

## Electronic Supplementary Information (ESI)

(7 pages)

### Sugar-Responsive Block Copolymers by Direct RAFT Polymerization of Unprotected Boronic Acid Monomers

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**Materials.** 2-Dodecylsulfanylthiocarbonylsulfanyl-2-methylpropionic acid (DMP) chain transfer agent (CTA) was prepared as previously reported.<sup>1</sup> *N,N*-Dimethylacrylamide (DMA, Fluka, 98%) was passed through a small column of basic alumina for catalyst removal prior to polymerization. 2,2'-Azobisisobutyronitrile (AIBN, Sigma, 98%) was recrystallized from ethanol. 3-Aminophenyl boronic acid (Boron Molecular), acryloyl chloride (Alfa Aesar, 96%), 1,3,5-trioxane (Acros Organics, 99.5%), pinacol (Acros Organics, 99%), sodium hydrogen carbonate (Acros Organics, 99.5%), sodium hydroxide pearl (Alfa Aesar, 97%), hydrochloric acid (Alfa Aesar, 36% (w/w) aq. solution), D-glucose (Mallinckrodt), *N,N*-dimethylformamide (DMF) (Aldrich 99.9%), tetrahydrofuran (THF) (Acros Organics, 99.9%), diethyl ether, dimethylsulfoxide-*d*<sub>6</sub> (DMSO-*d*<sub>6</sub>, Cambridge Isotope, 99.9% D), CDCl<sub>3</sub> (Cambridge Isotope, 99% D), and methanol-*d*<sub>4</sub> (Cambridge Isotope, 99.8% D) were used as received.

**Analyses.** GPC was conducted in DMF (with 0.05 M LiBr) at 55 °C with a flow rate of 1.0 mL/min (Viscotek GPC Pump; Columns: ViscoGel I-Series G3000 and G4000 mixed bed columns: molecular weight range 0-60 x 10<sup>3</sup> and 0-400 x 10<sup>3</sup> g/mol, respectively). Detection consisted of a Viscotek refractive index detector operating at  $\lambda = 660$  nm, a Viscotek UV-Vis detector operating at  $\lambda = 254$  nm, and a Viscotek Model 270 Series Platform, consisting of a laser light scattering detector (operating at 3 mW,  $\lambda = 670$  nm with detection angles of 7° and 90°) and a four capillary viscometer. Molecular weights were determined by the triple detection method. <sup>1</sup>H NMR spectroscopy was conducted with a Bruker Avance 400 spectrometer operating at 400 MHz. Dynamic light scattering was conducted with a Malvern Zetasizer Nano-S equipped with a 4 mW, 633 nm He-Ne laser and an Avalanche photodiode detector at an angle of 173°.

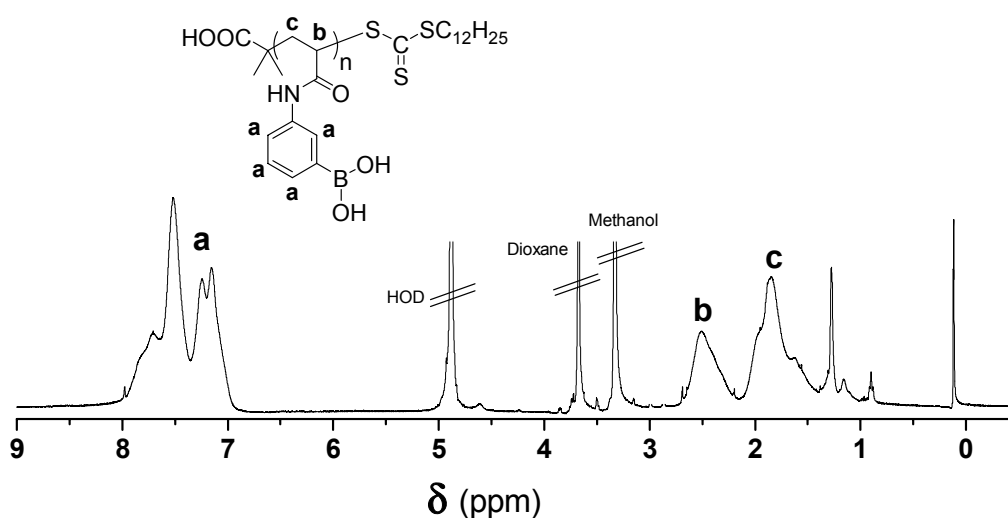
**Synthesis of 3-acrylamidophenylboronic acid monomer (APBA).** APBA was prepared by a method derived from Shinkai et al.<sup>2</sup> 3-Aminophenylboronic acid (3.0 g, 0.022 mol) was dissolved in a 1:1 mixture of THF (40 mL) and water (40 mL) in a round bottom flask. Sodium hydrogen carbonate (3.7 g, 0.044 mol) and acryloyl chloride (4.0 g, 0.044 mol) were added to the flask at 0-5 °C. The solution was stirred for 4 h and THF was subsequently evaporated. A solid crude product was obtained and stirred in ethyl acetate for 2 h. After filtering the solid materials, the ethyl acetate layer was washed with water (50 mL), saturated sodium bicarbonate solution (50 mL), water (50 mL) and brine (50 mL). The ethyl acetate layer was concentrated under reduced pressure providing the 3.5 g of orange solid in 84 % yield (4.17 g = 100% product). Further, the purification of monomer was carried out via the recrystallization from hot water three times. <sup>1</sup>H NMR

( $\delta$ , ppm) (400 MHz, DMSO- $d_6$ ): 10.07 (s, 1H, NH), 8.00 (s, 2H, B(OH) $_2$ ), 7.89, 7.83-7.81, 7.51-7.49, 7.31-7.29 (s, d, d, t, 1H each, ArH), 6.46-6.42, 6.27-6.22 (2d, dd, 1H each, vinyl CH $_2$ ), 5.75-5.72 (dd, 1H, vinyl CH).

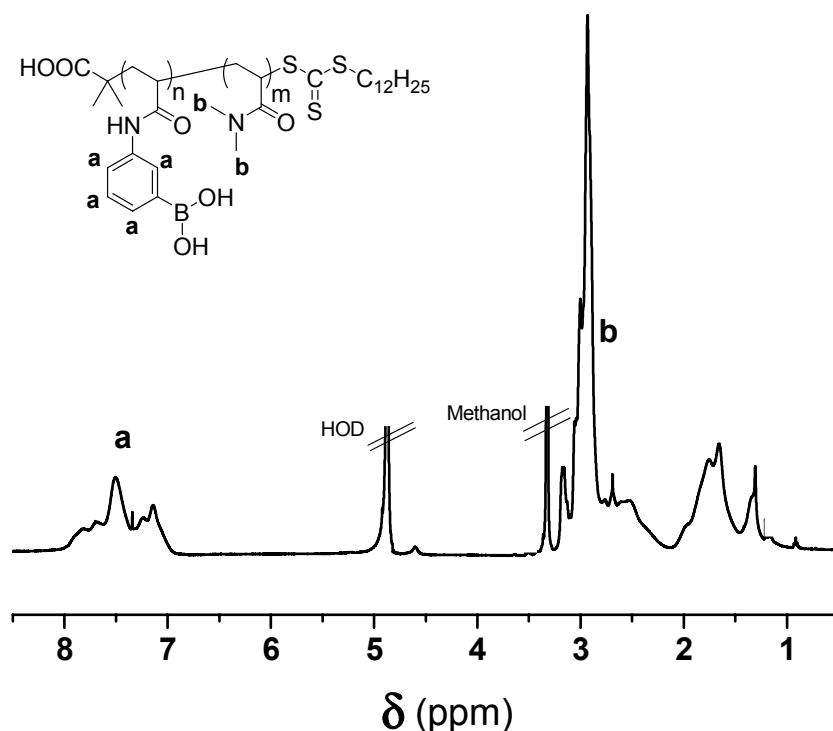
**RAFT homopolymerizations of APBA.** An example RAFT polymerization of APBA was as follows. APBA (1.50 g, 7.9 mmol), DMP (0.028 g, 0.079 mmol), AIBN (0.86 mg, 0.0079 mmol), and trioxane (35 mg, 0.39 mmol) (as an internal standard) were dissolved in 95/5 DMF/water (15 mL) in a sealed 20 mL vial. The molar ratio of [APBA]: [CTA]: [AIBN] was 100: 1: 0.1. The sealed vial was deoxygenated with nitrogen for approximately 30 min and then placed in a preheated reaction block at 70 °C. Samples were removed periodically by syringe to determine molecular weight, polydispersity index (PDI), and monomer conversion by SEC and  $^1\text{H}$  NMR spectroscopy. Methanol- $d_4$  was used as the solvent for  $^1\text{H}$  NMR spectroscopy.

**RAFT block copolymerizations of *N,N*-dimethylacrylamide (DMA) with a PAPBA macro-chain transfer agent (macro CTA).** An example RAFT block copolymerization was as follows. DMA (0.25 g, 2.5 mmol), PAPBA macro CTA ( $M_{n,\text{unprotected}} = 17,900$  g/mol,  $M_{n,\text{protected}} = 25,000$  g/mol,  $M_w/M_n = 1.09$ ) (0.45g, 0.025 mmol), AIBN (0.83 mg, 0.0051 mmol), and trioxane (11.5 mg) were dissolved in 95/5 DMF/water (2 mL) in a sealed 20 mL vial. The molar ratio of [APBA]: [CTA]: [AIBN] was 100: 1: 0.2. The solution was deoxygenated with nitrogen for approximately 30 min and then placed in a preheated reaction block at 70 °C. The polymerization was quenched after 20 h by removing the polymerization vial from the heating block and exposing the

reaction solution to air. The resulting PAPBA-*b*-PDMA (96% conversion; block composition calculated by SEC: PAPBA=49%, and PDMA= 51%; block composition calculated by  $^1\text{H}$  NMR spectroscopy (integration of aromatic protons ( $\text{C}_6\text{H}_4$ ) from 7-8 ppm of the PAPBA block compared to dimethyl protons ( $\text{CH}_3$ ) at 2.93 ppm of the PDMA block): PAPBA=56%, and PDMA= 44%;  $M_{n,\text{protected}} = 38,700$  g/mol;  $M_w/M_n = 1.17$ ) was isolated by precipitating into diethyl ether, filtering, and drying under vacuum. Methanol- $d_4$  was used as the solvent for  $^1\text{H}$  NMR spectroscopy. A new peak at 2.93 ppm was observed for the block copolymer, confirming the presence of the PDMA units ( $\text{CH}_3$  group) (Figure S1 & S2).



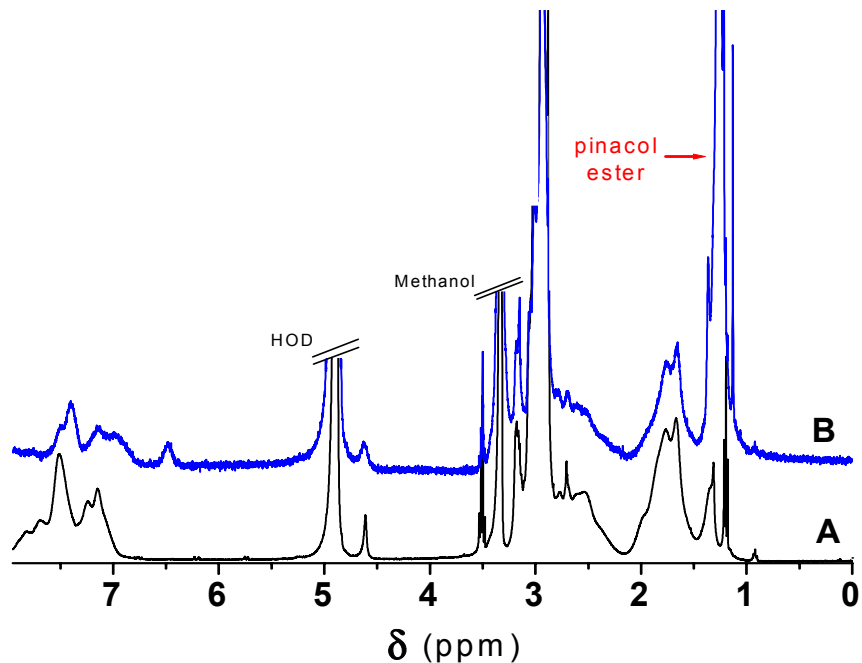
**Figure S1.**  $^1\text{H}$  NMR of PAPBA macro-CTA in methanol- $d_4$ . Residual DMF peaks removed.



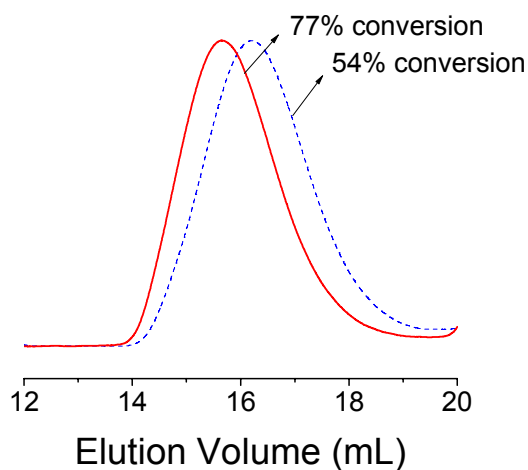
**Figure S2.**  $^1\text{H}$  NMR spectra of PAPBA-*b*-PDMA in methanol- $d_4$ . Residual ether peaks removed.

**General protection procedure for PAPBA and PAPBA-*b*-PDMA.** To facilitate analysis of the APBA (co)polymers by SEC, it was necessary to protect the boronic acid residues with pinacol. A typical protection procedure is as follows. PAPBA-*b*-PDMA (0.10 g, 0.52 mmol), pinacol (0.56 g, 4.7 mmol), and molecular sieves were placed in a Schlenk flask. Anhydrous DMF (10 mL) was added, and the mixture was stirred under  $\text{N}_2$  at 105 °C for 16 h. The mixture was filtered, and the protected (co)polymer was precipitated into cold diethyl ether. Successful protection was confirmed via  $^1\text{H}$  NMR spectroscopy by the appearance of pinacol ester methyl protons of protected PAPBA-*b*-PDMA at  $\delta = 1.26$  ppm (Figure S3). SEC analyses show an increase in molecular weight

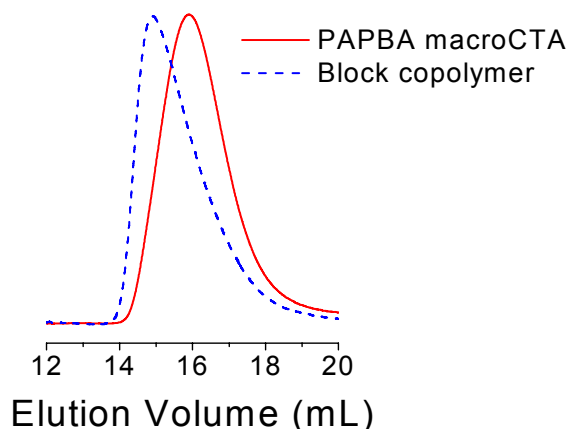
with conversion for PAPBA homopolymers and good blocking efficiency for PAPBA-*b*-PDMA (Figure S4 and S5).



**Figure S3.** <sup>1</sup>H NMR spectra for PAPBA-*b*-PDMA (A) before protection and (B) after protection (methanol-*d*<sub>4</sub>). Residual DMF peaks removed.



**Figure S4.** Normalized refractive index traces from size exclusion chromatography of PAPBA homopolymers



**Figure S5.** Normalized refractive index traces from size exclusion chromatography of PAPBA-*b*-PDMA block copolymer

**Dynamic light scattering (DLS) measurements of PAPBA-*b*-PDMA.** A 0.04% weight solution of PAPBA-*b*-PDMA (4.2 mg,  $M_n = 38,700$  g/mol,  $M_w/M_n = 1.17$ ) in basic water (10 mL, pH  $\approx$  11.0) was placed in 3,500 MWCO dialysis tubing and dialyzed 48 h against deionized water with constant stirring. The resulting aqueous solution was sonicated for 1 h, and the pH was adjusted to 8.7 and 10.7 using 1.0 M HCl and 0.5 M NaOH solutions. For solution studies with glucose, 0.1 mL of 0.5 M glucose solution was added to DLS samples. Samples were filtered with a 0.45  $\mu$ m nylon syringe filter, and DLS measurements were recorded at 25  $^{\circ}$ C.

## References

- 1 J. T. Lai, D. Filla and R. Shea, *Macromolecules*, 2002, **35**, 6754-6756.
- 2 Y. Kanekiyo, M. Sano, R. Iguchi and S. Shinkai, *J. Polym. Sci., Part A: Polym. Chem.*, 2000, **38**, 1302-1310.