LIGHT-RESPONSIVE SELF-ASSEMBLED MATERIALS BY SUPRAMOLECULAR POST-FUNCTIONALIZATION VIA HYDROGEN BONDING OF AMPHIPHILIC BLOCK COPOLYMERS

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MATERIALS

4-Isobutyloxy-4'-hydroxyazobenzene was synthesized according to a previously reported procedure.[1] All other commercially reagents were purchased from Sigma-Aldrich and used as received.

Experimental details and characterization data for the synthesis of the azocompounds acAZO$_i$, dAZO$_i$ and tAZO$_i$

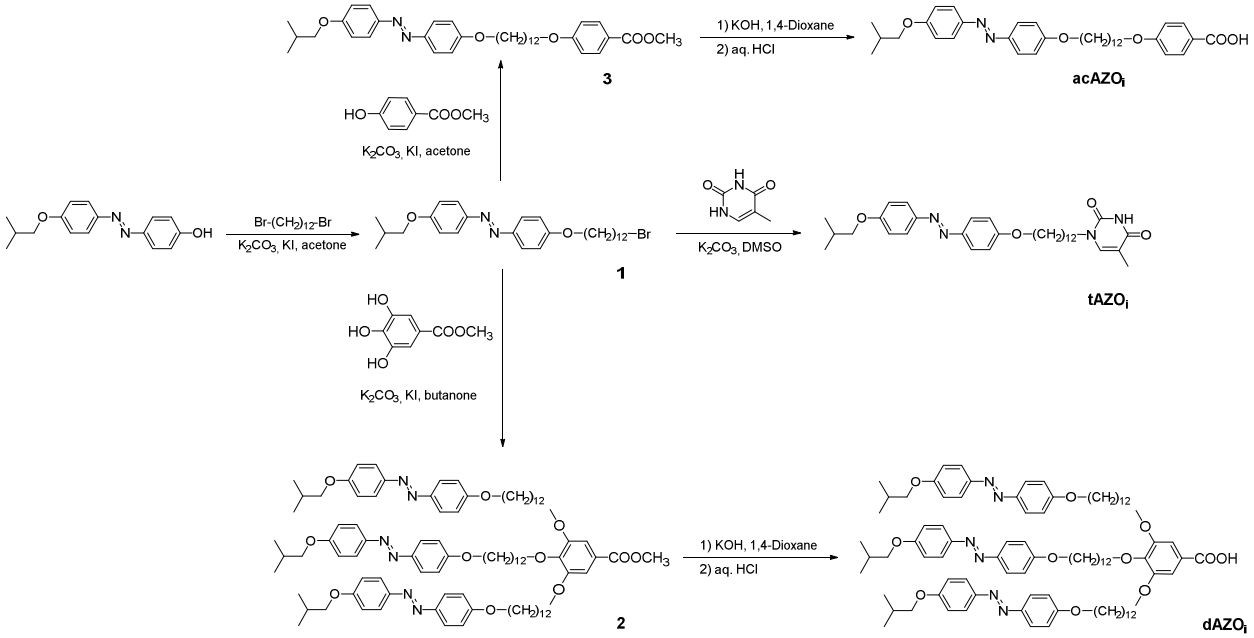

Figure S1. Synthesis of the azo molecules acAZO$_i$, dAZO$_i$ and tAZO$_i$.

Synthesis of 4-isobutyloxy-4'-(12''-bromododecyloxy)azobenzene (1). A solution of 4-isobutyloxy-4'-hydroxyazobenzene (3.00 g, 11.11 mmol) in acetone (50 mL) was added

[1] Blasco, E.; del Barrio, J.; Sánchez-Somolinos, C.; Piñol, M.; Oriol, L. *Polym. Chem.* **2013,** 4, (7), 2246-2254.

dropwise over more than 1 h to a mixture of 1,12-dibromododecane (4.38 g, 13.33 mmol), potassium carbonate (3.07 g, 22.22 mmol), 18-crown-6 (0.30 g, 1.11 mmol) in acetone (10 mL). Then, the reaction was stirred at reflux temperature for 12 h, allowed to cool down to room temperature and the solids filtered off. The solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography on silica gel using hexane/dichloromethane (2:1) as eluent. Yield: 64%. IR (KBr) ν (cm^{-1}): 1600, 1579, 1498, 1469, 1239, 1023, 552. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.90–7.82 (m, 4H), 7.02–6.94 (m, 4H), 4.01 (t, *J* = 6.6 Hz, 2H), 3.78 (d, *J* = 6.7 Hz, 2H), 3.40 (t, *J* = 6.9 Hz, 2H), 2.16–2.04 (m, 1H), 1.89–1.76 (m, 4H), 1.52–1.25 (m, 16H), 1.10 (d, *J* = 6.6 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 161.4, 161.3, 147.1, 147.1, 124.4, 114.8, 74.8, 68.5, 34.2, 33.0, 29.7, 29.6, 29.5, 29.4, 28.9, 28.4, 28.3, 26.2, 19.4.

Synthesis of methyl 3,4,5-tris[12-(4-(4'-isobutyloxyphenyldiazo)phenoxy)dodecyloxy)] benzoate (2). A mixture of compound 1 (1.50 g, 2.90 mmol), methyl gallate (0.16 g, 0.88 mmol), potassium carbonate (0.80 g, 5.80 mmol), tetrabutylammonium iodide (0.07 g, 0.18 mmol) and butanone (40 mL) was stirred at reflux temperature for 72 h. The solvent was removed under reduced pressure and the residue dissolved in dichloromethane and washed twice with water and once with brine. Finally, the organic layer was dried over anhydrous magnesium sulfate and evaporated. The crude product was purified by flash column chromatography on silica gel using hexane/dichloromethane (2:1) as eluent and gradually changing the composition of the eluent to dichloromethane. Yield: 62%. IR (KBr) ν (cm^{-1}): 1720, 1602, 1500, 1471, 1242, 1147, 845. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.95–7.76 (m, 12H), 7.25 (s, 2H), 7.05–6.90 (m, 12H), 4.07–3.95 (m, 12H), 3.88 (s, 3H), 3.79 (d, *J*=6.6 Hz, 6H), 2.17–2.04 (m, 3H), 1.90–1.66 (m, 12H), 1.51–1.22 (m, 48H), 1.04 (d, *J*=6.6 Hz, 18H). ^{13}C NMR (100 MHz, $CDCl_3$,)

δ (ppm): 167.1, 161.4, 161.3, 153.0, 147.1, 142.5, 124.8, 124.4, 114.8, 114.8, 108.1, 74.8, 73.6, 69.3, 68.5, 52.3, 29.8, 29.6, 29.5, 29.4, 28.4, 26.2, 26.2, 19.4.

Synthesis of 3,4,5-tris[12-(4-(4'-isobutyloxyphenyldiazo)phenoxy)dodecyloxy)]benzoic acid ($dAZO_i$). An aqueous solution of potassium hydroxide (0.1 g, 5 mL) was added to a solution of compound 2 (0.5 g, 0.33 mmol) in 1,4-dioxane (5 mL). The mixture was stirred and heated under reflux and the evolution of the reaction was followed by thin layer chromatography. When all the starting material had been consumed, the reaction mixture was neutralized with concentrated hydrochloric acid until pH 2. Then, the crude product was filtered off and washed with water. The product was purified by flash chromatography on silica gel using dichloromethane as eluent and gradually changing the composition of the eluent to ethyl acetate. Yield: 59%. IR (KBr) ν (cm^{-1}): 1688, 1581, 1500, 1471, 1241, 1147, 842. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.94–7.78 (m, 12H), 7.31 (s, 2H), 7.05–6.88 (m, 12H), 4.05–3.91 (m, 12H), 3.77 (d, *J*=6.6 Hz, 6H), 2.17–2.05 (m, 1H), 1.86–1.67 (m, 12H), 1.51–1.17 (m, 48H), 1.02 (d, *J*=6.6 Hz, 18H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.7, 161.4, 153.0, 147.1, 143.26, 124.4, 123.7, 114.8, 114.8, 108.7, 74.8, 73.7, 69.4, 68.5, 29.8, 29.6, 29.5, 29.4, 28.4, 26.2, 26.2, 19.4. MS (MALDI$^+$, dithranol, m/z): calcd. for $C_{91}H_{126}N_6O_{11}$, 1478.95; found, 1480.01 $[M+1]^+$, 1502.02 $[M+Na]^+$. Anal. calcd. for $C_{91}H_{126}N_6O_{11}$: C, 73.85%; H, 8.58%; N, 5.68%. Found: C, 73.83%; H, 9.00%; N, 5.53%.

Synthesis of *N*(1)-[12-(4-(4'-isobutyloxyphenyldiazo)phenoxy)dodecyloxy)]thymine ($tAZO_i$). A suspension of compound 1 (3 g, 6.38 mmol), thymine (2.41 g, 19.13 mmol) and potassium carbonate in dimethyl sulfoxide (DMSO) (250 mL) was stirred at 60 ºC for 12 h. Then, the reaction was poured into ethyl acetate (150 mL), washed twice with water and twice

with brine. Finally, the organic layer was dried over anhydrous magnesium sulfate. The solvent was distilled off giving an orange solid that was purified by flash column chromatography on silica gel using hexane/ethyl acetate (2:1) as eluent. Yield: 27%. IR (KBr) ν (cm^{-1}): 3154, 3032, 1681, 1601, 1580, 1499, 1471, 1241, 1145, 838. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.59 (s, 1H), 7.92–7.80 (m, 4H), 7.03–6.91 (m, 4H), 3.97 (t, *J* = 6.6 Hz, 2H,), 3.74 (d, *J* = 6.7 Hz, 2H), 3.65–3.57 (m, 2H), 2.17–2.06 (m, 1H), 1.83 (d, *J* = 1.1 Hz, 3H), 1.77–1.66 (m, 2H), 1.42–1.16 (m, 16H), 0.99 (d, *J* = 6.6 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 164.2, 161.4, 161.3, 150.8, 147.1, 140.5, 124.4, 114.8, 110.6, 74.8, 68.4, 48.7, 29.6, 29.3, 26.1, 22.2, 19.4, 12.5. MS (MALDI$^+$, dithranol, m/z): calcd. for $C_{33}H_{46}N_4O_4$, 562.35; found, 563.37 $[M+1]^+$, 585.36 $[M+Na]^+$. Calcd: C, 70.43%; H, 8.24%; N, 9.96%. Anal. calcd. for $C_{33}H_{46}N_4O_4$: C, 70.04%; H, 8.29%; N, 9.81%.

Synthesis of methyl 4-[12-(4-(4'-isobutyloxyphenyldiazo)phenoxy)dodecyloxy)] benzoate (3). Methyl 4-hydroxybenzoate (0.07 g, 0.44 mmol), 4-isobutyloxy-4'-(12''-bromododecyloxy)azobenzene (**1**) (0.25 g, 0.48 mmol), anhydrous potassium carbonate (0.18 g, 1.32 mmol) and a teaspoon of KI were stirred in acetone (10 mL). The solvent was removed under reduced pressure and the residue dissolved in dichloromethane and washed twice with water and once with brine. Finally, the organic layer was dried over anhydrous magnesium sulfate and evaporated. The crude product was recrystallized in ethanol. Yield: 72%. IR (KBr) ν (cm^{-1}): 1723, 1602, 1505, 1469, 1244, 1149. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.01–7.94 (m, 2H), 7.93–7.85 (m, 4H), 7.04–6.95 (m, 4H), 6.93–6.86 (m, 2H), 4.06–3.97 (m, 4H), 3.88 (s, 3H), 3.80 (d, *J*=6.6 Hz, 2H), 2.18–2.06 (m, 1H), 1.87–1.73 (m, 4H), 1.53–1.20 (m, 16H), 1.05 (d, *J*=6.7 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_{3,}$) δ (ppm): 167.1, 163.1, 161.4, 161.4, 147.1,

131.7, 124.4, 122.4, 114.8, 114.2, 74.8, 68.7, 68.5, 52.0, 29.8, 29.6, 29.5, 29.4, 28.4, 26.2, 26.2, 19.4.

Synthesis of 4-[12-(4-(4'-isobutyloxyphenyldiazo)phenoxy)dodecyloxy)] benzoic acid (acAZO). An aqueous solution of potassium hydroxide (0.15 g, 2.5 mL) was added to a solution of methyl methyl 4-[12-(4-(4'-isobutyloxyphenyldiazo)phenoxy)dodecyloxy)] benzoate (**3**) (0.15 g, 0.25 mmol) in ethanol (7.5 mL). The mixture was stirred and heated under reflux for 6 h. Then the crude product was precipitated by addition of concentrated hydrochloric acid until pH 2 and it was filtered. The product was recrystallized in ethanol. Yield: 87% IR (KBr) ν (cm^{-1}): 3133, 1719, 1699, 1619, 1508, 1466, 1205, 1139. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.00–7.92 (m, 2H), 7.93–7.85 (m, 4H), 7.04–6.95 (m, 4H), 6.98–6.89 (m, 2H), 4.05–3.96 (m, 4H), 3.80 (d, *J*=6.6 Hz, 2H), 2.18–2.06 (m, 1H), 1.87–1.73 (m, 4H), 1.53–1.20 (m, 16H), 1.04 (d, *J*=6.6 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$,) δ (ppm): 171.8, 163.8, 161.4, 161.4, 147.1, 132.5, 124.4, 121.5, 114.8, 114.3, 74.8, 68.8, 68.4, 29.7, 29.6, 29.5, 29.4, 28.4, 26.2, 26.2, 19.4.

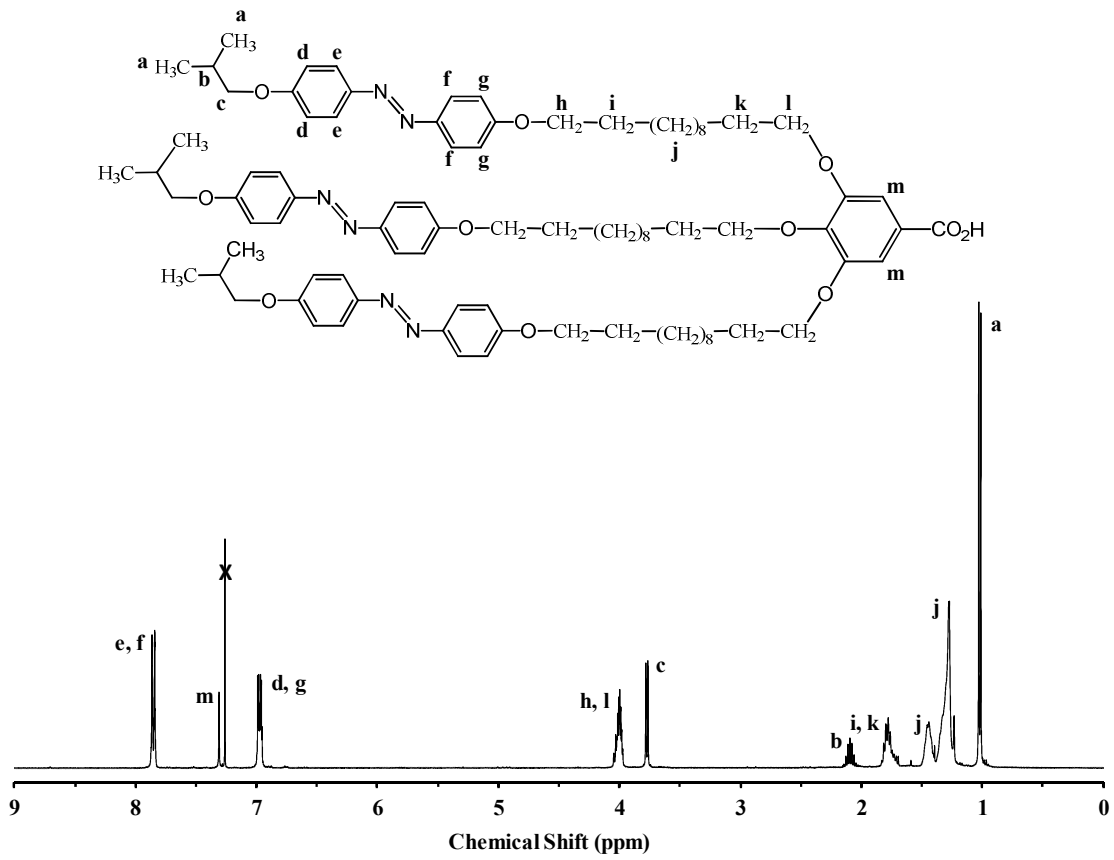

Figure S2. ^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **dAZO$_i$**

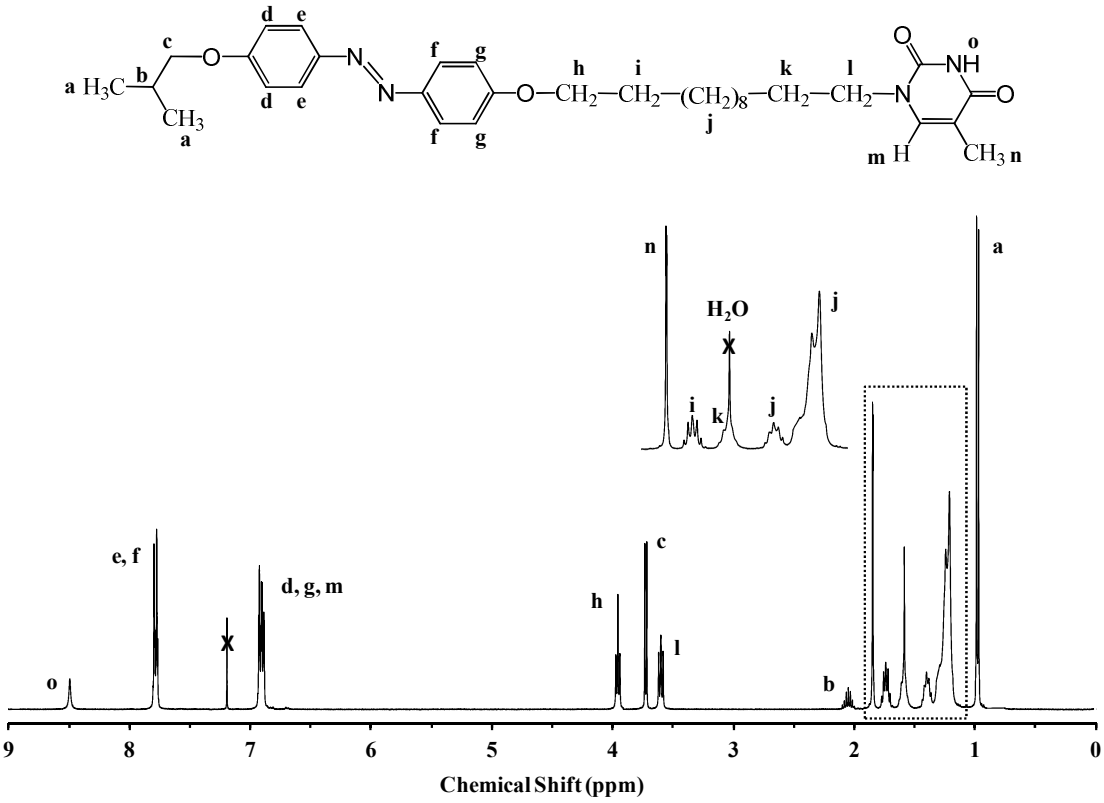

Figure S3. ^{1}H NMR spectrum (400 MHz, $CDCl_3$) of **tAZO$_i$**

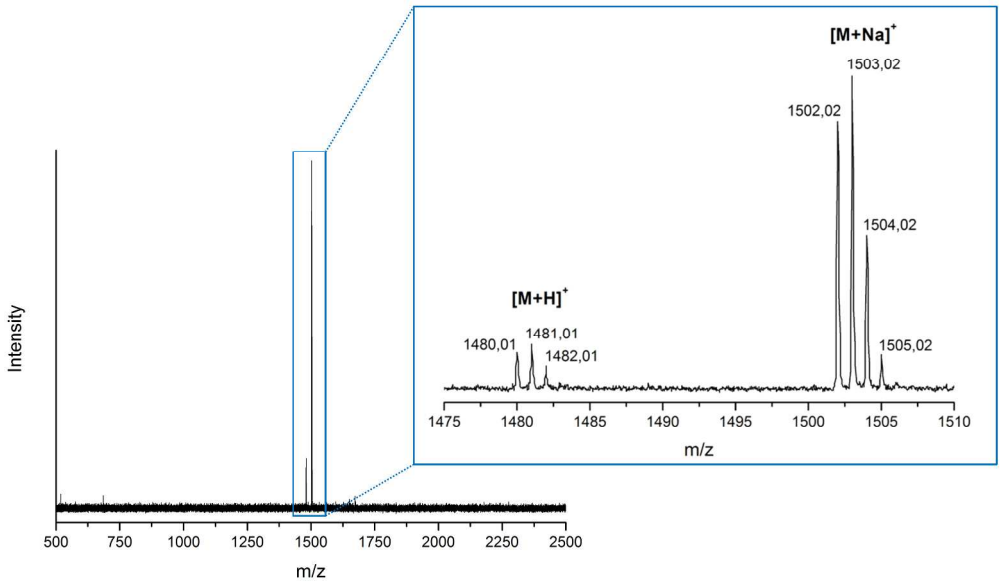

Figure S4. MALDI-TOF mass spectrum (MALDI$^+$, dithranol) of **dAZO$_i$** (MALDI-TOF MS was performed on an Autoflex mass spectrometer from Bruker Daltonics using dithranol as matrix)

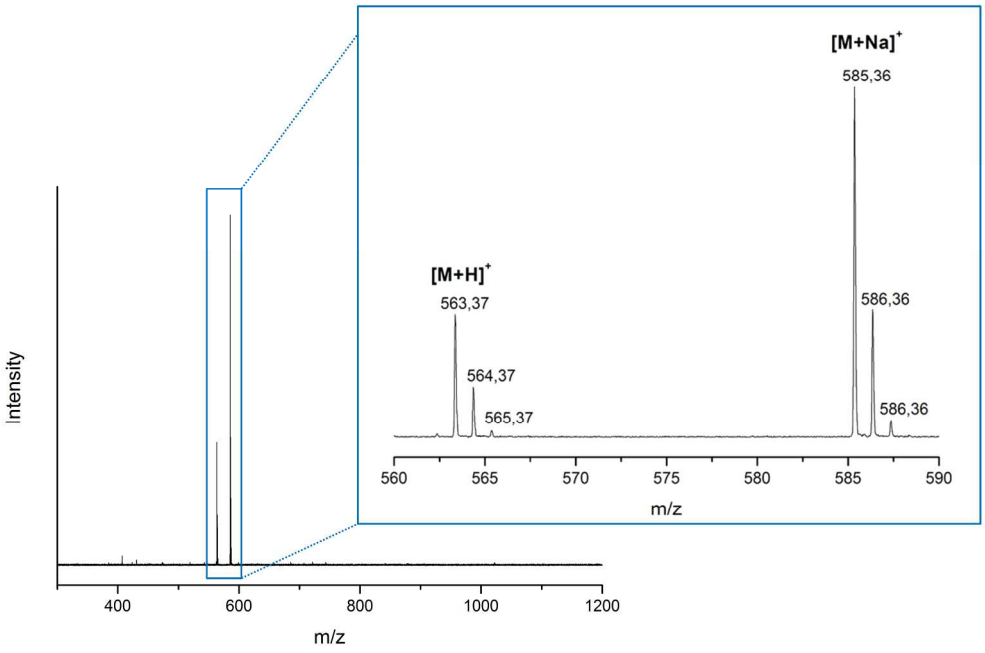

Figure S5. MALDI-TOF mass spectrum (MALDI+, dithranol) of **tAZOi** (MALDI-TOF MS was performed on an Autoflex mass spectrometer from Bruker Daltonics using dithranol as matrix)

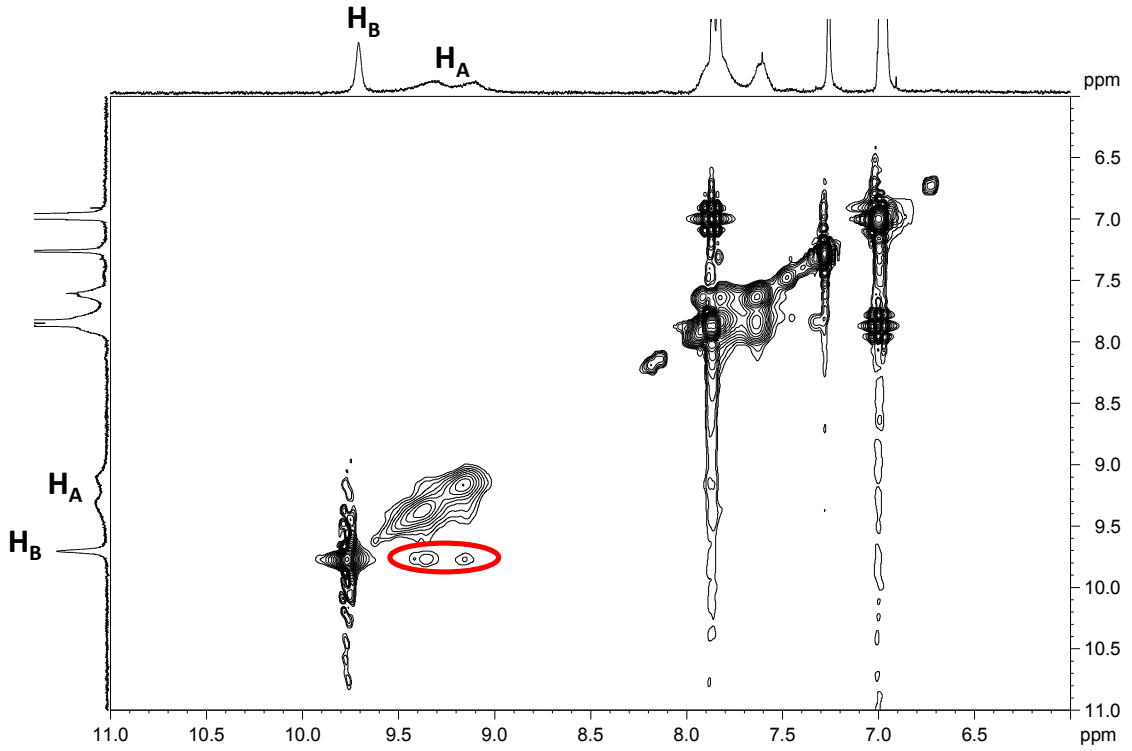

Figure S6. ^{1}H-^{1}H NOESY spectrum of **{PEG$_2$-*b*-PDAP•tAZO$_i$}** in $CDCl_3$ at 25ºC, t_{mixing} = 250 ms.

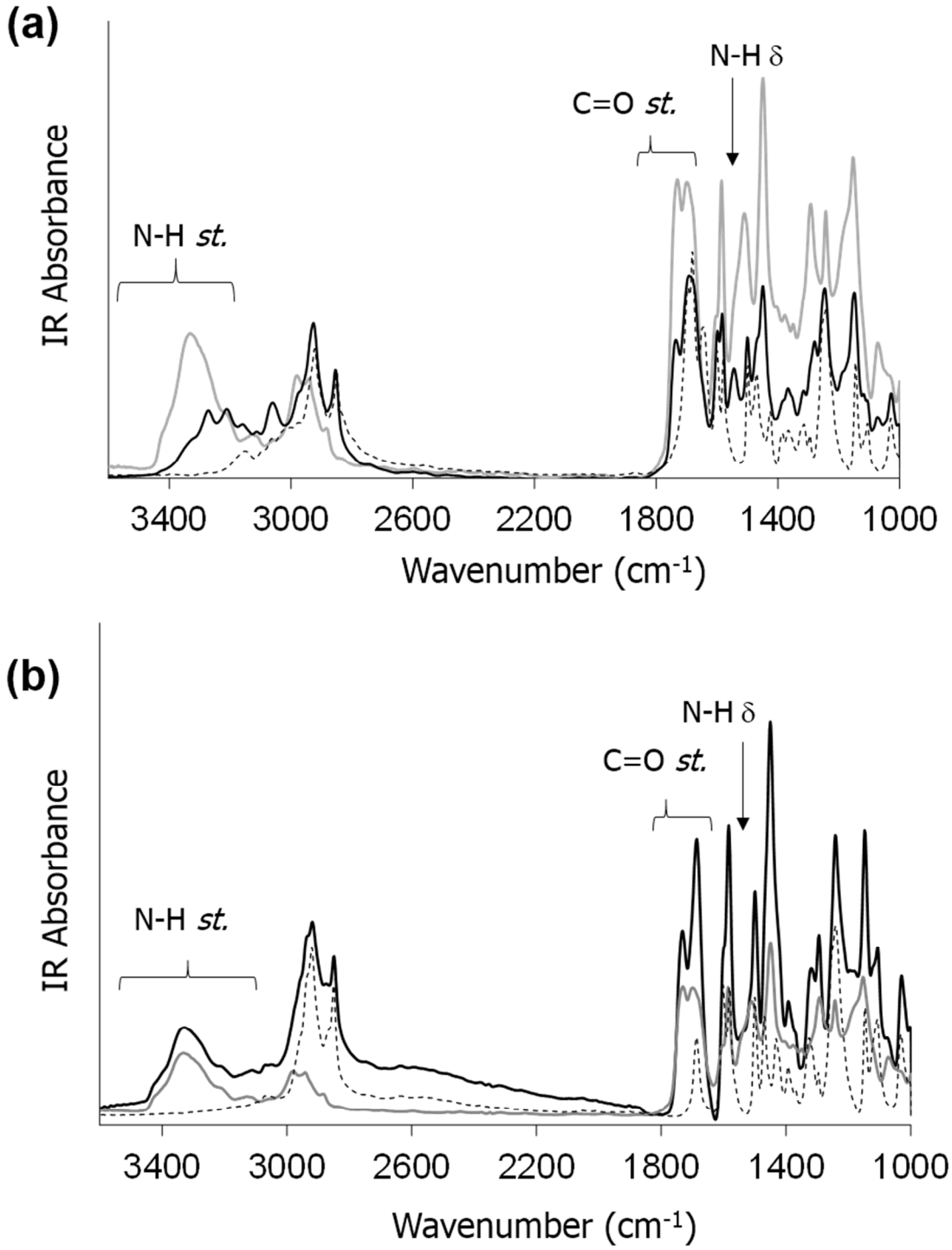

Figure S7. FTIR spectra at room temperature of (a) **{PDAP • tAZO$_i$}**, solid black line; **PDAP** homopolymer, grey line; **tAZO$_i$**; dashed line; (b) **{PDAP • dAZO$_i$}**, solid black line; **PDAP** homopolymer, grey line; **dAZO$_i$**; dashed line.

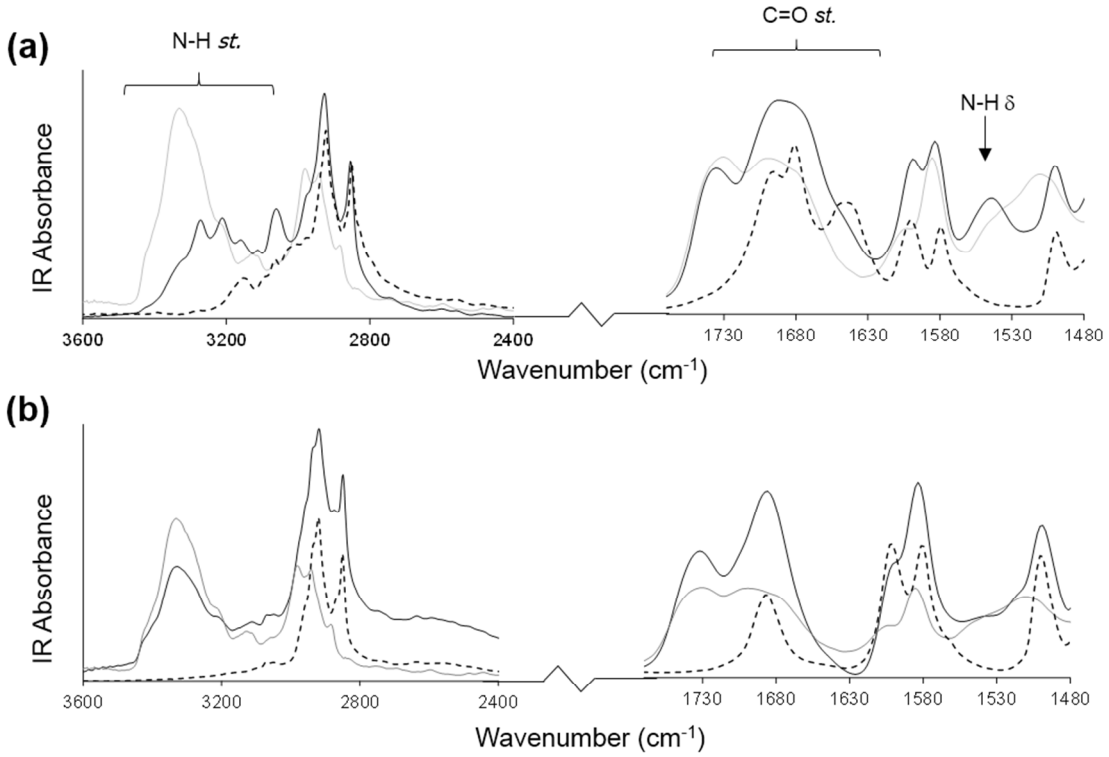

Figure S8. FTIR response at room temperature in the C=O *st.* and N-H δ and N-H *st.* regions corresponding to (a) **{PDAP • tAZO$_i$}** and (b) **{PDAP • dAZO$_i$}**: **{PDAP • AZO$_i$}**, solid black lines; **PDAP** homopolymer, grey lines; **AZO$_i$**, dashed lines.

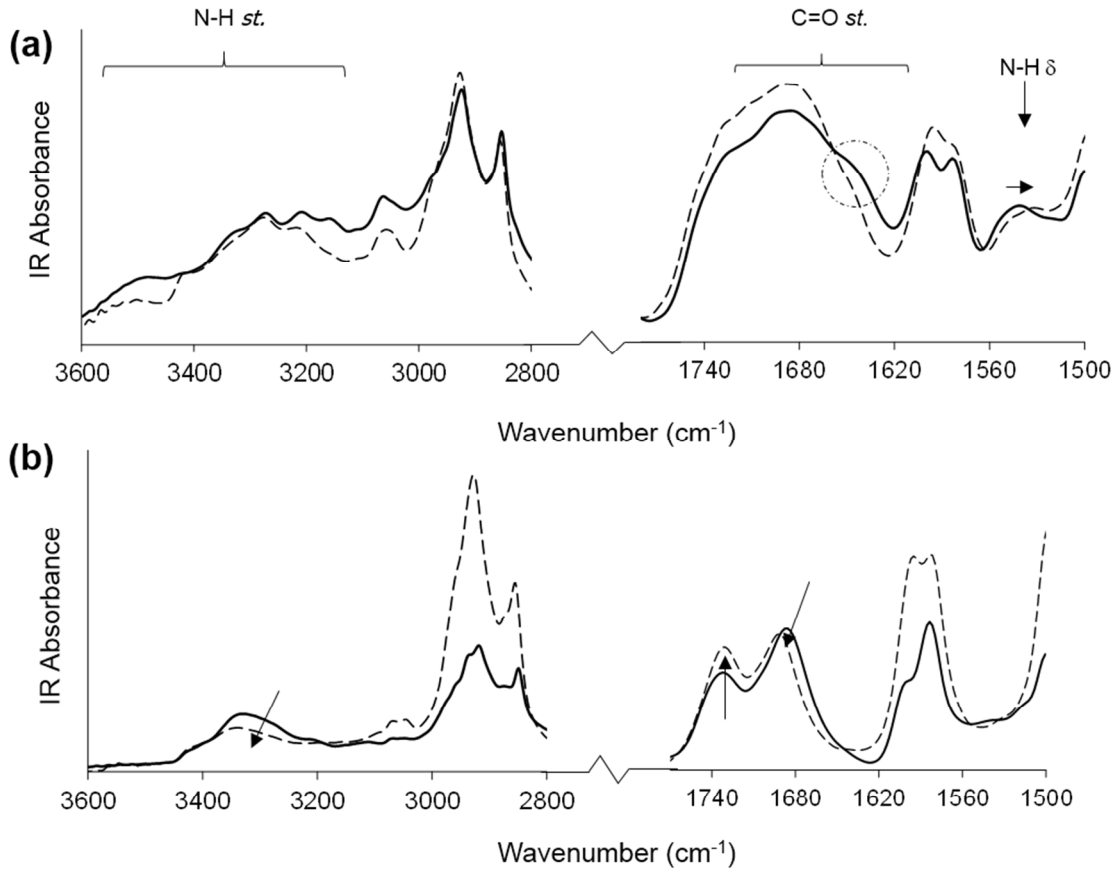

Figure S9. Temperature dependence of the FTIR response in the C=O *st.* and N-H δ and N-H *st.* regions corresponding to (a) **{PDAP•tAZO$_i$}** and (b) **{PDAP•dAZO$_i$}**: 40 ºC (solid line) and 160 ºC (dashed line).

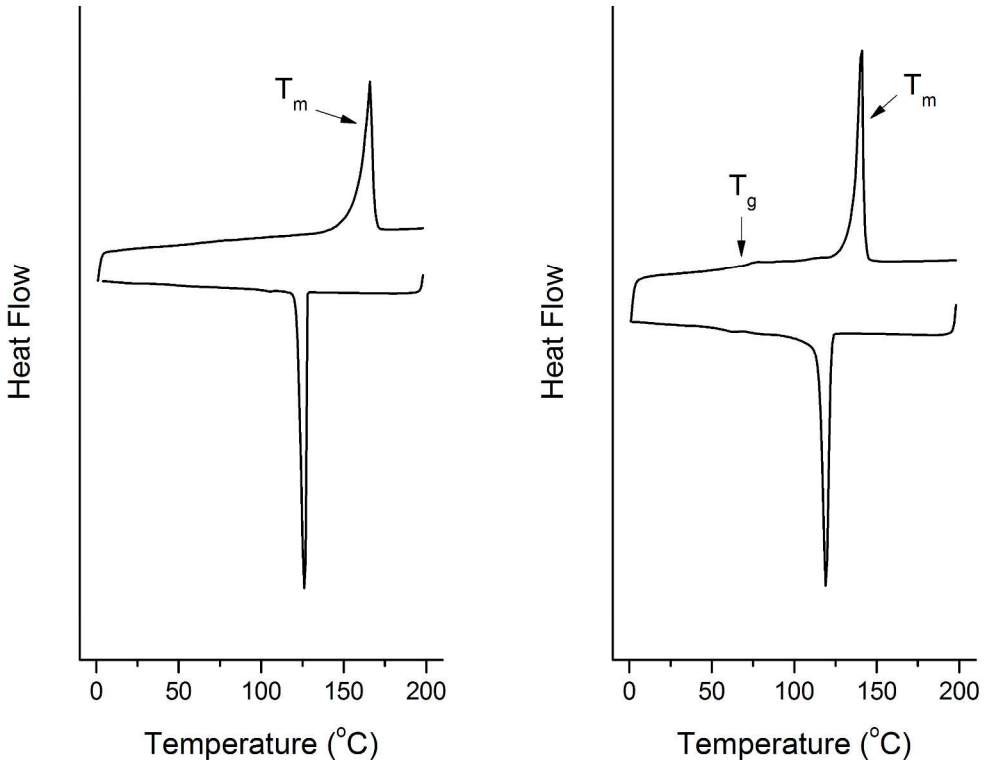

Figure S10. DSC curves (second scans) corresponding to the neat azoderivatives: **tAZO$_i$** (left) and **dAZO$_i$** (right).

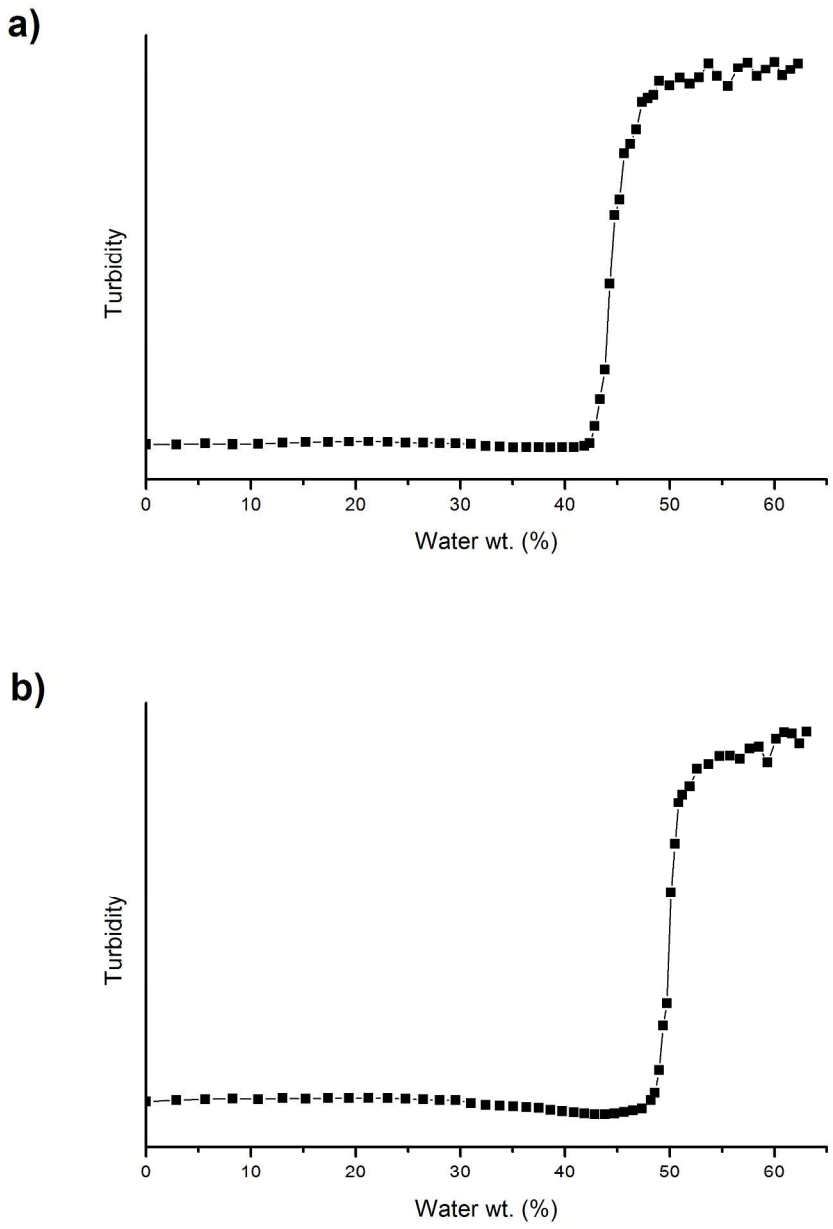

Figure S11. Turbidity plot of (a) **{PEG_{10}-*b*-PDAP • $tAZO_i$}**, and (b) **{PEG_2-*b*-PDAP • $tAZO_i$}** in THF versus amount of water added.

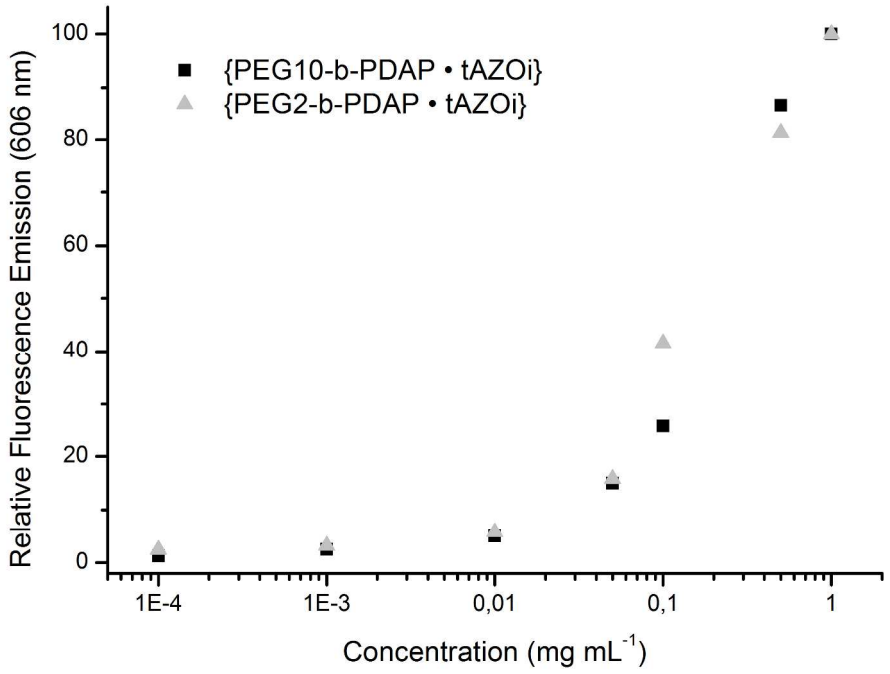

Figure S12. Fluorescence intensity of Nile Red at 606 nm (λ_{exc}= 550 nm) versus supramolecular BC concentration (mg mL^{-1}).

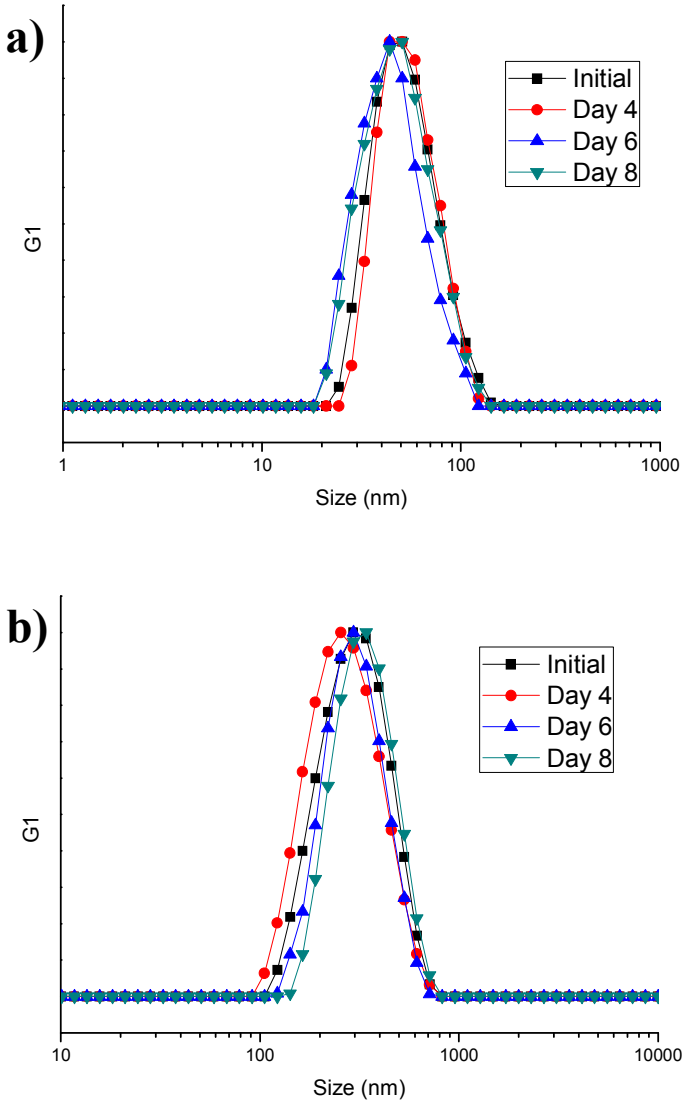

Figure S13. DLS measurements of a water suspension of (a) **{PEG_{10}-*b*-PDAP • $tAZO_i$}** micelles and (b) **{PEG_2-*b*-PDAP • $tAZO_i$}** vesicles.

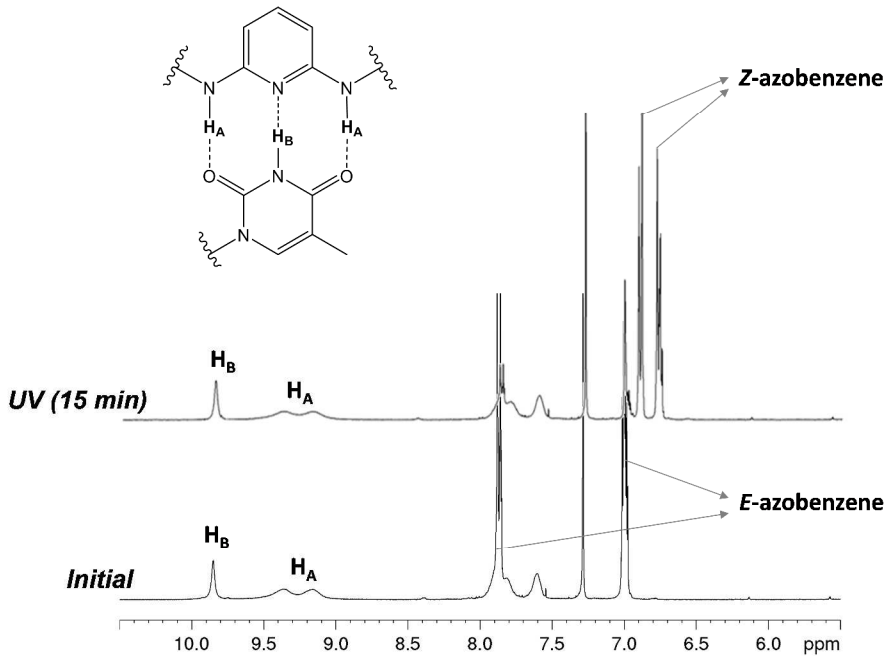

Figure S14. ^{1}H NMR spectra of **{PEG$_{10}$-*b*-PDAP • tAZO$_i$}** in $CDCl_3$ solution at 25ºC.