Interfacial engineering in spray-dried microcapsules

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INTRODUCTION AND OBJECTIVE

In the food sector, protection of an active ingredient, masking of undesirable properties, and the controlled release of substances are the major aims of the encapsulation process. Generally, encapsulation techniques can be divided into three classes: chemical techniques such as molecular inclusion and interfacial polymerization; physical techniques such as spray-drying, freeze-drying, air-suspension coating, and extrusion; and physico-chemical techniques such as coacervation and liposome entrapment. The principal technologies used for encapsulation of lipophilic food ingredients are spray-drying, coacervation, and extrusion. The structure of microcapsules prepared by these techniques is referred to as matrix type with the core material homogenously dispersed in the wall material (Drusch. Regier & Bruhn, 2012)

During microencapsulation of sensitive food ingredients by spray drying, one important step is the spray drying process itself, which affects the emulsion droplet size distribution, the emulsion stability with regard to the oil droplet size as well as the structural integrity of the interface. The latter has a strong impact on the encapsulation efficiency and the physical stability of reconstituted emulsions.

By interfacial engineering the barrier properties and the packing density at the oil/water (o/w) interface can be modified. The interface can be engineered by e.g. layer-by-layer electrostatic deposition technique that involves sequential layering of polymers at the o/w-interface of an emulsion or enzymatic modification of the o/w interface. Furthermore competitive adsorption of surface-active ingredients can increase the microencapsulation efficiency, a technique described as *in situ* coating (Elversson & Millqvist-Fureby, 2006).

Aim of the present contribution is to give an overview on the state of the art in interfacial engineering for improvement and modification of the functional properties of spray-dried microcapsules and to summarise own research in the field.

MATERIALS & METHODS

A concise review of the literature was performed to identify possible core material constituents, which allow structure modification. Existing studies in the field have been reviewed with special emphasis on elucidating the complex interplay between materials science aspects, process engineering aspects and functionality. Since it turned out that materials science aspects and engineering aspects in preparation of spray dried microcapsules are not available, the authors performed different studies on the behaviour emulsions with structured interface using lecithin and chitosan, β-lactoglobulin and pectin as well as transglutaminase-crosslinked sodium caseinate during spray-drying and the impact on functionality.

The experiments included the characterisation of the interfacial viscoelasticity, the analysis of possible changes in the oil droplet size distribution after atomisation using different atomisation units and conditions, characterisation of mass transport phenomena in single drop experiments using acoustic levitation, analysis of the microencapsulation efficiency after spray-drying and the analysis of the functionality, i.e. stability of the encapsulated ingredient and integrity of the reconstituted emulsion.

RESULTS AND DISCUSSION

When using lecithin and chitosan for formation of an interfacial bilayer an increase in the stability of the encapsulated ingredient (oil rich in polyunsaturated fatty acids) was observed. In spray-dried emulsions, the oxidative stability in the single layer emulsions (lecithin) was higher than in the multilayer emulsion (lecithin-chitosan). This was partly attributed to a lower microencapsulation efficiency in the spray-dried multilayer emulsion compared to the spray-dried single layer emulsion. Furthermore, it could be shown, that excess chitosan in the bulk carrier matrix affects the free volume elements and thus oxygen diffusion.

In bilayer emulsion prepared using β-lactoglobulin and pectin the oxidative stability of the encapsulated ingredient was influenced by both the physical state of the emulsions and the different constituents at the o/w-interface. In the liquid state, the oxidative stability was higher in the original emulsions when compared to the reconstituted emulsions. The differences in oxidative stability in the spray-dried emulsions could partly be attributed to the microencapsulation efficiency, but also the physical characteristics of the o/w-interface, which were investigated in more detail. The o/w-interface of the emulsions was predominantly elastic, although the elasticity was higher in single layer emulsions (β-lactoglobulin) compared to bilayer emulsions (β-lactoglobulin-pectin). The drying behavior of the different emulsions during levitation of single droplets was similar. Regarding the atomization process, the

emulsion spray droplet size generally decreased with increasing energy input irrespective of the type of atomizer. With rotary atomization, the spray droplet size distribution of the different emulsions was similar.

Enzymatic cross-linking of sodium caseinate at the oil-water interface increased the interfacial viscoelasticity indicating an increase in process stability. However, removal of excess sodium caseinate, which negatively affects free volume elements in the spray-dried matrix, decreased oxidative stability. Cross-linking of sodium caseinate in the continuous phase of the emulsion prior to spray drying increased the oxidative stability in the liquid emulsion, but not in the spray-dried emulsion.

CONCLUSION

In conclusion it was shown, that interfacial engineering can improve functionality when encapsulating sensitive food ingredients. However, process stability needs to be investigated and therefore a top-down approach taking engineering and food material science aspects into consideration is required to successfully apply the approach of interfacial engineering.

REFERENCES

- Drusch, S., Regier, M. and Bruhn, M. (2012) *Recent advances in the microencapsulation of oils high in polyunsaturated fatty acids.* In: *Novel technologies in food science - their impact on products, consumer trends and environment* McElhatton et al. (Eds.) ". Springer Verlag (Hamburg, Tokio, New York) 159-183.
- Elversson, A & Millqvist-Fureby, A. (2006) In situ coating - *An approach for particle modification and encapsulation of proteins during spray-drying.* International Journal of Pharmaceutics, 323, 52-63.

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