Supporting Information for:
Invertible Amphiphilic Homopolymers

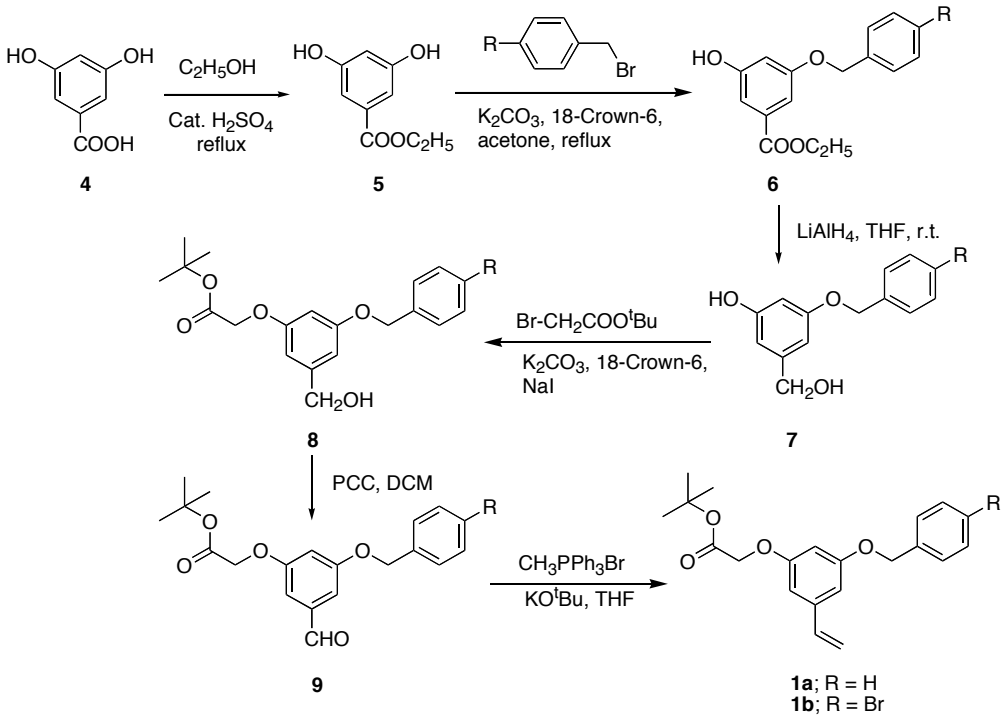
*Subhadeep Basu, Dharma Rao Vutukuri, Subarana Shyamroy, Britto S. Sandanaraj and S. Thayumanavan**

Department of Chemistry, University of Massachusetts, Amherst, MA 01003

EXPERIMENTAL

General methods: All reagents were commercially available and used as received unless stated otherwise. ^{1}H-NMR spectra were recorded on a 400 MHz NMR spectrometer using residual proton resonance of the solvents as internal standard. Chemical shifts are reported in parts per million (ppm). ^{13}C-NMR spectra were proton decoupled and recorded on a 100 MHz NMR spectrometer using the carbon signal of the deuterated solvent as the internal standard. Mass spectra were obtained at the Molecular Weight Characterization Facility at University of Massachusetts. The molecular weights of the polymers were determined by size exclusion chromatography on a single injector mode GPC, using THF as eluent and toluene as the internal reference; polystyrene standards were used for calibration and output was received and analyzed using a RI detector. The monomers **1a** and **1b** were synthesized starting from 3,5-dihydroxybenzoic acid in six steps.

Synthesis of monomer 1a and 1b:



Synthesis of Compound 5:

The title compound was synthesized from commercially available 3,5-dihydroxybenzoic acid (**4**) using ethanol and catalytic amount of fuming sulfuric acid.

Synthesis of Compound 6:

Ethyl-3,5-dihydroxybenzoate **5** (27.3 g, 150 mmol) was dissolved in acetone (750 mL). To this solution were added K_2CO_3 (20.7 g, 150 mmol) and 18-Crown-6 (1.9 g, 7.5 mmol) and stirred for 5 min. To this mixture, benzyl bromide (14.2 mL, 120 mmol) was added and stirred to reflux for 8 h. The reaction mixture was then cooled to room temperature and the solvent was evaporated to dryness. To this residue, water and diethylether were added and stirred for 30 min. The organic layer was separated and aqueous layer was extracted with diethylether. The combined organic layer was washed with water and brine solution. The organic layer was then evaporated to dryness and purified by silica gel chromatography to afford 14.5 g of **6** (35%). The major by-product of this reaction is the compound, where two benzyl groups are added to the two phenolic groups of compound **5**. ^{1}H NMR (400 MHz , $CDCl_3$) □ 7.43-7.31 (m, 5H), 7.26-7.25 (m, 1H), 7.16-7.15 (m, 1H), 6.67 (t, *J*=2.4 Hz, 1H), 5.01 (s, 2H), 4.35 (q, *J*=7.2 Hz, 2H), 1.37 (t, *J*=7.2 Hz, 3H); ^{13}C NMR (100 MHz , $CDCl_3$) □ 166.8, 159.9,157.0, 136.4, 132.2, 128.6, 128.1, 127.5, 109.5, 108.1, 107.3, 70.2, 61.4, 14.1.

Synthesis of compound 7:

$LiAlH_4$ (3.0 g, 79 mmol) was taken in dry THF (200 mL) and cooled to 0^0C. Compound **6** (14.3 g, 53 mmol) dissolved in dry THF (200 mL) was added drop wise to the above solution for 30 min. It was allowed to stir at room temperature for 12 h. The reaction mixture was quenched with ethyl acetate followed by water. The precipitated material was filtered and washed with ethyl acetate. The filtrate was then taken in a separating funnel. The organic layer was separated and the aqueous layer was extracted with ethyl acetate. The combined organic layer was washed with water, followed by brine solution. The organic layer was evaporated and purified by silica gel column chromatography to afford 10.8 g of compound **7** (89%). ^{1}H NMR (400MHz, $CDCl_3$) □ 8.28 (s, 1H), 7.47-7.29 (m, 5H), 6.53 (s, 1H), 6.47 (s, 1H), 6.36 (s, 1H), 5.0 (s, 2H), 4.52 (s, 2H); ^{13}C NMR (100 MHz, CD_3COCD_3) □ 160.8,159.1, 145.8, 138.4, 129.0, 128.3, 128.1, 106.8, 104.7, 101.2, 70.1, 64.5.

Synthesis of compound 8:

Compound **7** (4.8 g, 21 mmol) was dissolved in acetonitrile (60 mL). To this solution were added, K_2CO_3 (3.5 g, 25.2 mmol), NaI (3.2 g, 21 mmol) and 18-Crown-6 (0.33 g, 1.25 mmol) followed by *tert*-butyl bromoacetate (3.1 mL, 21 mmol). The reaction mixture was refluxed for 36 h. It was then cooled to room temperature and solvent was evaporated to dryness. The residue was partitioned between water and CH_2Cl_2. The organic layer was separated, and the aqueous layer was extracted with CH_2Cl_2. The

combined organic layer was dried over Na_2SO_4 and evaporated to dryness. The crude product was purified by silica gel chromatography to afford 7.0 g of compound **8** (97%). ^{1}H NMR (400MHz, $CDCl_3$) δ 7.41-7.38 (m, 5H), 6.64 (bs, 1H), 6.52 (bs, 1H), 6.49 (t, *J*=2.4Hz, 1H), 5.04 (s, 2H), 4.63 (s, 2H), 4.50 (s, 2H), 1.49 (s, 9H) ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.9, 160.0, 159.1, 143.4, 136.7, 128.5, 127.9, 127.4, 106.3, 105.1, 82.3, 70.0, 65.6, 65.1, 28.0.

Synthesis of compound 9:

To a stirred solution of compound **8** (7.0 g, 20.5 mmol) in dichloromethane (100 mL) was added pyridinium chlorochromate (5.2 g, 25 mmol). It was stirred at room temperature for 3h. The reaction mixture was filtered over alumina and the filtrate was evaporated and purified by silica gel chromatography to afford 6.2 g of compound **9** (88%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.88 (s, 1H), 7.4-7.34 (m, 5H), 7.13-7.12 (m, 1H), 6.98-6.97 (m, 1H), 6.82 (t, *J*=2.4 Hz, 1H), 5.09 (s, 2H), 4.5 (s, 2H), 1.49 (s, 9H) ^{13}C NMR (100 MHz, $CDCl_3$) δ 191.5, 167.4, 160.3, 159.5, 138.3, 136.1, 128.6, 128.2, 127.5, 109.3, 108.5, 107.1, 82.7, 70.3, 65.6, 27.9.

Synthesis of compound 1a:

Commercially available CH_3PPh_3Br (8.2 g, 22.8 mmol) was taken in dry THF (75 mL) and KO^{t}Bu (2.5 g, 22.8 mmol) was added to this under nitrogen atmosphere. This reaction mixture was stirred for 20 min and a solution of compound **9** (6.0 g, 17.6 mmol in 75 mL of dry THF) was added slowly with syringe to the above solution. The reaction mixture was further stirred at room temperature for 4 h. The reaction mixture was filtered and the filtrate evaporated and purified by silica gel chromatography to afford 5.2 g of compound **1a** (87%). ^{1}H NMR (400MHz , $CDCl_3$) δ 7.43-7.30 (m, 5H), 6.63-6.53 (m, 3H), 6.46 (t, *J*=2.46 Hz, 1H), 5.68 (d, *J*=8.66 Hz, 1H), 5.23 (d, *J*=6.0 Hz, 1H), 5.02 (s, 2H), 4.48 (s, 2H), 1.47 (s, 9H) ^{13}C NMR (100 MHz , $CDCl_3$) δ 167.8, 159.9, 159.0, 139.6, 136.7, 136.5, 128.8, 127.9, 127.4, 114.4, 106.3, 104.8, 101.4, 82.3, 70.0, 65.6, 27.9.

The monomer **1b** was synthesized following the above procedures.

Polymerization of the monomers 1a and 1b:

To a 1g/ mL solution of monomer **1a** (1.6 g, 4.72 mmol) in toluene was added AIBN (0.0076 g, 0.047 mmol) and the reactor was degassed by 4 freeze-thaw cycles before transferring to an oil-bath pre-heated to 110 °C. The reaction mixture was stirred for 24 h at this temperature and then allowed to cool down to room temperature. Solvent was removed under reduced pressure before it was cooled, to get the product polymer **2a**. The product was characterized for structure and molecular weight without further purification. SEC (polystyrene/ THF): M_n 57,000, M_w 131,500, PDI 2.3; ^{1}H-NMR (400 MHz, $CDCl_3$) δ 7.24-7.16 (m, 5H), 6.0-5.7 (m, 3H), 4.59 (s, 2H), 4.12 (s, 2H), 1.47-1.41 (m, 3H), 1.33 (s, 9H).

To a 1g/ mL solution of monomer **1b** (1.6 g, 4.72 mmol) in toluene was added AIBN (0.0076 g, 0.047 mmol) and the reactor was degassed by 4 freeze-thaw cycles before transferring to an oil-bath pre-heated to 110 °C. The reaction mixture was stirred for 24 h at this temperature and then allowed to cool down to room temperature. Solvent was removed under reduced pressure before it was cooled, to get the product polymer **2b**. The product was characterized for structure and molecular weight without further purification. SEC (polystyrene/ THF): $\bar{M}_n$ 47,800, $\bar{M}_w$ 119,500, PDI 2.5; ^{1}H-NMR (400 MHz, $CDCl_3$) δ 7.33-7.06 (m, 4H), 6.02-5.63 (m, 3H), 4.54 (s, 2H), 4.18 (s, 2H), 1.56-1.45 (m, 3H), 1.38 (s, 9H).

Hydrolysis of the polymers (2a and 2b):

To a solution of polymer **2a** (0.3 g, 0.88 mmol) in Tetrahydrofuran (15 mL) was added aqueous potassium hydroxide (0.5g, 8.8 mmol) dissolved in water (3 mL). Methanol (6 mL) was then added to this two-phase system to give a homogeneous solution. This mixture was then heated at reflux for 12 h. The reaction mixture was evaporated to dryness and the residue redissolved in water (15 mL) and the mixture heated at reflux for another 24 h. After cooling to room temperature, the reaction mixture was acidified with 2N HCl. The precipitate formed was collected by vacuum filtration and dried to afford polymer **3a**. Yield: 0.26 g (95%). ^{1}H-NMR (400 MHz, THF-d_8) δ 7.29-7.19 (m, 5H), 6.20-6.00 (m, 3H), 4.75 (s, 2H), 4.38 (s, 2H), 1.49-1.32 (m, 3H).

Following the above procedure the polymer **2b** (0.35 g, 0.84 mmol) was hydrolyzed to afford the polymer **3b**. Yield: 0.31 g (94%). ^{1}H-NMR (400 MHz, THF-d_8) δ 7.39-7.20 (m, 4H), 6.17-5.98 (m, 3H), 4.69 (s, 2H), 4.39 (s, 2H), 1.49-1.32 (m, 3H).

Sample preparation for TEM experiments:

TEM measurements were performed using a JEOL 100CX 100KV TEM. To prepare solutions for doing TEM for the normal micelle-like structures the polymers were dissolved in appropriate amount of water with KOH / CsOH as the base. For each COOH unit present in the polymer 1.5 equivalents of KOH / CsOH were added in order to form the carboxylate salts, which is soluble in water. This solution was then sonicated for 1-1.5 h to ensure solubility of the polymers. To prepare the solutions for doing TEM of inverted micelle-like particles, an appropriate amount of polymer was taken with calculated amount of toluene. To make the polymer soluble in non-polar solvent (toluene here) 1.5-2 equivalents of KOH / CsOH was added to the polymer solution, along with 3 equivalents of water, for each carboxylic acid group present in the measured amount of polymer. This solution was then sonicated for 4 hours to ensure a homogeneous solution. Control experiments without the polymers were also carried out in all cases. Samples were prepared by depositing aqueous or toluene solutions of the amphiphilic polymers onto copper EM grid that had been pre-coated with a thin film of Formvar and then coated with carbon. Water/Toluene was evaporated from the grids by leaving it under atmospheric pressure for one day.
The dilution studies with these micelle-like and inverted micelle-like structures were also done. The solutions made for both normal and reverse micelle were of the concentration

of 10^{-6} M. In order to study the structural integrity of the micelle-like and inverted micelle-like particles, both the solutions were diluted to 10^{-9} M and studied by TEM. The TEM images of these are shown in Figure S1 and S2. Comparing figure S1 with Figure 2E shows the particle size and morphology remains same even diluting the system 1000 times. Similar observation is given for inverted micelle-like particles. The sizes of the particles for both the normal and inverted micelle-like structures were calculated by taking an average of about 50 samples for each type of the particles. It was observed that the overall sizes of the particles also remain the same upon dilution.

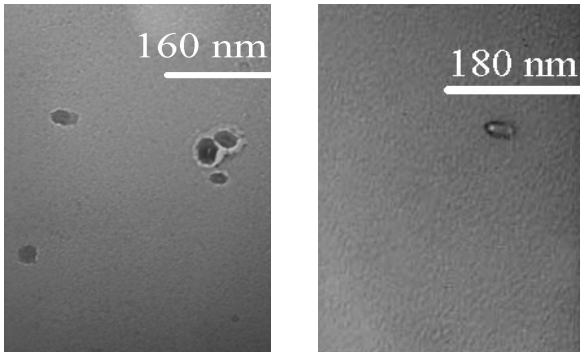


Figure S1 and **S2.** These figures show the structural integrity of the micelle-like (S1) and inverted micelle-like (S2) particles at concentrations of 10^{-9}M.