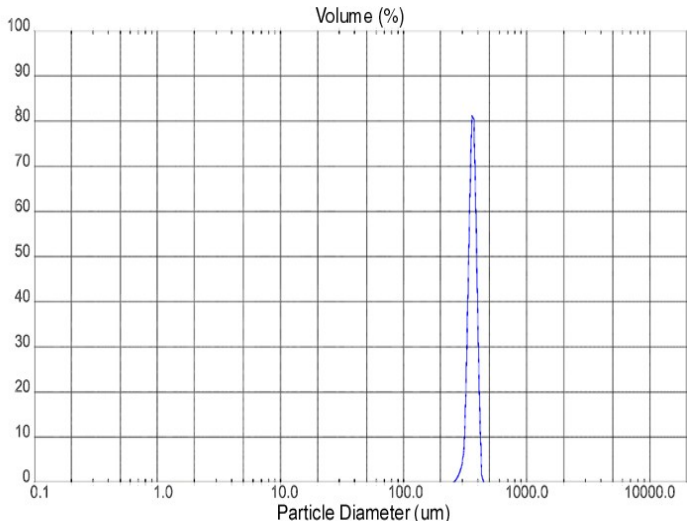
Microencapsulation and industrial application for uniform controlled release particles

T. Brandau, E. Brandau, A. Schmallenbach
BRACE GmbH, Taunusring 50, D-63755 Alzenau, Germany
(thorsten.brandau@brace.de)

Introduction

Applying vibrating nozzle processes for the production of microspheres and microcapsules has a lot of advantages when compared to other methods: Vibrating nozzle processes render it possible to produce particles with a monomodal grain size distribution and a single sharp maximum. d_{max}/d_{min}-values lower than 1.10, 1.05, or even 1.01 are customary for spherical granules produced with a vibrating nozzle microsphere unit designed by BRACE (see Picture 1).



Picture 1: Size Analysis of Microspheres (Malvern Mastersizer)

BRACE microspheres are solid spheres with a matrix-encapsulated active agent whereas BRACE microcapsules consist of a solid shell and a liquid or solidified core (Pictures 2 and 3).

Picture 2: Schematic drawing of Microcapsules and Microspheres. From left to right: Microcapsule with an encapsulated solution, Microcapsule with an encapsulated cell suspension, Microsphere with matrix encapsulated active agent.

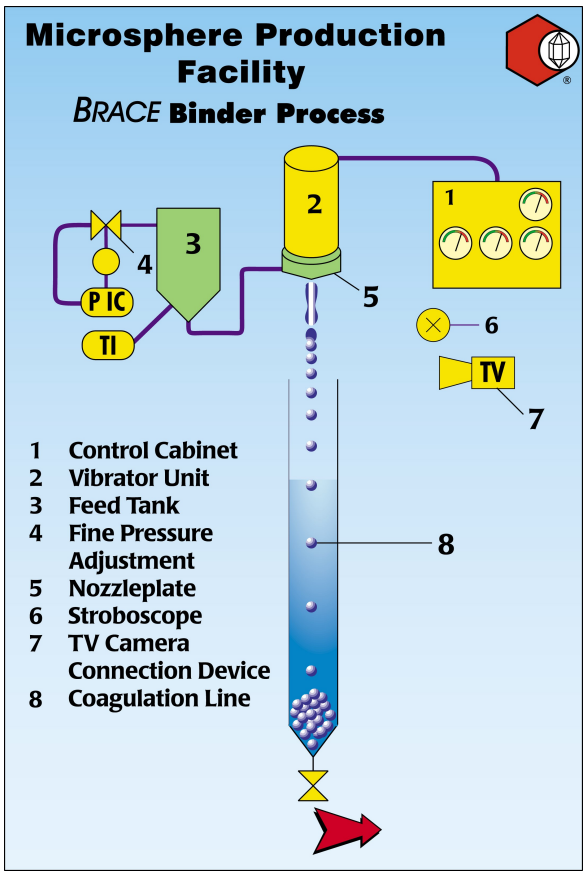
These two types of microgranules differ mainly in their release profiles: Microspheres usually show diffusion controlled release profiles with a permanent release rate that is controlled kinetically by means of the particle size, whereas microcapsules expel their content with a single burst as the shell breaks. On the other hand, microcapsules may exhibit extremely slow release rates when appropriate materials are used.

Picture 3: Flavour Core-Shell capsules for food applications (Microcapsules)

Experimental method

The vibrating nozzle process itself can be described as follows (Picture 4): A liquid feed is pumped from a feed tank (3) to the nozzle head (5), whereupon exiting the vibrating device (2) induces the breakup of the flow into uniform droplets. The surface tension of the liquid forms these droplets into spheres which are solidified during falling (8). This can be achieved by cooling, chemical reaction, or drying, depending on the materials and/or coagulation system used. The process is also suitable for molten materials as the head of the microsphere unit can be placed inside a heating chamber. The process is controlled visually either by using a stroboscopic lamp (6) or a camera set (7) for remote control. The electronic cabinet (1) that controls the microsphere unit can be integrated into an already established control system.

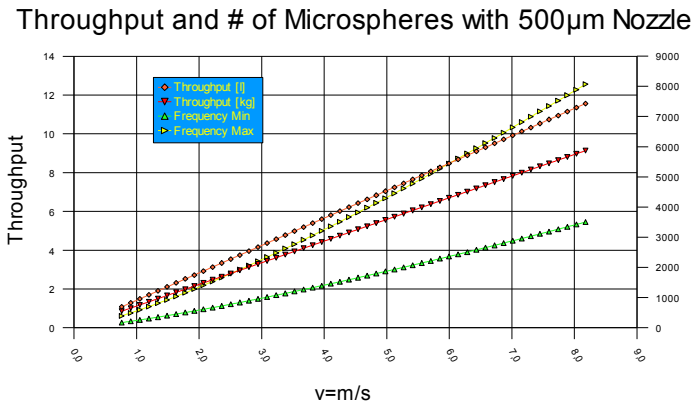
The production of microcapsules becomes easily possible when a special nozzle with an annular gap is used. Two different liquids – a shell and a core liquid – are pumped from two different feed tanks to the nozzle head. In doing so, it is possible to produce capsules with a liquid or solidified core inside a protecting shell that usually consists of a polymeric material like gelatine, agar, alginate, or something similar.



Picture 4: BRACE Microsphere Process (Binder Process)

Results and discussion

Various applications have shown that microspheres produced with laminar flow breakup processes have many advantages compared to classical preparation methods as spray-drying or spray-cooling. Due to the laminar nature of the flow, no sudden demixing processes occur when the flow is exiting the nozzle. Since the processes lead to monomodal size distributions, no polymorphisms occur. A truly controllable controlled release profile can therefore be designed by manipulating only one process parameter (particle size) instead of various ones such as load, size, drying rates etc.



Picture 5: Development of theoretical throughput against flow speed

By applying the double nozzle process for the production of core-shell microspheres, new materials with exiting properties can be obtained. These "real" capsules can be designed to release their contents with a burst as soon as the capsule becomes subject to low pressure, or to release their contents extremely slowly over a long time. Therefore, it becomes possible to provide solutions for both flavour chemistry and textile applications.

Since the processes are easily up-scalable, the retesting and scale-up time from laboratory-size to production-size throughputs is short. Usually, a production unit runs with the same feed compositions and the same parameters as the desktop unit, making it possible to test all parameters and recipes in small scale before putting the production unit into operation.

Since the processes are suitable for a wide range of materials such as alginates, gelatines, agar, waxes/thermoplastics, metal oxides, solutions, polymers etc., it is possible to obtain controlled release solutions for almost any kind of application – from food to feed, cosmetic to pharma, chemistry to automotive.

Conclusion

With the patented BRACE vibrating nozzle processes and the corresponding machinery, it becomes possible to produce large quantities of microgranules (microspheres and/or microcapsules) for top grade products. By adjusting just a few parameters, highly controllable products can be obtained that provide controlled release profiles for almost any application.

References

Brandau, E., *Process for producing powder from partially stabilised zirconium oxide.* EP-Patent EP 0 585 264 B1

Brandau, E., 1995, *Method for producing stabilized zirconium oxide powder.* US Patent US 5 420 086, 30 May

Brandau, E., 1993, *Verfahren und Vorrichtung zur Herstellung von Alginatkugeln.* DE-Patent DE 41 25 133 C2, 9 Sept.

Brandau, E., 1996, *Plant for the production of spherical alginate pellets.* EP-Patent EP 0 597 911 B1

Brandau, E., 1995, *Process and plant for the production of spherical alginate pellets.* US Patent US 5,472,648, 5 Dec.

Brandau, E., 1995, *Verfahren und Vorrichtung zur Herstellung von kugelförmigen Teilchen aus flüssiger Phase.* EP-Patent EP 0 467 221 B1, 4 Oct.

Brandau, E., 1998, *Process and device for producing plastic particles.* EP-Patent EP 0 735 940 B1, 2 Sept.

Brandau, E., 1994, *Verfahren zur Herstellung von Aluminiumoxidkugeln.* EP-Patent EP 0 556 222 B1

Brandau, E., 2001, *Process for producing aluminium oxide beads.* US Patent US 6 197 073 B1, 6 Mar.

Brandau, E., 1998, *Process for producing stabilised hafnium oxide powder or hafnium oxide-containing powder.* EP-Patent EP 0 687 246 B1, 1 Apr.

Brandau, T., 2002, *Preparation of monodisperse controlled release microcapsules*, Int. J. of Pharmaceutics, 242, 179-184