

Fabrication of the Core-shell Microcapsules by Using the Microfluidic System for Brachytherapy

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Keywords: Lab-on-a-chip, Microfluidics, Microcapsules

According to the Korean National Cancer Center, the incidence of prostate cancer has increased by more than 2.6 times than 10 years ago, in Republic of Korea. Among the prostate cancer treatment methods, brachytherapy is receiving enormous attentions due to its high treatment rate and less sequela. Brachytherapy is a procedure that is placing radioactive seeds into the patient's tumor to destroy the cancer cells by radiation at close distance. For the prostate cancer treatment, the radioactive seeds are made of metallic rods containing cesium-131 (¹³¹Cs). However, the metallic rods remain in the patient's body after treatment, making their daily life uncomfortable. To solve this problem, we developed a brachytherapy seeds made of biocompatible polymer with core-shell geometry.

A microfluidic system was designed to produce microcapsules from the double emulsions consist of biocompatible polymer for the shell and ¹³¹Cs as a core. The microfluidic system was made by softlithography. A mold for the microfluidic chip was designed using CAD and fabricated on a silicon wafer. The microfluidic chip was then templated from the mold using polydimethylsiloxane (PDMS) elastomer. The microfluidic chip has three inlets (A, B and C) and one outlet as prussian blue (PB) shown in the Fig. 1a. PB and Cs at distilled water is injected through the inlet A to form a core-phase. Uniform core-shell emulsions are created by the drop-breakup mechanism at the intersection of the channels. Ethoxylated trimethylolpropane triacrylate (ETPTA) with photoinitiator is injected through the inlet B to form a shell of the double emulsion. And, hexadecane is injected into the inlet C as a continuous phase. ETPTA was used to form a shell and PB was used to impregnate cesium ions in the core-phase. PB adsorbs Cs ions through both physical and chemical mechanism. Finally, uniform microcapsules were generated from the continuous photopolymerization of the ETPTA shells of the produced double emulsions by UV irradiation at the downstream of the microchannel, as shown in the Fig. 1a (UV curing zone). Microscope image of the produced microcapsules and their size distributions are presented in the Fig. 2.

In this study, we fabricated core-shell microcapsules of uniform size with Cs impregnation in their core, using the microfluidic system. As a future work, leakage of the core-shell microcapsules will be evaluated through series of cold and hot experiments. In addition, extension of its potential applications is expected by introducing different functional materials, such as magnetic nanoparticles, gold nanoparticles, fluorescence and etc.

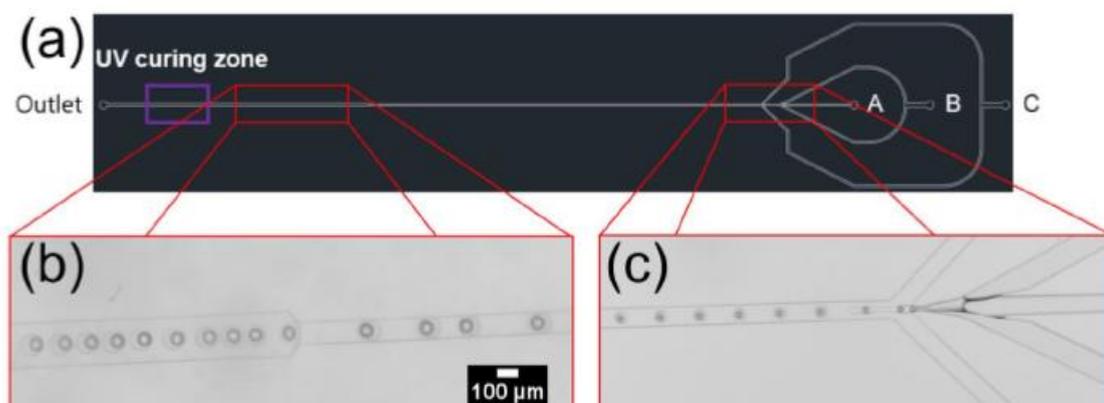


Fig. 1. Microfluidic system for the generation of uniform microcapsules. Chip design (a), microscope images of produced double emulsions at the downstream (b), and channel intersection (c).



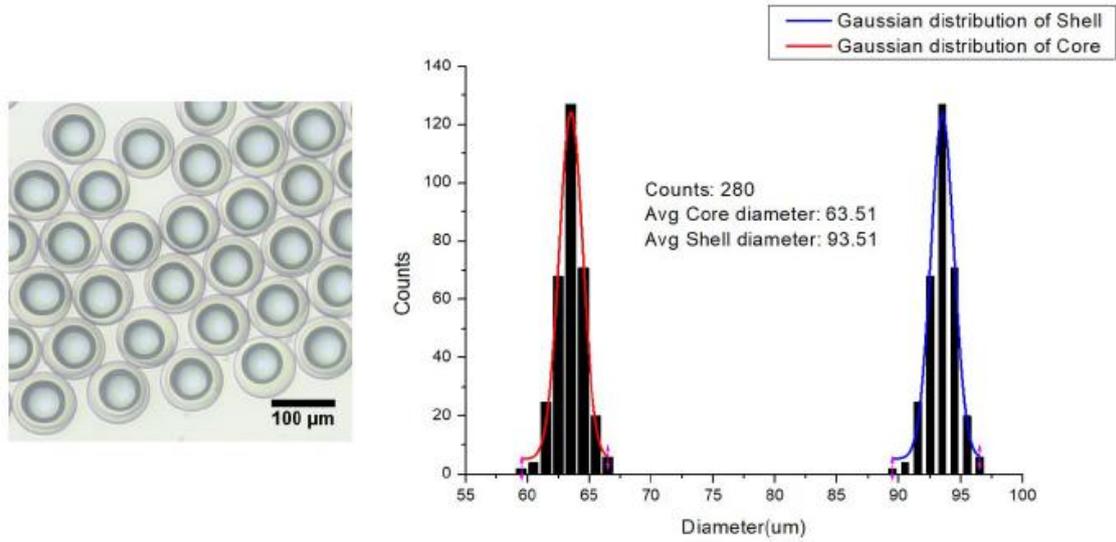


Fig. 2. Produced microcapsules. Microscope image of the collected core-shell microcapsules(left), and the particle size distribution of the microcapsules(right).

Acknowledgments

This work was supported by Radiation Technology R&D program through the National Research Foundation of Korea funded by the Ministry of Science and ICI (2017M2A2A6A05016598)

