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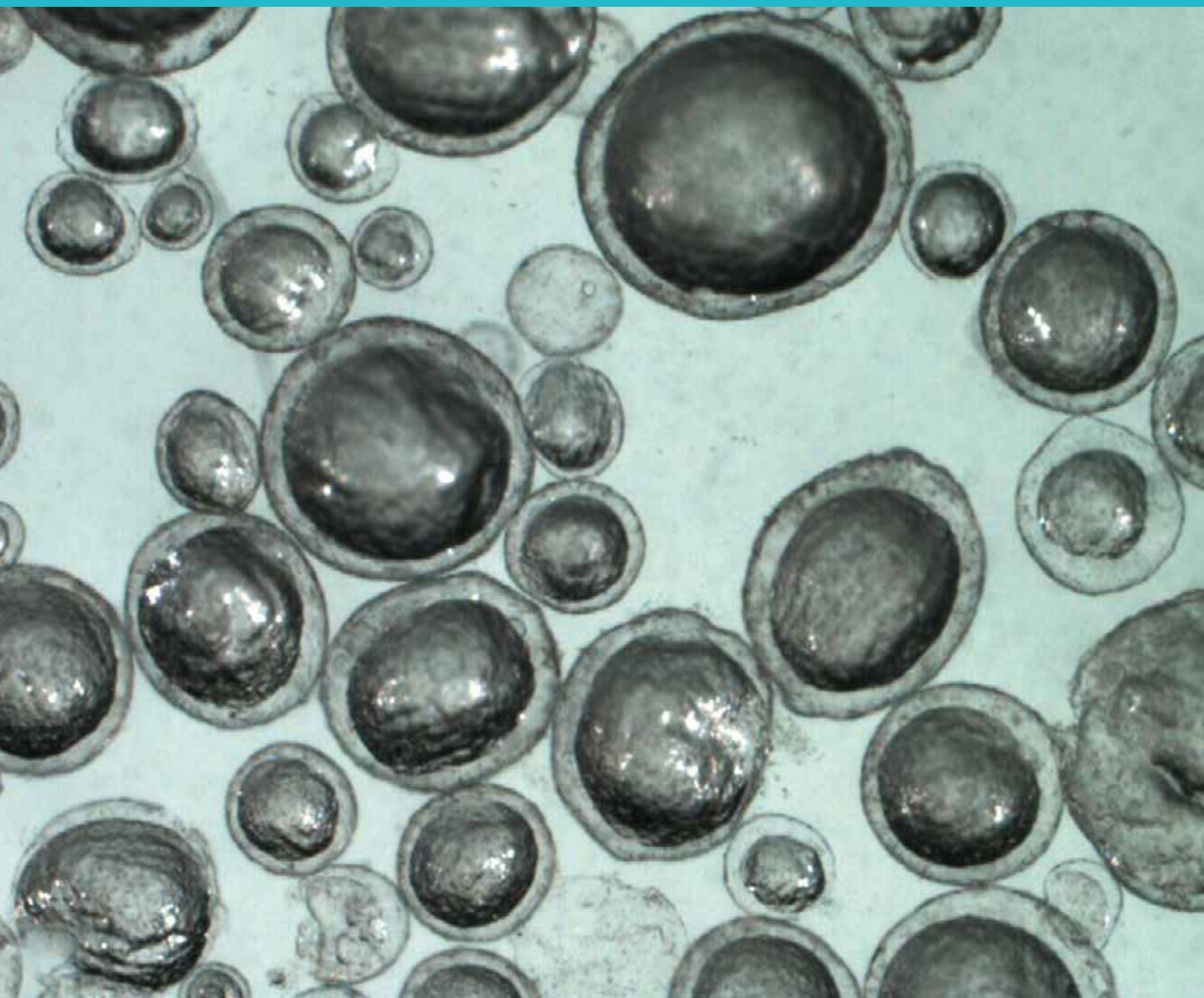
FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT

SMART MATERIALS
FUNCTIONALIZED PARTICLES WITH A CORE-SHELL STRUCTURE



SMART MATERIALS

Smart materials are materials that undergo a self-initiated or externally-triggered reaction to environmental conditions (e. g. changes to temperature, pH values or mechanical loads), thereby achieving a pre-defined purpose. Examples of smart materials include OLEDs, piezoelectrics, carbon nanotubes (CNTs) and hydrogels.

In the field of particle technology, core-shell particles with a desired functionality can be generated or modified in highly-specialized processes. This can enable the controlled release of active substances, or adaptable particle surfaces. Fields of application range from pharmaceuticals, specialty chemicals, agriculture and construction through to energetic materials and propellants.

The Fraunhofer ICT has many years of experience in modifying the product properties of specialty and fine chemicals, pharmaceutical products and energetic materials (propellants and explosives) using particle technology.

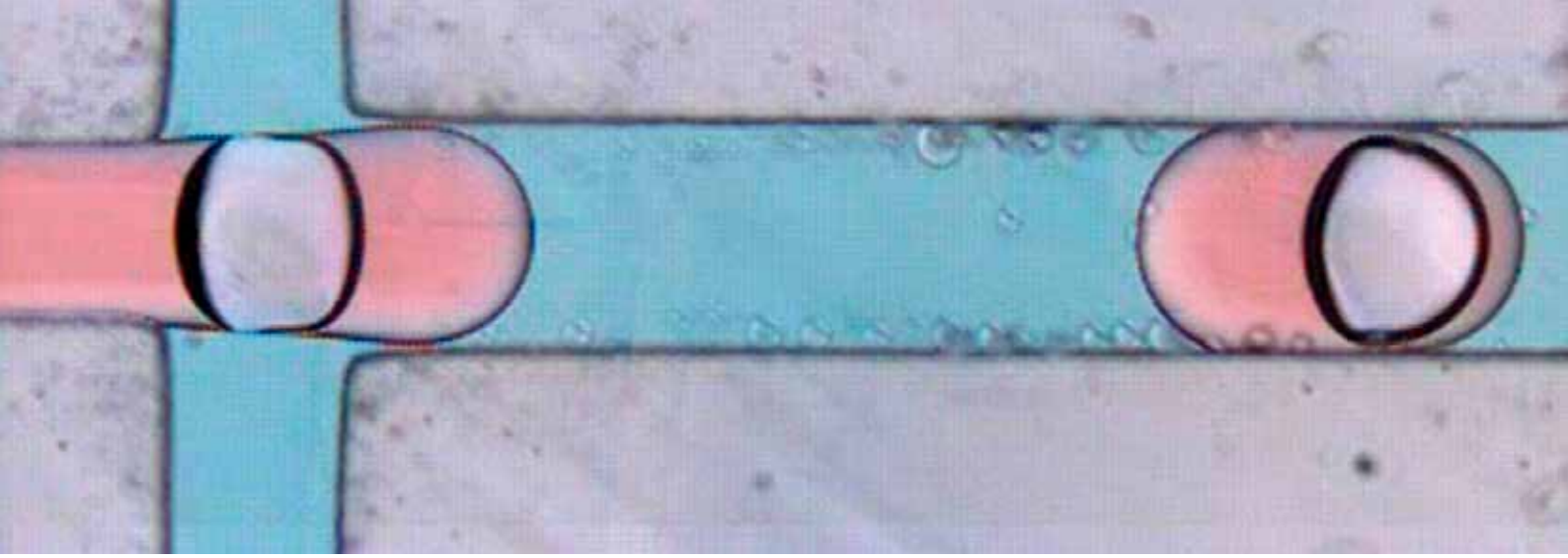
Depending on the phase of the material system (solid/solid, liquid/liquid), the specific requirements placed on the materials (hazardous substances, sensitivity, availability/price) and the necessary throughputs, tailored processes are investigated and developed for the production and modification of particles according to customer requirements. These include in particular fluidized bed coating and continuous micro-encapsulation in microfluidic structures.

COVER PICTURE

Spherical ammonium dinitramide particles with polymer shell.

LARGE PICTURE

Fluidized bed unit for hazardous processes.



Production of multi-phase emulsions using flow focusing in microfluidic structures.

FLUIDIZED BED COATING

Fluidized bed technology is a well-established process for coating and refining particles, which is most frequently used in the pharmaceutical industry. In the fluidized bed process, a nozzle system is used to apply thin layers of a liquid coating material to particles fluidized by a gas flow. The coating is solidified to core-shell particles during processing.

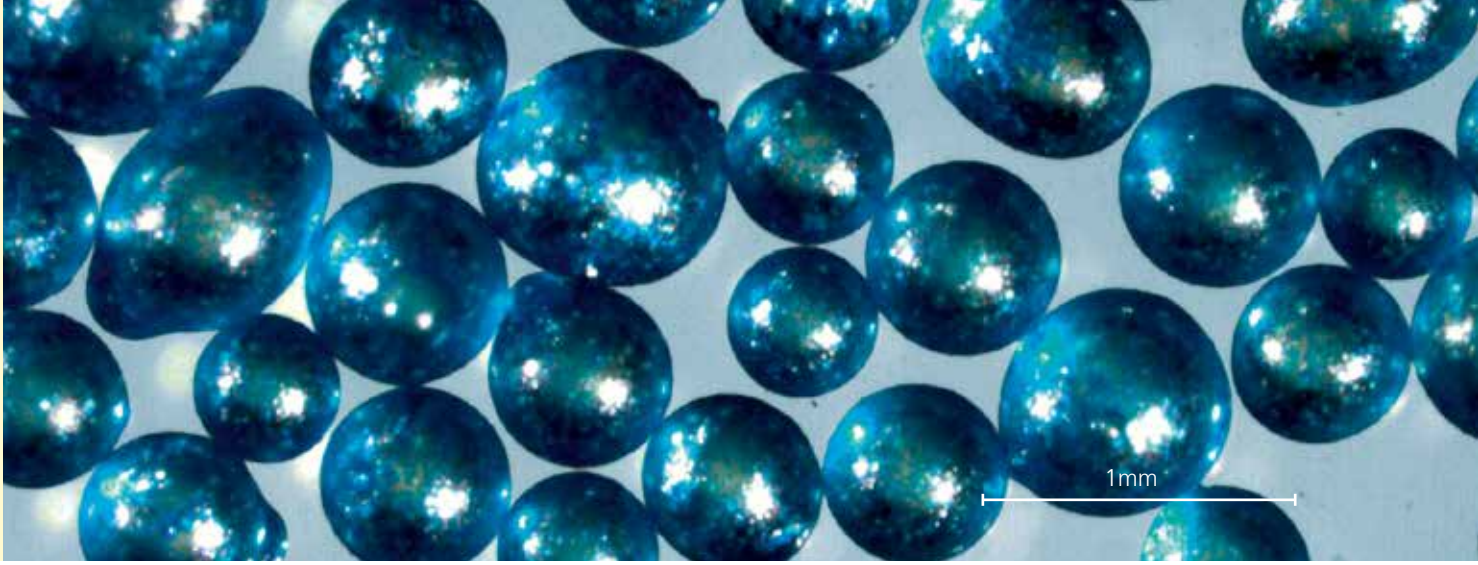
The fluidized bed systems available at the Fraunhofer ICT enable batch sizes of 200 g up to 5 kg, using either dried air or nitrogen as a process gas. Through modification of the equipment explosion-sensitive or hygroscopic core materials and also solvent-based coating materials can be safely processed.

The aim of particle coating is to improve the particle properties through:

- Increased compatibility against reactive substances in further processing
- Protection of hygroscopic materials from humidity and moisture
- Decrease in the sensitivity of energetic materials (desensibilization)
- Increase in mechanical strength
- Functionalization of particle coatings or composite particles by incorporating (nanoscale) active substances such as stabilizers, burn rate modifiers or bonding agents.

MICRO-ENCAPSULATION IN MICROFLUIDIC STRUCTURES

For the small and medium-scale production of functionalized particles or microcapsules using wet chemistry, continuous processes with microfluidic structures offer an alternative to fluidized bed processing. Specialized flow management in the microreactor allows the continuous shearing off and segmentation of droplets, which can subsequently be hardened to form solid particles or multilayered capsules.



Glass pellets with polyacrylate coating.

Specific features of microreactors, such as the significantly intensified heat and mass transport, higher mixing efficiency and low reactor volume, generate a range of advantages in comparison to conventional batch processes:

- high process stability, product quality and purity through precise dosing and conditioning, low residence time and high mixing efficiency
- flexible and precise control of particle size or capsule structure, with low particle-size distributions, through the targeted selection of the microreactor geometry and process conditions (flow conditions, pressure etc.)
- high flexibility through modular construction and variable throughput
- scalable production quantities while maintaining optimal process parameters through parallelization (numbering up)
- high energy and resource efficiency due to low reactor volumes and possibility of direct connection to downstream processing.

SERVICE PORTFOLIO

Drawing on our long-standing experience in product, process and technological development in the field of specialty and fine chemicals, we offer customer-specific support in the design and optimization of new products and processes.

- Feasibility and parameter studies on the production of functionalized particles and capsules
- Construction of prototypes, and validation on a laboratory and pilot scale
- Process development from the laboratory application through to pilot level, through the selection and adjustment of reactor technology and process control
- Execution of potentially hazardous processes e.g. involving explosives or flammable solvents
- Real-time monitoring of processes, identification of optimal process conditions and characterization of the products using cutting-edge measurement and analytical techniques
- Accelerated reactor development and optimization through CFD-based simulation and fabrication of microfluidic reactors at the Fraunhofer ICT, e.g. through laser structuring.

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