#### **Electronic Supplementary Information**

of

## Synthesis of well-defined $\alpha, \omega$ -telechelic multiblock copolymers in water: *In situ* generation of $\alpha, \omega$ -diols

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#### Materials

Poly(ethylene glycol) (PEG, av.  $M_w$ =1000 g.mol<sup>-1</sup>, BioUltra, Sigma-Aldrich), *N*,*N*-dimethylacrylamide (DMA, 99%, Sigma-Aldrich), *N*,*N*-diethylacrylamide (DEA, 99%, Sigma-Aldrich), poly(ethylene glycol) methyl ether acrylate (PEGA<sub>480</sub>, 97%, Sigma-Aldrich, av.  $M_w$ = 480 g.mol<sup>-1</sup>), *n*-butyl isocyanate (>98%, Sigma-Aldrich), 2-isopropanol (IPA, HPLC grade, VWR), water (HPLC grade, VWR) were used as received without further purification. Cuprisorb<sup>TM</sup> resin was purchased from Seachem. Cu(I)Br (CuBr, 97%, Sigma-Aldrich) was washed sequentially with acetic

acid glacial and ethanol and dried over reduced pressure. *N*-isopropylacrylamide (NIPAAm, 97%, Sigma-Aldrich) was recrystallized three times from *n*-hexane and dried over reduced pressure prior to use. N, N, N', N', N'', N''-Hexamethyl-[tris(aminoethyl)amine] (Me<sub>6</sub>-TREN) was synthesized according to a reported procedure<sup>1</sup>, deoxygenated and stored at 4°C under nitrogen prior to use. 3-dihydroxypropyl 2-bromo-2-methylpropanoate was synthesized according to a reported procedure<sup>2</sup>.

#### Instrument and analysis

<sup>1</sup>H, <sup>13</sup>C NMR spectra were recorded on Bruker ACF-250 and DPX-400 spectrometers using deuterated solvents obtained from Sigma-Aldrich.

IR spectra were collected on a Bruker VECTOR-22 FT-IR spectrometer using a Golden Gate diamond attenuated reflection cell.

HRMS (ESI) data were collected in positive mode, using a Bruker HCT Ultra ESI spectrometer.

MALDI-ToF MS spectra were recorded in reflection mode on a Bruker Daltonics Ultraflex II MALDI-ToF mass spectrometer, equipped with a nitrogen LASER delivering 2ns laser pulses at 337 nm with positive ion ToF detection performed using an accelerating voltage of 25 kV. The matrix solution was prepared by dissolving trans-2-[3-(4-tertbutylphenyl)-2-methyl-2-propenylidene] malononitrile (DCTB) in THF (200 mg/mL). Sodium iodide was dissolved in THF (2 mg/ mL). Polymer samples were dissolved in THF (1 to 5 mg/mL). Samples were prepared by mixing 5  $\mu$ L of polymer solution, 5  $\mu$ L of salt solution and 20  $\mu$ L of matrix solution. Calibration was performed with a poly(ethylene glycol) methyl ether acrylate  $M_w$  1100 g.mol<sup>-1</sup> standard. SEC using a CHCl<sub>3</sub> eluent was carried out at 30°C on a Varian 390-LC system with a CHCl<sub>3</sub> + 2% TEA eluent, equipped with 2 × PLgel 5 mm mixedD columns (300 × 7.5 mm), 1 × PLgel 5 mm guard column (50 × 7.5 mm), autosampler and a refractive index detector. DMF SEC traces were obtained on a Varian 390-LC system using a DMF (5 mM NH<sub>4</sub>BH<sub>4</sub>) eluent at 50°C, equipped with refractive index, UV and viscometry detectors, 2 × PLgel 5 mm mixed D columns (300 × 7.5 mm), 1 × PLgel 5 mm guard column (50 × 7.5 mm) and autosampler. Narrow linear poly(methyl methacrylate) standards in range of 200 to 1.0 × 106 g·mol<sup>-1</sup> were used to calibrate the system. All samples were passed through 0.45 μm PTFE filter before analysis. Cloud point temperatures were recorded on an Agilent Technologies Cary 60 UV-Vis using a cuvette with 1cm path length.

Dynamic light scattering (DLS) experiment were carried out at 25°C on a MALVERN Zetasizer instrument (backscattering angle 173°C) using a plastic cuvette with 1 cm path length.

#### Synthesis of initiators

#### Synthesis of ethylene bis(2-bromoisobutyrate)

The synthesis was adapted from a reported procedure. To a 2 L 3 neck RB flask equipped with a magnetic stirring bar and a dropping funnel was added, under nitrogen, ethylene glycol (8 mL, 0.14 mol). Anhydrous dichloromethane (700 mL) was canulated into the flask. Triethylamine (60 mL, 3 eq.) was added to the reaction mixture *via* a deoxygenated syringe and allowed to cool to 0 °C. 2-Bromoisobutyryl bromide (37.6 mL, 2.5 eq.) was added under nitrogen, dropwise (over one hour) to the reaction mixture *via* the dropping funnel. After a complete addition, the reaction mixture was allowed to stir at 0 °C for one hour and at ambient temperature overnight. The mixture was filtered and the volatiles were removed by rotary evaporation. The resulting brown solution was dissolved in chloroform (300 mL) and treated with 1M HCl solution (250 mL), saturated NaHCO<sub>3</sub> solution (250 mL) and three times with deionised water (3 x 250 mL). The organic layer were dried over dry MgSO<sub>4</sub> and passed twice through a basic activated alumina oxide column. The volatiles were removed *in vacuo* to give a light brown solid (40.66 g, 78 % yield).

<sup>1</sup>H NMR (CDCl<sub>3</sub>, 400 MHz), δ (ppm): 4.37 (s, 4H, RO-(C*H*<sub>2</sub>)<sub>2</sub>-OR) and 1.87 (s, 12H, -(C*H*<sub>3</sub>)<sub>2</sub>).<sup>13</sup>C NMR (CDCl<sub>3</sub>, 100 MHz), δ (ppm): 63.2 and 30.7. FT-IR (v, cm<sup>-1</sup>): 3000 (C-H stretch) 1750 (O-CO-R), 1380 (-(CH<sub>3</sub>)<sub>2</sub>), 1300 (CH stretch), 1200 (CH stretch). HRMS (ESI, m/z, Da): [M + Na<sup>+</sup>] 382.9 (*382.94 Th*).



Figure S1. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) spectrum of ethylene bis(2-bromoisobutyrate).



Figure S2. <sup>13</sup>C NMR (100MHz, CDCl<sub>3</sub>) spectrum of ethylene bis(2-bromoisobutyrate).



Figure S3. FT-IR spectrum of ethylene bis(2-bromoisobutyrate).

#### Synthesis of poly(ethylene glycol) bis (2-bromoisobutyrate).

Poly(ethylene glycol) (av.  $M_w$  1000 g.mol<sup>-1</sup>, 15 g, 15 mmol) was charged in a 500 mL three neck RB flask equipped with a dropping funnel, magnetic stirring bar and rubber septa and left to degas under nitrogen for 30 mins. Anhydrous toluene (300 mL) was canulated into the flask and the mixture left to stir for 5 mins. Subsequently, 50 mL of solvent was distilled under reduced pressure. Triethylamine (5.2 mL, 2.5 eq.) was added to the solution via a deoxygenated syringe and the mixture placed in an ice bath.  $\alpha$ -bromoisobutyryl bromide (3.9 mL, 2.5 eq.) was added dropwise via the dropping funnel. Upon complete addition, the mixture was left to stir at 0°C for 30 minutes and at ambient temperature overnight.

The mixture was filtered to remove the amine salt and the volatiles removed by rotary evaporation. The solid was dissolved in dichloromethane (150 mL) and washed three times with a saturated solution of  $Na_2CO_3$  (2\* 75 mL). The organic phase was dried over MgSO<sub>4</sub> before the volatiles were removed by rotary evaporation to yield a light yellow liquid. The solid was dissolved in THF and precipitated twice in cold petroleum ether (60-80°C) to yield a light yellow solid (15.4 g, 84 % yield).

<sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz),  $\delta$  (ppm): 4.33 (t, 4H, J<sub>1</sub>=9.6 Hz, J<sub>2</sub>=4.9Hz, CO-O-C*H*<sub>2</sub>-CH<sub>2</sub>), 3.75 (t, 4H, J<sub>1</sub>=9.6 Hz, J<sub>2</sub>=4.9Hz, CO-O-CH<sub>2</sub>-C*H*<sub>2</sub>), 3.65 (s, 74H, -O-C*H*<sub>2</sub>-C*H*<sub>2</sub>) and 1.95 (s, 12H, -(C*H*<sub>3</sub>)<sub>2</sub>). <sup>13</sup>C NMR (CDCl<sub>3</sub>, 75 MHz),  $\delta$  (ppm): 70.5, 68.7, 65.1 and 30.7. FT-IR (v, cm<sup>-1</sup>): 3000 (C-H stretch) 1750 (O-CO-R), 1380 (-(CH<sub>3</sub>)<sub>2</sub>), 1300 (CH stretch), 1200 (CH stretch). HRMS (ESI, m/z, Da): [2M + Na<sup>+</sup>] 621.9 (*DP<sub>n</sub>* 18, *621.2 Th*).



Figure S4. <sup>1</sup>H NMR (300 MHz, CDCl<sub>3</sub>) spectrum of poly(ethylene glycol) bis(2-bromoisobutyrate).



Figure S5. <sup>13</sup>C NMR (75 MHz, CDCl<sub>3</sub>) spectrum of poly(ethylene glycol) bis(2-bromoisobutyrate).



Figure S6. FT-IR spectrum of poly(ethylene glycol) bis(2-bromoisobutyrate).



Figure S7. MALDI-ToF spectrum of poly(ethylene glycol) bis(2-bromoisobutyrate).

## Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN in IPA:H<sub>2</sub>O and polymerizations

#### Monitoring the disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN in water

The theoretical disproportionation curve was obtained by preparing a solution of Cu(II)Br<sub>2</sub> (91.48 mg, 0.41 mmol) in the presence of Me<sub>6</sub>-TREN (109.5  $\mu$ L, 0.5 eq.) in H<sub>2</sub>O, in a volumetric flask (25 mL ± 0.04 mL). The main solution was diluted 10 times using volumetric flasks (5 mL ± 0.025 mL). Disproportionation was performed by adding Cu(I)Br (9.4 mg, 6.5 10<sup>-5</sup> mol) to a solution of solvent (2 mL) and Me<sub>6</sub>-TREN (9  $\mu$ L, 0.5 eq.), which was left to stir and deoxygenate with nitrogen for 15 minutes. Subsequently, the solution was filtered under nitrogen to remove any Cu(0) particles, and the filtrate diluted 10 times using a volumetric flask (5 mL ± 0.025 mL). UV-Vis spectrum was recorded using a quartz cuvette (path length 1 cm).



Figure S8. Monitoring the disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN in water.

### Monitoring the disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN in 50% v/v IPA:H<sub>2</sub>O.

The theoretical disproportionation curve was obtained by preparing a solution of Cu(II)Br<sub>2</sub> (91.48 mg, 0.41 mmol) in the presence of Me<sub>6</sub>-TREN (109.5  $\mu$ L, 0.5 eq.) in IPA:H<sub>2</sub>O 50 % v/v, in a volumetric flask (25 mL ± 0.04 mL). The main solution was diluted in five concentrations (diluted 50 to 10 times) using volumetric flasks (5 mL ± 0.025 mL). Disproportionation was performed by adding Cu(I)Br (9.4 mg, 6.5 10<sup>-5</sup> mol) to a solution of solvent (2 mL) and Me<sub>6</sub>-TREN (9  $\mu$ L, 0.5 eq.), which was left to stir and deoxygenate with nitrogen for 15 minutes. Subsequently, the solution was filtered under nitrogen to remove any Cu(0) particles, and the filtrate diluted 10 times using a volumetric flask (5 mL ± 0.025 mL). UV-Vis spectrum was recorded using a quartz cuvette (path length 1 cm).



Figure S9. Monitoring the disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN in 50% v/v IPA-H<sub>2</sub>O.

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of PEGA<sub>480</sub> $DP_n$ =8 in IPA:H<sub>2</sub>O 1:1..

This procedure is adapted from Zhang *et. al.* procedure<sup>3</sup> to yield telechelic polymers in a solvent/water system. To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (1.5 mL), Me<sub>6</sub>-TREN (29.5  $\mu$ L, 0.4 eq.) and Cu(I)Br (31.8 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with ethylene bis(2-bromoisobutyrate) (100 mg, 0.28 mmol), PEGA<sub>480</sub> (978  $\mu$ L, 8 eq.) and IPA:H<sub>2</sub>O 4:1 (2 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.



Figure S10. Monitoring of the polymerization of poly(ethylene glycol) methyl ether acrylate (av.  $M_w$ =480 g.mol<sup>-1</sup>) in 50 % v/v IPA:H<sub>2</sub>O at 0°C after 2 hours by <sup>1</sup>H NMR (MeOD, 300 MHz).

## Disproportionation of Cu(I)Br in the presence of $Me_6$ -TREN to catalyse the polymerization of NIPAAm $DP_n=20$ in IPA:H<sub>2</sub>O 1:1..

This procedure is adapted from Zhang et al. procedure<sup>3</sup> to yield telechelic polymers in a solvent/water system. To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (1.5 mL), Me<sub>6</sub>-TREN (29.5  $\mu$ L, 0.4 eq.) and Cu(I)Br (31.8 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with ethylene bis(2-bromoisobutyrate) (100 mg, 0.28 mmol), NIPAAm (630 mg, 20 eq.) and IPA:H<sub>2</sub>O 4:1 (2 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.



**Figure S11.** Monitoring the polymerization of *N*-isopropylacrylamide in 50% v/v IPA:H<sub>2</sub>O at 0°C after 2 hours by <sup>1</sup>H NMR (MeOD, 400 MHz).



**Figure S12**. SEC trace (DMF eluent) of poly(*N*-isopropylacrylamide) (92 % conv. by <sup>1</sup>H NMR), [I]:[M]:[Me<sub>6</sub>-TREN]:[CuBr] 1:20:0.4:0.8 initiated by ethylene bis(2-bromoisobutyrate).



**Figure S13**. (Left) Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN in water. (Middle) Polymerization of *N*-isopropylacrylamide in IPA:H<sub>2</sub>O 1:1  $\nu/\nu$ . (Right) Lyophilized polymer after copper removal with Cuprisorb<sup>TM</sup> resin.

# Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN in H<sub>2</sub>O and polymerizations

## Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n$ =30 in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (1.5 mL), Me<sub>6</sub>-TREN (12.5  $\mu$ L, 0.4 eq.) and Cu(I)Br (5.9 mg, 0.4 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with 3-dihydroxypropyl 2-bromo-2-methylpropanoate (25 mg, 0.1 mmol), NIPAAm (352 mg, 30 eq.) and H<sub>2</sub>O (1.5 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.



**Figure S14.** Monitoring the polymerization of *N*-isopropylacrylamide in water after 30 minutes by <sup>1</sup>H NMR (D<sub>2</sub>O, 250 MHz).



**Figure S15.** SEC traces (DMF eluent) of poly(*N*-isopropylacrylamide) (97% conversion by <sup>1</sup>H NMR) initiated by 3-dihydroxypropyl 2-bromo-2-methylpropanoate.

Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm  $DP_n=20$  in H<sub>2</sub>O using a lack of ligand.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (1.5 mL), Me<sub>6</sub>-TREN (9  $\mu$ L, 0.4 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), NIPAAm (185 mg, 20 eq.) and H<sub>2</sub>O (1.5 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.



**Figure S16.** NMR spectrum (D<sub>2</sub>O, 250 MHz) of  $poly(N-isopropylacrylamide)_{10}-b-poly(ethylene glycol)-b-poly(N-isopropylacrylamide)_{10}$  (80 % conv. by <sup>1</sup>H NMR) using a lack of Me<sub>6</sub>-TREN ligand [I]:[CuBr]:[Me<sub>6</sub>-TREN]:[M] 1:0.8:0.4:20.

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n=20$ in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added  $H_2O$  (1.5 mL), Me<sub>6</sub>-TREN (13  $\mu$ L, 0.6 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and

magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1  $10^{-5}$  mol), NIPAAm (185 mg, 20 eq.) and H<sub>2</sub>O (1.5 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.



**Figure S17.** Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of *N*-isopropylacrylamide with poly(ethylene glycol) bis(2-bromoisobutyrate) in H<sub>2</sub>0 at 0°C. (A) Evolution of Ln([M]<sub>0</sub>/[M]) in function of time. (B) Evolution of molecular weight ( $M_n$  obtained by DMF SEC) and dispersity ( $D=M_w/M_n$ ) in function of monomer conversion (by <sup>1</sup>H NMR).



**Figure S18.** Monitoring the polymerization of *N*-isopropylacrylamide in H<sub>2</sub>O at 0°C by <sup>1</sup>H NMR (250 MHz, D<sub>2</sub>O).

## Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n=20$ in H<sub>2</sub>O using an excess of ligand.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (1.5 mL), Me<sub>6</sub>-TREN (17.5  $\mu$ L, 0.8 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), NIPAAm (185 mg, 20 eq.) and H<sub>2</sub>O (1.5 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.



**Figure S19.** SEC traces (DMF eluent) of poly(*N*-isopropylacrylamide)<sub>10</sub>-*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide)<sub>10</sub> (> 99 % conv. by <sup>1</sup>H NMR,  $M_n$  6900 g.mol<sup>-1</sup>, D=1.16) using an excess of Me<sub>6</sub>-TREN ligand [I]:[CuBr]:[Me<sub>6</sub>-TREN]:[M] 1:0.8:0.8:20.



**Figure S20.** NMR spectrum (D<sub>2</sub>O, 250 MHz) of poly(*N*-isopropylacrylamide)<sub>10</sub>-*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide)<sub>10</sub> (> 99 % conv. by <sup>1</sup>H NMR,  $M_n$  6900 g.mol<sup>-1</sup>, D=1.16) using an excess of Me<sub>6</sub>-TREN ligand [I]:[CuBr]:[Me<sub>6</sub>-TREN]:[M] 1:0.8:0.8:20.

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n$ =40 in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (2 mL), Me<sub>6</sub>-TREN (13  $\mu$ L, 0.6 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), NIPAAm (365 mg, 40 eq.) and H<sub>2</sub>O (4 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n$ =80 in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (2 mL), Me<sub>6</sub>-TREN (13  $\mu$ L, 0.6 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), NIPAAm (739 mg, 80 eq.) and H<sub>2</sub>O (6 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.

Chain extension was performed by cannulation of a deoxygenated solution of NIPAAm (739 mg, 80 eq.) and  $H_20$  (6 mL) after 30 minutes of polymerization.

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n$ =160 in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (2 mL), Me<sub>6</sub>-TREN (19.5  $\mu$ L, 0.8 eq.) and Cu(I)Br (14 mg, 1.2 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), NIPAAm (1.48 g, 160 eq.) and H<sub>2</sub>O (10 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n$ =320 in H<sub>2</sub>O

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added  $H_2O$  (2 mL), Me<sub>6</sub>-TREN (19.5  $\mu$ L, 0.8 eq.) and Cu(I)Br (14 mg, 1.2 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and

magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1  $10^{-5}$  mol), NIPAAm (2.95 g, 320 eq.) and H<sub>2</sub>O (12 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.



**Figure S21.** SEC traces (DMF eluent) of chain extension of poly(*N*-isopropylacrylamide) (> 99 % conv. by <sup>1</sup>H NMR,  $M_n$  13800 g.mol<sup>-1</sup>, D=1.17) initiated by poly(ethylene glycol) bis(2-bromoisobutyrate) with *N*-isopropylacrylamide (739 mg, 80 eq.).



**Figure S22.** Monitoring of the chain extension of poly(*N*-isopropylacrylamide) in H<sub>2</sub>O at 0°C by <sup>1</sup>H NMR (D<sub>2</sub>O, 250 MHz).

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n=10$ and DMA $DP_n=11$ in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (1.5 mL), Me<sub>6</sub>-TREN (13  $\mu$ L, 0.6 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), NIPAAm (92 mg, 10 eq.) and H<sub>2</sub>O (1.5 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.

Chain extension was performed by cannulation of a deoxygenated solution of DMA (92  $\mu$ L, 11 eq.) and H<sub>2</sub>0 (1.5 mL) after 30 minutes of polymerization.



Figure S23. Monitoring of the chain extension of poly(N-isopropylacrylamide) in H<sub>2</sub>O at 0°C with dimethylacrylamide by <sup>1</sup>H NMR (D<sub>2</sub>O, 250 MHz).



**Figure S24.** SEC traces (DMF eluent) of chain extension of poly(*N*-isopropylacrylamide) (> 99 % conv. by <sup>1</sup>H NMR,  $M_n$  10700 g.mol<sup>-1</sup>, D=1.12) initiated by poly(ethylene glycol) bis(2-bromoisobutyrate) with dimethylacrylamide (84 µL, 11 eq.).

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of NIPAAm $DP_n=10$ and DEA $DP_n=9$ in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (1.5 mL), Me<sub>6</sub>-TREN (13  $\mu$ L, 0.6 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), NIPAAm (92 mg, 10 eq.) and H<sub>2</sub>O (1.5 mL). The mixture was left to stir until complete dissolution of the monomer (typically 2 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.

Chain extension was performed by cannulation of a deoxygenated solution of DEA (101  $\mu$ L, 9 eq.) and H<sub>2</sub>0 (1.5 mL) after 30 minutes of polymerization.

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of PEGA<sub>480</sub> $DP_n$ =20 in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (2 mL), Me<sub>6</sub>-TREN (13  $\mu$ L, 0.6 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), PEGA<sub>480</sub> (719  $\mu$ L, 20 eq.) and H<sub>2</sub>O (2 mL). The mixture was left to stir until complete dissolution of the monomer (typically 1 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.

### Disproportionation of Cu(I)Br in the presence of Me<sub>6</sub>-TREN to catalyse the polymerization of PEGA<sub>480</sub> $DP_n$ =40 in H<sub>2</sub>O.

To an oven dried Schlenk tube fitted with a magnetic stirring bar and rubber septum was added H<sub>2</sub>O (2 mL), Me<sub>6</sub>-TREN (11  $\mu$ L, 0.6 eq.) and Cu(I)Br (9.4 mg, 0.8 eq.). The solution was left to degas for 20 minutes and to stir for an extra 10 minutes. In a vial fitted with a rubber septum and magnetic stirring bar was charged with poly(ethylene glycol) bis(2-bromoisobutyrate) (100 mg, 8.1 10<sup>-5</sup> mol), PEGA<sub>480</sub> (1.44 mL, 40 eq.) and H<sub>2</sub>O (4 mL). The mixture was left to stir until complete dissolution of the monomer (typically 1 minutes) and deoxygenated with nitrogen for 10 minutes. The solution was cannulated into the Schlenk tube and the reaction was left to polymerize at 0°C.



Figure S25. Monitoring of the polymerization of poly(ethylene glycol) methyl ether acrylate (av.  $M_w$ =480 g.mol<sup>-1</sup>) in H<sub>2</sub>O at 0°C after 30 minutes by <sup>1</sup>H NMR (D<sub>2</sub>O, 250 MHz).



**Figure S26**. SEC traces (DMF eluent) of poly[poly(ethylene glycol) methyl ether acrylate] (> 95 % conv. by <sup>1</sup>H NMR) with different degrees of polymerization, initiated by poly(ethylene glycol) bis(2-bromoisobutyrate).

#### **Post-polymerization modifications**

#### Hydrophobic modification of telechelic poly(NIPAAm) with butyl isocyanate.

 $\alpha, \omega$ -Hydroxyl terminated poly(NIPAAm) ( $M_n$  5600 g.mol<sup>-1</sup>, 50 mg, 8.9 10<sup>-6</sup> mol) was added to a 50 mL RB flask equipped with a magnetic stirring bar and a rubber septum. The polymer was dried under vacuum at 70°C overnight before anhydrous DMF (10 mL) was added under nitrogen flow. Butyl isocyanate (40 µL, 40 eq.) and dibutyltin dilaureate (3 drops) were added via a deoxygenated syringe. The reaction mixture was placed in an oil bath at 60°C and left to stir for 9h. Following the reaction, the solution was dialyzed over deionized water (MWCO 3.5 kDa) for one week. The success of the functionalization of the hydroxyl end groups was assessed by <sup>1</sup>H NMR.



**Figure S27.** <sup>1</sup>H NMR ( $d_6$ -DMSO, 400 MHz) of butyl isocyanate modified poly(N-isopropylacrylamide)<sub>10</sub>-b-poly(ethylene glycol)-b-poly(N-isopropylacrylamide)<sub>10</sub>.



**Figure S28.** COSY ( $d_6$ -DMSO, 400 MHz) of butyl isocyanate modified poly(N-isopropylacrylamide)<sub>10</sub>-b-poly(ethylene glycol)-b-poly(N-isopropylacrylamide)<sub>10</sub>.



**Figure S29.** <sup>1</sup>H NMR ( $d_6$ -DMSO, 400 MHz) of butyl isocyanate modified poly(N-isopropylacrylamide)<sub>10</sub>-b-poly(ethylene glycol)-b-poly(N-isopropylacrylamide)<sub>10</sub> with assigned integrations.



**Figure S30.** DLS measurement of 1 mg/mL solution of hydrophobically modified  $poly(N-isopropylacrylamide)_{10}$ -*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide)\_{10} in water, by intensity.



**Figure S31.** DLS measurement of 1 mg/mL solution of hydrophobically modified  $poly(N-isopropylacrylamide)_{10}$ -*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide)\_{10} in water, by intensity.

#### Cloud points recording and evolutions

#### Cloud point recording by UV-Vis spectroscopy.

A solution of 1 mg/mL of (co)polymer in deionised water was prepared and left to stir for 2 hours at ambient temperature. Subsequently 1 mL of the solution was placed in a plastic cuvette and left to equilibrate at 20°C for 5 minutes into the UV-Vis spectrometer. A temperature ramp from 20°C to 90°C was then applied with a gradient of 1°C/min and the absorbance recorded at  $\lambda$ =650 nm.

The cloud point temperature was then extracted from positive curvature point of the recorded curve.



**Figure S32**. Cloud point recording of poly(*N*-isopropylacrylamide)<sub>30</sub> initiated by 3-dihydroxypropyl 2-bromo-2-methylpropanoate in H<sub>2</sub>O.



**Figure S33.** Cloud point recording of poly(*N*-isopropylacrylamide)-*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide) in H<sub>2</sub>O,  $DP_n=20$ .



**Figure S34.** Cloud point recording of poly(*N*-isopropylacrylamide)-*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide) in H<sub>2</sub>O,  $DP_n$ =40.



**Figure S35.** Cloud point recording of poly(*N*-isopropylacrylamide)-*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide) in H<sub>2</sub>O,  $DP_n$ =80.



**Figure S36.** Cloud point recording of poly(*N*-isopropylacrylamide)-*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide) in H<sub>2</sub>O,  $DP_n$ =160.



**Figure S37.** Cloud point recording of poly(*N*-isopropylacrylamide)-*b*-poly(ethylene glycol)-*b*-poly(*N*-isopropylacrylamide) in H<sub>2</sub>O,  $DP_n$ =320.



**Figure S38.** Evolution of the cloud point temperature of poly(N-isopropylacrylamide)-b-poly(ethylene glycol)-b-poly(N-isopropylacrylamide) in H<sub>2</sub>O in function of the observed molecular weight (SEC, DMF eluent) and the solution concentration.



**Figure S39.** Cloud point recording of poly(N-isopropylacrylamide)-b-poly(ethylene glycol)-b-poly(N-isopropylacrylamide) in H<sub>2</sub>O with different degrees of polymerization (1 mg.mL<sup>-1</sup> solution).

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