論文の内容の要旨
Dissertation Abstract

論文題目
Dissertation Title Fabrication of Hollow Microcapsules from Microbubble Templates

（マイクロバブルをテンプレートとして用いた中空マイクロカプセルの製造）

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Hollow microcapsules are expected to become an integral part in medical and industrial applications as such as drug delivery systems, ultrasound contrast agents, confinement fusion targets, light weight fillers, damping materials, and energy storage media. In essence the benefit of hollow capsules relies in the fact that these are small, have large inner volumes, and have better stability which is suitable for chemical loading. In this work we introduce new facile techniques to fabricate hollow biocompatible microcapsules. The disclosed techniques rely on the stabilization of micro bubbles in polymeric solutions for a time long enough to allow polymer adsorption onto the micro bubble surface. In the present study three different microcapsules were fabricated via bubble templating. Each capsule was fabricated to be potentially employed in different applications. Furthermore, the techniques are not restricted to the materials employed, which allow us to synthetize inorganic hollow capsules using the same principles. Yet, only those fabricated with biodegradable polymers are covered in the present study. Since microcapsules with tunable sizes are desired, we report on the size control of each of the capsules created using our bubble template method. Furthermore we also proved that the methods are scalable. Mass production can be achieved and the details for mass producing these capsules are disclosed in this study.

Concerning the study of microcapsules fabricated using PLA as the coating polymer, the conditions required to synthesize uniform microcapsules were clarified. The average size of these capsules was 1um and epifluorescence microscopy confirmed that there was a single hollow (air) core inside of them. Furthermore the conditions required for achieving a bigger stable micro bubble were clarified and capsules with an average size of 5um were fabricated. For tailoring the microcapsule size we focused on the effect of (1) PLA concentration, (2) PLA molecular weight, and (3) PVA in aqueous medium on the radius distribution of fabricated hollow PLA microcapsules. The experimental conditions for mass producing hollow PLA microcapsules are well documented.

Regarding the study of microcapsules fabricated using colloidal PAH as the coating polymer; we successfully controlled the microcapsule radius by changing the concentration of PAH in the Na2CO3 solution. The zeta potential of these PAH microcapsules is positive at pH = 8.5, which allowed the adsorption of poly-sodium styrene sulfonate (PSS) onto the PAH microcapsules, and a bilayer capsule was made. Furthermore, the bilayer PAH/PSS capsule solution was titrated until the pH was adjusted to 7.0 and they were stable at this pH, proving that they can be potentially used for pharmaceutical applications. The required conditions for successful synthesis of bilayer capsules were determined as well. On the basis of the analysis of the zeta potentials and Fourier transform infrared-attenuated total reflection (FTIR-ATR) spectra for both PAH and PAH/PSS hollow microcapsules, the adsorption mechanism of PSS onto hollow PAH microcapsules was elucidated as well.