

# Uniform biodegradable fiber-like micelles and block comicelles via “living” crystallization-driven self-assembly of poly(L-lactide) block copolymers

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1 **Supporting Information of**

2 **Uniform Biodegradable Fiber-Like Micelles and Block Co-micelles via**  
3 **‘Living’ Crystallization-Driven Self-Assembly of Poly(L-lactide) Block**  
4 **Copolymers: The Importance of Reducing Unimer Self-Nucleation via**  
5 **Hydrogen Bond Disruption**

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## 1        **Materials and Methods**

2 All reactions were carried out in an MBraun MB150B-G glove box under nitrogen  
3 atmosphere or using standard Schlenk line techniques. Solvents for self-assembly were  
4 purchased at HPLC grade and filtered through a PTFE membrane with pore size of 450 nm.  
5 Solvents for reactions were obtained from a Grubbs type solvent purification system. All  
6 reagents and solvents were purchased from Sigma-Aldrich (UK), Acros, Fluka, Fisher  
7 Chemical and Alfa Aesar, and used as received unless otherwise noted. *L*-Lactide were  
8 purified by azeotropic distillation or recrystallization respectively from toluene, followed by  
9 drying at 50 °C under reduced pressure over night prior to use. *N*-Isopropylacrylamide  
10 (NIPAm) was recrystallized twice from methanol before use. 2,2'-Azobis(2-  
11 methylpropionitrile) (AIBN) was recrystallized twice from methanol and stored in the dark at  
12 4 °C. 2-Vinylpyridine (2VP) was passed through a basic aluminium oxide column before use.  
13 DBU were dried over CaH<sub>2</sub> and distilled under vacuum before use.

14 Matrix-assisted laser desorption/ionization time of flight (MALDI-TOF) mass spectrometry  
15 measurements were performed using a Bruker Ultraflex extreme running in linear mode.  
16 Samples were prepared using a *trans*-2-[3-(4-*tert*-butylphenyl)-2-methyl-2-  
17 propenylidene]malononitrile matrix (20 mg/mL in THF) and the polymer sample (2 mg/mL  
18 in THF), mixed in a 10:1 (v/v) ratio. Approximately 1 µL of the mixed solution was deposited  
19 onto a stainless steel sample plate and allowed to dry in air.

20 <sup>1</sup>H and <sup>13</sup>C NMR spectra were obtained using a Varian 400 MHz spectrometer with CDCl<sub>3</sub>  
21 (<sup>1</sup>H NMR: δ = 7.26 ppm; <sup>13</sup>C NMR δ = 77.16 ppm) as solvents and integrations of all peaks  
22 were against to TMS/Cl standard in NMR solvents. DOSY NMR spectra were obtained using  
23 a Varian 500 MHz spectrometer with CDCl<sub>3</sub> as solvents.

24 Infrared spectra (IR) were recorded on a Perkin Elmer Spectrum One Fourier Transform  
25 Infrared Spectrometer (FT-IR).

26 Thermogravimetric analysis (TGA) was performed on a TA Instruments Q100 calorimeter at  
27 a scan rate of 10 °C/min under nitrogen.

28 Gel Permeation Chromatography (GPC) was conducted on a Viscotek VE2001 GPCmax  
29 chromatograph equipped with a refractive indices (RI) and a UV detector array. *n*-  
30 Bu<sub>4</sub>NBr/THF (0.1 w/w %) was used as the eluent, with the flow rate set at 1 mL/min. The  
31 columns used were of grade GP5000HHR followed by GP2500HHR (Viscotek) at a constant

1 temperature of 30 °C. The calibration of RI detector was carried out using polystyrene  
2 standards (Viscotek). Samples were prepared at 2 mg/mL in eluent and filtered through a  
3 Ministart SRP 15 filter (polytetrafluorethylene membrane, pore size = 0.45 μm).

4 Dynamic light scattering (DLS) was employed to determine the size of micelles formed in  
5 selective solvents. The measurements were performed at 25 °C on a Malvern Instruments  
6 Zetasizer Nano S using a 5 mW He–Ne laser (633 nm) and a detector oriented at 173°.  
7 Samples (1 mL) were measured in an optical glass cuvette (10.0 mm path length) with a  
8 concentration of 0.05 mg/mL. The results of DLS studies are reported as apparent  
9 hydrodynamic radii ( $R_{h,app}$ ), acknowledging that the particles have been modelled as spheres  
10 in the experiments conducted.

11 Transmission electron microscopy (TEM) images were obtained on a JEOL 1400 microscope  
12 with a SIS MegaViewIII digital camera, which was operated at 120 kV. Selected area  
13 electron diffraction (SAED) data and scanning transmission electron microscopy (STEM)  
14 images were obtained on a JEOL JEM-2100F field emission TEM equipped with an Oxford  
15 Instruments X-Max 80 mm<sup>2</sup> X-ray detector WITH Aztec software from Oxford Instruments.  
16 STEM was operated in high angle annular dark field imaging (HAADF) mode. Samples were  
17 prepared by drop casting 4 μL of the micelle solution onto a carbon coated copper grid.  
18 Copper grids (400 mesh) were purchased from Agar Scientific and carbon films were  
19 prepared on mica sheets by carbon sputtering with an Agar TEM Turbo Carbon Coater. The  
20 carbon films were deposited onto the copper grids by floatation on water and the carbon  
21 coated grids were allowed to dry in air. For TEM images, samples were stained with uranyl  
22 acetate solution (2% wt in EtOH). For STEM and SAED data, no staining was applied.

23 For micelle contour lengths analysis, ca. 200 micelles in several images were traced manually  
24 using the ImageJ software package developed at the US National Institute of Health. The  
25 number average micelle length ( $L_n$ ) and weight average micelle length ( $L_w$ ) were calculated  
26 using eq. S1 from measurements of the contour lengths ( $L_i$ ) of individual micelles, where  $N_i$  is  
27 the number of micelles of length  $L_i$ , and  $n$  is the number of micelles examined in each sample.  
28 The distribution of micelle lengths is characterized by both  $L_w/L_n$  and the ratio of standard  
29 deviation/ $L_n$  ( $\sigma/L_n$ ).

$$30 \quad L_n = \frac{\sum_{i=1}^n N_i L_i}{\sum_{i=1}^n N_i} \quad L_w = \frac{\sum_{i=1}^n N_i L_i^2}{\sum_{i=1}^n N_i L_i} \quad (\text{eq.S1})$$

1 Atomic force microscopy (AFM) analyses were performed in ambient conditions using a  
2 Bruker Multimode VIII atomic force microscope equipped with a ScanAsyst-HR fast  
3 scanning module and a ScanAsyst-Air-HR probe (tip radius, 2 nm), utilising peak force  
4 feedback control. Samples for AFM were prepared by drop casting 6  $\mu$ L of micelle colloidal  
5 solution onto freshly cleaved mica before drying with a gentle stream of nitrogen.

6 X-ray scattering measurements (small- and wide-angle, SAXS and WAXS, respectively)  
7 were performed in transmission geometry using a Ganesha small angle X-ray scattering  
8 apparatus (SAXSLAB, Denmark). Solution samples were sealed into 1.5 mm diameter quartz  
9 capillary tubes (Capillary Tube Supplies, Cornwall, UK) and solid-state samples were drop  
10 cast onto mica or Kapton film (4,4'-oxydiphenylene-pyromellitimide, DuPont). The capillary  
11 or film was then secured in position, perpendicular to the X-ray beam and the detector was  
12 positioned at a distance of 1050 mm and 100 mm for the SAXS and WAXS measurements  
13 respectively. All measurements were recorded after evacuating the chamber to reduce air  
14 scattering. All the SAXS data was analyzed after applying corrections for the scattering from  
15 the solvents and the empty capillary tube. SAXGUI (from SAXSLAB) was used for empty  
16 cell correction and SIMPLE SUBTRACT (in-house) for solvent.

17 Computation of ctanol-water partition coefficient normalized by the Connolly surface area  
18 ( $\text{LogP}_{\text{oct}}/\text{SA}$ ) values.  $\text{LogP}_{\text{oct}}/\text{SA}$  values were calculated with a similar reported method.<sup>1</sup>  
19  $\text{LogP}_{\text{oct}}/\text{SA}$  values were calculated with the ALogP98 method in Materials Studio 2019. The  
20 surface area was calculated after minimizing the energy of the solvents with the Forcite  
21 Molecular Dynamics module in Materials Studio 2019.

## 22 **Synthesis procedures**

23 **Synthesis of 4-cyano-4-(((phenethylthio)carbonothioyl)thio)pentanoic acid (CTA-**  
24 **COOH).** Following previously reported procedures,<sup>2-3</sup> in an oven-dried round bottom flask,  
25 2-Phenylethanethiol (4.0 mL, 29.86 mmol) was added dropwise to a stirred suspension of  
26  $\text{K}_3\text{PO}_4$  (8.0 g, 37.69 mmol) in acetone (20 mL) and stirring for 1 h.  $\text{CS}_2$  (5.5 mL, 91.45 mmol)  
27 was added and the solution turned bright yellow. After stirring for 16 h, the suspension was  
28 filtered, and the cake was washed with acetone (2 x 20 mL). After removing the solvents  
29 from the filtrate under reduced pressure, the resulting yellow solid was suspended in diethyl  
30 ether (100 mL). Solid iodine (3.2 g, 12.61 mmol) was gradually added and then stirred at  
31 room temperature for 1 h, and the insoluble white precipitate was removed by filtration. The  
32 yellow-brown filtrate was washed with an aqueous solution of sodium thiosulfate, dried over

1 magnesium sulfate, and then evaporated to yield yellow solid. 4,4'-azobis(4-cyanopentanoic  
2 acid) (ACVA) (5.1 g, 17.90 mmol) was added to a solution of the solid in ethyl acetate (50  
3 mL). The solution was degassed by nitrogen bubbling for 30 min and heated at reflux under  
4 nitrogen for 16 h. After removal of the solvents under reduced pressure, the crude product  
5 was washed with water (5 × 100 mL). The organic phase was concentrated and purified by  
6 silica chromatography using a mixed eluent (hexane:ethyl acetate = 4:1, gradually increasing  
7 to 1:1) to afford CTA-COOH as an orange oil (4.3 g, 44%). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>, 298  
8 K): δ (ppm) 7.4-7.2 (m, 5H, Ph), 3.60 (t, 2H, PhCH<sub>2</sub>CH<sub>2</sub>), 3.00 (t, 2H, PhCH<sub>2</sub>), 2.70 (t, 2H,  
9 CH<sub>2</sub>COOH), 2.6-2.4 (m, 2H, CNCCCH<sub>2</sub>), 1.90 (s, 3H, CH<sub>3</sub>). <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>, 298  
10 K): δ (ppm) 216.5 (C=S), 177.2 (C=O), 139.2, 128.9, 128.6, and 126.9 (Ph), 118.9 (CN), 46.4  
11 (CCN), 38.1 (CH<sub>2</sub>CS), 34.2 (PhCH<sub>2</sub>), 33.6 (CNCCCH<sub>2</sub>), 29.6 (CH<sub>2</sub>COOH), 24.9 (CH<sub>3</sub>).

12 **Synthesis of 6-hydroxyhexyl 4-cyano-4(((phenethylthio)carbonothioyl)thio)pentanoate**  
13 **(CTA-OH)**. In an oven-dried Schlenk flask, CTA-COOH (1.0 g, 3.24 mmol) and 1,6-  
14 hexanediol (3.0 g, 25.92 mmol) were dissolved in dry CHCl<sub>3</sub> (50 mL). EDC·HCl (0.95 g,  
15 4.87 mmol) and DMAP (59 mg, 0.487 mmol) were dissolved in dry CHCl<sub>3</sub> (15 mL) in  
16 another oven-dried Schlenk flask at ambient temperature, followed by adding into the  
17 reaction flask via a syringe. The reaction mixture was stirred under reflux for 48 h, filtered  
18 and concentrated to yield orange oil residue. The crude product was purified by silica  
19 chromatography (hexane: ethyl acetate = 3:1 as eluent) to afford CTA-OH as an orange oil  
20 (870 mg, 61%). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>, 298 K): δ (ppm) 7.4-7.2 (m, 5H, Ph), 4.12 (t, 2H,  
21 COOCH<sub>2</sub>), 3.66 (t, 2H, CH<sub>2</sub>OH), 3.59 (t, 2H, PhCH<sub>2</sub>CH<sub>2</sub>), 3.00 (t, 2H, Ph-CH<sub>2</sub>), 2.64 (t, 2H,  
22 CH<sub>2</sub>-COOH), 2.6-2.4 (m, 2H, CN-C-CH<sub>2</sub>), 1.90 (s, 3H, CH<sub>3</sub>), 1.7-1.4 (m, 8H,  
23 CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH). <sup>13</sup>C NMR (125 MHz, CDCl<sub>3</sub>, 298 K): δ (ppm) 216.5 (C=S), 171.6  
24 (C=O), 139.2, 128.9, 128.6, and 126.9 (Ph), 118.9 (CN), 65.3 (COOCH<sub>2</sub>), 62.9 (CH<sub>2</sub>OH),  
25 46.4 (CCN), 38.1 (CH<sub>2</sub>CS), 34.2 (PhCH<sub>2</sub>), 34.1 (CNCCCH<sub>2</sub>), 32.7 (CH<sub>2</sub>CH<sub>2</sub>OH), 30.6  
26 (CH<sub>2</sub>COOH), 28.7 (COOCH<sub>2</sub>CH<sub>2</sub>), 25.8 (COOCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>), 25.5 (CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH), 24.9  
27 (CH<sub>3</sub>).

28 **Synthesis of PLLA<sub>47</sub>**. In a nitrogen-filled glove box, solutions of DBU (11.2 uL, 0.18 mmol)  
29 and CTA-OH (28 mg, 0.062 mmol) in dry DCM (2 mL) were added to solution of *L*-lactide  
30 (400 mg, 2.78 mmol) in dry DCM (1mL). After stirring for 1 min at room temperature, the  
31 solution was quenched with benzoic acid and stirred for 30 min. After removed from the  
32 glove box, the reaction solution was precipitated three times into MeOH and collected by  
33 centrifugation. The Polymer was further dried in a vacuum oven for 16 h before

1 characterization (367 mg, 92%).  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 5.17 (q, 102H,  
2  $\text{CHCH}_3$ ), 1.57 (d, 306H,  $\text{CHCH}_3$ ).  $M_n$  (NMR):  $7698 \text{ g}\cdot\text{mol}^{-1}$ . MALDI:  $m/z = 7232$ ,  $\text{DP}_n = 47$ .  
3 GPC ( $n\text{-Bu}_4\text{NBr/THF}$ , PS standard):  $M_n = 9800 \text{ g}\cdot\text{mol}^{-1}$ ,  $D_m = 1.09$ .  $v_{\text{max}}$  (neat)/ $\text{cm}^{-1}$ : 3000-  
4 2880 (C-H); 1755, 1044 (C=O); 1456 ( $\text{CH}_3$ ); 1210-1163 (C(O)-O); 1088 (C-O).

5 **Synthesis of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub>.** PLLA<sub>47</sub> (100 mg, 0.015 mmol), NIPAm (355 mg, 3.2  
6 mmol) and AIBN (0.47 mg, 0.003 mmol) were dissolved in 1,4-dioxane (3 mL) in a Schlenk  
7 flask. The solution was then freeze-pump-thawed four times and heated for 3.5 h at 70 °C.  
8 The reaction was quenched by immersion of the ampoule in liquid nitrogen and the block  
9 copolymer was precipitated in hexane three times, followed by drying under vacuum (403 mg,  
10 88%). DP of PNIPAm was confirmed by  $^1\text{H}$  NMR spectrum based on PLLA DP according to  
11 MALDI-TOF spectrometry.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 7.0-5.6 (br, 244H,  $\text{NH-}$   
12  $\text{CH}(\text{CH}_3)_2$ ), 5.16 (q, 94H,  $\text{CH}(\text{CH}_3)$  from PLLA), 4.00 (br, 267H,  $\text{NH-CH}(\text{CH}_3)_2$  from  
13 PNIPAm), 2.3-0.7 (3673 H, m,  $\text{CH}_3$  from PNIPAm,  $\text{CH}(\text{CH}_3)$  from PLLA,  $\text{CHCH}_2$  from  
14 PNIPAm). GPC ( $n\text{-Bu}_4\text{NBr/THF}$ , PS standard):  $M_n = 180,600 \text{ g}\cdot\text{mol}^{-1}$ ,  $D_m = 1.11$ .  $v_{\text{max}}$   
15 (neat)/ $\text{cm}^{-1}$ : 3510-3313 (N-H); 3000-2880 (C-H); 1755 (C=O); 1644 (NH-C=O); 1458 ( $\text{CH}_3$ );  
16 1386-1367 (C-H), 1276-1185 (C-O); 1130,1088 (C-O).

17 **Synthesis of PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub>.** PLLA<sub>47</sub> (100 mg, 0.015 mmol), 2VP (886  $\mu\text{L}$ , 8.25 mmol)  
18 and AIBN (0.47 mg, 0.003 mmol) were dissolved in 1,4-dioxane (2 mL) in a Schlenk flask.  
19 The solution was then freeze-pump-thawed four times and heated for 16 h at 70 °C. The  
20 reaction was quenched by immersion of the ampoule in liquid nitrogen and the polymer was  
21 precipitated in hexane three times, followed by drying under vacuum (403 mg, 88%). DP of  
22 P2VP was confirmed by  $^1\text{H}$  NMR spectrum based on PLLA DP according to MALDI-TOF  
23 spectrometry.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  (ppm) 8.41-8.07 (m, 503H, Ar from P2VP),  
24 7.20-6.30 (m, 1510H, Ar from P2VP), 5.16 (q, 94H,  $\text{CH}(\text{CH}_3)$  from PLLA), 2.28-1.48  
25 (1940H, m,  $\text{CH}(\text{CH}_3)$  from PLLA,  $\text{CHCH}_2$  from P2VP). GPC ( $n\text{-Bu}_4\text{NBr/THF}$ , PS standard):  
26  $M_n = 63,245 \text{ g}\cdot\text{mol}^{-1}$ ,  $D_m = 1.25$ .  $v_{\text{max}}$  (neat)/ $\text{cm}^{-1}$ : 3000-2880 (C-H); 1755, 1044 (C=O); 1590,  
27 1585 (Ar); 1472, 1433 (Ar-C-N); 1088 (C-O); 745 (Ar).

## 28 Self-assembly procedures

29 All solvent compositions are given as volume ratio (v:v). All micelle length measurements  
30 were carried out on ~200 micelles.

31 **Self-nucleation of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub>.** 100  $\mu\text{L}$  of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> solution  
32 (10 mg/mL in DMSO) was added to a vial with an additional 100  $\mu\text{L}$  of DMSO followed by

1 slow addition of 1800  $\mu\text{L}$  of EtOH resulting a polymer solution of 0.5 mg/mL. The vial  
2 contents were aged at 23  $^{\circ}\text{C}$  for 5 days before TEM characterization. A large amount of non-  
3 spherical aggregates and polydisperse micelles was observed by TEM images (Figure S7d).  
4 To avoid the formation of spherical aggregates a heating-cooling method was employed. 100  
5  $\mu\text{L}$  of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> solution (10 mg/mL in DMSO) was added to a vial with 100  $\mu\text{L}$   
6 DMSO and 1800  $\mu\text{L}$  EtOH resulting a polymer solution of 0.5 mg/mL. The vial was sealed  
7 and heated at 70  $^{\circ}\text{C}$  for 4 h, followed by slowly cooling to 23  $^{\circ}\text{C}$ . And the solution was  
8 carried on aging for 24 h. The polydisperse fiber-like micelles formed were characterized by  
9 TEM.

10 **Self-nucleation of PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub>.** 100  $\mu\text{L}$  of PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> solution (10 mg/mL in  
11 DMSO) was added to a vial with 100  $\mu\text{L}$  DMSO and 1800  $\mu\text{L}$  EtOH resulting a polymer  
12 solution of 0.5 mg/mL. The vial was sealed and heated at 70  $^{\circ}\text{C}$  for 4 h, followed by slowly  
13 cooling to 23  $^{\circ}\text{C}$ . And the solution was carried on aging for 24 h. The formed polydisperse  
14 fiber-like micelles were characterized by TEM.

15 **Preparation of seed micelles.** All seed micelle solutions were prepared by sonication of the  
16 polydisperse micelle solutions from self-nucleation of polymer in selective solvents and  
17 characterized by TEM.

18 For PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> seeds ( $L_n = 36$  nm,  $L_w/L_n = 1.10$ ,  $\sigma/L_n: 0.26$ ): sonication of  
19 PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> polydisperse micelles in DMSO/EtOH (1:9) was carried out for 2 h in  
20 a water sonication bath cooled with ice.

21 For PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> seeds ( $L_n = 33$  nm,  $L_w/L_n = 1.13$ ,  $\sigma/L_n: 0.38$ ): sonication of  
22 PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> polydisperse micelles in DMSO/EtOH (1:9) was carried out for 2 h in  
23 a dry ice/acetone bath with a Ultrasonication probe.

24 For PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> seeds ( $L_n = 29$  nm,  $L_w/L_n = 1.11$ ,  $\sigma/L_n: 0.34$ ): sonication of PLLA<sub>47</sub>-*b*-  
25 PNIPAm<sub>267</sub> polydisperse micelles in DMSO/EtOH (1:9) was carried out for 2 h in a in a  
26 water sonication bath cooled with ice.

27 **Seeded-growth of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub>.**

28 For seeded-growth without H-bond disruption reagents: 20  $\mu\text{L}$  (for  $m_{unimer}:m_{seed} \leq 10.0$ ) or  
29 10  $\mu\text{L}$  (for  $m_{unimer}:m_{seed} > 10.0$ ) of seed micelle solution (0.5 mg/mL, DMSO:EtOH = 1:9)  
30 was diluted in 400  $\mu\text{L}$  EtOH to which was added PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> unimer (10 mg/mL in  
31 DMSO). The volumes of unimer added in were 2.5, 5, 10, 7.5, 10 and 15  $\mu\text{L}$  corresponds to



1 unimer-to-seed mass ratios of 2.5, 5, 10, 15, 20 and 30, respectively. And the resulting  
2 solution was then manually shaken for 10 s and aged for 5 days at 23 °C before TEM  
3 characterization.

4 For seeded-growth with H-bond disruption reagent: 20  $\mu\text{L}$  (for  $m_{\text{unimer}}:m_{\text{seed}} \leq 10.0$ ) or 10  $\mu\text{L}$   
5 (for  $m_{\text{unimer}}:m_{\text{seed}} > 10.0$ ) of seed micelle solution (0.5 mg/mL, DMSO:EtOH = 1:9) was  
6 diluted in 400  $\mu\text{L}$  TFE/EtOH with volume ratio of 3:97, 3:97, 5:95, 8:92, 10:90 and 15:85  
7 corresponds to unimer-to-seed mass ratios of 2.5, 5, 10, 15, 20 and 30, respectively, and to  
8 which solution was added PLLA<sub>47-b</sub>-PNIPAm<sub>267</sub> unimer (10 mg/mL in DMSO) with volumes  
9 of 2.5, 5, 10, 7.5, 10 and 15  $\mu\text{L}$  respectively. And the resulting solution was then manually  
10 shaken for 10 s and aged for 5 days at 23 °C before TEM characterization.

#### 11 **Seeded-growth of PLLA<sub>47-b</sub>-PNIPAm<sub>267</sub> for kinetic studies.**

12 Same procedures were adopted with seeded-growth experiments of PLLA<sub>47-b</sub>-PNIPAm<sub>267</sub>.  
13 After unimer addition, aliquots were taken after samples aged for 1 d, 3 d, and 5 d for TEM  
14 characterization.

#### 15 **Seeded-growth of PLLA<sub>47-b</sub>-PNIPAm<sub>267</sub> for solvent effect studies.**

16 10  $\mu\text{L}$  of seed micelle solution (0.5 mg/mL, DMSO:EtOH = 1:9) was diluted in 400  $\mu\text{L}$   
17 solution of EtOH and selected solvents (MeOH, THF, Dioxane, DMF, DMSO, Acetone and  
18 TFE) individually with volume ratio of 0.5:9.5, 1:9 and 1.5:8.5, respectively. Similar  
19 procedures of unimer addition were adopted with seeded-growth experiments of PLLA<sub>47-b</sub>-  
20 PNIPAm<sub>267</sub>. And the resulting solution was then manually shaken for 10 s and aged for 5  
21 days at 23 °C before TEM characterization.

#### 22 **Preparation of samples for SAXS analysis.**

23 To obtain quality data from SAXS experiments, micelles were prepared at higher  
24 concentrations compare with the method mentioned above. Polydisperse micelles of PLLA<sub>47-b</sub>-  
25 PNIPAm<sub>267</sub> was prepared at a polymer concentration of 1 mg/mL by adding 200  $\mu\text{L}$  of  
26 unimer solution (10 mg/mL in THF) to 1800  $\mu\text{L}$  of EtOH. THF was employed as the  
27 common solvent in this preparation due to the large volatility compared with that of DMSO,  
28 which allowing the micelle solutions to be concentrated by applying nitrogen flow and  
29 resulting micelles suspended in TFE/EtOH. The solution was heated at 70 °C for 4 hours and  
30 slowly cool to 23 °C. The solution was further aged for 5 days and then characterized by  
31 TEM. The formed polydisperse micelles were sonicated at -78 °C in a dry ice/acetone bath

1 for 1 h with a Ultrasonicate probe. TEM images showed that the seed micelles had a  $L_n$  (and  
2  $L_w/L_n$ ) of 36 (1.05) nm. 260  $\mu\text{L}$  seed solution was diluted in 1 mL TFE/EtOH (1:9). To the  
3 seed solution, 94  $\mu\text{L}$  of unimer (50 mg/mL in THF) was added and the solution was manually  
4 shaken for 10 s. The final solution had a polymer concentration of 4.6 mg/mL. After ageing  
5 for 24 h, the micelle was determined a  $L_n$  (and  $L_w/L_n$ ) value of 1040 (1.04) by TEM. The  
6 sample with a concentration of 4 mg/mL was prepared by adding 50  $\mu\text{L}$  TFE/EtOH (1:9) to  
7 the micelle solution (100  $\mu\text{L}$ ). The rest micelle solution was concentrated by applying  
8 nitrogen flow to  $\sim 120$   $\mu\text{L}$ . The concentrated micelle solution had a concentration of 30  
9 mg/mL. Samples with 20 mg/mL was prepared by adding 25  $\mu\text{L}$  TFE/EtOH (1:9) to the  
10 concentrated micelle solution (50  $\mu\text{L}$ ). The micelle solution prepared for SAXS had been  
11 used in other characterizations (AFM, SAED and PXR).

### 12 **Seeded-growth of PLLA<sub>47-b</sub>-P2VP<sub>503</sub>.**

13 Analogous procedures were adopted to those used for the seeded-growth experiments with  
14 PLLA<sub>47-b</sub>-PNIPAm<sub>267</sub> in both EtOH and TFE/EtOH. After the unimer addition, samples were  
15 manually shaken for 10 s and aged for 5 days at 23 °C before TEM characterization.

### 16 **Preparation of pentablock co-micelles**

17 For central block 1 micelles: 20  $\mu\text{L}$  of PLLA<sub>47-b</sub>-PNIPAm<sub>267</sub> seed micelle solution ( $L_n =$   
18 33 nm, 0.5 mg/mL, DMSO/EtOH = 1:9) was diluted in 400  $\mu\text{L}$  TFE/EtOH (1:9) to which was  
19 added PLLA<sub>47-b</sub>-PNIPAm<sub>267</sub> unimer (9  $\mu\text{L}$ , 10 mg/mL in DMSO). And the resulting solution  
20 was then manually shaken for 10 s and aged for 3 days at 23 °C before TEM characterization.

21 For triblock 1 co-micelles: PLLA<sub>47-b</sub>-P2VP<sub>503</sub> unimer (3  $\mu\text{L}$ , 10 mg/mL in DMSO) was then  
22 added to the central block 1 micelle solution (200  $\mu\text{L}$ ). The resulting solution was then  
23 manually shaken for 10 s and aged for 3 days at 23 °C before TEM characterization.

24 For pentablock 1 co-micelles: PLLA<sub>47-b</sub>-PNIPAm<sub>267</sub> unimer (3  $\mu\text{L}$ , 10 mg/mL in DMSO)  
25 was added to triblock 1 co-micelle solution (100  $\mu\text{L}$ ) (see above). The resulting solution was  
26 then manually shaken for 10 s and aged for 3 days at 23 °C before TEM characterization.

27 For central block 2 micelles: 20  $\mu\text{L}$  of PLLA<sub>47-b</sub>-P2VP<sub>503</sub> seed micelle solution ( $L_n = 29$  nm,  
28 0.5 mg/mL, DMSO/EtOH = 1:9) was diluted in 400  $\mu\text{L}$  TFE/EtOH (1:9) to which was added  
29 PLLA<sub>47-b</sub>-P2VP<sub>503</sub> unimer (9  $\mu\text{L}$ , 10 mg/mL in DMSO). And the resulting solution was then  
30 manually shaken for 10 s and aged for 3 days at 23 °C before TEM characterization.

1 For triblock 2 co-micelles: PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> unimer (5  $\mu$ L, 10 mg/mL in DMSO) was  
2 then added to the central block 2 micelle solution (200  $\mu$ L) (see above). The resulting solution  
3 was then manually shaken for 10 s and aged for 3 days at 23 °C before TEM characterization.

4 For pentablock 2 co-micelles: PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> unimer (5  $\mu$ L, 10 mg/mL in DMSO) was  
5 added to the triblock 2 co-micelle solution (100  $\mu$ L) (see above). The resulting solution was  
6 then manually shaken for 10 s and aged for 3 days at 23 °C before TEM characterization.

### 7 **Discussion on defects in pentablock comicelles.**

8 Triblock co-micelles and pentablock co-micelles were successfully prepared by alternating  
9 seeded-growth of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> and PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> unimers. One of the features  
10 of these block co-micelles was that the grown segments were not equivalent in length as  
11 would be expected for a controlled living CDSA process (Figure 9**Error! Reference source**  
12 **not found.**). This is proposed caused by the different addition rates of BCPs with different  
13 corona-forming block lengths as previously reported.<sup>4-6</sup> In a typical experiment of preparing  
14 triblock co-micelles, the growth of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> unimer from PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub>  
15 seed micelles is suggested to be a slow step as a consequence of unfavourable corona-corona  
16 interactions between PNIPAm ( $\delta = 24.8 \text{ MPa}^{1/2}$ ) and P2VP ( $\delta = 20.8 \text{ MPa}^{1/2}$ ). Once the first  
17 unimer from PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> has been added in this slow step, further unimers can  
18 deposit more rapidly. This might result in different lengths in the newly grown outer  
19 segments. In the preparation of pentablock co-micelles, the non-equivalent growth would be  
20 amplified by the same reason of switching to a different unimers.

### 21 **Abbreviation**

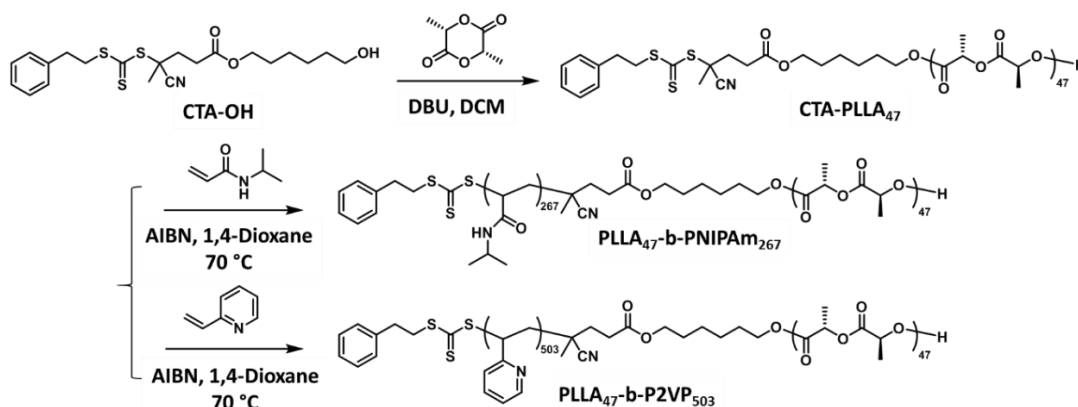
22 DCM: dichloromethane; TFE: trifluoroethanol; MeOH: methanol; EtOH: ethanol; DMF:  
23 N,N-Dimethylformamide; DMSO: Dimethyl sulfoxide; THF: tetrahydrofuran; Dioxane: 1,4-  
24 dioxane; CDSA: crystallization-driven self-assembly;  $\sigma$ : standard deviation.

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1 **Supplementary figures**



2  
3 **Scheme S1.** Synthesis of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> and PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> diblock copolymers

4 **Table S1.** Molar mass characterization of the polymers prepared.

Polymer	$M_w$ (g·mol <sup>-1</sup> ) <sup>a</sup>	$M_n$ (kg·mol <sup>-1</sup> ) <sup>b</sup>	$M_n$ (kg·mol <sup>-1</sup> ) <sup>c</sup>	$D_M$ <sup>c</sup>	Block ratio (Core:Corona) <sup>b</sup>
PLLA <sub>47</sub>	7232	7.6	10.2	1.09	-
PLLA <sub>47</sub> - <i>b</i> -PNIPAm <sub>267</sub>	-	37.4	180 <sup>d</sup>	1.11	1:5
PLLA <sub>47</sub> - <i>b</i> -P2VP <sub>503</sub>	-	59.7	63.2	1.25	1:10

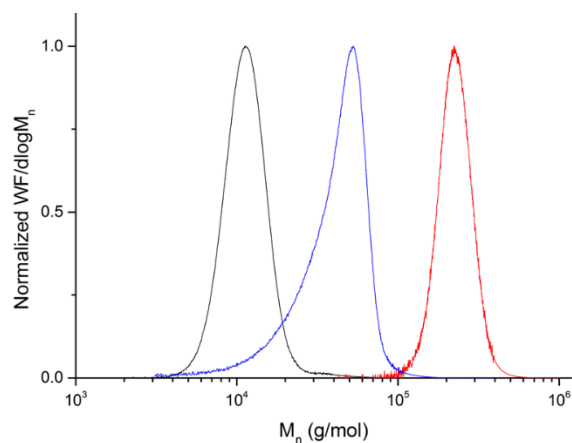
<sup>a</sup> determined by MALDI;

<sup>b</sup> block ratio (according to degree of polymerization (DP)) determined by <sup>1</sup>H NMR spectroscopy;

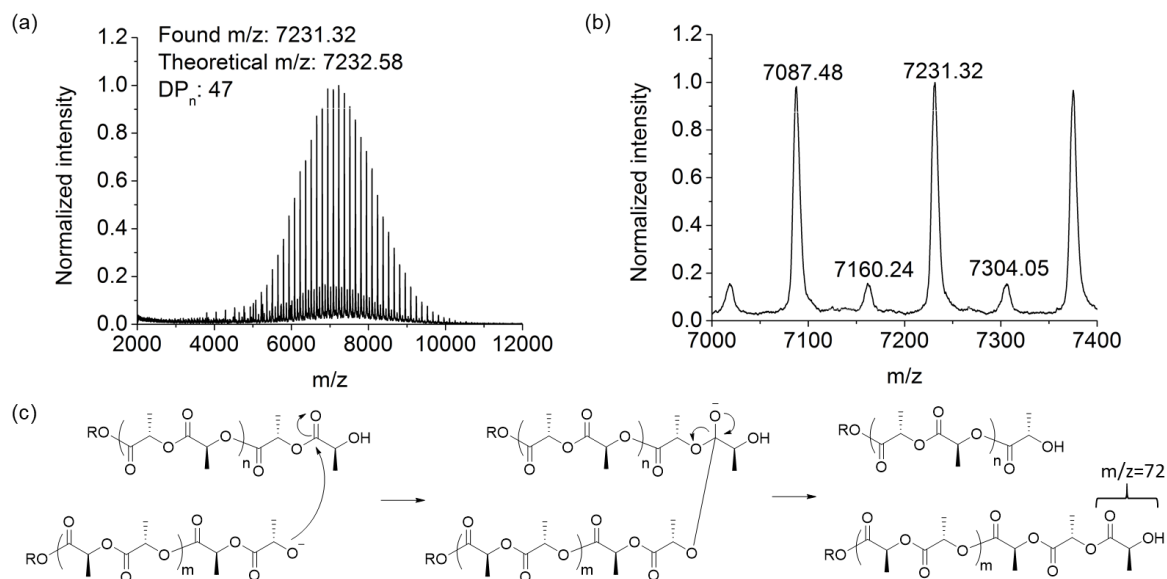
<sup>c</sup> determined by GPC relative to polystyrene (PS) standards in *n*-Bu<sub>4</sub>NBr/THF.

<sup>d</sup> The molar mass estimated by GPC is much larger than that determined by <sup>1</sup>H NMR integration. We attribute this to exclusion interactions between the high polar polymer and the low-polarity styrene/divinylbenzene column. Such effects have been previously noted for highly polar polymers<sup>7</sup>

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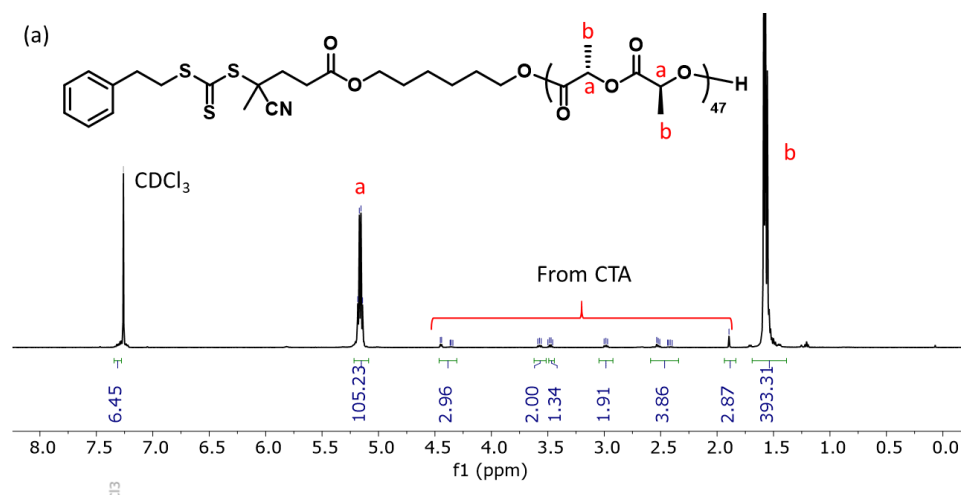


1  
 2 **Figure S1.** GPC chromatographs (refractive index trace) in  $n\text{-Bu}_4\text{NBr/THF}$  of PLLA<sub>47</sub> (black,  $\bar{D}_m =$   
 3 1.09), PLLA<sub>47</sub>-b-P2VP<sub>503</sub> (blue,  $\bar{D}_m = 1.25$ ), PLLA<sub>47</sub>-b-PNIPAm<sub>267</sub> (red,  $\bar{D}_m = 1.11$ ).

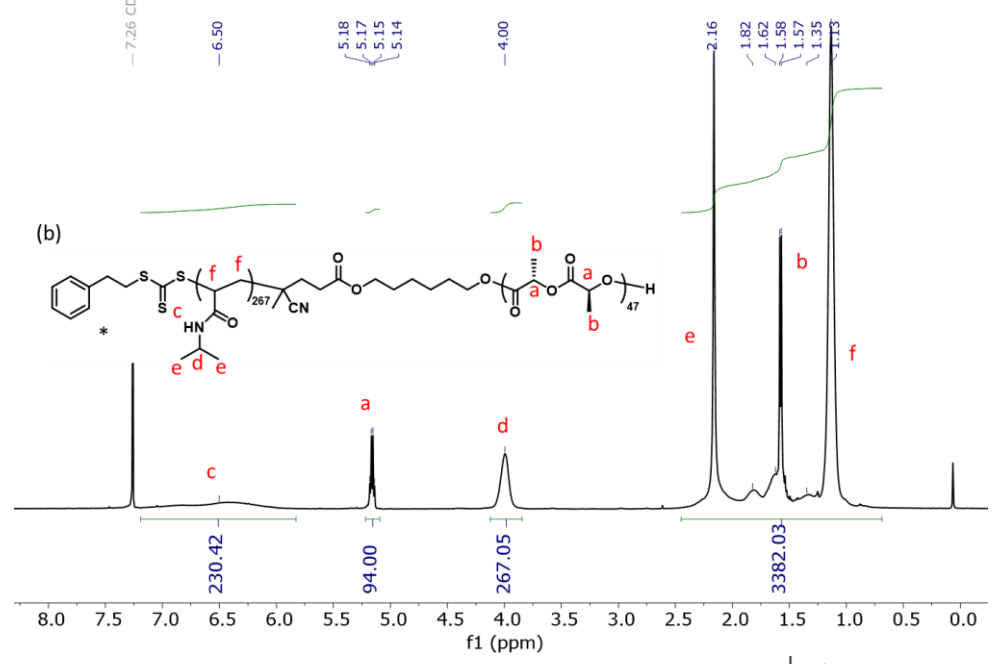


4  
 5 **Figure S2.** (a) MALDI-TOF MS of CTA-PLLA<sub>47</sub>; (b) Zoom-in MALDI-TOF MS of CTA- PLLA<sub>47</sub>;  
 6 (c) Mechanism of transesterification in *L*-lactide polymerization, which corresponds to the minor  
 7 population possessing a  $m/z$  difference of 72 compared with major population in MALDI-TOF MS.

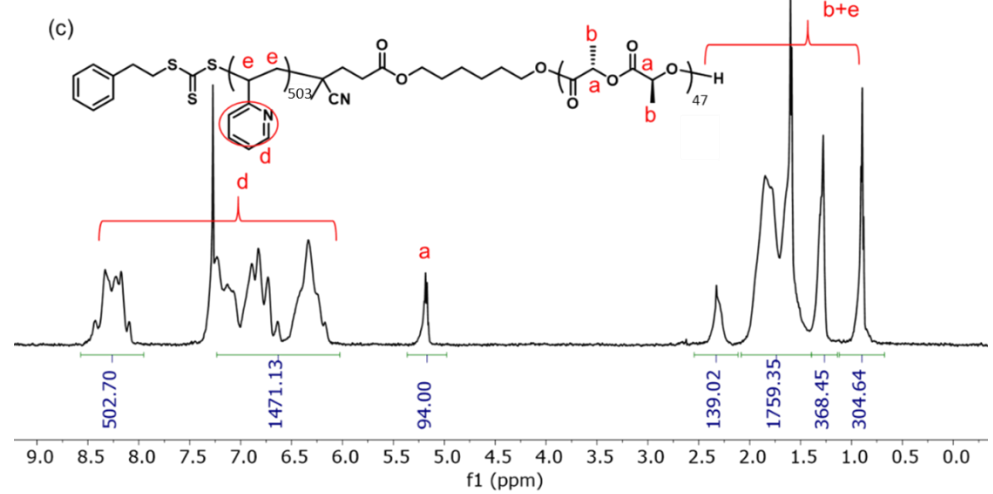
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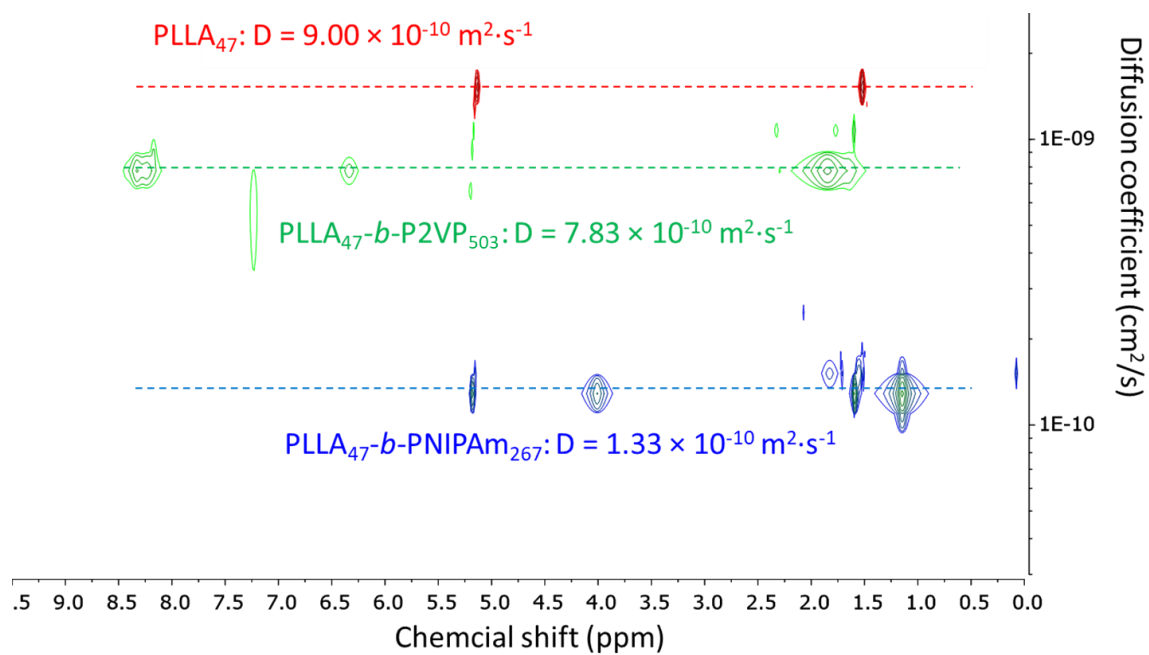
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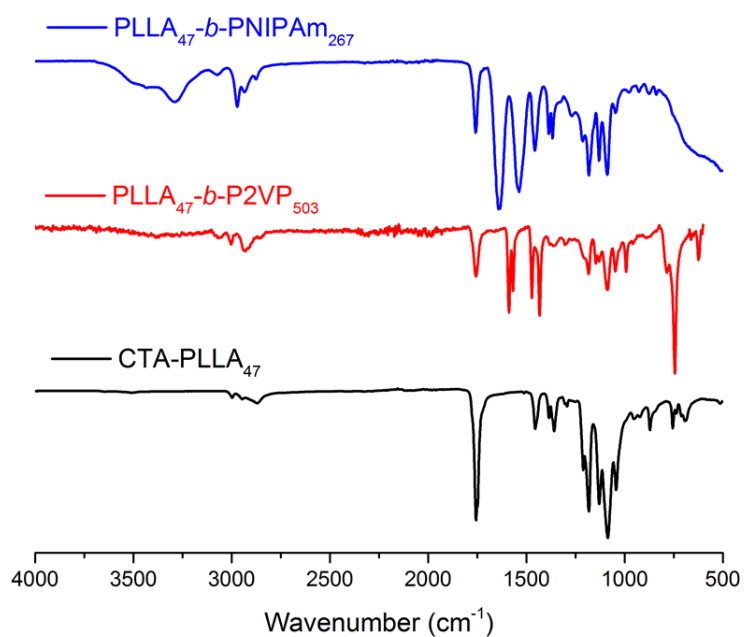
4 **Figure S3.**  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ) spectra of (a) CTA- $\text{PLLA}_{47}$ ; (b)  $\text{PLLA}_{47}$ -*b*- $\text{PNIPAm}_{267}$  and  
 5  $\text{PLLA}_{47}$ -*b*- $\text{P2VP}_{503}$ .



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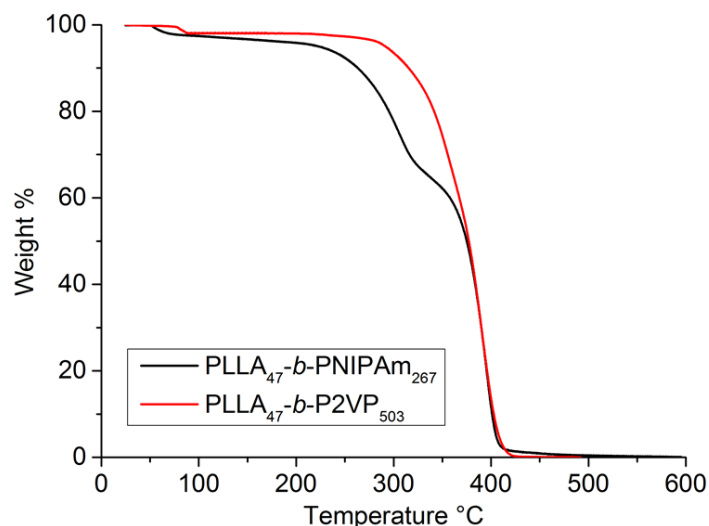
2 **Figure S4.**  $^1\text{H}$  DOSY NMR (500 MHz,  $\text{CDCl}_3$ ) spectra of  $PLLA_{47}$  (red),  $PLLA_{47}\text{-}b\text{-}P2VP_{503}$  (green)  
 3 and  $PLLA_{47}\text{-}b\text{-}PNIPAm_{267}$  (blue).

4

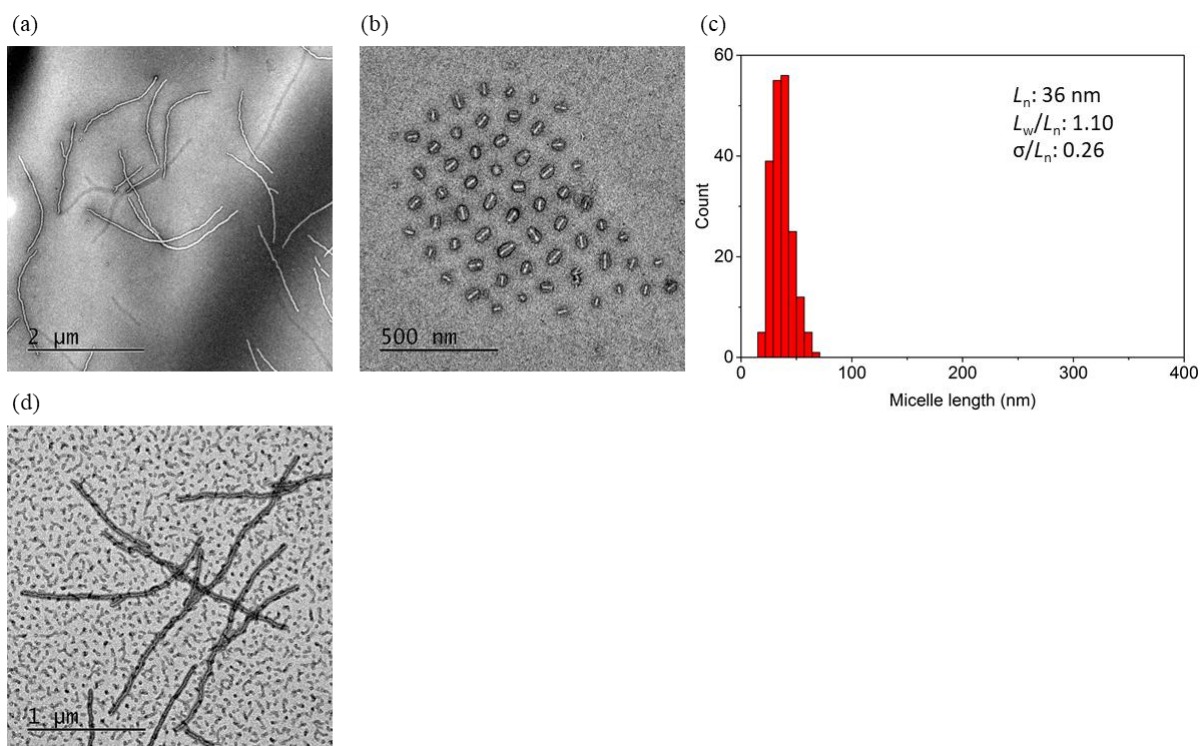


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6 **Figure S5.** FT-IR characterization of PLLA-containing polymers.

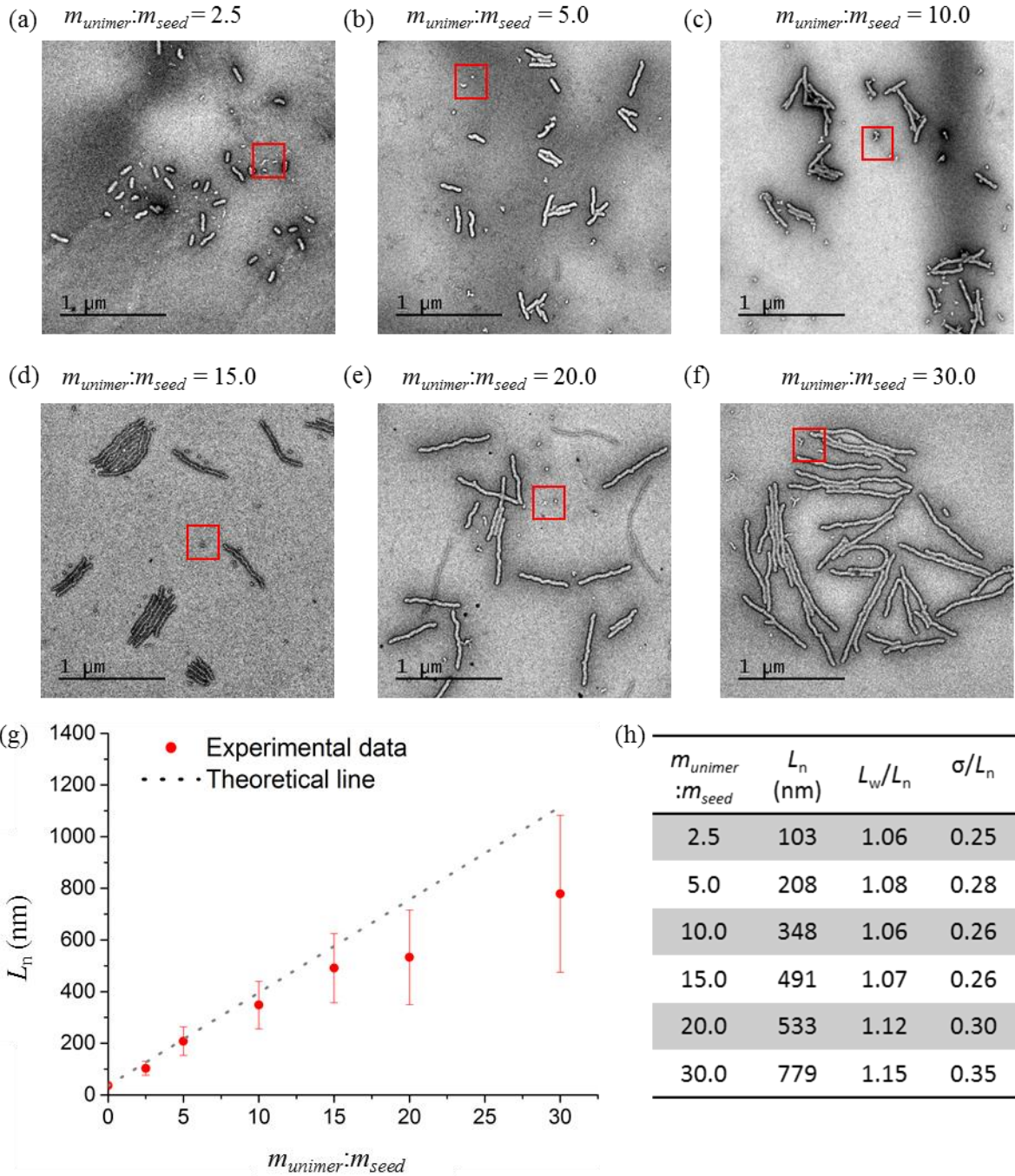


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 2 **Figure S6.** Thermogravimetric analysis (TGA) for PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> (black) and PLLA<sub>47</sub>-*b*-  
 3 P2VP<sub>503</sub> (red). TGA was performed at a scan rate of 10 °C/min under nitrogen.



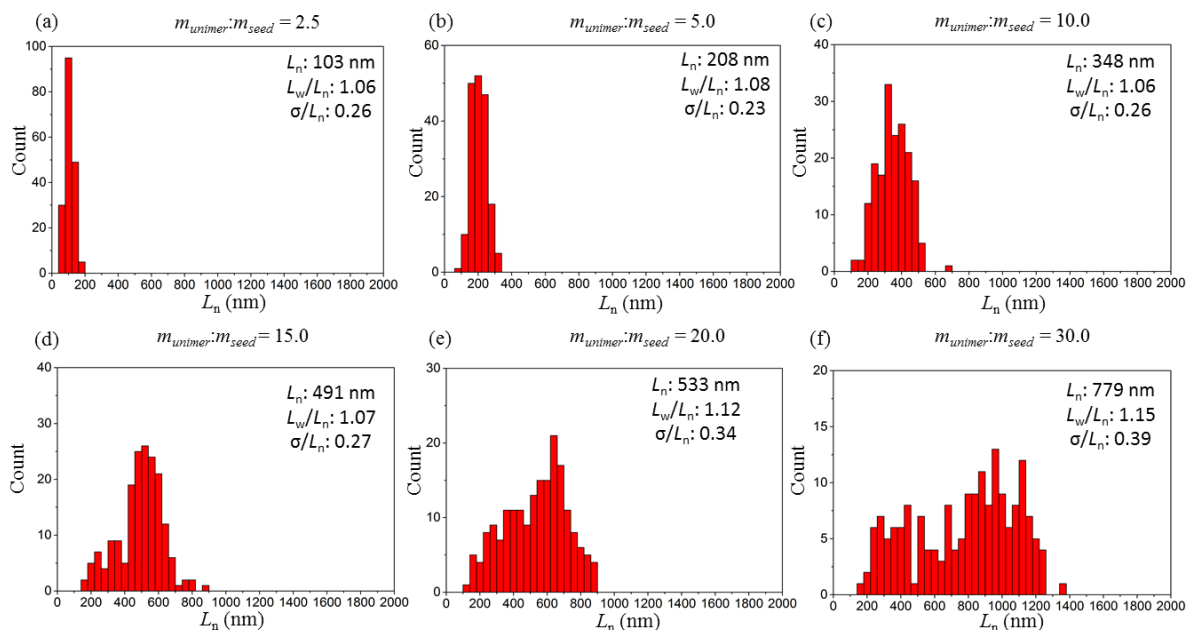
4  
 5 **Figure S7.** (a) TEM images of polydisperse PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles prepared by heating the  
 6 polymer in DMSO/EtOH (1:9) at a concentration of 0.5 mg/mL at 70 °C for 2 h followed by slow  
 7 cooling down to 23 °C ; (b) TEM images of seeds prepared by sonication of polydisperse micelles at  
 8 0 °C for 2 h in a sonic cleaning bath; (c) contour length histogram of measured seeds length,  $L_n = 36$   
 9 nm,  $L_w/L_n = 1.10$ ,  $\sigma/L_n = 0.26$ . TEM samples were stained with a 2 wt% solution of uranyl acetate in  
 10 EtOH; (d) TEM images of polydisperse PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles prepared by addition of  
 11 unimers in DMSO to ethanol and aging at 23 °C for 5 days. A significant amount of non-spherical  
 12 aggregates was observed.





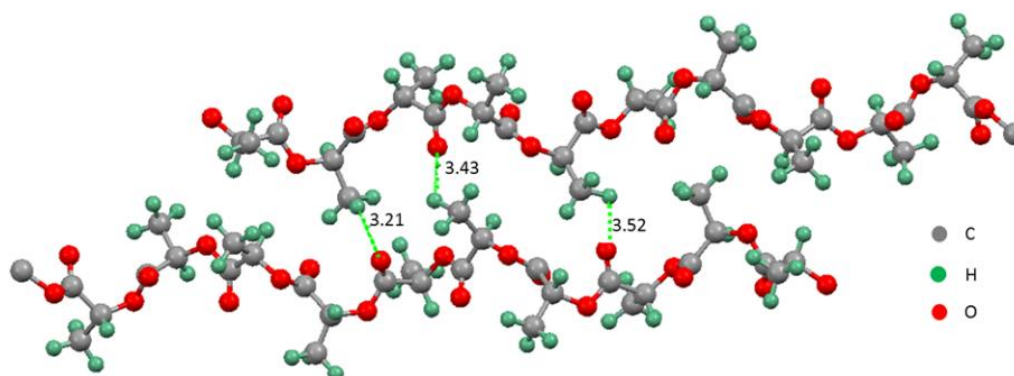
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2 **Figure S8.** TEM images of samples (aging for 5 days) of elongated PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles  
 3 prepared by seeded growth from seed micelles ( $L_n = 36$  nm,  $L_w/L_n = 1.10$ ,  $\sigma/L_n: 0.26$ ) in EtOH after  
 4 addition of unimers (in DMSO) with unimer-to-seed mass ratios of (a) 2.5, (b) 5.0, (c) 10.0, (d) 15.0,  
 5 (e) 20.0 and (f) 30.0; (g) plot of micelle number average length verse unimer-to-seed ratios (the error  
 6 bars represent the standard deviation); (h) measured length data summary. Red rectangles highlight  
 7 non-spherical particles. TEM samples were stained with a 2 wt% solution of uranyl acetate in EtOH.



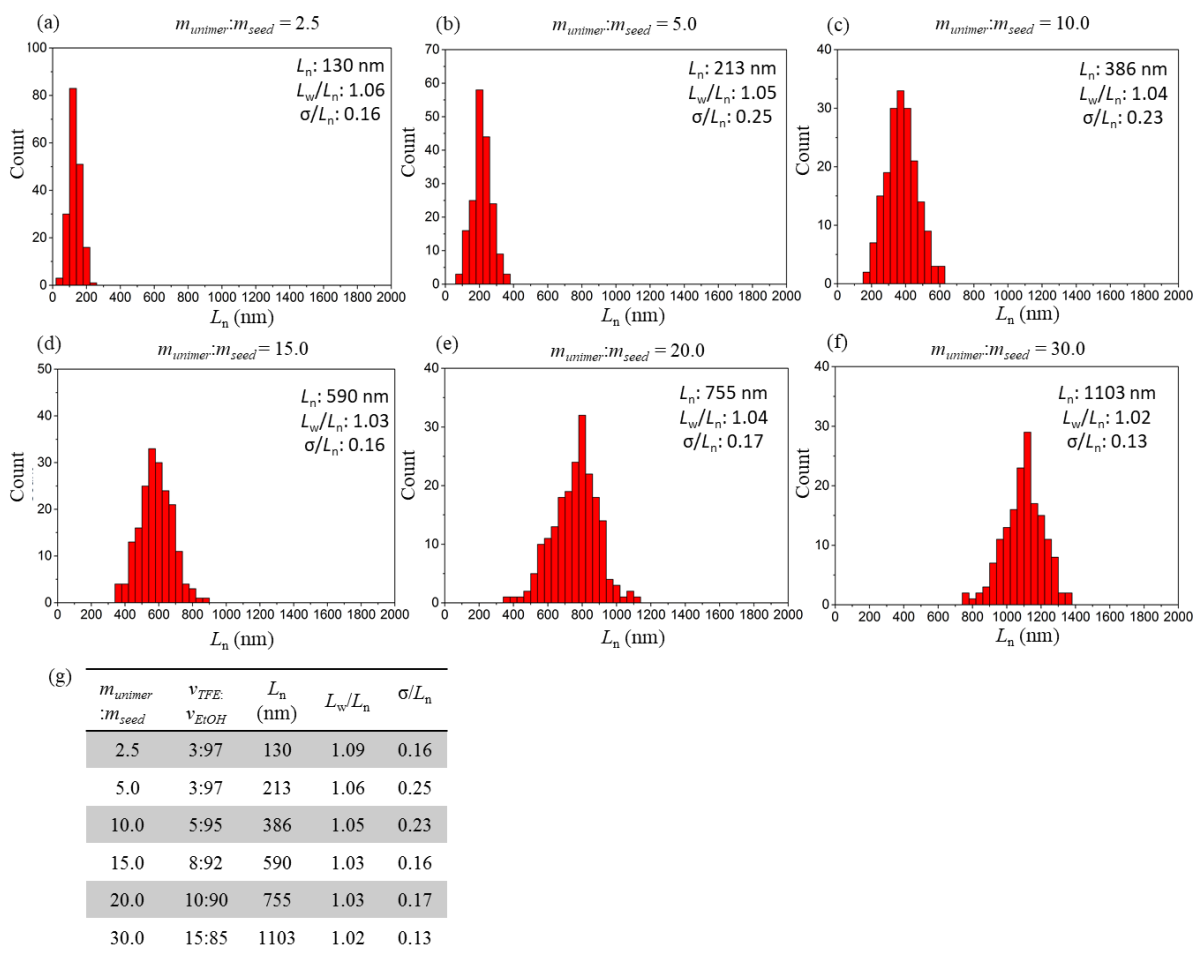
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2 **Figure S9.** Contour length histogram of 5 days aged elongated PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles  
 3 prepared by seeded growth off seed micelles ( $L_n = 36$  nm,  $L_w/L_n = 1.10$ ,  $\sigma/L_n = 0.26$ ) in EtOH after the  
 4 addition of unimers (in DMSO) with unimer-to-seed mass ratios of (a) 2.5, (b) 5.0, (c) 10.0, (d) 15.0,  
 5 (e) 20.0 and (f) 30.0.



6

7 **Figure S10.** Measurement of O...H distance between two adjacent chains in a model of PLLA  $\alpha$ -form  
 8 crystal cell unit.



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2 **Figure S11.** Contour length histogram of 5 days aged uniform PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles  
3 prepared by seeded growth off seed micelles ( $L_n = 36$  nm,  $L_w/L_n = 1.10$ ,  $\sigma/L_n = 0.26$ ) in TFE/EtOH with  
4 volume ratios of (a) 3:97, (b) 3:97, (c) 5:95, (d) 8:92, (e) 10:90 and (f) 15:85 after the addition of  
5 unimers (in DMSO) with unimer-to-seed mass ratios of (a) 2.5, (b) 5.0, (c) 10.0, (d) 15.0, (e) 20.0 and  
6 (f) 30.0, respectively; (g) measured length data summary.

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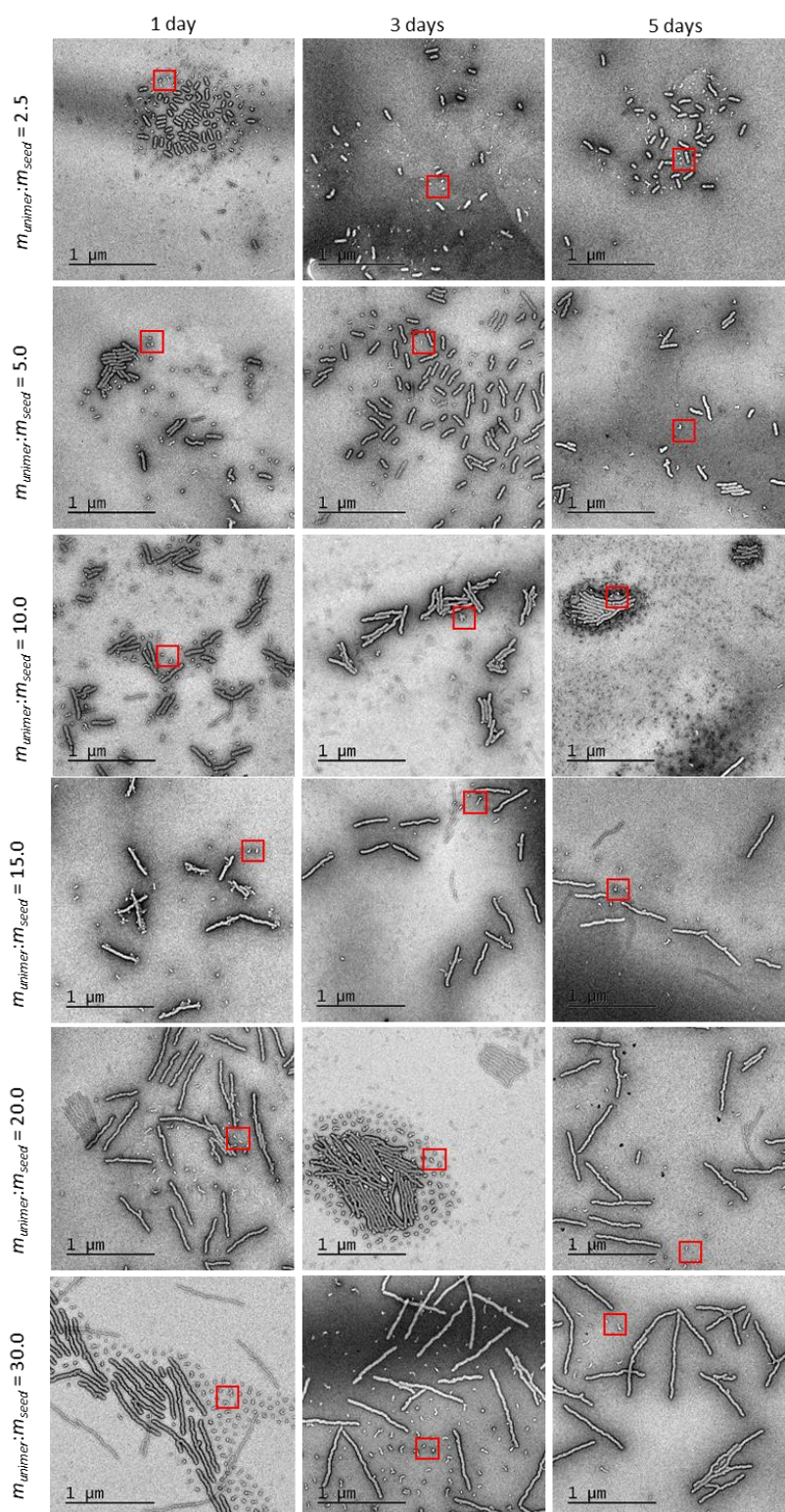
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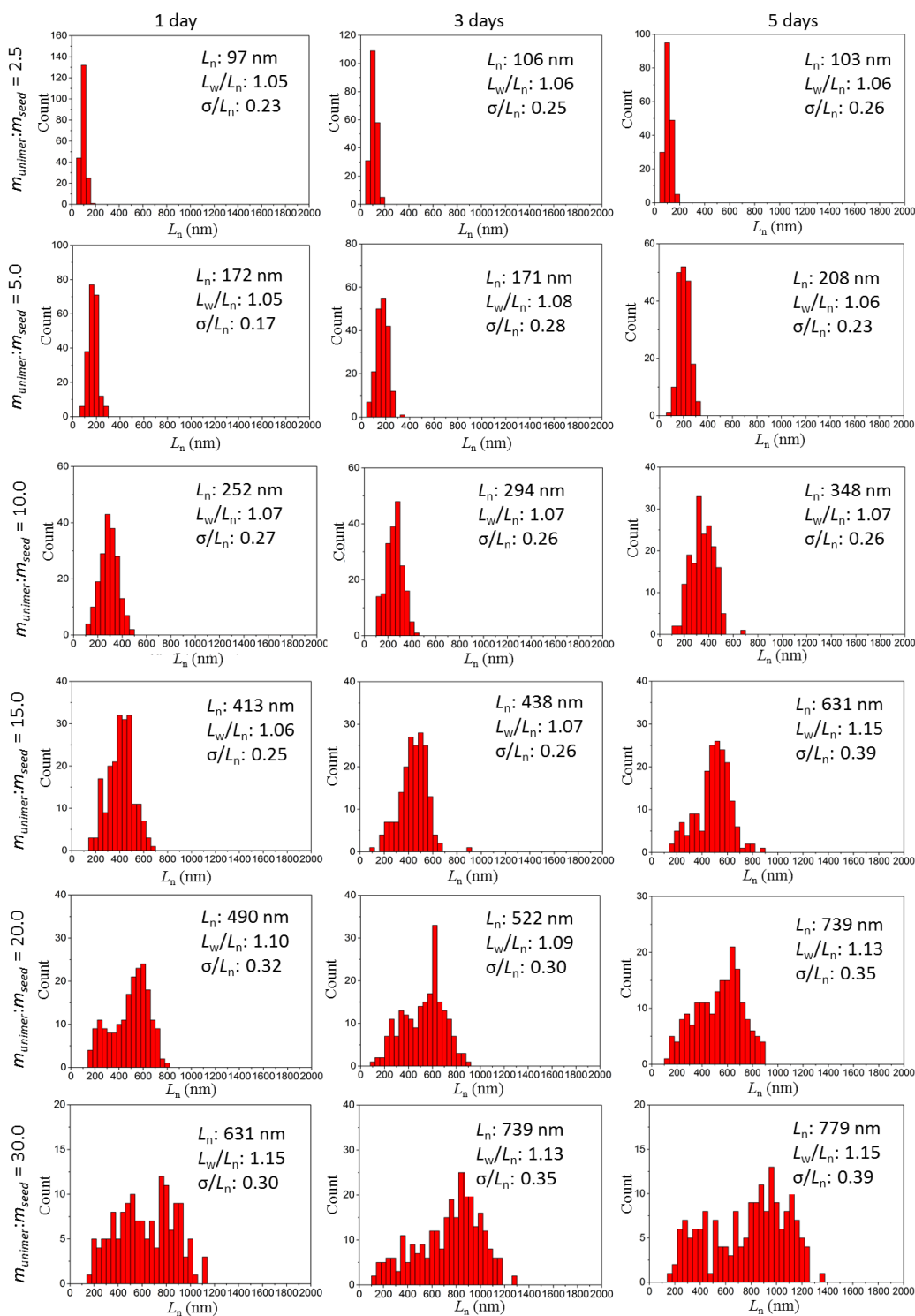


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3 **Figure S12.** TEM images of elongated PLLA<sub>47</sub>-b-PNIPAm<sub>267</sub> micelles in kinetic studies prepared by  
 4 seeded growth off seed micelles ( $L_n = 36$  nm,  $L_w/L_n = 1.10$ ,  $\sigma/L_n: 0.26$ ) in EtOH after addition of  
 5 unimers (in DMSO) with unimer-to-seed mass ratios of 2.5, 5.0, 10.0, 15.0, 20.0 and 30.0; Red  
 6 rectangles highlight non-spherical particles. TEM samples were stained with a 2 wt% solution of  
 7 uranyl acetate in EtOH.



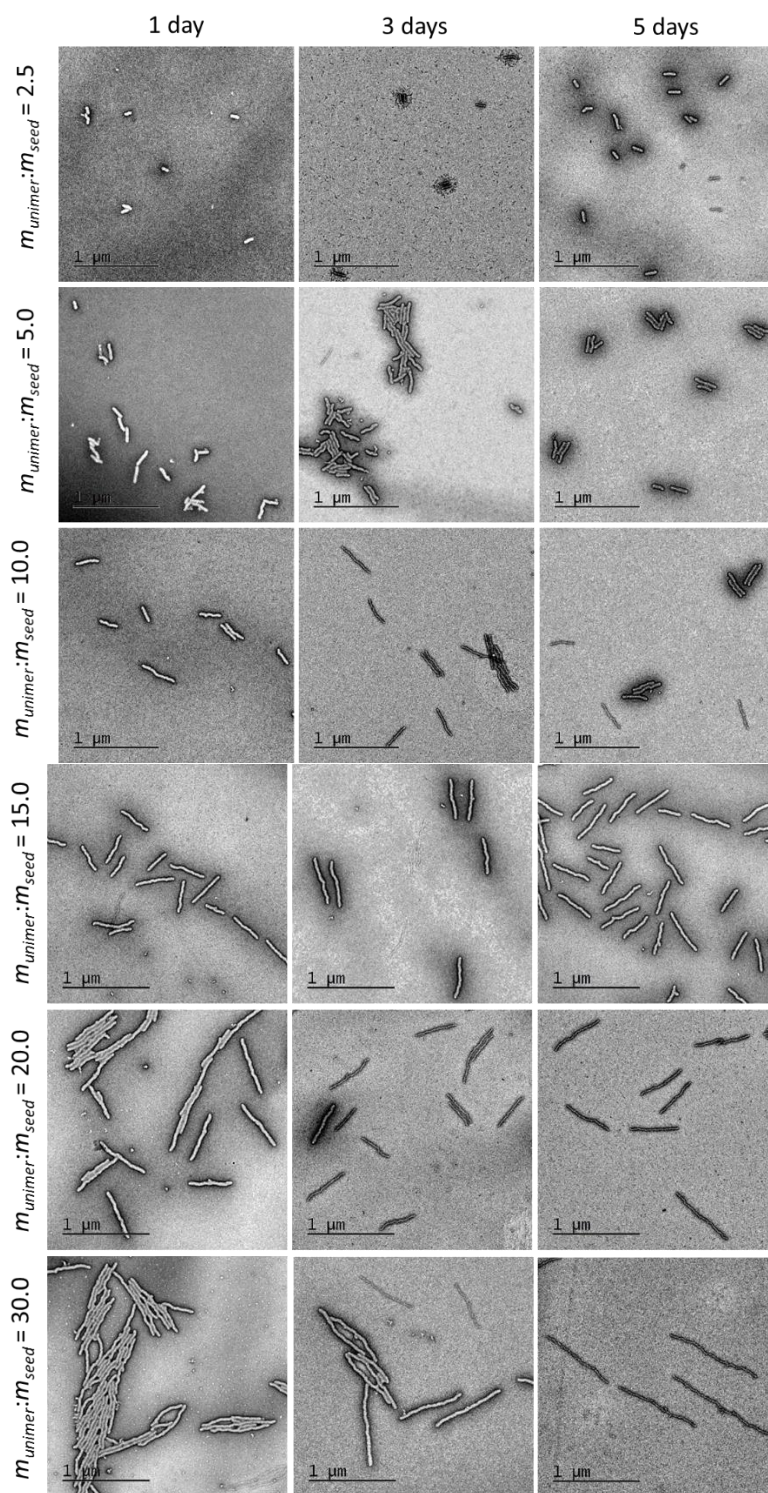
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3 **Figure S13.** Contour length histograms of elongated PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles in kinetic studies  
 4 prepared by seeded growth off seed micelles ( $L_n = 36 \text{ nm}$ ,  $L_w/L_n = 1.10$ ,  $\sigma/L_n: 0.26$ ) in EtOH after  
 5 addition of unimers (in DMSO) with unimer-to-seed mass ratios of 2.5, 5.0, 10.0, 15.0, 20.0 and 30.0.

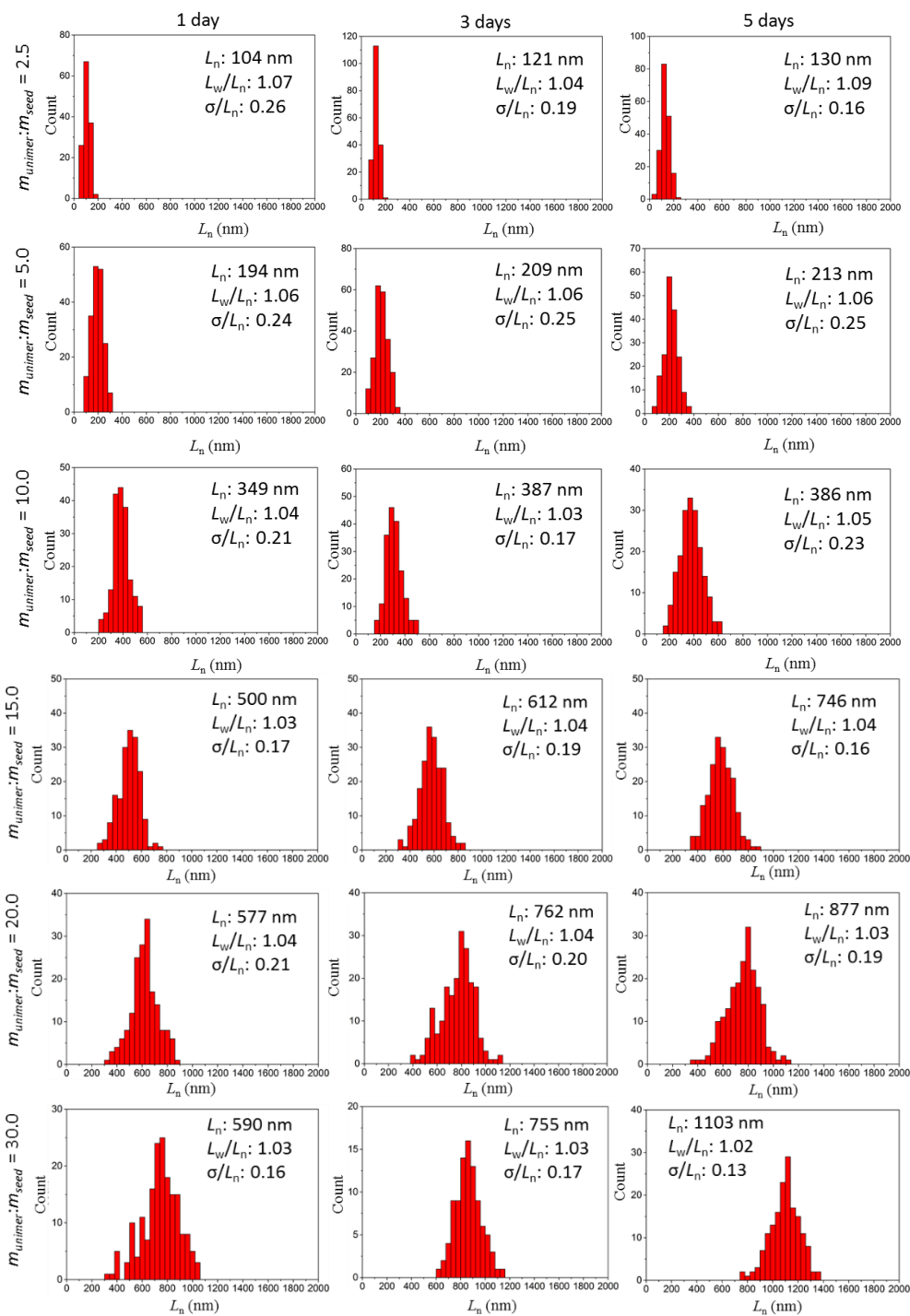


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3 **Figure S14.** TEM images of uniform PLLA<sub>47</sub>-*b*-PNIPAM<sub>267</sub> micelles in kinetic studies prepared by  
4 seeded growth off seed micelles ( $L_n = 36$  nm,  $L_w/L_n = 1.10$ ,  $\sigma/L_n: 0.26$ ) in TFE/EtOH with volume  
5 ratios of 3:97, 3:97, 5:95, 8:92, 10:90 and 15:85 after addition of unimers (in DMSO) with unimer-to-  
6 seed mass ratios of 2.5, 5.0, 10.0, 15.0, 20.0 and 30.0, respectively; TEM samples were stained with a  
7 2 wt% solution of uranyl acetate in EtOH.



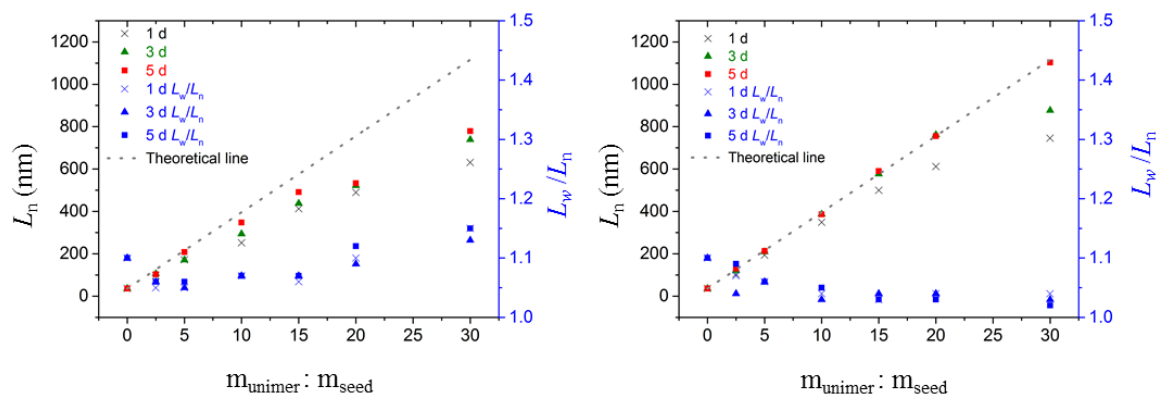
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3 **Figure S15.** Contour length histograms of uniform PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles in kinetic studies  
 4 prepared by seeded growth off seed micelles ( $L_n = 36 \text{ nm}$ ,  $L_w/L_n = 1.10$ ,  $\sigma/L_n = 0.26$ ) in TFE/EtOH with  
 5 volume ratios of 3:97, 3:97, 5:95, 8:92, 10:90 and 15:85 after addition of unimers (in DMSO) with  
 6 unimer-to-seed mass ratios of 2.5, 5.0, 10.0, 15.0, 20.0 and 30.0, respectively.

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2 **Figure S16.** Plots of micelle lengths as a function of time monitored over 5 days. Unimers (in DMSO)  
 3 was added to seed solutions (0.5 mg/mL,  $L_n = 36$  nm) in (a) and in (b) EtOH TFE/EtOH ( $v:v = 3:97$ ,  
 4  $3:97$ ,  $5:95$ ,  $8:92$ ,  $10:90$  and  $15:85$  for  $m_{\text{unimer}}:m_{\text{seed}} = 2.5, 5.0, 10.0, 15.0, 20.0$  and  $30.0$ , respectively).  
 5 Black label - micelle average length; blue label -  $L_w/L_n$ .

6 **Table S2.** Data summary of kinetic studies on seeded-growth of PLLA<sub>47</sub>-*b*-PNIPAM<sub>267</sub> micelles in  
 7 EtOH over 5 days.

In EtOH	$m_{\text{unimer}}:m_{\text{seed}}$							
	0 (seed)	2.5	5.0	10.0	15.0	20.0	30.0	
1 d	$L_n$	36	97	172	252	413	490	631
	$L_w$	40	102	180	271	439	540	728
	$L_w/L_n$	1.1	1.05	1.05	1.07	1.06	1.10	1.15
	$\sigma$	9.4	22.5	36.7	68.2	104.7	157.2	246.6
	$L_n/\text{eq}$	-	27	29	23	26	23	20
	$\sigma/L_n$	0.26	0.23	0.17	0.27	0.25	0.32	0.39
3 d	$L_n$	36	106	171	294	438	522	739
	$L_w$	40	113	184	300	468	570	830
	$L_w/L_n$	1.1	1.06	1.08	1.07	1.07	1.09	1.13
	$\sigma$	9.4	26.7	48.2	75.9	113.8	155.8	258.5
	$L_n/\text{eq}$	-	30	28	27	27	25	24
	$\sigma/L_n$	0.26	0.25	0.28	0.26	0.26	0.30	0.35
5 d	$L_n$	36	103	208	348	491	533	779
	$L_w$	40	109	221	373	527	596	899
	$L_w/L_n$	1.1	1.06	1.06	1.07	1.07	1.12	1.15
	$\sigma$	9.4	26.6	47.9	92.2	133.9	183.5	304.1
	$L_n/\text{eq}$	-	29	35	32	31	25	26
	$\sigma/L_n$	0.26	0.26	0.23	0.26	0.27	0.34	0.39

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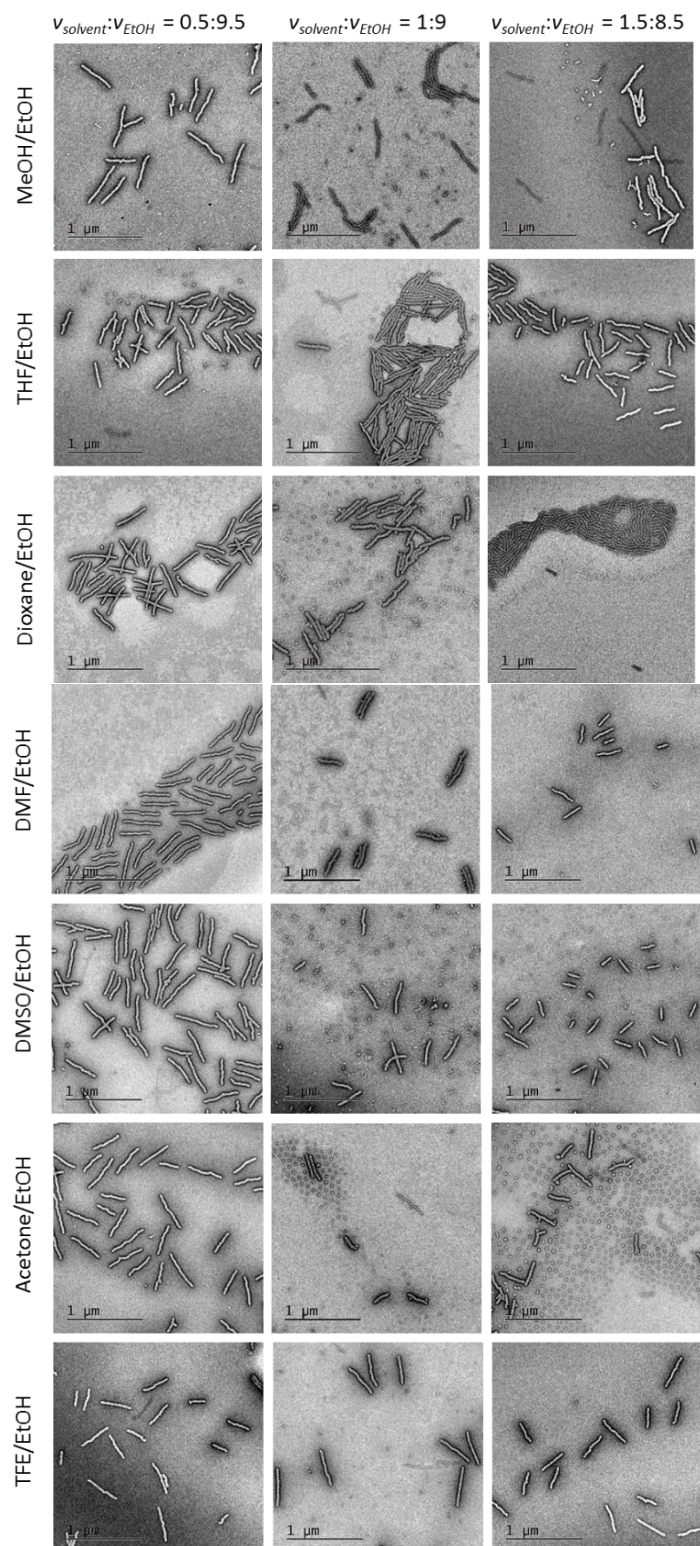


1 **Table S3.** Data summary of kinetic studies over 5 days on seeded-growth of PLLA<sub>47</sub>-*b*-PNIPAM<sub>267</sub>  
 2 micelles in TFE/EtOH with volume ratios of 3:97, 3:97, 5:95, 8:92, 10:90 and 15:85 after the addition  
 3 of unimers (in DMSO) with unimer-to-seed mass ratios of 2.5, 5.0, 10.0, 15.0, 20.0 and 30.0,  
 4 respectively.

In TFE/EtOH	$m_{unimer}:m_{seed}$							
	0 (seed)	2.5	5.0	10.0	15.0	20.0	30.0	
1 d	$L_n$	36	104	194	349	500	612	746
	$L_w$	40	111	205	365	515	636	778
	$L_w/L_n$	1.1	1.07	1.06	1.04	1.03	1.04	1.04
	$\sigma$	9.4	27.3	47.5	73.6	85.1	120.4	155.3
	$L_n/eq$	-	30	32	31	31	29	24
	$\sigma/L_n$	0.26	0.26	0.24	0.21	0.17	0.19	0.16
3 d	$L_n$	36	121	209	387	577	762	877
	$L_w$	40	125	222	399	600	795	908
	$L_w/L_n$	1.1	1.04	1.06	1.03	1.04	1.04	1.03
	$\sigma$	9.4	22.5	51.8	67.6	122.7	157.9	165.1
	$L_n/eq$	-	34	34	35	36	36	28
	$\sigma/L_n$	0.26	0.19	0.25	0.17	0.21	0.20	0.19
5 d	$L_n$	36	130	213	386	590	755	1103
	$L_w$	40	142	228	406	606	779	1122
	$L_w/L_n$	1.1	1.09	1.06	1.05	1.03	1.03	1.02
	$\sigma$	9.4	20.4	55.1	90.1	95.7	133.6	138.2
	$L_n/eq$	-	37	36	35	37	36	35
	$\sigma/L_n$	0.26	0.16	0.25	0.23	0.16	0.17	0.13

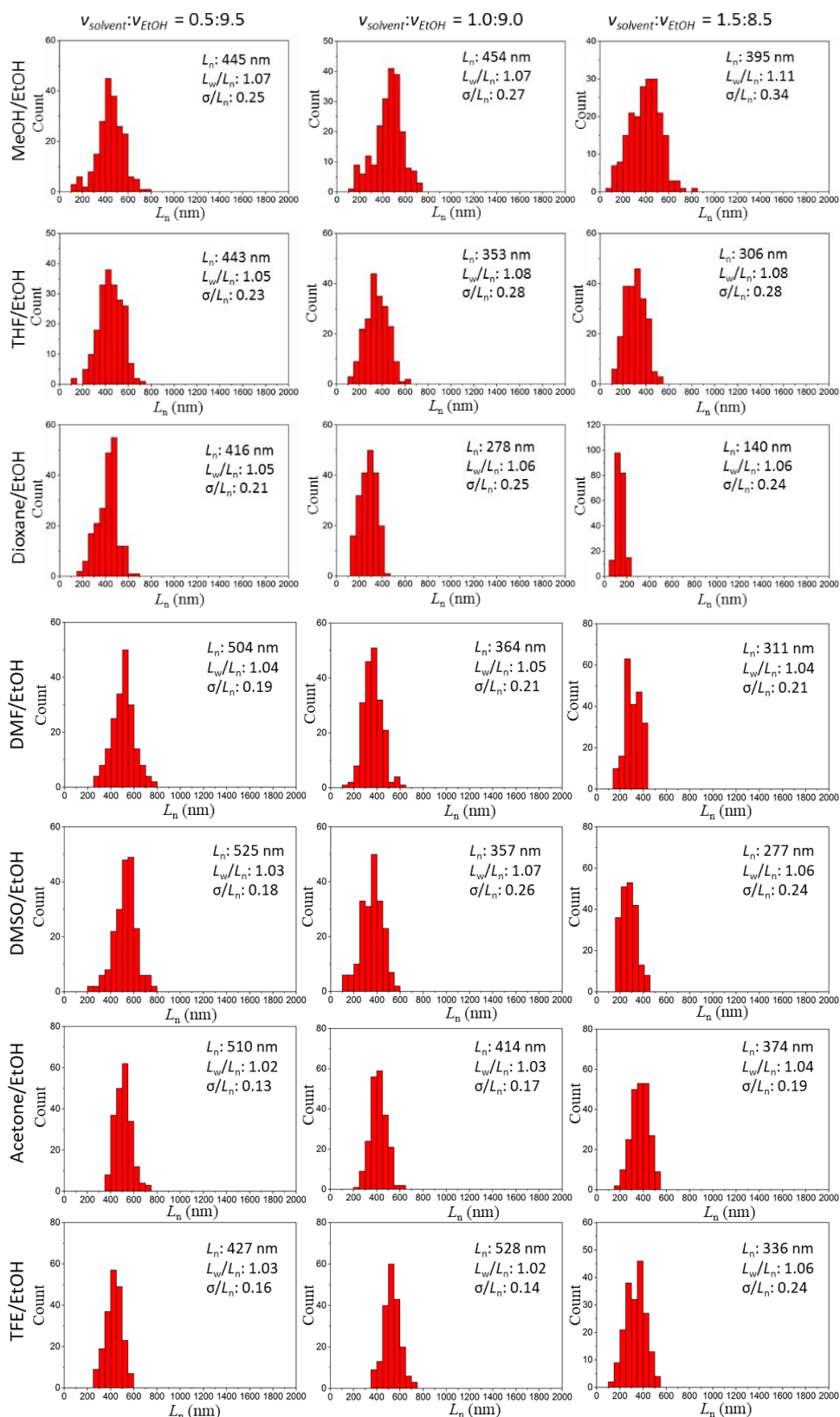
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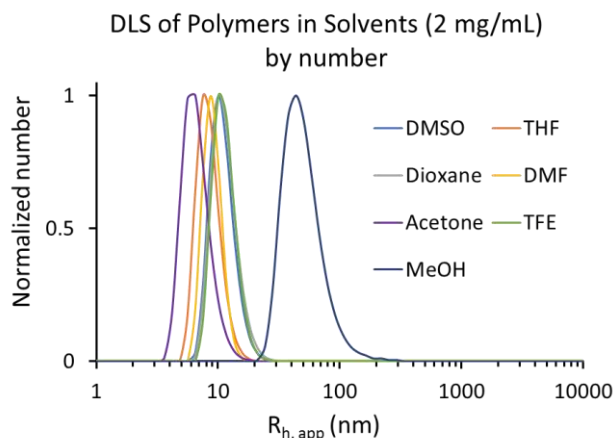
3 **Figure S17.** TEM images of uniform PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles in solvent effect studies  
 4 prepared by adding unimers ( $m_{unimer}:m_{seed} = 15.0$ , in DMSO) to seed micelles ( $L_n = 36$  nm,  $L_w/L_n =$   
 5  $1.10$ ,  $\sigma/L_n: 0.26$ ) in TFE/EtOH ( $v:v = 0.5:9.5, 1.0:9.0$  and  $1.5:8.5$ ); TEM samples were stained with a 2  
 6 wt% solution of uranyl acetate in EtOH. Inset: 100 nm.



1

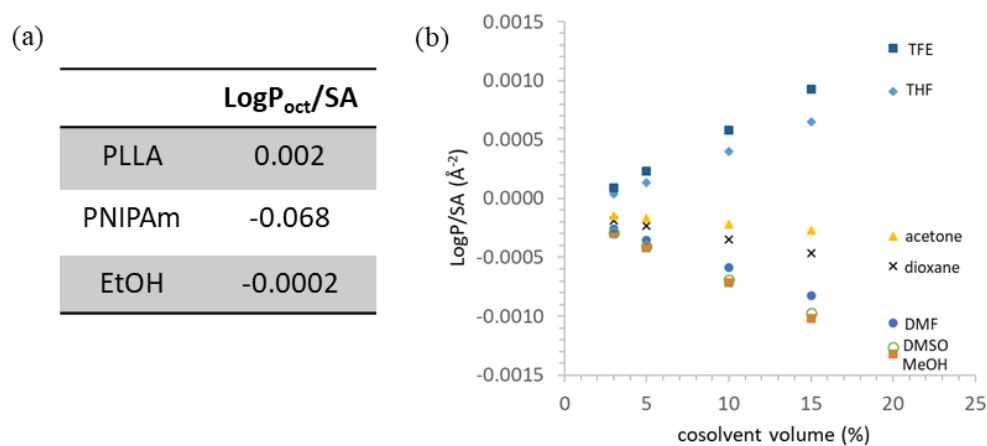
2

3 **Figure S18.** Contour length histograms of uniform PLLA<sub>47</sub>-b-PNIPAm<sub>267</sub> micelles in solvent effect  
 4 studies prepared by adding unimers ( $m_{unimer}:m_{seed} = 15.0$ , in DMSO) to seed micelles ( $L_n = 36$  nm,  
 5  $L_w/L_n = 1.10$ ,  $\sigma/L_n = 0.26$ ) in TFE/EtOH ( $v:v = 0.5:9.5$ ,  $1.0:9.0$  and  $1.5:8.5$ ).



1

2 **Figure S19.** Solutions of PLLA<sub>47</sub>-*b*-PNIPAM<sub>267</sub> in various solvents (2 mg/mL) characterized by DLS.



3

4 **Figure S20.** Calculated LogP<sub>oct</sub>/SA values of (a) PLLA, PNIPAm, EtOH and (b) solvent mixture.

5 **Table S4.** Table of Dimroth and Reichardt's Transition Energy ( $E_T(30)$ ) of Cosolvents.

Solvents	$E_T(30)$	$\pi^*$	$\alpha$	$\beta$
H <sub>2</sub> O*	62.3	1.09	1.17	0.47
TFE	61.2	0.73	1.49	0.00
DMSO	44.8	1	0.00	0.76
DMF	43.1	0.88	0.00	0.69
Acetone	41.6	0.71	0.08	0.48
THF	38.9	0.58	0.00	0.55
1,4-Dioxane	38.1	0.55	0.00	0.37
MeOH	53.6	0.60	0.98	0.66
<i>n</i> -Pentane*	30.2	0.00	0.00	0.00

$\alpha$ : scale of hydrogen bonding donor acidity

$\beta$ : scale of hydrogen bonding acceptor basicity

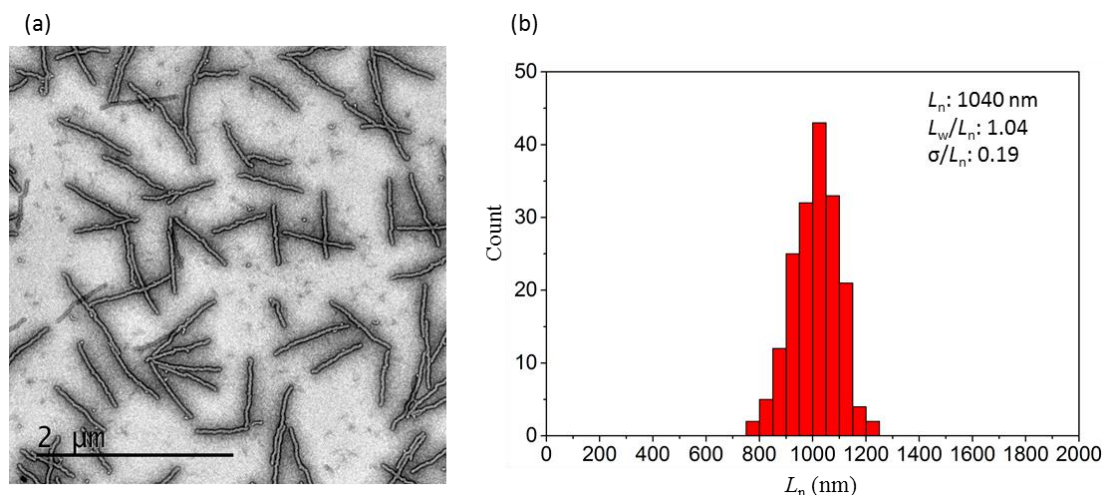
$\pi^*$ : solvatochromic parameter

$E_T$ : Dimroth and Reichardt's Transition Energy, a re-examined data from  $E_T(30)_0$

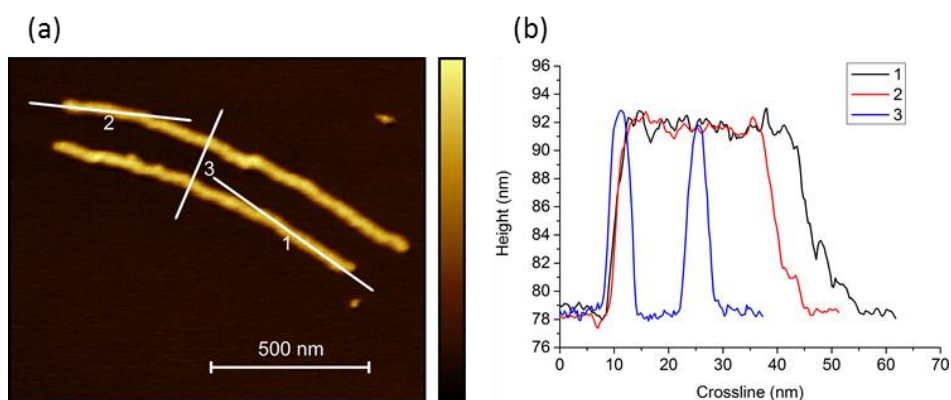
$$E_T(30) = E_T(30)_0 + s(\pi^* + d\delta) + a\alpha + b\beta$$

\* Scale reference of  $E_T$

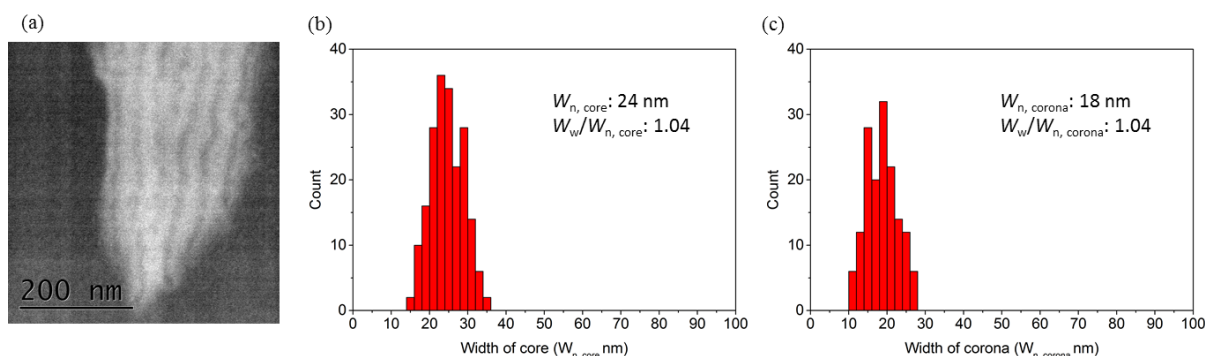
6



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2 **Figure S21.** (a) TEM images of PLLA<sub>47</sub>-b-PNIPAm<sub>267</sub> micelles prepared for characterization  
3 experiments with length of  $L_n = 1040$  nm ( $L_w/L_n = 1.04$ ); (b) contour length histogram of measured  
4 length data. TEM image was stained with uranyl acetate solution (2% in EtOH).

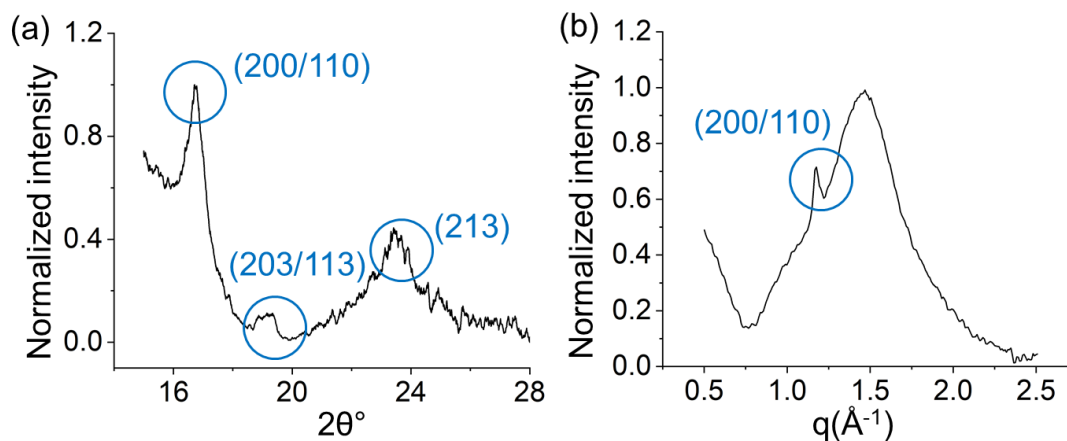


5  
6 **Figure S22.** AFM images of PLLA<sub>47</sub>-b-PNIPAm<sub>267</sub> micelles with controlled length. (a) Height image  
7 of micelles; (b) height profile by crossline measurements.

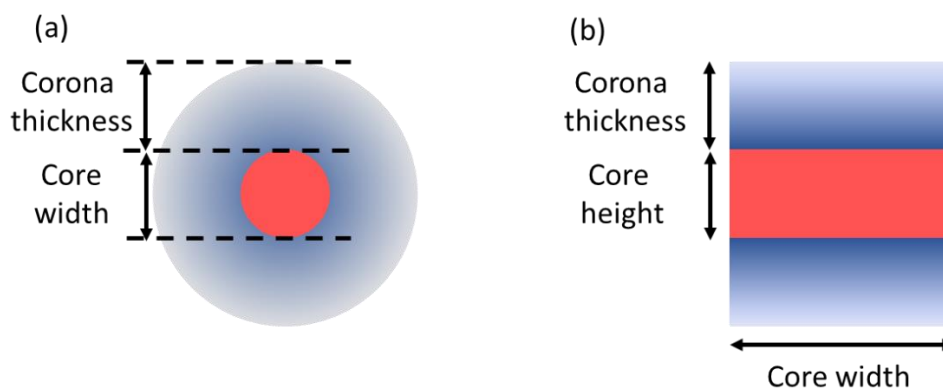


8  
9 **Figure S23.** (a) STEM images of PLLA<sub>47</sub>-b-PNIPAm<sub>267</sub> micelles in dark-field (white area is corona  
10 while dark area is core), (b) contour width histograms of core width measurement, and (c) contour  
11 width histograms of corona width measurement.

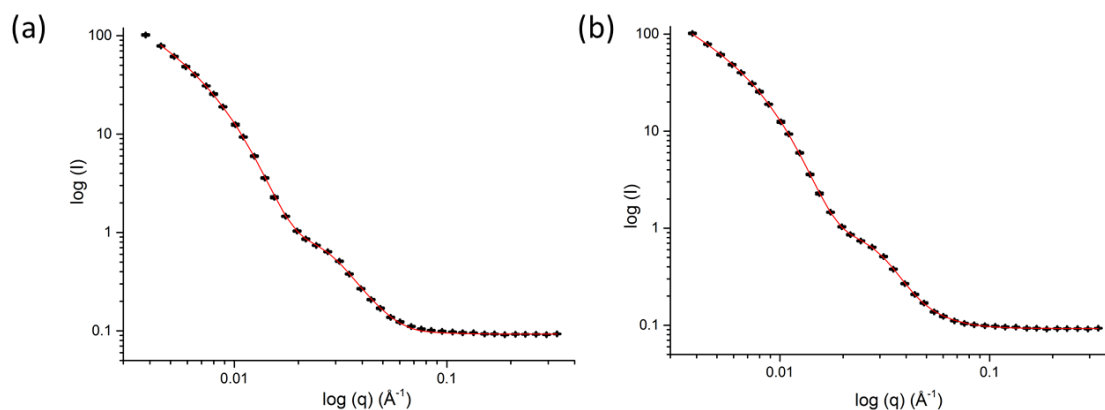




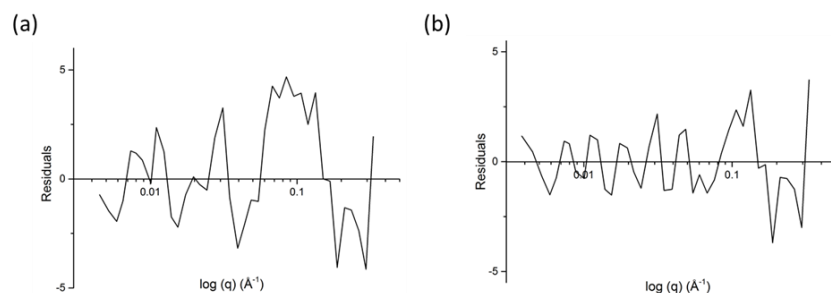
1  
 2 **Figure S24.** (a) PXRD profile of PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles; (b) normalized intensity by WAXS  
 3 for PLLA<sub>47</sub>-*b*-PNIPAm<sub>267</sub> micelles in EtOH with 30 mg/mL. The blue circles identify the Bragg peaks.



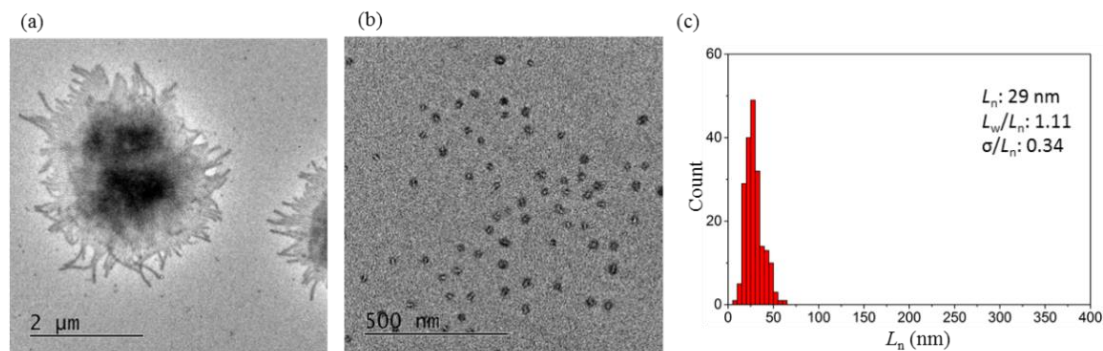
4  
 5 **Figure S25.** Schematic representation of the models used to fit SAXS data. (a) Model 1 has a  
 6 homogeneous circular cross-section core (red) and a surrounding corona (blue) with decaying density;  
 7 (b) Model 2 has a homogeneous rectangular cross-section core (red) with a decaying density corona  
 8 (blue) attached on the long core edges.



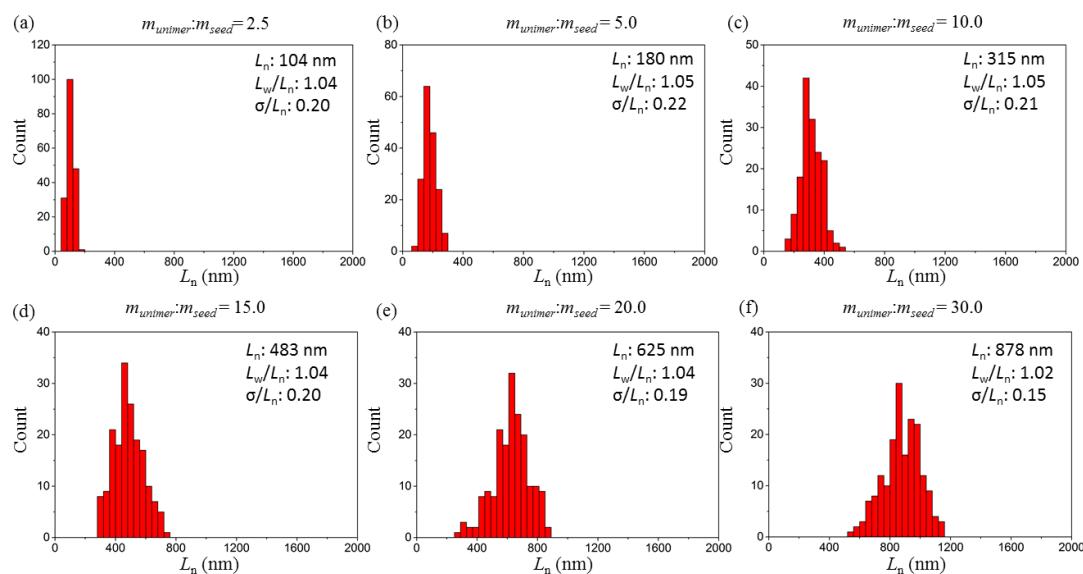
9  
 10 **Figure S26.** Plot of  $\log(I)$  vs  $\log(q)$  from SAXS data of a 4 mg/mL suspension of PLLA<sub>47</sub>-*b*-  
 11 PNIPAm<sub>267</sub> micelles (black in a and b) and fitting from Model 1 (red in a) and Model 2 (red in b)



1  
2 **Figure S27.** Plot of residual vs  $\log(q)$  from Model 1 fitting data (a) and Model 2 fitting data (b).

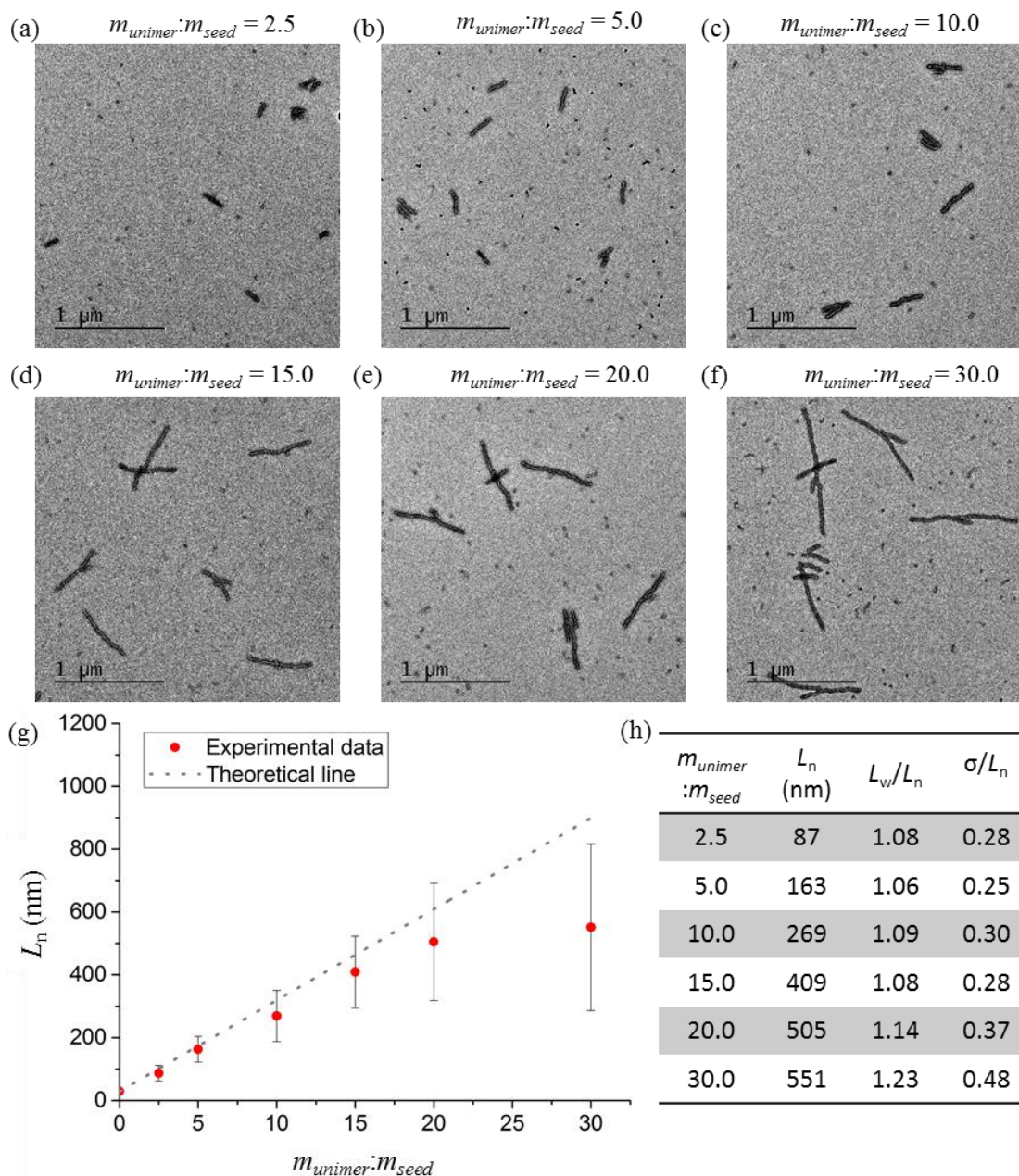


3  
4 **Figure S28.** (a) Polydisperse PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> micelles in DMSO/EtOH (1:9) with a concentration  
5 of 0.5 mg/ml prepared by heating the polymer in DMSO/EtOH (1:9) at 70 °C for 2 h followed by  
6 slow cooling over 2.5 h; (b) seeds prepared by sonication of polydisperse micelles at 0 °C for 2 h in a  
7 sonic cleaning bath; (c) contour length histogram of measured seeds length,  $L_n = 36$  nm,  $L_w/L_n = 1.10$ .



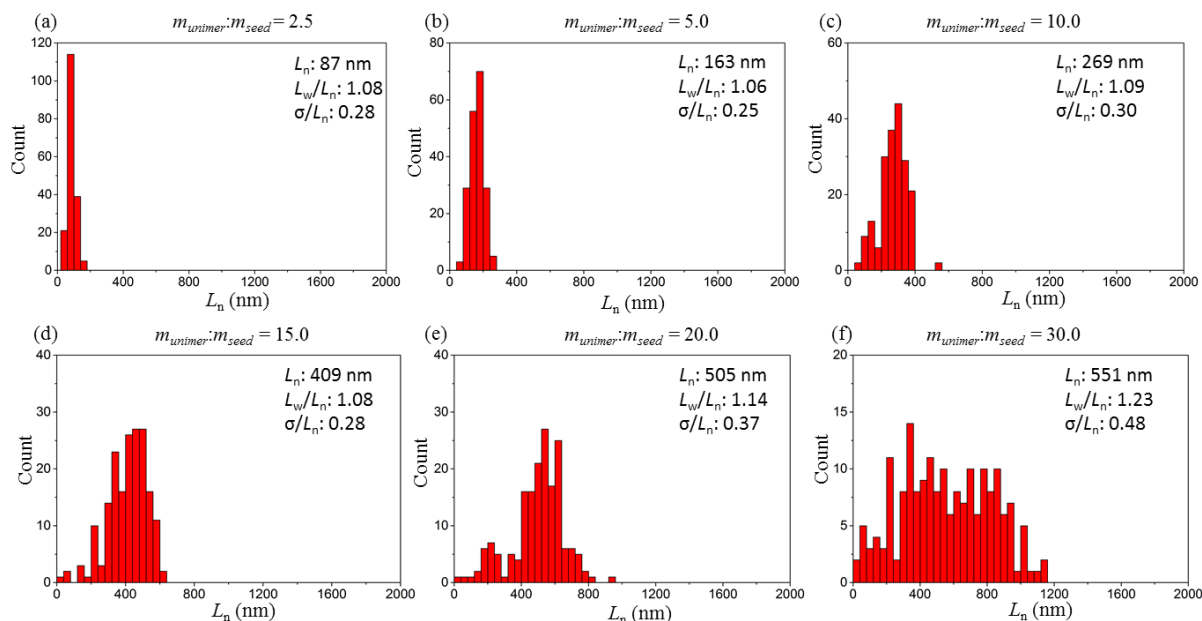
8  
9 **Figure S29.** Contour length histogram of 5 days aged uniform PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> micelles prepared  
10 by seeded growth off seed micelles ( $L_n = 29$  nm,  $L_w/L_n = 1.11$ ,  $\sigma/L_n = 0.34$ ) in TFE/EtOH with volume  
11 ratios of (a) 3:97, (b) 3:97, (c) 5:95, (d) 8:92, (e) 10:90 and (f) 15:85 after the addition of unimers (in

1 DMSO) with unimer-to-seed mass ratios of (a) 2.5, (b) 5.0, (c) 10.0, (d) 15.0, (e) 20.0 and (f) 30.0,  
 2 respectively.



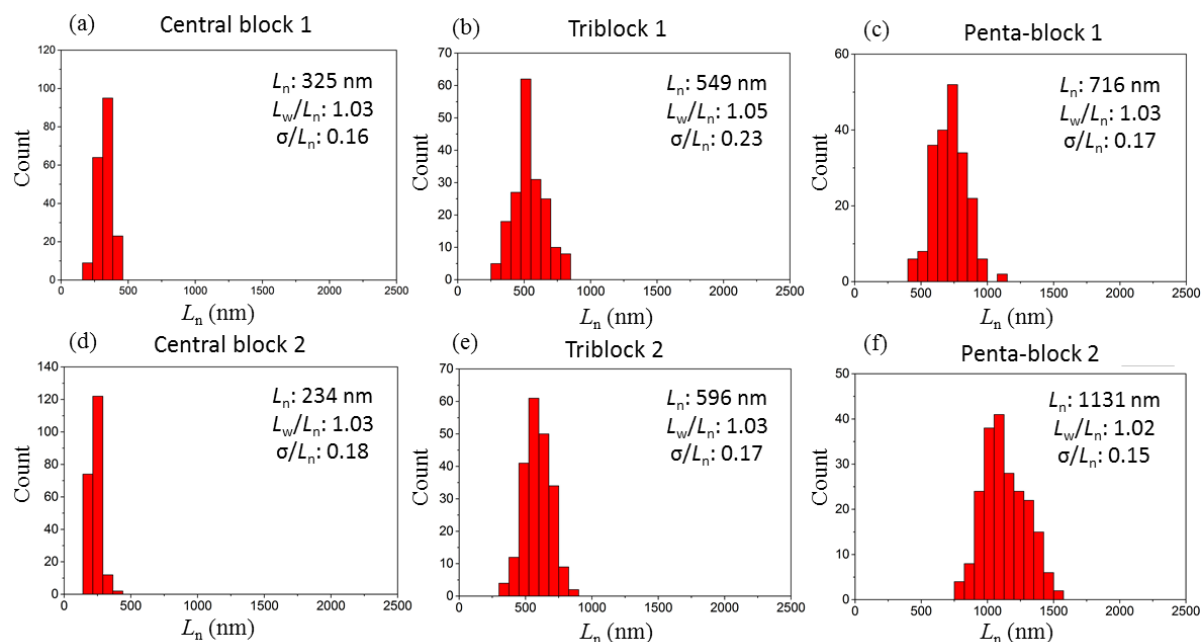
3  
 4 **Figure S30.** TEM images of 5 days aged samples of uniform PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> micelles prepared by  
 5 seeded growth off seed micelles ( $L_n = 29$  nm,  $L_w/L_n = 1.11$ ,  $\sigma/L_n: 0.34$ ) in EtOH after the addition of  
 6 unimers (in DMSO) with unimer-to-seed mass ratios of (a) 2.5, (b) 5.0, (c) 10.0, (d) 15.0, (e) 20.0 and  
 7 (f) 30.0; (g) plot of number average micelle length vs  $m_{unimer}:m_{seed}$  (the error bars represent the  
 8 standard deviation); (h) summary of measured length and solvent compositions; error bars were based  
 9 on standard deviation.





1

2 **Figure S31.** Contour length histogram of 5 days aged uniform PLLA<sub>47</sub>-*b*-P2VP<sub>503</sub> micelles prepared  
 3 by seeded growth off seed micelles ( $L_n = 29$  nm,  $L_w/L_n = 1.11$ ,  $\sigma/L_n = 0.34$ ) in EtOH after the addition  
 4 of unimers (in DMSO) with unimer-to-seed mass ratios of (a) 2.5, (b) 5.0, (c) 10.0, (d) 15.0, (e) 20.0  
 5 and (f) 30.0.



6

7 **Figure S32.** Contour length histograms of prepared block co-micelles: (a) central block 1, (b) triblock  
 8 co-micelles 1, (c) pentablock co-micelles 1, (d) central block 2, (e) triblock co-micelles 2 and (f)  
 9 pentablock co-micelles 2.

10

1 **Formula for SAXS Data Fitting with Model 2**

2 Model 2 (Figure S33) describes a long rigid micelle with a rectangular cross-section ( $2a$  by  $2b$ )  
 3 core covered by corona on two faces perpendicular to the  $a$  direction. The core has a uniform  
 4 scattering length density,  $\rho_{\text{core}}$ . The coronas have a rectangular cross-section ( $2b$  by  $c$ ) with a  
 5 linear decaying scattering intensity from the inner,  $\rho_{\text{in}}$ , to outer side,  $\rho_{\text{out}}$ . For the fitting  
 6 process, the long rods approximation is used by considering the micelle length ( $2l$ ) is  
 7 significantly greater than the reciprocal of the minimum  $q$ . The scattering intensity ( $I(q)$ )  
 8 from long rods solution can be described as:

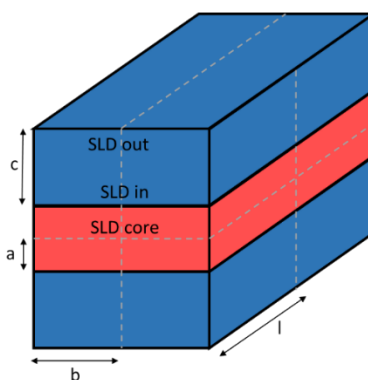
$$I(q) = \frac{2\pi l}{q} \langle F_a(Q \sin \phi) F_{bd}(q \cos \phi) \rangle_\phi$$

9 where the angle brackets represent an average over the azimuthal angle of  $q$  with respect to  
 10 the long micelle axis. The structure factors for the cross-section are defined as follows:

$$F_b(q) = 2b \text{sinc}(qb)$$

$$F_a(q) = 2 \sum_{j=1, N} (\rho_j + \rho_{j+1}) d_j \text{sinc}(qd_j)$$

11 where  $\rho_j = \rho_{\text{core}}$  for  $j = 1$ ,  $\rho_j = \rho_{\text{solvent}}$  for  $j = 1 + N$ , and  $\rho_j = \rho_{\text{in}} + (\rho_{\text{out}} - \rho_{\text{in}})[(j - 1.5)/(N - 1)]$   
 12 otherwise, while  $d_j = a$  for  $j = 1$  and  $d_j = a + c(j - 1)/(N - 1)$  otherwise. The three dimensions,  
 13  $a$ ,  $b$ , and  $c$  were assumed to have Schultz distributions and the expression was averaged  
 14 numerically over these distributions.



15  
 16 **Figure S33.** Schematic representation of Model 2 used in SAXS data fitting. Distances  $a$ ,  $b$ ,  $c$  and  $l$   
 17 represent half the core thickness, half the micelle width, the corona thickness and the micelle length  
 18 respectively. SLD = scattering length density.

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