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Microencapsulation of oil droplets using freezing-induced gelatin–acacia complex coacervation

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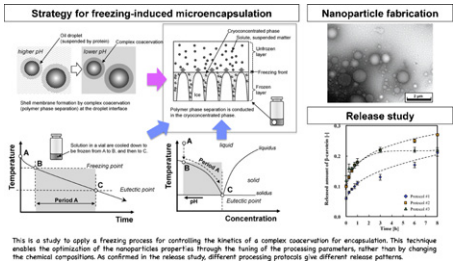
HIGHLIGHTS

- This is a work on engineering nanoparticles that encapsulate oil droplets.
- A gelatin–acacia complex coacervation was employed for encapsulation technique.
- A freezing process was applied to control the kinetics of a complex coacervation.
- The encapsulation properties could be controlled by the cryoprocessing parameters.
- The release patterns could be tuned without changing the chemical compositions.

GRAPHICAL ABSTRACT



This is a study to apply a freezing process for controlling the kinetics of a complex coacervation for encapsulation. This technique enables the optimization of the nanoparticles properties through the tuning of the processing parameters, rather than by changing the chemical compositions. As confirmed in the release study, different processing protocols give different release patterns.

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ABSTRACT

A freezing process was applied to control the kinetics of a gelatin–acacia complex coacervation technique for encapsulating emulsified oil droplets. An oil-in-water emulsion was stabilized with a gelatin–acacia solution, and the pH of the solution was adjusted to a selected value with acetic acid. When the pH of the emulsion was adjusted to 4.7, the system was visibly stable at ambient temperature for up to 12 h. Freezing the emulsion caused polymer phase separation (complex coacervation) in the cryoconcentrated phase and resulted in encapsulated oil droplets and the accumulation of a cream layer in the freeze-thawed solution. Observation by transmission electron microscopy clarified the formation of 50–4000 nm core–shell nano-microparticles, the surfaces of which were surrounded by polymeric membranes. The membrane properties of the particulate systems were dependent on the cooling rate that was used during freezing. For example, when an emulsion with a pH of 4.7 was frozen, a cooling rate of −1.0 °C/min maximized the encapsulation yield, whereas a rate of −2.0 °C/min was effective in limiting the release rate of the ingredient (β-carotene) from the oil phase through the shell membrane. The results of this study suggest that the formation of nano-microparticles could be highly associated with the kinetics of freezing, so their resultant properties could be fine-tuned using a freezing operation. This is a potential concept providing a novel strategy for engineering core–shell nanoparticles.

1. Introduction

Encapsulation by complex coacervation is recognized as a potential technique for fabricating nanoparticles with a lipid core. This process could potentially be used for designing nano/microencapsulation systems to realize desirable functions, such as preservability, miscibility, deliverability, and controlled

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