PREPARATION AND CHARACTERIZATION OF MICROCAPSULES CONTAINING FLUORESCENT NANOPARTICLES SENSITIVE TO ORGANIC SOLVENT

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ABSTRACT

The development of a novel technique to fabricate the spherical microcapsule encapsulating fluorescent nanoparticles is presented. The water droplets including the nanoparticles are formed in the organic polymer solution suspended with the well-defined amphiphilic copolymers. By utilizing the self-assembly of polymers on the surface of droplets, the polymer microcapsules as containers of nanoparticles are fabricated. The encapsulation performance of fluorescent nanoparticles is characterized by using TEM image analysis and a fluorescent confocal laser microscope.

KEYWORDS: Microcapsule, Encapsulation, Droplet, PS-b-PMMA

INTRODUCTION

The diverse interests and wide range of applications of polymeric microcapsule targeted for use of the controlled release have led to the development of various methods and procedures for forming microcapsules. However, the conventional methods have difficulty in fabricating microcapsules of uniform size and containing biomolecules sensitive to an organic solvent [1]. The purpose of this paper is to fabricate uniform microcapsules containing organic sensitive fluorescent nanoparticles and their encapsulation is characterized.

The recent technique provides the method to form uniform microcapsules using the self-assembly of a block copolymer dissolved in the organic phase droplet [2,3]. However, since most biomolecules for use of drug delivery are affected by organic solvent, they must be enclosed in the water phase droplet [4]. Fig. 1 describes the microcapsule fabrication using the self-assembly of an amphiphilic polymer at the interface of water phase droplet containing fluorescent nanoparticles.

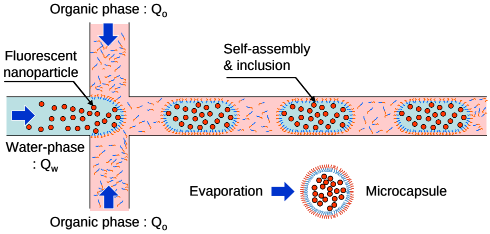

Figure 1. Fabrication of microcapsules containing the biomaterials sensitive to an organic solvent using water phase droplets

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EXPERIMENTAL EVALUATION

PS-b-PMMA as the amphiphilic polymer was synthesized by atomic transfer radical polymerization [5]. Fig. 2 describes the procedures of polymerization. The molecular and poly dispersity index were measured to be 9837 g/mole and 1.08, respectively. The cross microchannel was fabricated to generate droplets (Fig. 3(a)). The size of the square microchannel was 100 μm. PS-b-PMMA was dissolved in the organic phase of CH_2Cl_2 with the concentration of 1 mg/ml and was introduced into the middle channel with the flow rate of 10 μL/min. The nanoparticles-suspended water was flown through two side channels with the flow rate of 6 μL/min. Fig. 3(b) also shows the continuous generation of droplets containing the fluorescent nanoparticles.

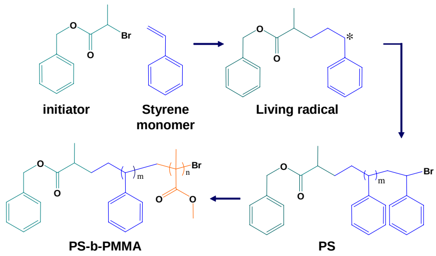
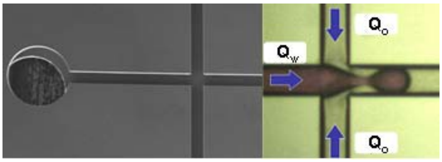


Figure 2. Synthesis procedures of PS-b-PMMA amphiphilic polymer designed for the shell structure



(a) (b)

Figure 3. Fabricated cross-patterned microchannel and visualization of droplet formation of the water phase containing the fluorescent nanoparticles

RESULTS AND DISCUSSION

Fig. 4 shows the SEM images of the solidified microcapsules. The uniform size of 43 μm was obtained. The encapsulation of the fluorescent nanoparticles was examined by using the TEM images. Fig. 5(a) implies that the fluorescent nanoparticles were enclosed with thin wall of PS-b-PMMA. However, the exact shape of nanoparticles was not shown since the transmission thickness of TEM was less than 60 nm. The beam energy of 80 KeV was irradiated onto the surface of microcapsule and the focused part of polymeric shell was removed. The TEM image in Fig. 5(b) indicates that the fluorescent nanoparticles were perfectly encapsulated. In addition, the fluorescence of microcapsules was measured by using the multi-photon confocal laser scanning microscope. Fig. 6 shows the emission of fluorescence at the wavelength of 612nm, implying that the fluorescent nanoparticles were positioned well inside microcapsules.

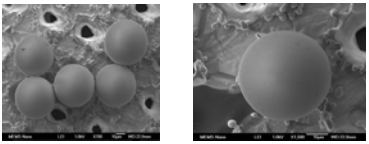


Figure 4. SEM images of microcapsules fabricated from the water phase droplets and their size uniformity

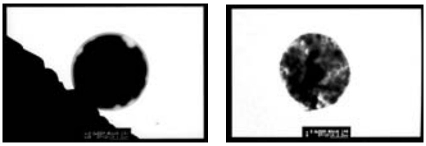


Figure 5. TEM images of microcapsules containing the fluorescent nanoparticles

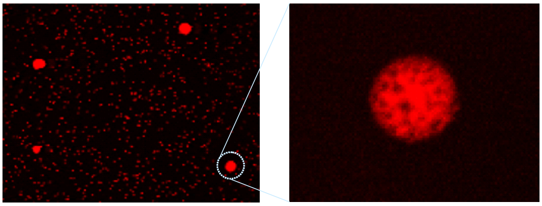


Figure 6. Visualization of fluorescence of microcapsules containing fluorescent nanoparticles emitting at 612nm

CONCLUSIONS

The microcapsule containing the fluorescent nanoparticles was successfully demonstrated using the self-assembly of the amphiphilic polymer in the droplets. Based on this procedure, any biomolecules sensitive to an organic solvent can be encapsulated. The fabrication of the drug-enclosed microcapsules using biocompatible polymers such as PLA and PLGA will be studied.

ACKNOWLEDGEMENT

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