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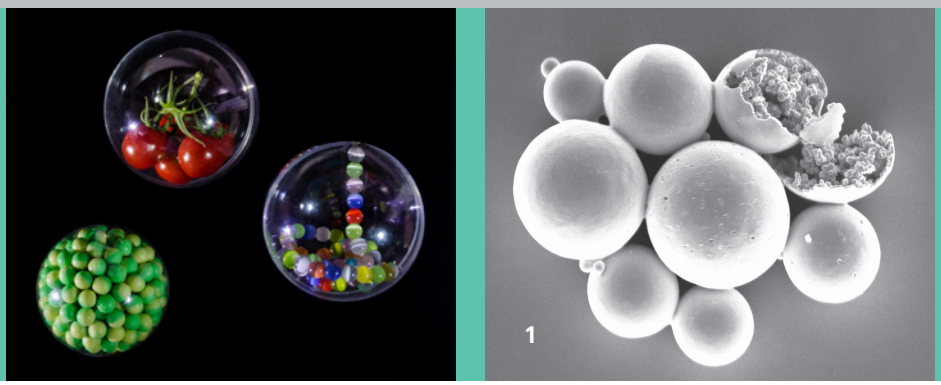


1 *„Capsules in Capsule“: Polyurethane nanocapsules in cellulose microcapsule.*

POLYMERIC NANO- AND MICRO-PARTICLES WITH CUSTOMIZED FUNCTIONALITIES

Fraunhofer Institute for Microengineering and Microsystems IMM

Carl-Zeiss-Strasse 18-20
55129 Mainz | Germany

Contact

Dr. Anna Musyanovych
Phone: +49 6131 990-246
anna.musyanovych@imm.fraunhofer.de

www.imm.fraunhofer.de

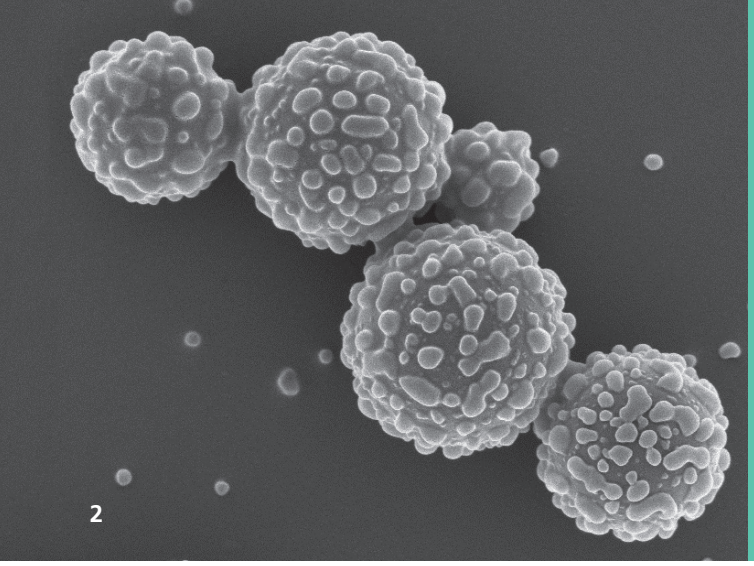
Introduction

Advances in nanotechnology offer immense potential towards the development and production of innovative materials with improved, customized properties, demanded by the industry. The benefits and valuable contributions of polymer based nano- and microparticles have been demonstrated in diverse areas of application such as *coatings, construction, adhesives, food, agriculture, textiles, packaging, cosmetics, and life science.* To match the application requirements, the physical and chemical properties of the end-product can be adjusted by the effective combination of properly chosen materials. The encapsulation of active ingredients in polymeric particles protects them against environmental conditions, thus prolonging the lifetime and reactivity of the end-product.

Our main focus is the development of energy-/cost-efficient and high-throughput synthetic strategies for the preparation of polymeric particles and capsules in batch and in continuous flow. We specialize in the preparation of particles that react to external stimuli, e.g. mechanical stress, temperature, pH, presence of enzymes, and are able to release the encapsulated payloads in a controlled way.

Preparation methods

Different synthetic approaches and techniques are used to reach the desired properties of the particles such as size, porosity, morphology, chemical composition and encapsulation profile. The preparation of particles is customized to each particular system and includes the following formulation methods:



Chemical:
- Polymerization (*in situ* and at interface)
- Polyaddition/polycondensation
- Polymer analogous reaction

Physical:
- Emulsification/solvent evaporation
- Ionic/thermal gelation
- Nanoprecipitation
- Spontaneous emulsification, etc.

Particle properties

Size:
From 50 nm to 20 µm (other size is possible upon request)

Morphology:
- Solid, homogeneous
- Core-shell (with solid or liquid core)
- Biphasic (Janus particle) or multiphasic "Capsules in Capsule"

Particle material:
Particles can be prepared from different synthetic and natural monomers and polymers. Our focus lies on using cost-effective and commercially available materials.

Encapsulated materials:
Different hydrophilic and lipophilic compounds, liquid or solid in nature, can be encapsulated as a single payload or in combination with other liquids or solids.

Surface functionalization:
- Great variety of chemical functionalities is available
- Variation of groups density
- Homogeneous or gradient functionalization is possible.

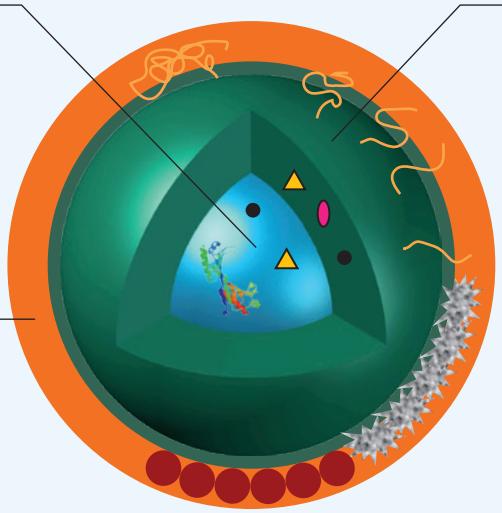
Process scale up

After completion of the particle development in a research batch-scale it might be necessary to scale-up the formulation process to the commercial production. Our team of experts can establish and optimize continuous processes for our customers up to commercial production, according to their specific needs.

2 *Composite polyacrylate-based particles.*
3 *Lab-scale prototype for the continuous formulation of polymer-based particles through emulsification/solvent evaporation.*

Encapsulated materials
- Lipophilic and hydrophilic compounds, e.g. oils, vitamins, catalysts, peroxides, salts, fragrances, etc.
- Enzymes, proteins
- Fluorescent agents, markers
- Inorganic nanoparticles, e.g. iron oxide, gold, titanium dioxide, hydroxyapatite, QDs, etc.

Surface functionalization
- Physical adsorption or covalent attachment of functional (macro)molecules
- Inorganic layer through adsorption of inorganic nanoparticles or *in-situ* growth of inorganic nanocrystals



Particle material
- Polyacrylates
- Polyurethanes
- Polyamides
- Polysiloxanes
- Polyvinyl acetates
- Polyesters
- Poly(alkylcyanacrylate)
- Polylactides and copolymers
- Polysaccharides, e.g. dextran, cellulose, alginate, etc.
- Proteins, e.g. gelatin
- Wax, etc.