Spray Drying
Nanomaterials

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1. Introduction Spray Drying

Spray drying is a fascinating continuous process to transform liquids (solutions, emulsions, slurries, pastes or even melts) into micron size particles with adjustable distribution, shape, porosity, density and chemical composition.

Spray drying is widely applied in the materials, chemical, food and pharmaceutical industries.

Spray dryed nanomaterials (nanoparticles, nanosuspensions) are already used as:

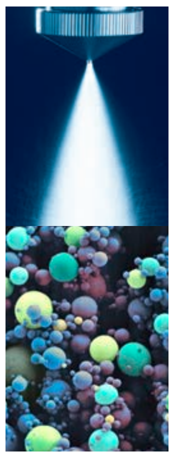
- Coatings in turbine engines, automotive parts, photocatalytic and biological implants (titania, alumina, zirconia, yttria coatings)
- Advanced Ceramics of metal carbides, nitrides or borides (eg. new super conducting ceramics)
- Toners and Magnetic Tapes (eg. ferrites)
- Inhalable Dry Powders (treatment of asthma, cystic fibrosis, chronic pulmonary infections, lung cancer etc.)
- Nanoparticulate Drugs (drug delivery) with high bioavailability

2. Mini Spray Dryer B-290 – Particle technology in the lab

The Mini Spray Dryer B-290 offers quick and gentle drying of aqueous and organic solutions to free flowing powder. It is the ideal laboratory spray dryer for R&D feasibility studies on innovative materials like nanoparticle agglomerates.

Features and benefits:

- Glassware enables visible spray process
- Short set-up and cleaning times
- Integrated nozzle cleaning function
- High performance cyclone separation
- Optional closed cycle with Inert Loop B-295
- Easy scale-up of the process
- On-line Spray Dryer Application Database

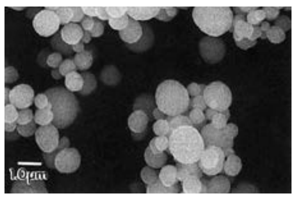


Technical data:

Evaporation capacity	1 L/h water
Sample volume	30 mL – 1 L
Drying air flow rate	up to 35 m³/h
Spray flow rate	0.1 – 1 L/h (5-8 bar)
Heating power	2300 W
Max. inlet temperature	220 °C
Chamber size (D, H)	16.5 cm, 60 cm
Dimensions (L x W x H)	60 x 50 x 110 cm
Weight	48 kg table-top
Nozzle	Two-fluid co-current
Typical yield	40 – 60%
Particle size	2 – 25 µm

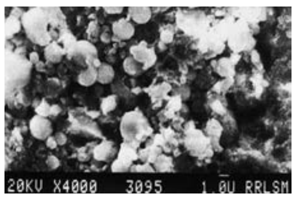
3. Applications and SEM photographs

Lithium tantalate



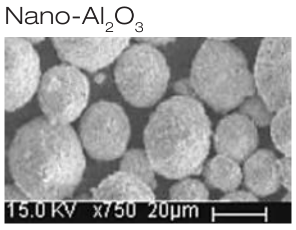
Smooth and spherical micron size $LiTaO_3$ particles [1]

Alumina



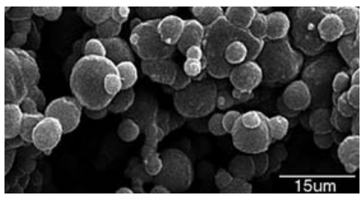
Spray dryed Boehmite sol from aluminum nitrate [2]

Nano-Al_2O_3



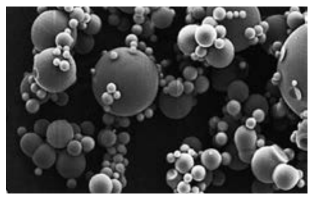
30 - 40 nm nano-Al_2O_3 agglomerates [3]

Carbon nanotubes



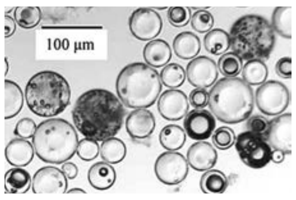
Styrene-butadiene rubber (SBR) composites with 26% Carbon nanotubes (CNTs) addition [4]

Silica gel



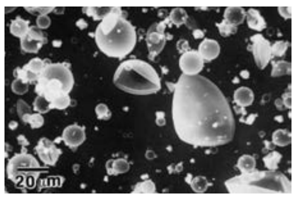
Silica gel with 7.7w% dexmedotomi - dine HCl drug (magnification 2500x) [5]

Xerogel



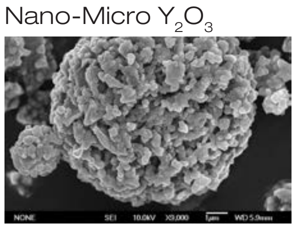
Spray dryed hollow glass microspheres (Xerogel) [6]

Glass spheres



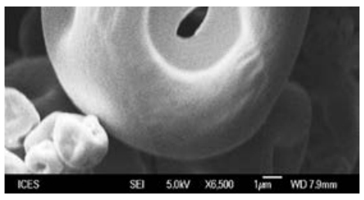
Calcined mesoporous hollow silica spheres [7]

Nano-Micro Y_2O_3



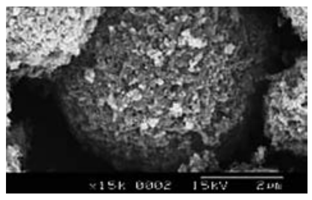
Nanosuspension producing Nano-Micro Particles of Y_2O_3

Polyacrylate



Hollow polyacrylate nanoparticle aggregate, density << 1 g/cm³ [8]

Hydroxyapatite



Hydroxyapatite nanoagglomerate of 80 – 100 nm crystallites [11]

Product	Application	Spray conditions	Results
Lithium tantalate $LiTaO_3$ [1]	Electronic ceramics powder ($BaTiO_3$, $LiNbO_3$, PLZT, ZnO)	B-190, lithium acetate and tantalum ethoxide as starting materials, 160 °C drying temperature	Smooth, spherical powder, high purity and porosity after calcinations
Alumina powder [2]	Ceramic powders via sol-gel route	B-190, Boehmite sol from aluminum nitrate, 1 L/h 165 °C/105 °C , 0.5 mm nozzle,	Spherical 2 µm particles, submicron crystallites, good compaction
Nano-Al_2O_3 agglomerates [3]	Plasma spray coating, nanoparticulate suspensions	B-290, 300 mL H_2O, 7 g PEG, 70 g 30 – 40 nm nano-Al_2O_3, 30 min stirred at 90 °C, PVA, cellulose derivate	Spherical particles (20 – 30 µm), free flowing powder
Carbon nanotubes in rubber composites [4]	Additive in rubbers, improved dispersion, hardness and strength	B-290, 180 °C, 240 mL/L, 35.2 m³/h, 667 L/h, carbon nanotubes in styrene-butadiene	Fine, spherical particles <10 µm, CNT's well-dispersed
Silica gel (SiO_2) microparticles [5]	Carrier material for controlled parenteral drug delivery	B-191, 134 °C, 2-5 mL/min, 600 NL/h, 0.7 mm nozzle, Sedative drug dexmedetomidine, silica sol 2.3 pH	Smooth spherical microparticles, narrow distribution, up to 77 % yield
Hollow glass spheres [6]	Hydrogen gas storage, fuel cells, photo-enhanced diffusion	B-290, 120 °C/78 °C, 38 m³/h, 350 L/h, 145 mL/h, suspension of 20 % xero-gel, 10 % $FeCl_2$, 68 % CTAC	Hollow glass microspheres
Mesoporous Silica [7]	Materials for catalysis, separation and sensor technologies	B-190, 76 °C outlet temp., hydrolyzed silicon alkoxide and surfactant (water, HCl, CTAC and TEOS)	Hollow particles with mesoporous shells, pore sizes 25Å, 1770 m²/g
Hollow Nanoparticle Aggregates [8]	Carrier for inhaled nanoparticulate drug delivery (to the lungs)	B-290 + B-295, polyacrylate and silica nanoparticles (150 nm, 5 nm), 110 °C/60 °C, 350 L/h, 4 mL/min, 40 m³/h, ethanol/water 70/30 (v/v)	Hollow nanoparticulate aggregates, 10 µm, density << 1 g/cm³, high flowability, high therapeutic efficacy
Superconducting Ceramics [9], [10]	Research on new high temperature superconducting ceramics	B-190, 200 °C/100°C, 750 NL/h, 5 mL/min, 30 m³/h, $Cu(NO_3)_2\ _3H_2O$, $Ba(NO_3)_2$ and $Y(NO_3)_3$ $6H_2O$ dissolved in distilled water (aqueous nitrate solution)	Fine hollow spherical blue-grey powder, average 4 µm size, yield 60 %
Hydroxyapatite (HAP) [11]	Bio ceramic as controlled release carrier of protein or bone filling material	B-191, 90 – 92 °C, 35 m³/h, slurry containing 15 wt% hydroxyapatite (HAP, $Ca_{10}(PO_4)_6(OH)_2$), ethylene vinyl acetate (EVA) as binder copolymer	Porous HAP microspheres of 2 – 15 µm, cluster of many 80 and 100 nm crystallites

4. References

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