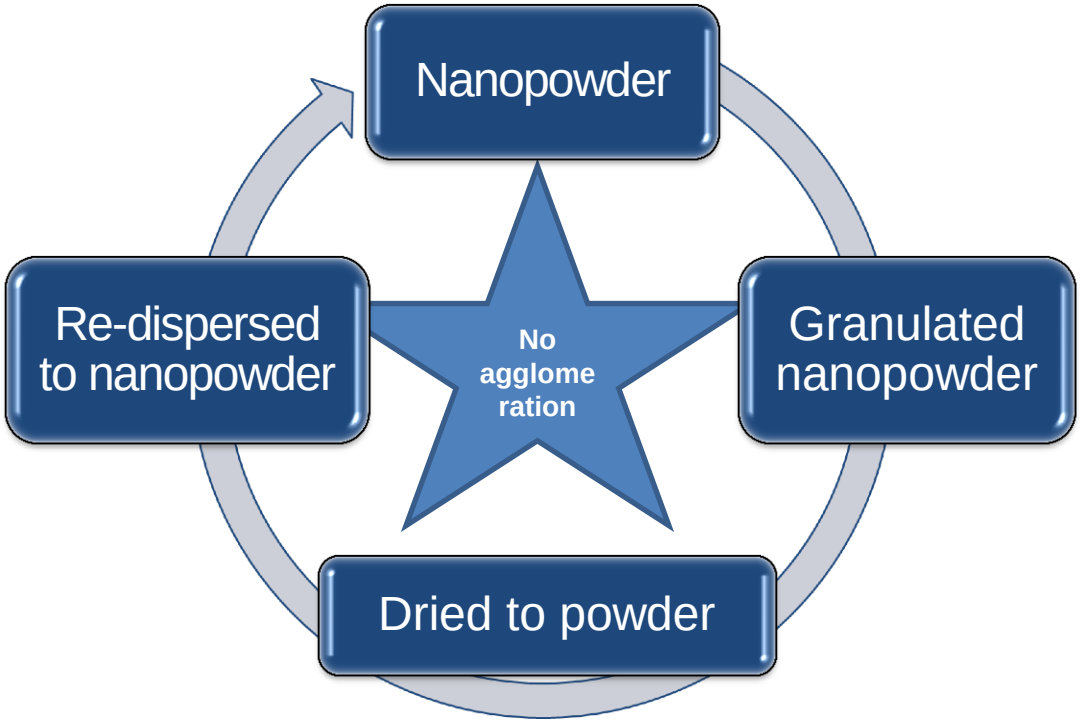


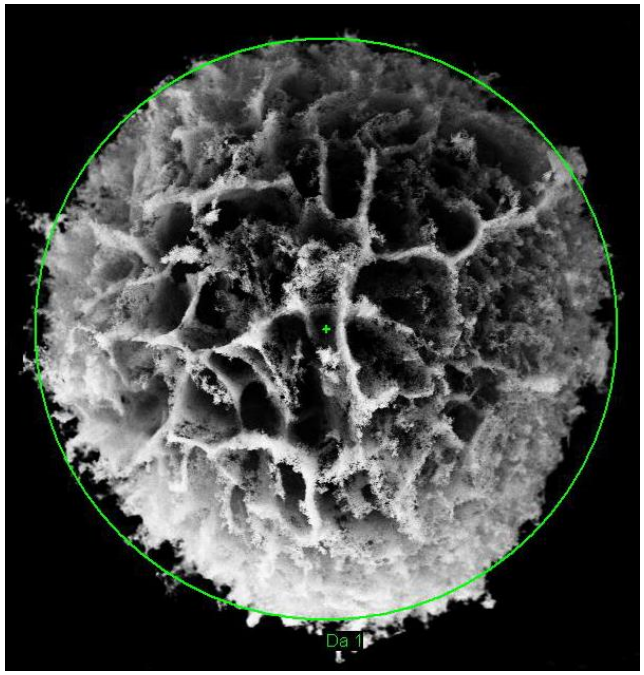
Ceramics
Biomaterials
Grinding wheels



Catalysts
Nanomaterials
Pharmaceuticals
Chemicals

Freeze Granulation of nanopowders





- Unique process to retain nanomaterial particle size
- Nano-particles keep separated
- Re-dispersible end-result

Freeze Granulation

- Method to preserve nano properties
- Method to produce *homogeneous* granules and preserve material homogeneity
- Method to avoid strong bonding and oxidation
- Method to produce granules of nano materials that can be handled and processed in dry state
- Method to produce granules, easy to re-disperse to original particle size distribution

PowderPro AB

Founded in 2000, as a spin-off company from the Swedish Ceramic Institute, to provide equipment for freeze granulation

» A privately owned, expanding company

» Science-based

» Affiliated to Swerea IVF AB and Chalmers Industriteknik

» Especially experienced in the ceramic and powder metallic fields

» Looking to expand into fields where high-quality freeze granulation can improve processes and output quality

Freeze Granulation

Models: LS-2 and LS-6

Small scale with capacity to process up to 6 litre suspension per hour

Medium scale with capacity of processing 25 litre per hour is under development

Freeze drier GT-2

Heated trays for quick drying

Capacity to dry ca 2 litre of granules that is achieved from ca 1 litre powder suspension.

Driers with much higher capacity exist on the market

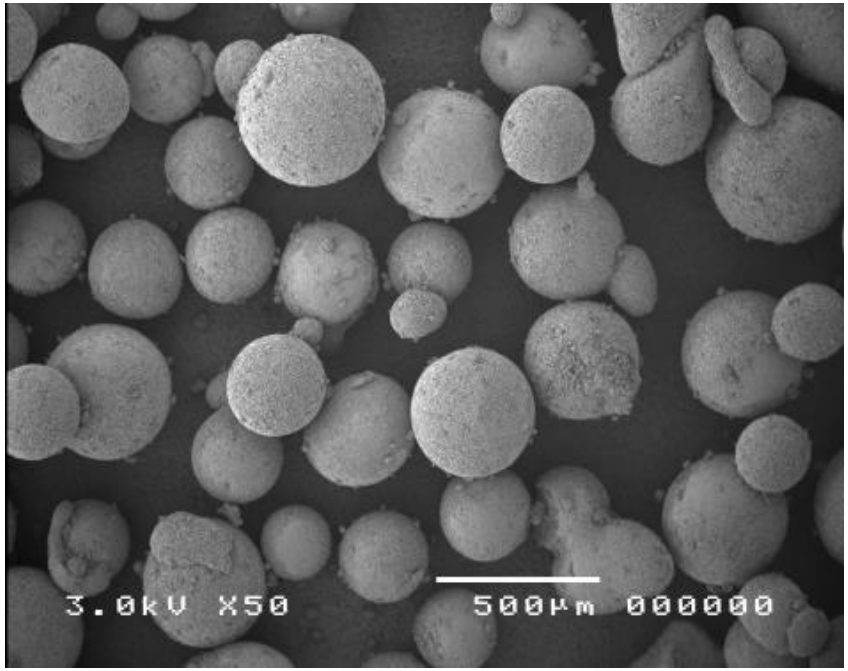
Aspects in processing of small units of matter

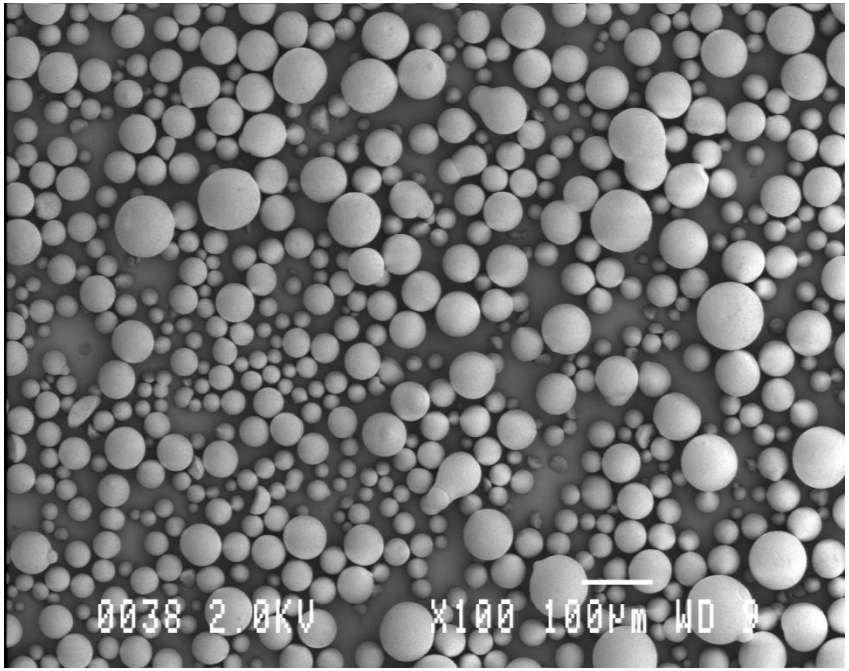
- Difficulties to retain homogeneity during processing
- Difficulties to keep small units separated
- Drying from suspension causes agglomeration, segregation and oxidation
- Difficulties to obtain handable/processable nanopowders in dry state
- Difficulties to re-disperse from dry state

Freeze Granulation Process Benefits

- Homogeneous granules
  - *No cavity or void formation*
  - *No migration of any substances or small particles to surface*
  - *No, or limited, shrinkage of granules*
  - *No formation of a dried shell*
- Granule density controlled by suspension composition
- Vacuum drying minimizes oxidation
- High yield, low waste of material
- Process allows latex (water insoluble polymers) as binder
- Recycling of solvent possible

Granule properties





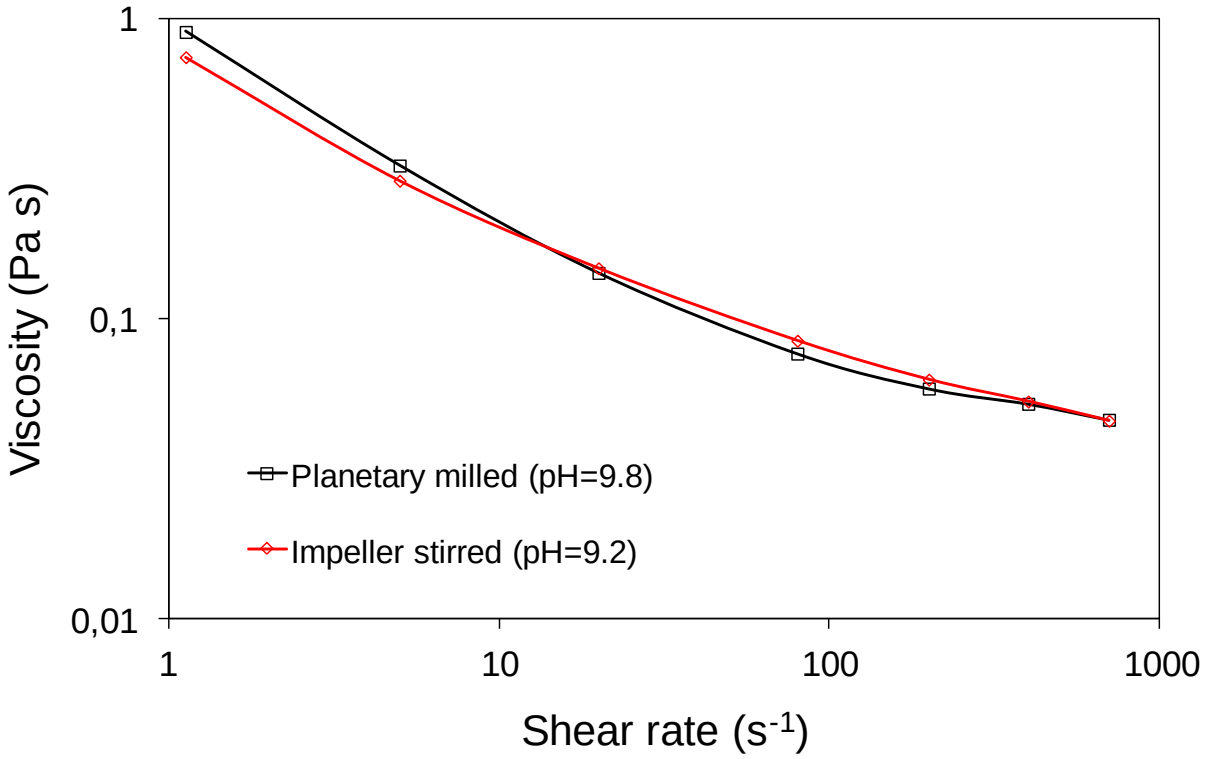
Free-flowing granules with a wide granule size distribution (20–500 µm)

Density depends on solids in suspension

Size depends on suspension viscosity and granulation parameters

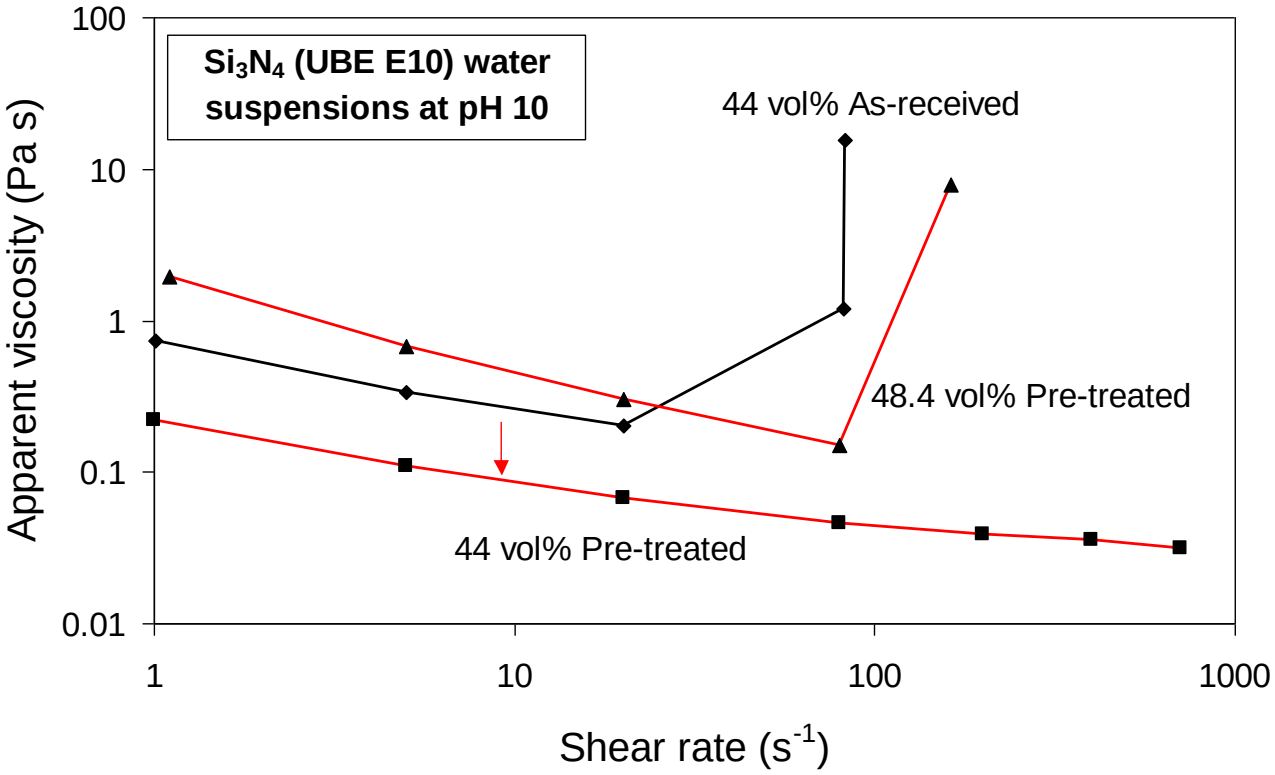
Re-dispersibility of submicron powders - 1

Freeze granulated/freeze-dried powders can be re-dispersed with impeller stirring to the same de-agglomerated state as with planetary ball milling.

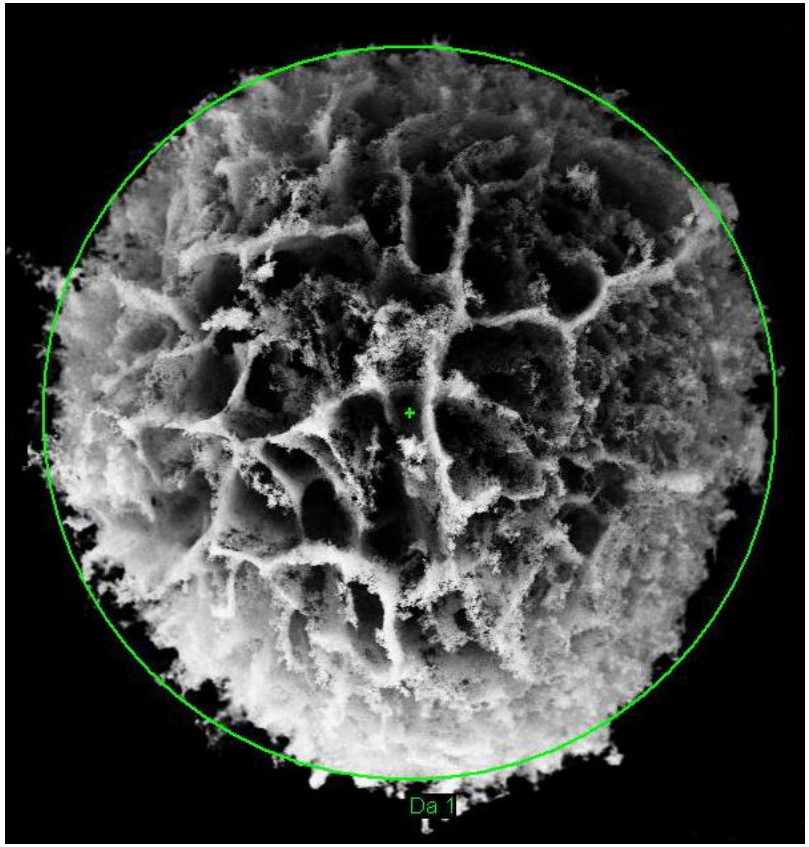


Re-dispersibility of submicron powders - 2

Powders, difficult to deagglomerate, can be dispersed at low concentrations, freeze granulated/freeze-dried and re-dispersed at higher concentrations..



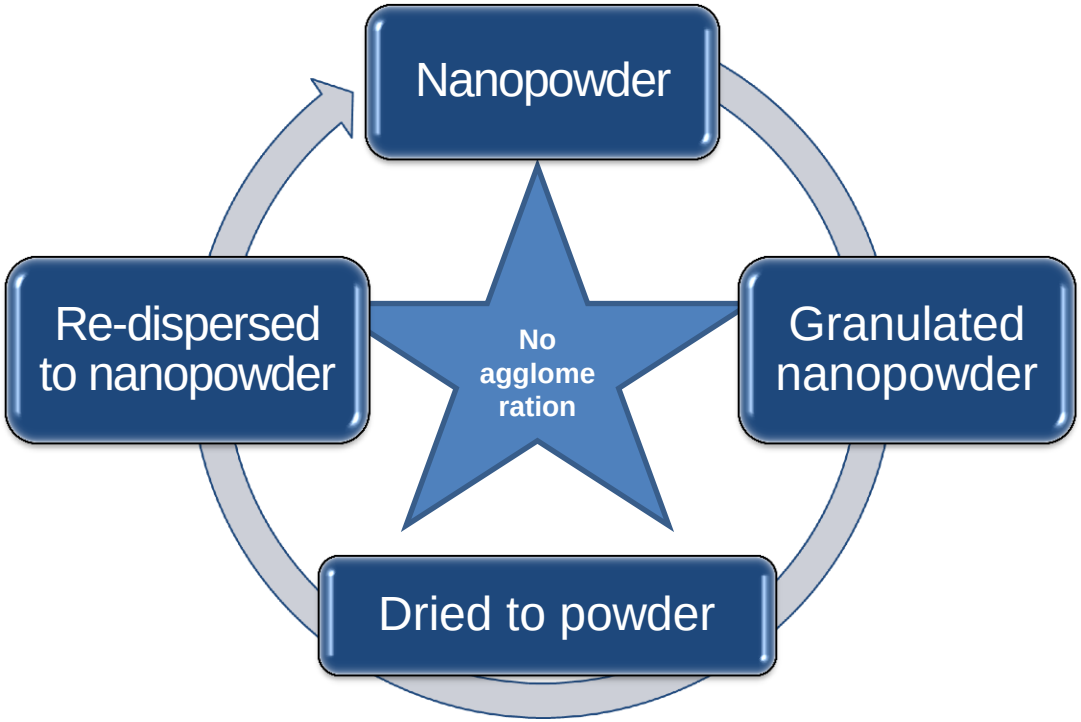
Granules of ”nano” powders

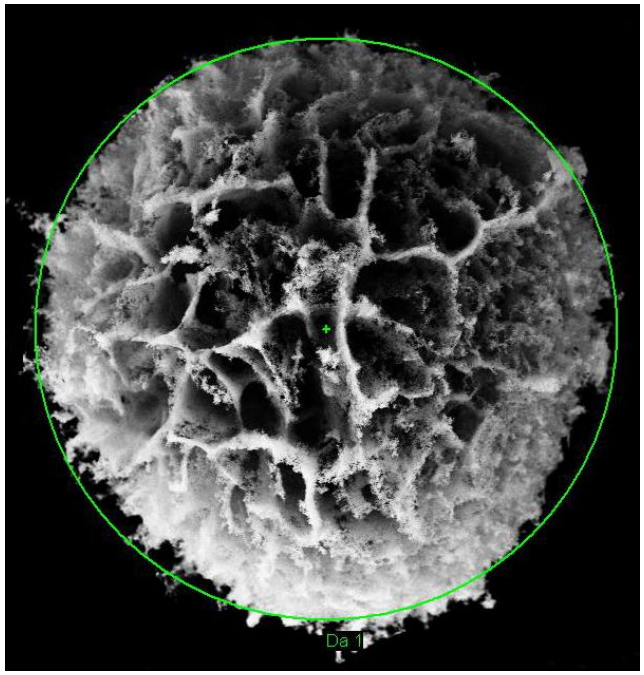


Granule based on 10-30 nm particles at low concentration

Granule based on 500 nm particles at high concentration

Freeze Granulation of nanopowders





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Various aspects and uses

- All kinds of material in dispersed form can be granulated
- Ideal for preparation of fine powder mixes with suitable additives for subsequent processing
- Suspension quality always determines and will reflect the granule quality in terms of homogeneity
- Favorable preparation step for material synthesis owing to the homogeneity of the granulated material
- Water as medium is preferred but also organic solvents with suitable freezing point (-25 to +10°C) can be used.

PowderPro – Offers and services

- Supplies freeze granulation equipments for Lab, Pilote-scale and production
- Carry out test granulations of customer-supplied materials
- Supports process implementation and start-up with customers

PowderPro has close collaboration with Swerea IVF AB in research related to freeze granulation in a wide range of material/applications.

Mission

PowderPro's mission is to provide first-class Freeze Granulation and drying techniques for processing of ceramic and metal powders, nanomaterials, diamonds, proteins, enzymes, fine chemicals and pharmaceuticals.

Freeze Granulation - Summary

- Provides a competitive technique for the manufacture of granules for various purposes
- Preserves the material homogeneity
- Enhances subsequent processing performance
- Enables equally appropriate process for smaller and larger quantities with equal results
- Enables controlled granule density can be
- Provides mild drying with low degree of oxidation