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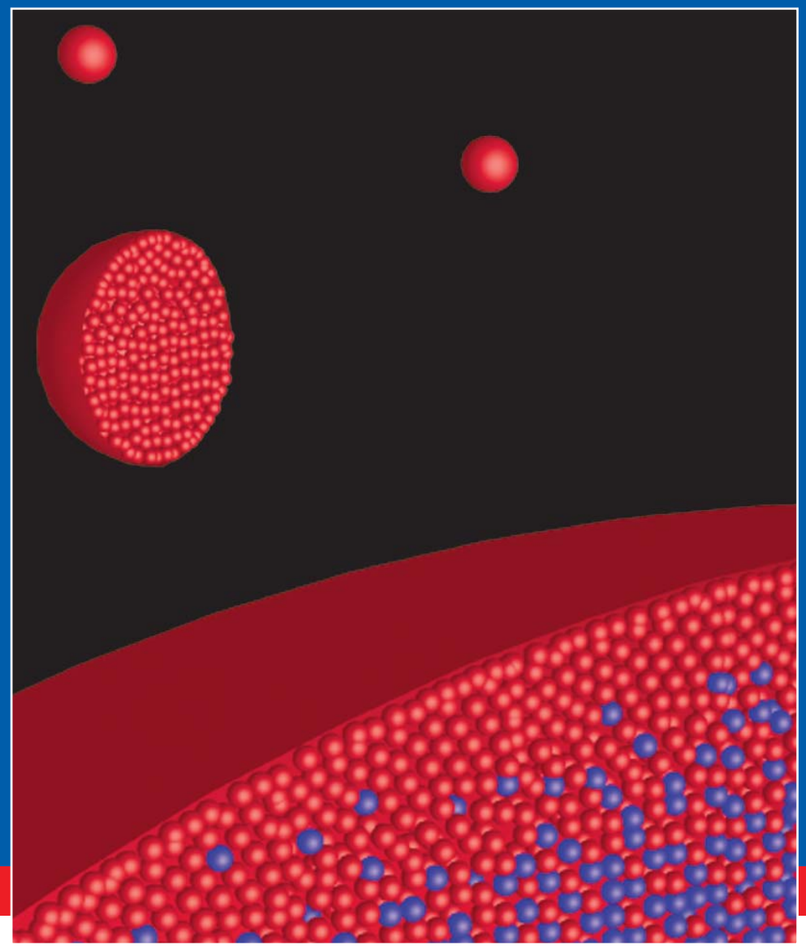
HOSOKAWA MICRON

The Hosokawa Micron Group will always be the leading global company covering the mountain range of Powder Technologies. The Group will achieve peaks of excellence in the development and commercialisation of advanced materials, process equipment and systems engineering.

FM 41014

NANO PARTICLE TECHNOLOGY AND PARTICLE DESIGN



HOSOKAWA MICRON

PROCESS TECHNOLOGIES FOR TOMORROW SM

PARTICLE DESIGN

Particle Design

The chemistry and physics of nanotechnology represents a paradigm shift in particle design with a new generation of particles created with specific properties. These properties can be mechanical, optical, electric or chemical in nature. Not only does the production of nanoparticles offer the potential of more effect for much less mass but in many cases the product effect can be quite different from that achieved with micron sized particles.

Advanced material development offers potential in a range of industries including pharmaceuticals, cosmetics, battery manufacture, metallurgy and fuel cell engineering. Hosokawa Micron's ability, within the field of nanotechnology, provides the unprecedented ability to transform molecular materials into new structures with fundamentally new properties that can give manufacturers a competitive advantage and provide consumers with greater performance.

Particle Production

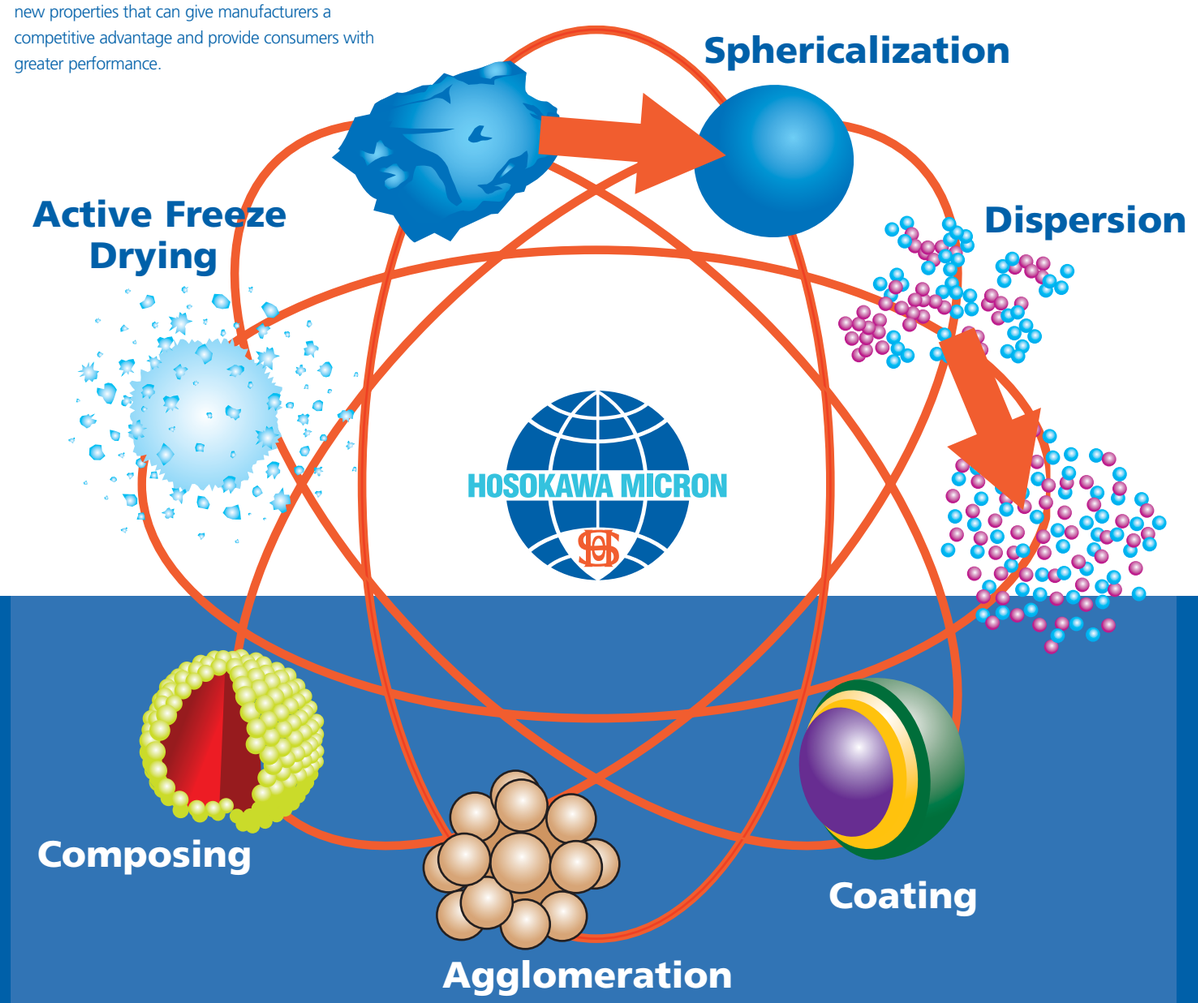
Hosokawa Micron has designed a new nanotechnology product portfolio to develop particle modification technologies which will improve powder characteristics and/or create new powder characteristics without changing any chemical properties.

Partnerships in Particle Design

Hosokawa Micron engineers are able to work directly with customers to create unique nano-composites and engineered particles to meet specific demands. Working in conjunction with Hosokawa Micron nanotechnology engineers, in centres in Europe, Japan and USA means customers have access to the best resources in pioneering particle design.

Contract Processing

For companies wishing to enter the market with low volumes of material production whilst they await installation of their own production systems or whilst they undertake market tests, Hosokawa Micron are able to provide a contract nano-processing service.



HOSOKAWA MICRON TECHNOLOGY

PARTICLE DESIGN

Dry Process Particle Design Technologies

The two generic approaches to the manufacture of nanoparticles of, top-down/bottom-up technologies are currently being pursued in the drive to create high value particles by nanoparticle technology. Amongst the most promising top-down methods are ultrafine comminution, aerosol routes and very rapid precipitation. In the longer term, bottom-up molecular self-assembly routes are likely to become important commercially.

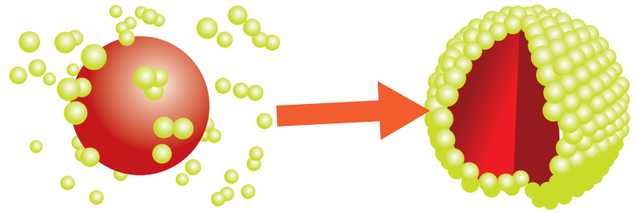
These technologies not only produce added value materials but can also lead to process improvements by reducing process steps and energy costs.

Downstream processing

Once nanosized materials are produced either in liquid or gas phase, elements of classical powder technologies are applied to further process materials. These processes can involve drying, blending, coating or agglomeration.

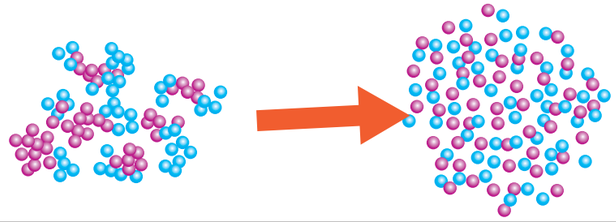
Composing

Nano-scaled guest particles are permanently fused onto the surface of micron-scaled host particles without the need of binders. In this way material properties of both components can be combined and effect a functionalisation of the host particles. This means properties like conductivity, flowability, chemical reactivity or solubility can be enhanced or manipulated. In principle, composing is a process similar to sintering.



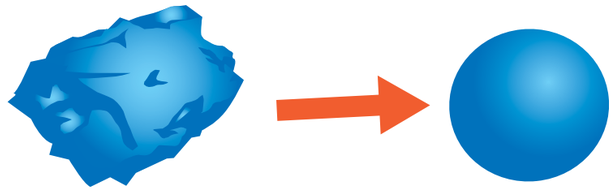
Dispersion

The utilisation of nano-scaled particles requires high shear forces to decompose agglomerates to aggregates or single particles. Hosokawa Micron's particle design technologies enable distributive and dispersive mixing in one apparatus. High-intensive mixing delivers optimum mixing quality down to the nanometre range. This processing enhances colour tone, reactivity and calcinations ability.



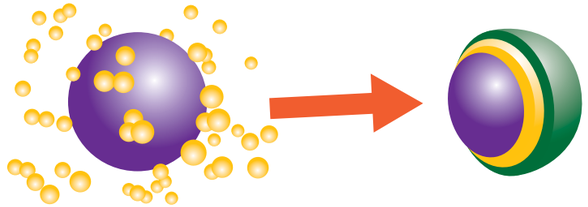
Sphericalization

Particle shape design by sphericalization improves flow properties and packing density.



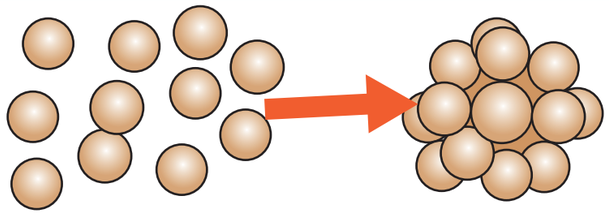
Coating

Particles can also be coated by a solid or liquid coating agent. Solid coating agents can be molten in the melting temperature range between 70° up to 90°C. Purpose of the coating process can be the hydrophobisation, functionalisation, control or deceleration of solubility of the core particle.



Agglomeration

Granulation or agglomeration of fine particles can be conducted in Hosokawa Micron's particle design equipment under certain conditions. Ideal spherical particles give a raspberry like structure. The state of mixing can be fixed, dusty materials can be de-dusted and the flowability can be manipulated by agglomeration.



HOSOKAWA MICRON TECHNOLOGY

PARTICLE DESIGN

Through extensive research and development, Hosokawa Micron has developed a range of equipment to advance particle modification technologies for the production of materials with improved functionality.

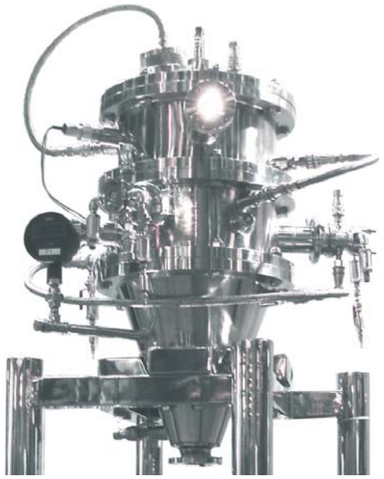
Current technologies available for the manufacture of functional nanopowders are dispersion, mixing (normal, ordered or precision), coating, fusion, reactions (solid-solid surface), Mechano Chemical Bonding (MCB), shape control, agglomeration, nanogrinding, drying from nanoslurries and the measurement techniques employed in evaluating these materials.

With Hosokawa Micron equipment available as lab sized units and production size systems and with worldwide expertise of these new technologies Hosokawa Micron are ideally positioned to work with customers to commercialise nanotechnology and market nanomaterials to fuel the demand for the new generation of functional powders.

NANOCREATER

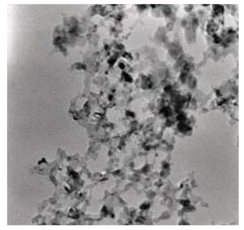
Following table shows different one component products generated by NANOCREATOR and their particle sizes calculated by BET method.

Product	Particle size x_{BET} / nm	Product	Particle size x_{BET} / nm	Product	Particle size x_{BET} / nm
Al_2O_3	19	Mn_3O_4	80	TiO_2	29
Al_2O_3	35	SiO_2	13	TiO_2	34
Al_2O_3	50	SiO_2	37	TiO_2	56
CaO	105	SiO_2	55	TiO_2	63
CeO_2	9	SiO_2	100	TiO_2	98
CeO_2	42	SnO_2	18	ZrO_2	19
MgO	17	SnO_2	32	ZrO_2	36

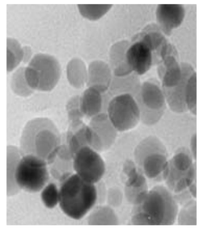


- Particle Production

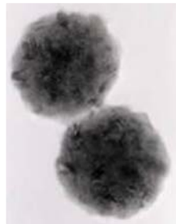
A continuous production system for nanosize metal oxide. The particle is created in a build up method that allows particle size to be adjusted from a few nm to a few hundred nm. Single component or multi-component particles can be created.



Magnesia



Zirconia



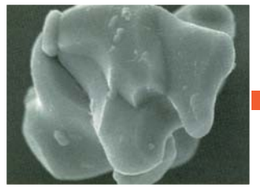
Barium titanate

APPLICATION EXAMPLES

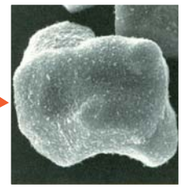
NOBILITA

Lithium cobaltate/nano carbon for rechargeable batteries

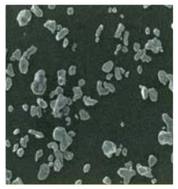
Carbon black is bonded onto the surface of the lithium cobaltate, in a mechanofusion process. Originally in agglomerate form the carbon black is dispersed in this process and fuses in a thin layer onto the base material. Conductivity of the electrodes is improved, there are no agglomerates in the bulk material and the viscosity of the slurry is reduced.



Lithium cobaltate



Composite



Nano carbon (agglomerate)

- Particle Production

Designed for high speed powder mixing, combining particles into composites in a dry process without binders, by applying mechanical force. Also used for particle surface modification and shape enhancement.

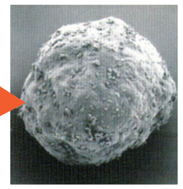
- from 0.5 ltr. lab unit to 300 ltr. production unit
- GMP conformable design available

MECHANOFUSION®

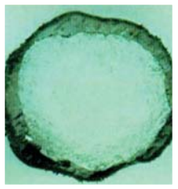
Pharmaceuticals (carrier/drug)

Active substance particles are dispersed and fixed mechanically in a thin layer onto the carrier particle. The flow properties of the composites are extremely good and promote uniform metering of the active substance. Resoption of the active substance is simultaneously accelerated because the active substance is available over a very large surface area.

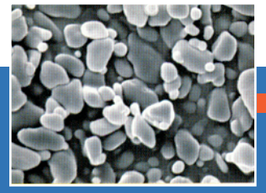
Organic carrier (Carrier/Drug)



Composite



Cross section



Ultra-fine drug

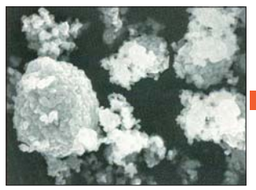
- Particle Production/Design

Mechanofusion precisely mixes different types of particles by applying mechanically generated load to the material during processing. In addition, it produces particle composites and controls the formation of particle shape.

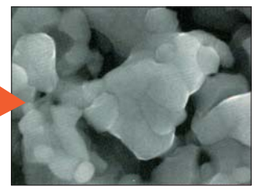
- from 0.1ltr capacity lab units to 200ltr production units
- pharmaceutical GMP systems available

NANOCULAR™ P

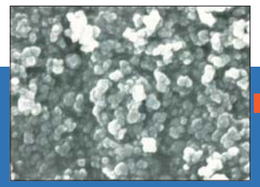
In conjunction with mechanical energy (shear and press forces) Nanocular P utilises low temperature plasma (glow discharge) to modify the particle surface and to initiate chemical reaction, composing, sintering, doping and synthesis.



Nickel oxide



Anode structure of composite



YSZ

PROCESS TECHNOLOGIES FOR TOMORROW SM

ACTIVE FREEZE DRYING

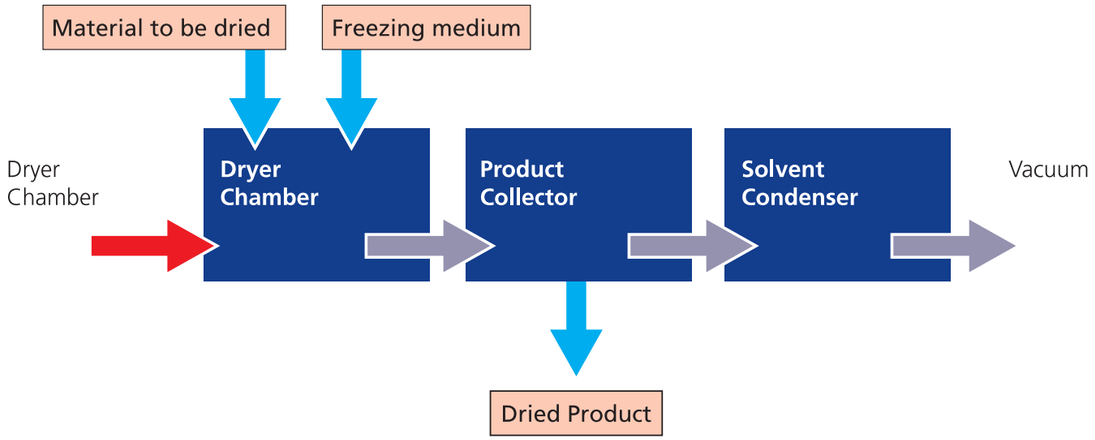
A quicker and less labour intensive freeze drying process with the potential to produce loose and free-flowing powders at low temperatures and low pressures, all in one vessel.

This short introduction illustrates how the newly developed Active Freeze Drying technology is seen as an important step in the world of freeze drying and powder technology.

The Active Freeze Dryer consists of a specially designed drying chamber and collecting filter. In the chamber the material to be dried is frozen very quickly with the aid of a freezing medium. During the subsequent sublimation the heat is applied through the jacket and efficiently distributed throughout the product by the stirrer. The initially frozen coarse granules will gradually reduce in size due to the sublimation

of the connecting ice structure in between the frozen material. The released dried particles will make up a loose powder moving to the filter. Finally all material is transformed into a fine and loose powder. After breaking the vacuum the dryer can easily be discharged from the filter or dryer vessel.

Active Freeze Dryers exhibit a better heat transfer rate due to the motion of the product, which shortens the drying process. Overall, the freeze drying process is simplified because all steps are done in a single processing unit instead of conventional methods involving trays filled with product being manually transferred between freezing units, drying chambers and crushers. This single vessel operation results in minimal risk for contamination and easy handling.



NANO CONTAINMENT

With the advancement of Nano Technology and the perceived hazards associated with handling Nano Powders, Hosokawa has developed a new range of Containment equipment designed specifically to contain these ultra fine powders.

A high visibility, cost effective, mid-range option for the containment of products and processes with containment levels below 1µg/m³. Suitable for applications that require the containment of larger pieces of equipment or a larger processing area. A mobile, wheeled Isolator with short production lead times.

- acrylic canopy for full visibility without dark spots and shadows, to give full operational visibility.
- location of glove ports in any position on all four sides of canopy for all round access.
- includes HEPA filtration and a continuous liner bag out port.

THE CYCLOMIX®

The Cyclomix technology combines fast and efficient convective mixing with high intensity shear mixing. This makes this machine interesting for many applications in nano-technology:

Nano-particle dispersion

Nano-particles usually exhibit a strong cohesive character. When mixed with impact forces only the majority of the particle clusters tend to remain bonded. The combined shear and impact forces of the Cyclomix improves mixing to produce well distributed nano-material.

Coating with nano-particles

The shear forces in the Cyclomix are extremely effective in distributing small particles over larger carrier particles to give a uniform coating.

Nano particle embedment

Extended processing with the Cyclomix of nano-materials and coarser particles will not only result in an even coating of the base material with the nano-sized particles, but with time the nano-particles are also embedded into the larger solids.

The mixing energy for this intensive mixing process is efficiently cooled away by the cooling jacket.

Nano-particle agglomeration

The unique motion of the particles rolling in the shear zone is also effective for the agglomeration of ultra-fine materials. The rolling motion results in more or less spherical agglomerates, the centrifugal forces densify the agglomerates and the impact knife will limit the size of agglomerates.

PICOLINE

During R&D and early stage development work for new products, where multiple processes need to be evaluated, trialed and improved the amounts of product available may be quite small. Such small quantities may be as a result of extreme prices per gram of product or the fact that the product does not exist in larger quantities.

In order to process these small quantities Hosokawa Micron have developed a range of pin mills, bead mills, jet mills, classifiers and mixers capable of handling amounts down to <1g. The Picoline range of machines offers product development on a miniature scale using production technologies suitable for scale up to production volumes.

Picoline offers:

- Maximum yields
- Minimum space requirement
- Easy clean, simple maintenance
- Low capital investment costs

NANOGRINDING

Submicron and nanoparticles can be produced in a 'top to bottom' process by wet milling. Agitated media mills such as the Alpine AHM Mill are used to grind such particles to a fineness down to 10nm. The grinding process is carried out in a closed circuit and can take place in water or another suitable liquid.

The process requires a high specific energy input, very small grinding beads and a high performance wear protection material.

The interacting forces between particles in the submicron range lead to strong agglomeration effects thus particles have to be stabilised against re-agglomeration by use of chemical additives or an electro static or steric mechanism.