

Supporting Information

Synthesis of Nano-capsules via Aqueous RCMP-PISA and Encapsulation

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1. Experimental Section

Materials. Methyl methacrylate (MMA) (>99.8%, Tokyo Chemical Industry (TCI), Japan), poly(ethylene glycol) methacrylate (PEGMA) (average molecular weight = 300) (98%, Sigma Aldrich, USA), ethylene glycol dimethacrylate (EGDMA) (98%, Sigma Aldrich), iodo-2-methylpropionitrile (CP-I) (>95%, TCI), tetrabutylammonium iodide (BNI) (> 98%, TCI), NaI (>99.5%, Kanto Chemical, Japan), 2,2'-azobis(2,4-dimethyl valeronitrile) (V65) (95%, Wako Pure Chemical, Japan), 4,4'-azobis(4-cyanovaleric acid) (V501) (95%, Wako Pure Chemical, Japan), and rhodamine-B (Rh-B) (>95%, TCI),

Measurements. The GPC analysis was performed on a Shodex GPC-101 liquid chromatograph (Tokyo, Japan) equipped with two Shodex KF-804L mixed gel columns (300 × 8.0 mm; bead size = 6 μm; pore size = 3000 Å) (Tables 1 and 2). The eluent was dimethylformamide (DMF) (containing LiBr (10 mM)) at a flow rate of 0.8 mL/min (40 °C). Sample detection and quantification were conducted using a Shodex differential refractometer RI-101. The column systems were calibrated with standard poly(methyl methacrylate)s (PMMA)s. The GPC analysis was also performed on a Shimadzu (Kyoto, Japan) LC-2030C plus liquid chromatograph equipped with two Shodex LF-804 (300 × 8.0 mm; bead size = 6 μm; pore size = 3000 Å) and one KD-802 (300 × 8.0 mm; bead size = 6 μm; pore size = 150 Å) (Table 4). Sample detection and quantification were conducted using a Shimadzu differential refractometer RID-20A. The eluent was DMF (containing LiBr (10 mM)) at a flow rate of 0.35 mL/min (40 °C). The column systems were calibrated with standard PMMA)s.

The NMR spectra were recorded on a Bruker (Germany) BBFO400 spectrometer (400 MHz) at ambient temperature. DMSO-*d*₆ (Cambridge Isotope Laboratories (CIL), USA) was used as a solvent for the NMR analysis. The monomer conversion was determined from the peak area.

The TEM images were obtained on a JEM-1400 transmission electron microscope (JEOL) operated at 100 kV. The TEM grid was carbon-coated on 200 mesh (copper) (Ted Pella, United States). The sample solution was dropped on the TEM grid and dried under vacuum at room temperature.

The DLS measurement was carried out on a Malvern Zetasizer Nano ZSP (Worcestershire, UK) at room temperature. The test angle for the DLS analysis was 173° (backscattering detection).

The UV-Vis absorption spectra were recorded on a Shimadzu UV-3600 (Kyoto, Japan) at room temperature with a quartz cell with an optical path length of 1 cm.

Preparation of PPEGMA-I Macroinitiator. For example, a mixture (6 g) of PEGMA (8 M), Iodine (I₂) (40 mM), V65 (160 mM), BNI (80 mM), and ethanol (20 wt% of the mixture) was heated in a Schlenk flask at 60 °C under argon atmosphere with magnetic stirring for 3.5 h. The reaction mixture was diluted with 2 mL ethanol. The polymer was purified by reprecipitation using a mixture of hexane and diethyl ether (1:1 (v/v)) as a non-solvent.

PISA. For example, a mixture (83.8 g) of MMA (8 M), PPEGMA-I (20 mM), V501 (40 mM), NaI (160 mM), and water (90 wt% of the mixture) was heated in a reaction vessel at 60 °C under argon atmosphere with mechanical stirring (1000 rpm). The vessel was a 100 mL jacketed cylindrical reaction vessel (ChemGlass, USA) connected with an overhead mechanical stirrer (Heidolph, Germany) and a water bath (Lauda, Germany). The pH of the solution was adjusted to 7 by adding saturated sodium bicarbonate (NaHCO₃) solution. An aliquot (0.1 mL) of the solution was taken out, dried under vacuum, diluted with DMF, and analyzed with DMF-GPC. Another aliquot (0.02 mL) of the solution was taken out, diluted with DMSO-*d*₆, and analyzed with ¹H NMR. Another aliquot (0.1 mL) was diluted with 5 mL water. This solution was used as the stock solution for the subsequent DLS and TEM analyses.

Encapsulation of Rhodamine-B Dye in Nano-capsules. A mixture (83.8 g) of MMA (8 M), PPEGMA-I (20 mM), V501 (40 mM), NaI (160 mM), Rh-B, and water (90 wt% of the mixture) was heated in a reaction vessel at 60 °C under argon atmosphere with mechanical stirring for 4 h. The concentration of Rh-B was 15 mM in water. The pH of the solution was adjusted to 7 by adding saturated sodium bicarbonate (NaHCO₃) solution. An aliquot (1 mL) of the solution was taken out, diluted with 4 mL of acetone, and analyzed with UV-Vis spectrophotometer. Another aliquot (1 mL) of the solution was taken out, diluted with 10 mL of water, and dialyzed with water for 84 h using

cellulose dialysis tube (Orange Scientific, MWCO: 6000-8000). Water was changed in every 6 h. An aliquot (0.1 mL) of the dialyzed solution was diluted with 1 mL water and analyzed with DLS and TEM. An aliquot (1 mL) of the dialyzed solution was diluted with acetone (4 mL) and analyzed with UV-Vis spectroscopy. We multiplied the absorbance of the after-dialysis sample by 11, because 1 mL of the solution was diluted with 10 mL of water. Then, we compared the absorbance of the before-dialysis and after-dialysis samples to calculate the encapsulation efficiency.

2. UV-Vis Spectrum of the Supernatant Solution.

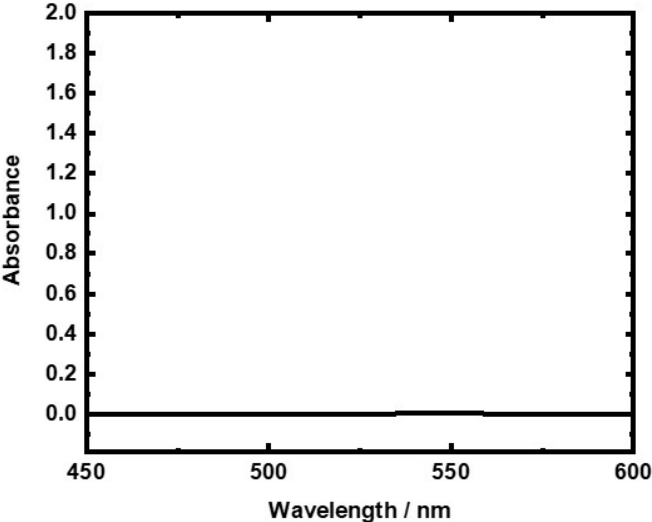


Fig. S1. UV-Vis absorption spectrum of the dialyzed solution (the last run in the change of water).