Supplementary Information

Supramolecular Three-Armed Star Polymers via Cyclodextrin Host/Guest Self-Assembly

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Additional Experimental Procedures

Synthesis of N-(adamantan-1-yl)-6-hydroxyhexanamide

According to the literature procedure,[1] 11.8 g aluminium chloride (88.50 mmol, 2.2 eq.) were suspended in 100 mL of anhydrous DCM. At 0 °C 17.2 mL triethylamine (124.08 mmol, 3.1 eq.) were added dropwise via a syringe. After stirring for 15 minutes at 0 °C, the mixture was warmed to ambient temperature. Subsequently, a solution of 4.2 mL ε-caprolacton (39.74 mmol, 1.0 eq.), 6.1 mL triethylamine (46.89 mmol, 1.2 eq.) and 8.25 g adamantylamine hydrochloride (43.95 mmol, 1.1 eq.) in 100 mL anhydrous DCM was added dropwise. The mixture was stirred over night and subsequently poured into an ice cold solution of 30 g sodium carbonate in 300 mL ice water. The organic phase was separated and the aqueous phase extracted three times with 200 mL DCM. The combined organic extracts were washed with 500 mL deionized water, 500 mL brine, dried over sodium sulfate, filtered and concentrated in vacuo. The resulting solid was recrystallized from an acetonitrile/methanol mixture to give 7.09 g (26.72 mmol, 67%) of the product as off-white crystals.

^{1}H-NMR (400 MHz, $CDCl_3$): [δ, ppm] = 1.31 – 1.43 (m, 2H, C***H***$_2$-CH_2-CH_2-O), 1.51 – 1.73 (m, 10H, C***H***$_2$-CH_2-O; C***H***$_2$-CH_2-C=O; 3x C***H***$_{2,adamantyl}$), 1.92-2.00 (m, 6H, 3x NH-C-C***H***$_{2,adamantyl}$), 2.01 - 2.12 (m, 5H, 3x C***H***$_{adamantyl}$; C***H***$_2$-C=O-NH), 3.63 (t, 2H, C***H***$_2$-OH), 5.17 (br s, 1H, N***H***).

^{13}C-NMR (100 MHz, $CDCl_3$): [δ, ppm] = 25.4 (***C***H_2-CH_2-C=O; ***C***H_2-CH_2-CH_2-C=O), 29.6 (3x ***C***$H_{adamantyl}$), 32.4 (***C***H_2-CH_2-OH), 36.5 (3x ***C***$H_{2,adamantyl}$), 37.7 (***C***H_2-C=O), 41.8 (3x ***C***$H_{2,adamantyl}$-C-NH), 51.9 (***C***-NH), 62.6 (***C***H_2-OH), 172.3 (***C***=O).

ESI-MS: $[M + Na^+]_{exp}$ = 288.36 *m*/*z* and $[M + Na^+]_{calc}$ = 288.1939 *m*/*z*.

Synthesis of N,N,N-(tris-1-(mono-(6-desoxy)-β-CD)-1H-1,2,3-triazol-4-yl)methanamine (β-CD_3)

This compound was prepared from a modified literature procedure.[46] In a 50 mL Schlenk-tube tripropargylamine (34 mg, 0.26 mmol, 1.0 eq.), β-CD-N_3 (1.00 g, 0.86 mmol, 3.3 eq.) and PMDETA

(0.16 mL, 0.77 mmol, 3.0 eq.) were dissolved in DMF (11mL). After three freeze-pump-thaw cycles the tube was backfilled with Argon and CuBr (112 mg, 0.78 mmol, 3.0 eq.) was added under a flow of Argon. The tube was sealed again and subjected to two freeze-pump-thaw cycles. Subsequently the tube was backfilled with Argon and immersed in an oil bath at 70 °C for 4 days. After cooling to ambient temperature the product was precipitated in an excess of acetone. The product was filtered, dissolved in 10 mL EDTA-solution (5 wt%) and dialyzed with a SpectraPor3 membrane (MWCO = 2000 Da) for 3 days at ambient temperature. Finally the solvent was removed in vacuo to yield β-CD_3 (574 mg, 0.16 mmol, 61%) as an off-white solid.

^{1}H NMR (400 MHz, D_2O): [δ, ppm] = 3.18 (d, 3H, N-NC*H(gem)*$_2$), 3.32 (d, 3H, N-NC*H(gem)*$_2$), 3.37 - 4.14 (m, 124H, CD-*H*2,3,4,5,6), 4.24 (t, 3H, NC*H(gem)*$_2$-C), 4.66 (dd, 3H, NC*H(gem)*$_2$-C), 4.93 - 5.18 (m, 21H, CD-*H*1), 8.02 (s, 3H, $H_{triazole}$).

ESI-MS: $[M + 2Na^{2+}]_{exp}$ = 1828.33 *m*/*z* and $[M + 2Na^{2+}]_{calc}$ = 1828.0926 *m*/*z* (refer to Figure S11 for a more detailed ESI-MS characterization)

Preparation for dynamic light scattering experiments

Adamantyl-functionalized polymer, e.g. PDMAAm (M_{nGPC} = 14600 g·mol^{-1}, 12.4 mg, 3.0 eq.) and β-CD_3 (1.4 mg, 1.0 eq.) were dissolved in D_2O (1 mL, *c* = 5 mg·mL^{-1}) and stirred at 25 °C.

Control experiments in dynamic light scattering

For control experiments, the linear polymer was dissolved together with the linker molecule β-CD_3 in H_2O and analyzed over several days without any change in the hydrodynamic radius being observed (Figure S12a). $PDMAAm_{143}$ was additionally mixed with variable amounts of β-CD (Figure S12b) and no increase in size was observed. In Figure S12c the increase of the hydrodynamic radius with time is depicted. As a further control the β-CD_3 was mixed in an excess with the polymer (Figure S12d).

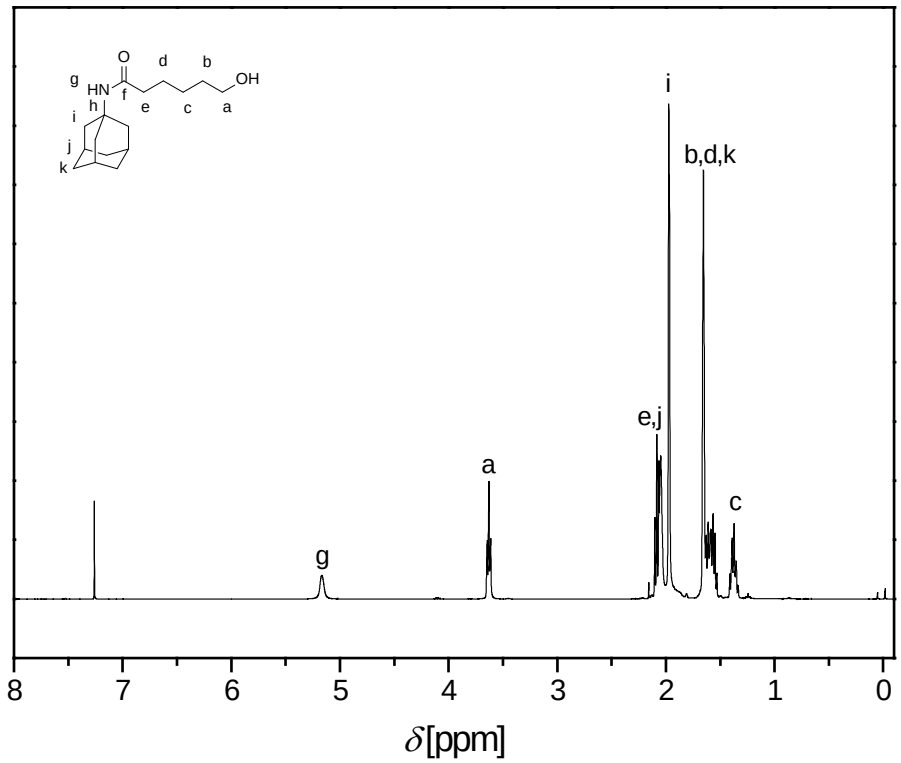

Figure S1. ^{1}H-NMR spectrum of *N*-(adamantan-1-yl)-6-hydroxyhexanamide.

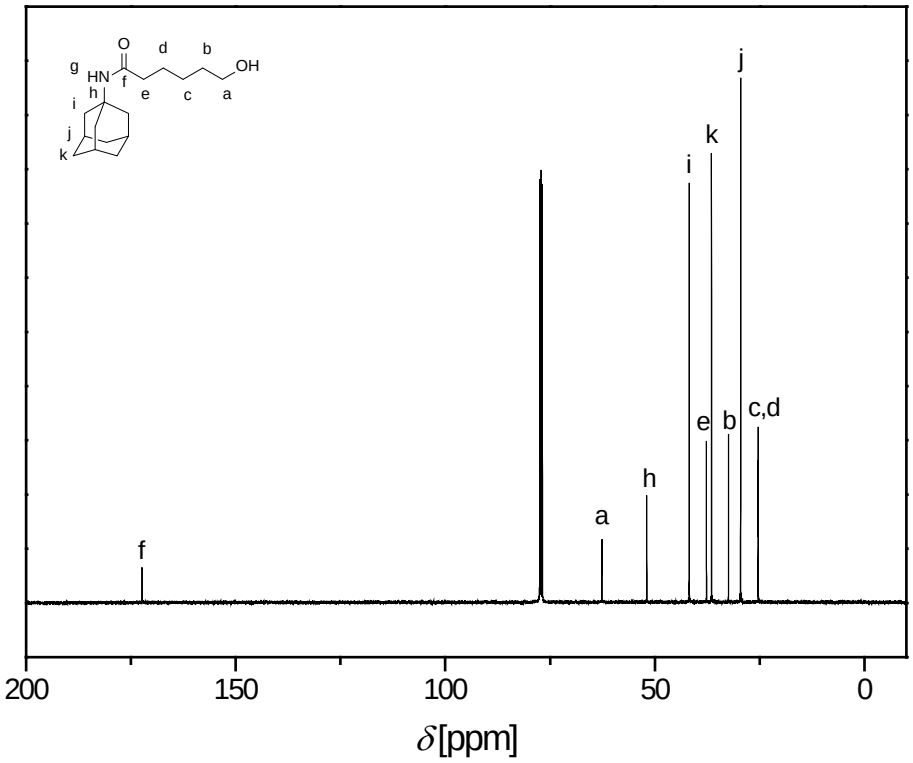

Figure S2. ^{13}C-NMR spectrum of *N*-(adamantan-1-yl)-6-hydroxyhexanamide.

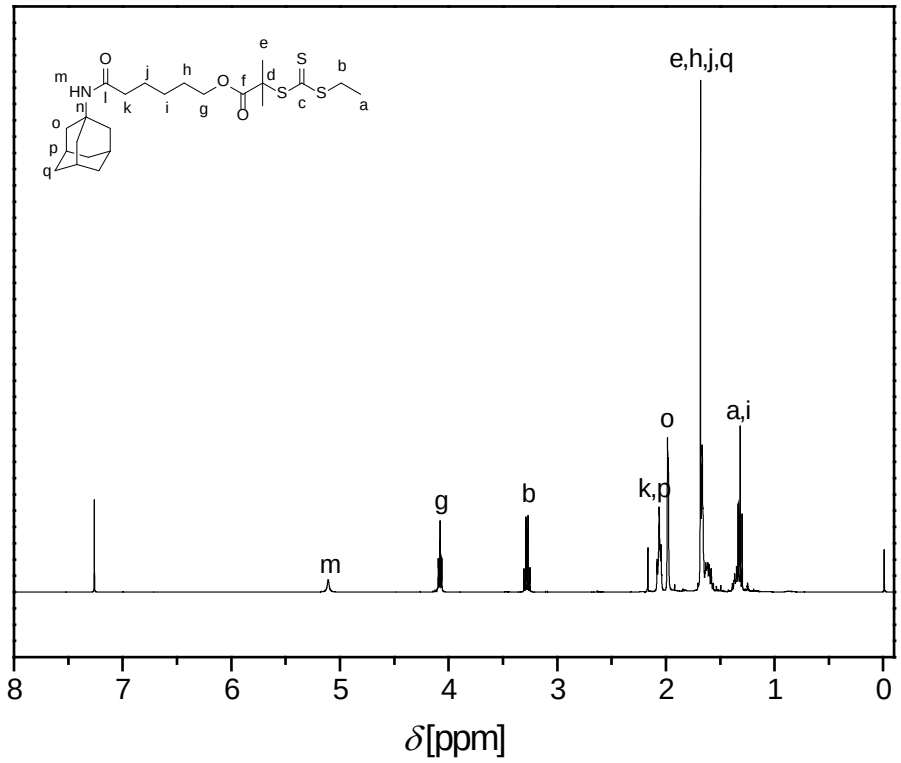

Figure S3. ^{1}H-NMR spectrum of 6-(adamantan-1-ylamino)-6-oxohexyl 2-(((ethylthio)carbonothioyl)thio)-2-methylpropanoate (**CTA1**).

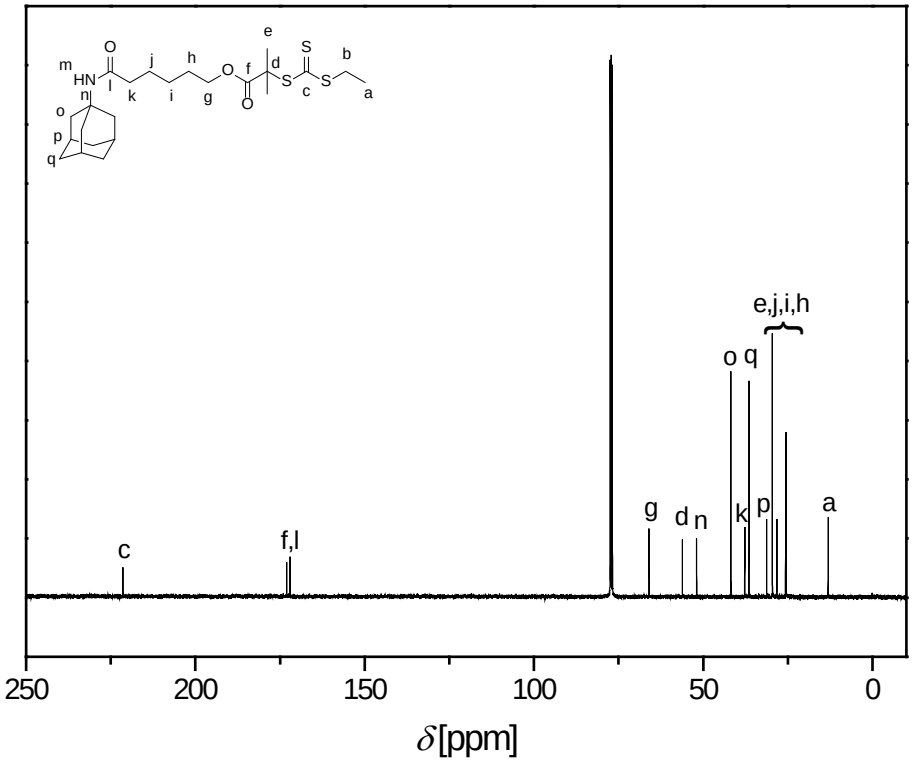

Figure S4. ^{13}C-NMR spectrum of 6-(adamantan-1-ylamino)-6-oxohexyl 2-(((ethylthio)carbonothioyl)thio)-2-methylpropanoate (**CTA1**).

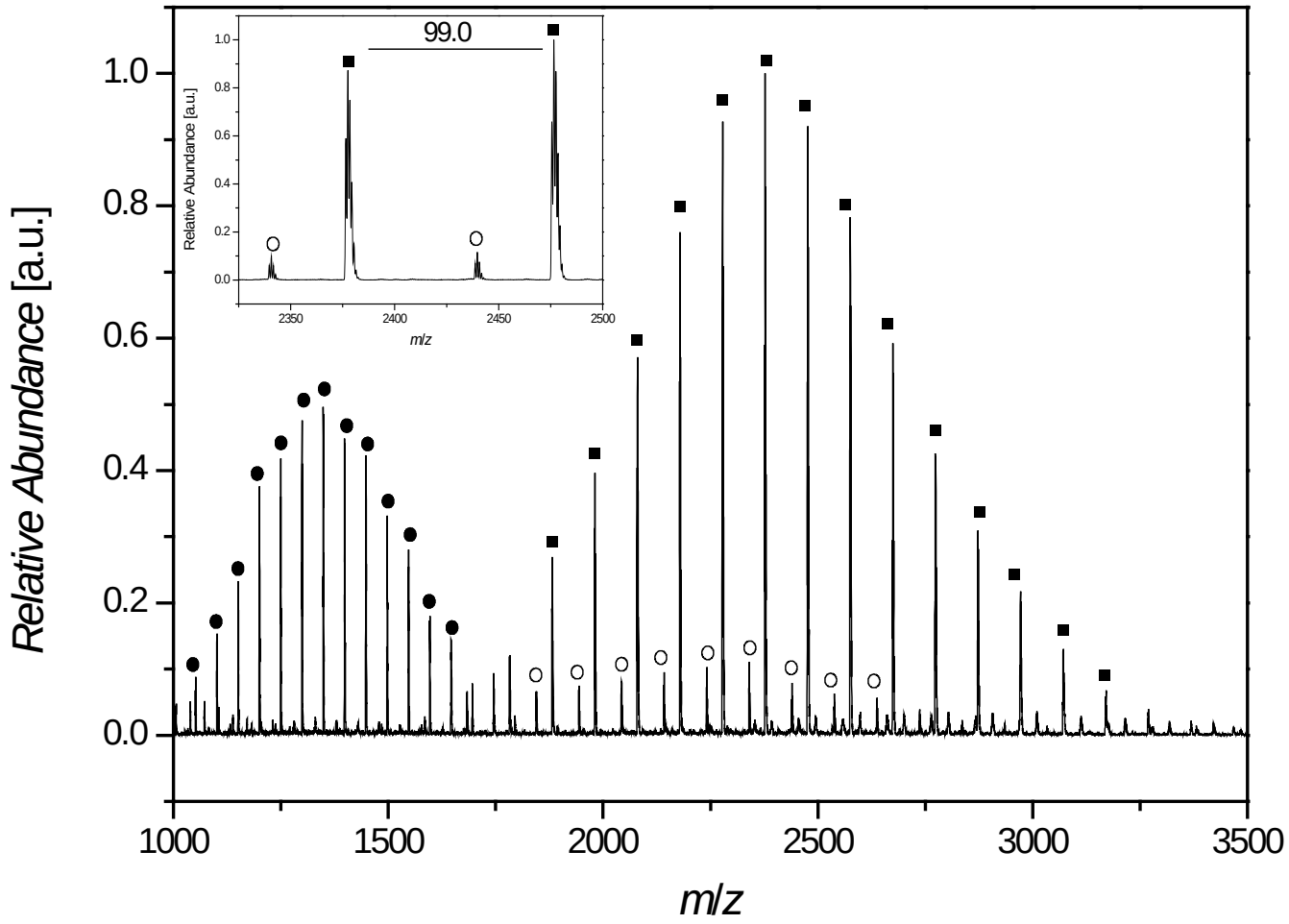

Figure S5. ESI-MS-spectrum of an adamantyl-functionalized PDMAAm (M_{nGPC} = 3900 g·mol^{-1}, $Đ_M$ = 1.07) polymerized with **CTA1**.

Table S1. Theoretical and experimental *m*/*z* of PDMAAm polymerized with **CTA1**.

Species	m/z_{theo}	$m/z_{exp.}$	$\Delta\ m/z$
■ [**CTA1**(DMAAm)$_{20}$+Na]$^+$	2476.5550	2476.55	0.00
● [**CTA1**(DMAAm)$_{23}$+2Na]$^{2+}$	1348.8408	1348.82	0.02
○ [**CTA1**(DMAAm)$_{25}$-Adamantyl+Na]$^+$	2440.5060	2439.82	0.69

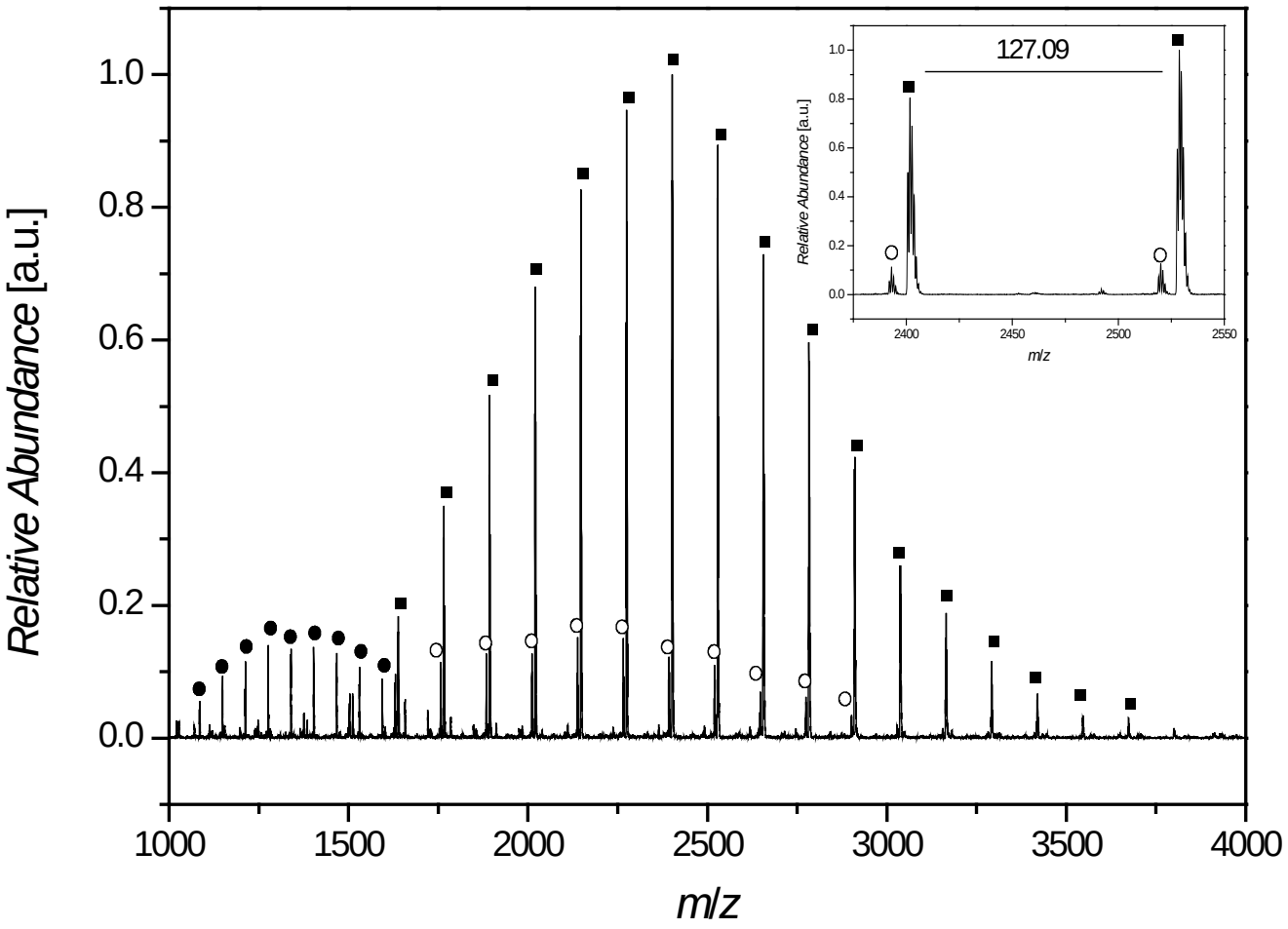

Figure S6. ESI-MS-spectrum of an adamantyl-functionalized PDEAAm (M_{nGPC} = 2700 g·mol^{-1}, $Đ_M$ = 1.08) polymerized with **CTA1**.

Table S2. Theoretical and experimental *m*/*z* of PDEAAm polymerized with **CTA1**.

Species	m/z_{theo}	$m/z_{exp.}$	$\Delta\, m/z$
■ [**CTA1**(DEAAm)$_{16}$+Na]$^+$	2528.7821	2528.82	0.04
● [**CTA1**(DEAAm)$_{17}$+2Na]$^{2+}$	1339.4358	1339.45	0.01
○ [**CTA1**(DEAAm)$_{17}$-Adamantyl+Na]$^+$	2520.7644	2520.00	0.76

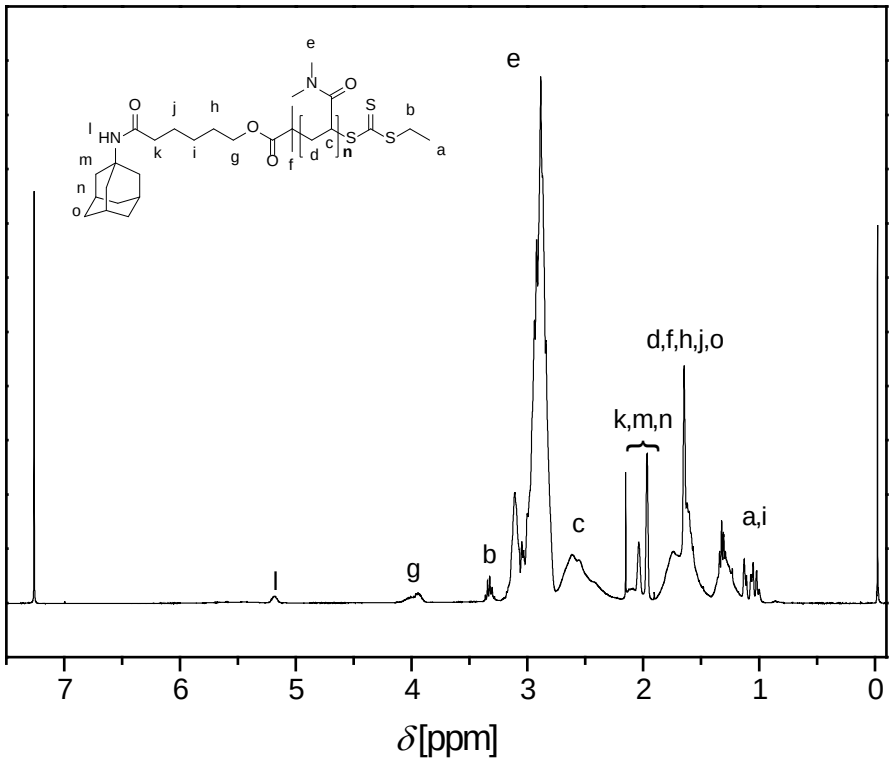

Figure S7. ^{1}H-NMR spectrum of an adamantyl-functionalized PDMAAm (M_{nGPC} = 3900 g·mol^{-1}, $Đ_M$ = 1.07) recorded in $CDCl_3$ at 25 °C.

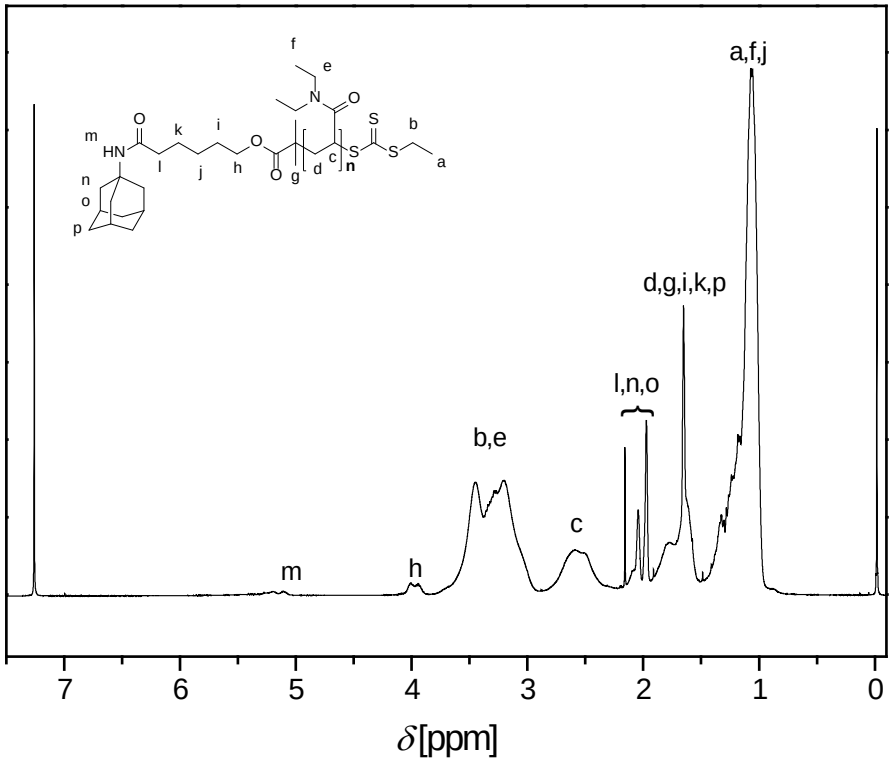

Figure S8. ^{1}H-NMR spectrum of an adamantyl-functionalized PDEAAm (M_{nGPC} = 2700 g·mol^{-1}, $Đ_M$ = 1.08) recorded in $CDCl_3$ at 25 °C.

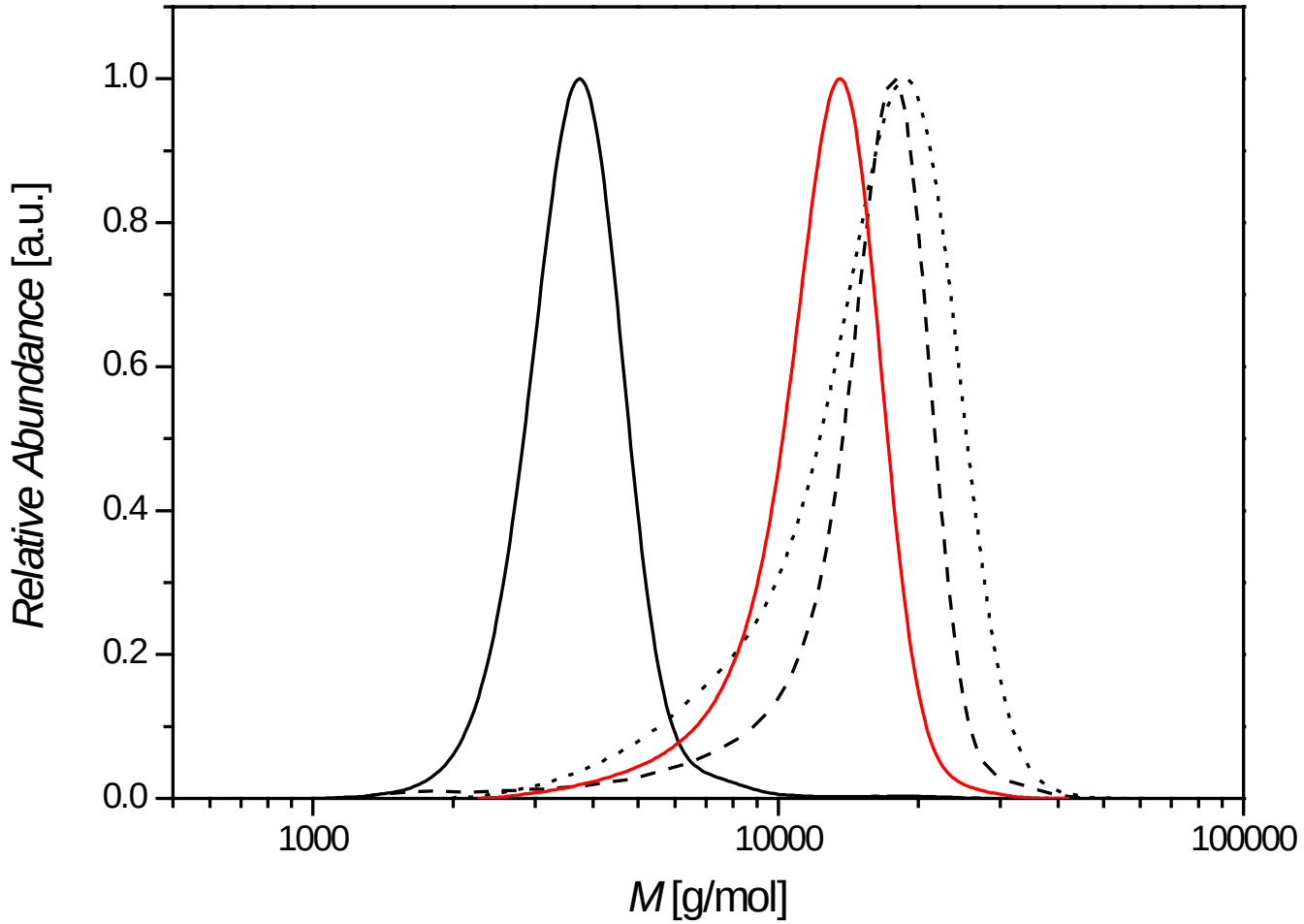

Figure S9 Molecular weight distributions for PDMAAm$_{31}$-Ad (solid black line), PDMAAm$_{143}$-Ad (dashed black line), PDMAAm$_{202}$-Ad (dotted black line), and PDEAAm$_{87}$-Ad (solid red line).

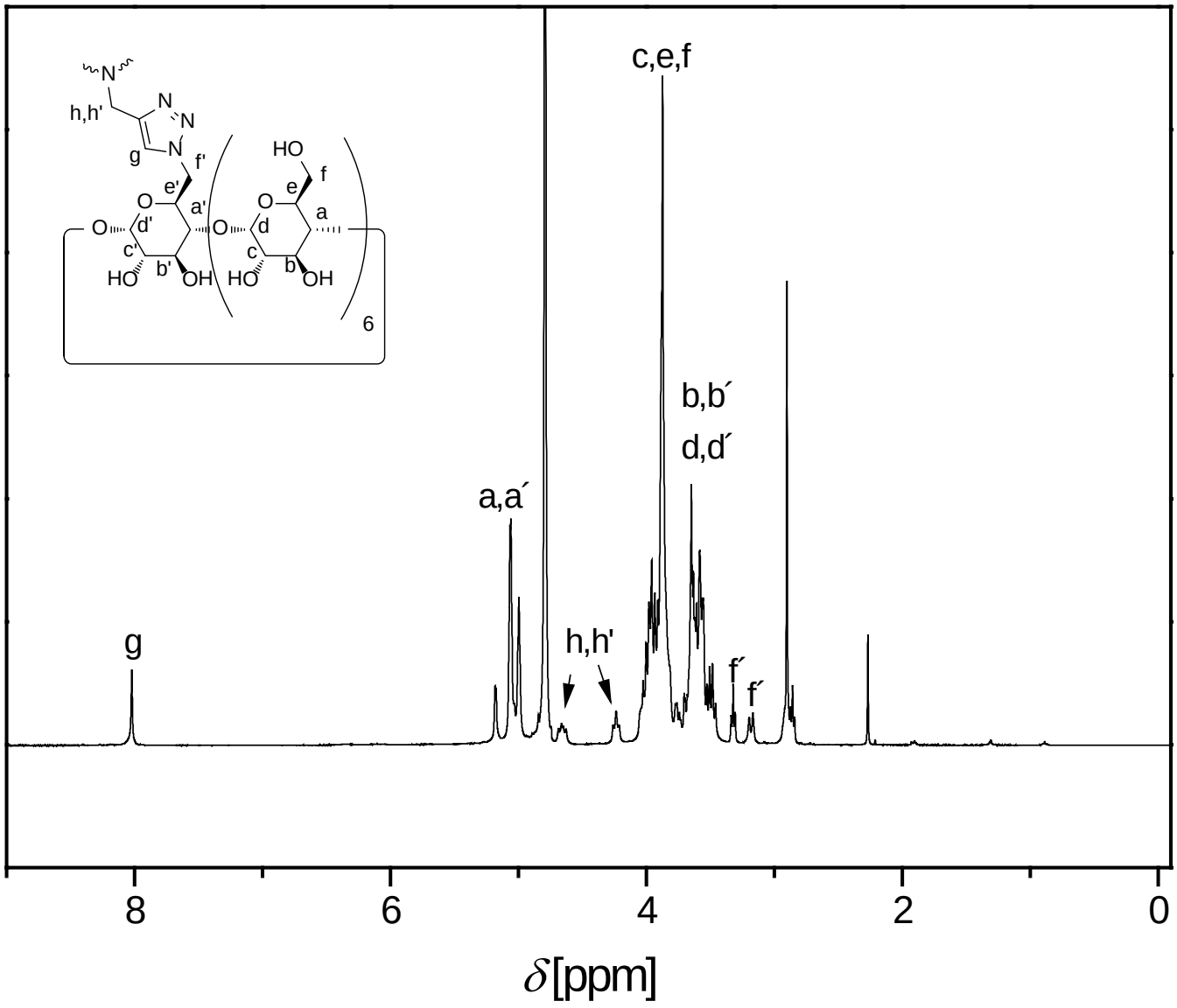

Figure S10. ^{1}H-NMR spectrum of the three-pronged β-CD core (β-CD_3) recorded in D_2O at 25 °C.

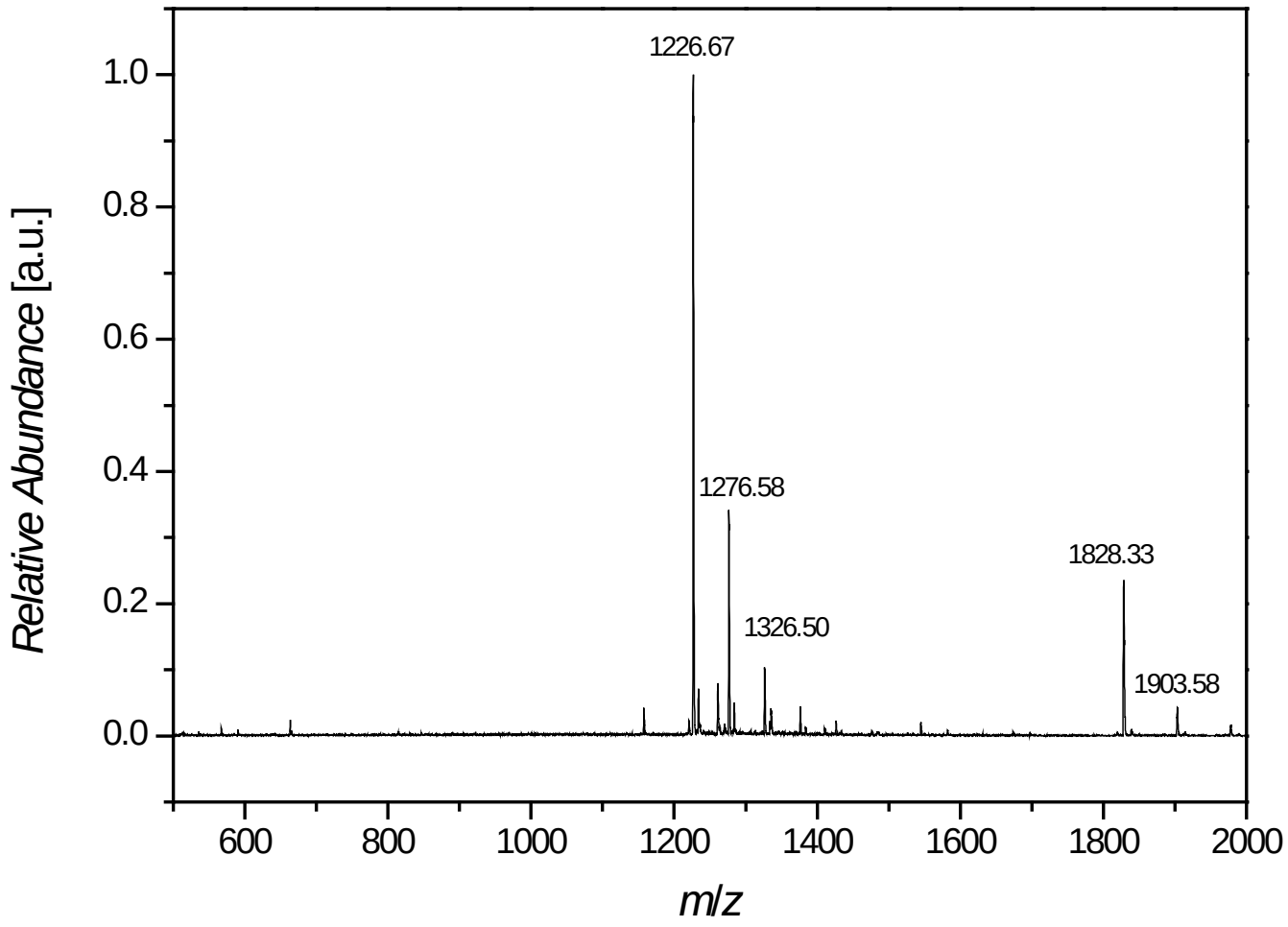

Figure S11. ESI-MS-spectrum of the three-pronged β-CD core (β-CD_3) (ionized with NaI).

Table S3. Theoretical and experimental *m*/*z* of β-CD_3 (ionized with NaI).

Species	m/z_{theo}	$m/z_{exp.}$	Δ *m*/*z*
$[\beta\text{-}CD_3+2Na]^{2+}$	1828.0926	1828.33	0.24
$[\beta\text{-}CD_3+I^-+3Na]^{2+}$	1903.0397	1903.58	0.54
$[\beta\text{-}CD_3+3Na]^{3+}$	1226.3916	1226.67	0.28
$[\beta\text{-}CD_3+I^-+4Na]^{3+}$	1276.6564	1276.58	0.22
$[\beta\text{-}CD_3+2I^-+5Na]^{3+}$	1326.3211	1326.50	0.18

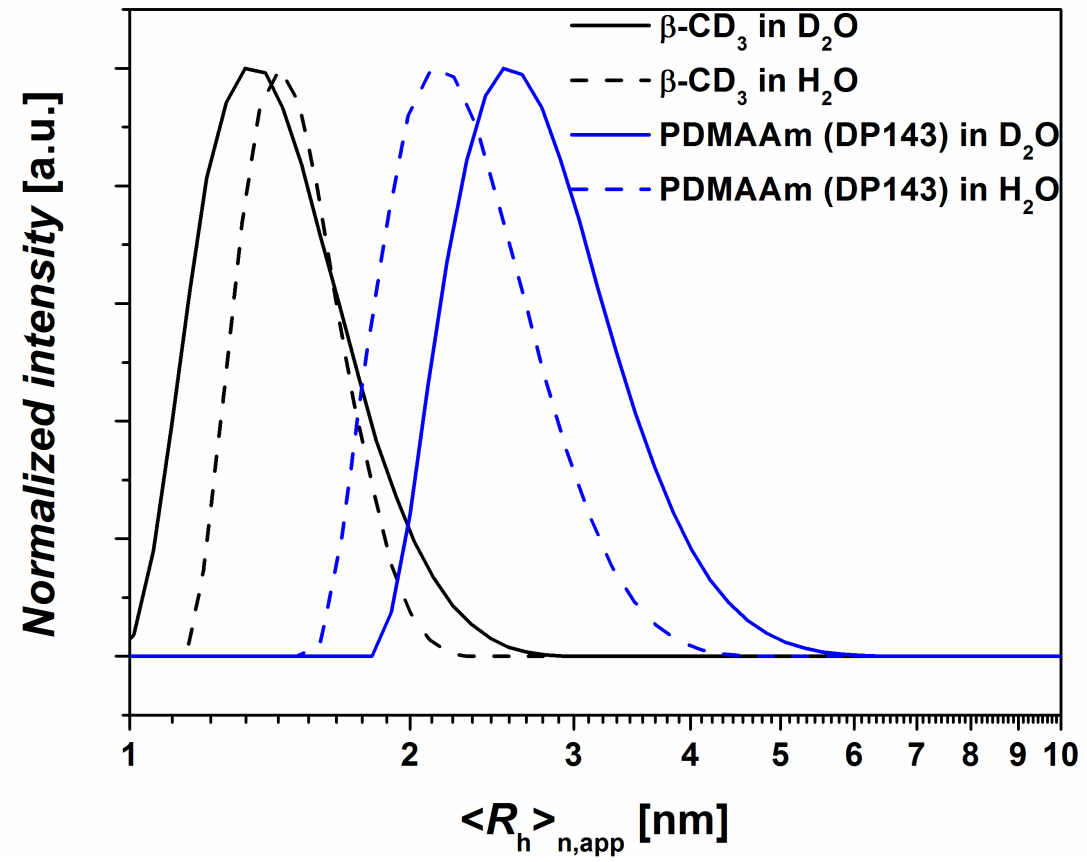

Figure S12. Comparison of the number averaged hydrodynamic radii for the core (β-CD_3) (black line) and $PDMAAm_{143}$ (blue line) in different solvents: H_2O (dashed line) and D_2O (straight line) at 25 °C.

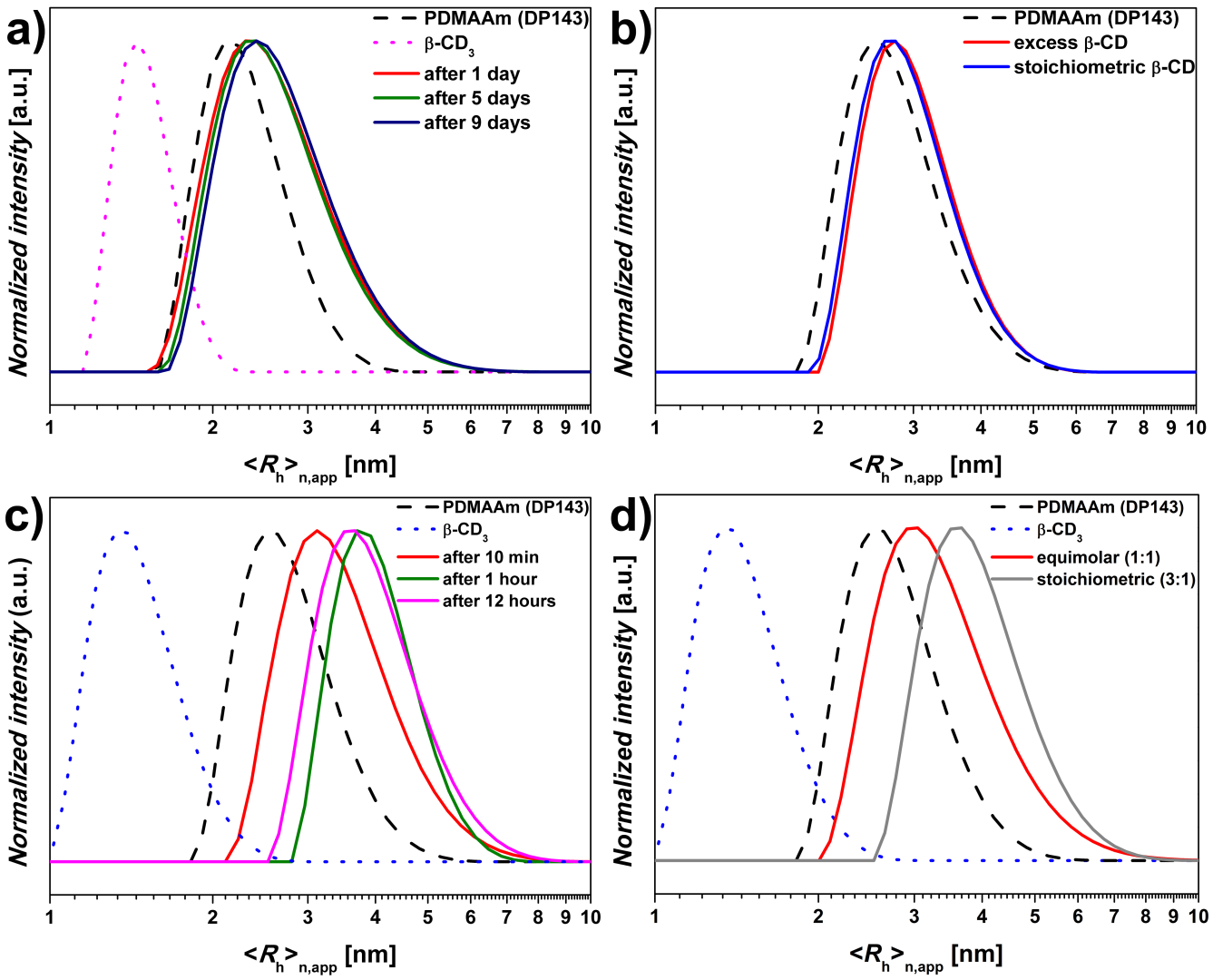

Figure S13. Number averaged hydrodynamic radii a) for $PDMAAm_{143}$ mixed with the β-CD_3 core and the resulting supramolecular star polymers over several days in H_2O at 25 °C; b) for $PDMAAm_{143}$ mixed with β-CD at 25 °C in D_2O; c) for $PDMAAm_{143}$ mixed with the β-CD_3 core in a time dependent investigation of the self-assembly process; d) for $PDMAAm_{143}$ mixed with a molar excess of 3:1 of the β-CD_3 core (red line) and for a stoichiometric mixture of $PDMAAm_{143}$ and the β-CD_3 core with a molar ratio of 3:1 (grey line) (D_2O, 25 °C).

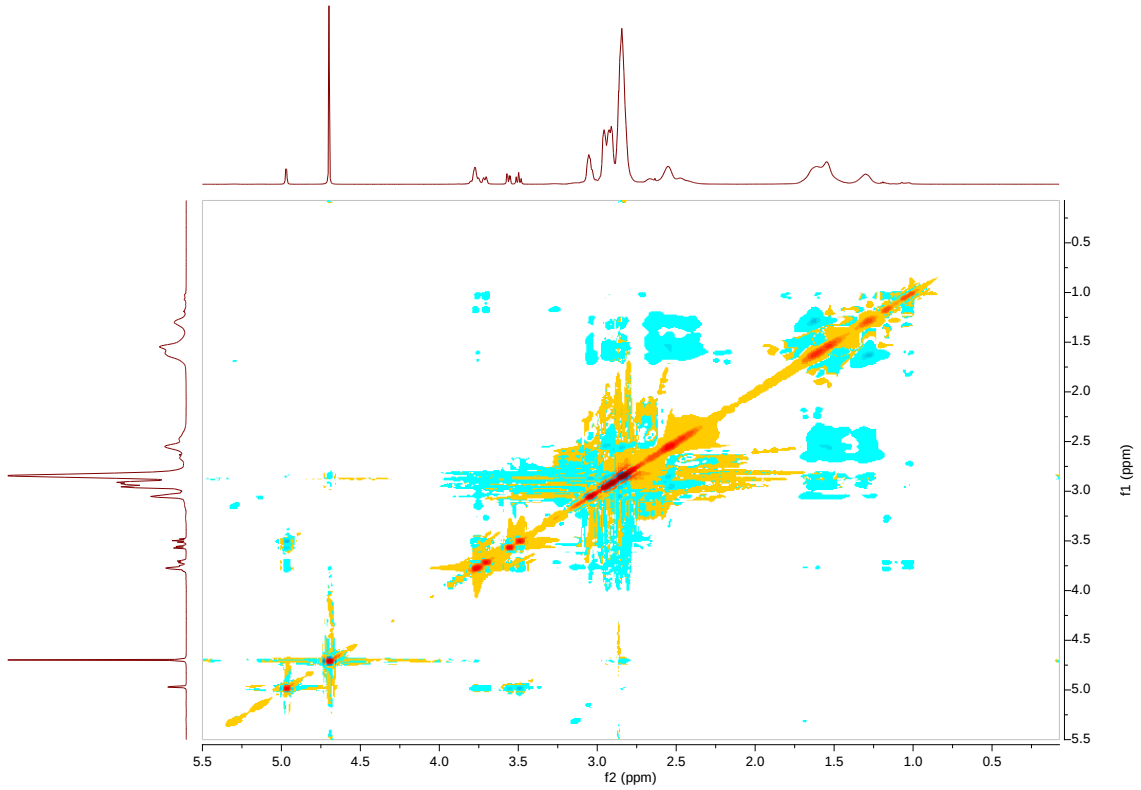

Figure S14. 2D ROESY NMR spectrum of a 1:1.1 molar mixture of PDMAAm (M_{nGPC} = 12800 g·mol^{-1}, $Đ_M$ = 1.10) polymerized with EMP and β-CD in D_2O at 25 °C.

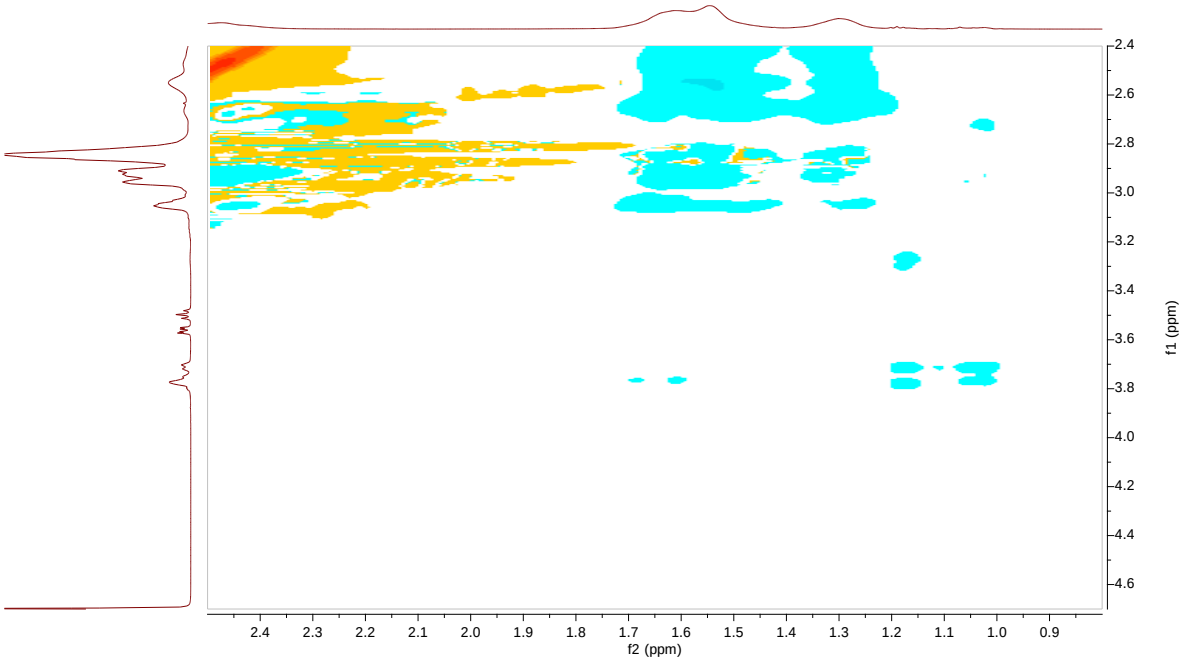

Figure S15. Magnification of the 2D ROESY NMR spectrum of a 1:1.1 molar mixture of PDMAAm (M_{nGPC} = 12800 g·mol^{-1}, $Đ_M$ = 1.10) polymerized with EMP and β-CD in D_2O at 25 °C.

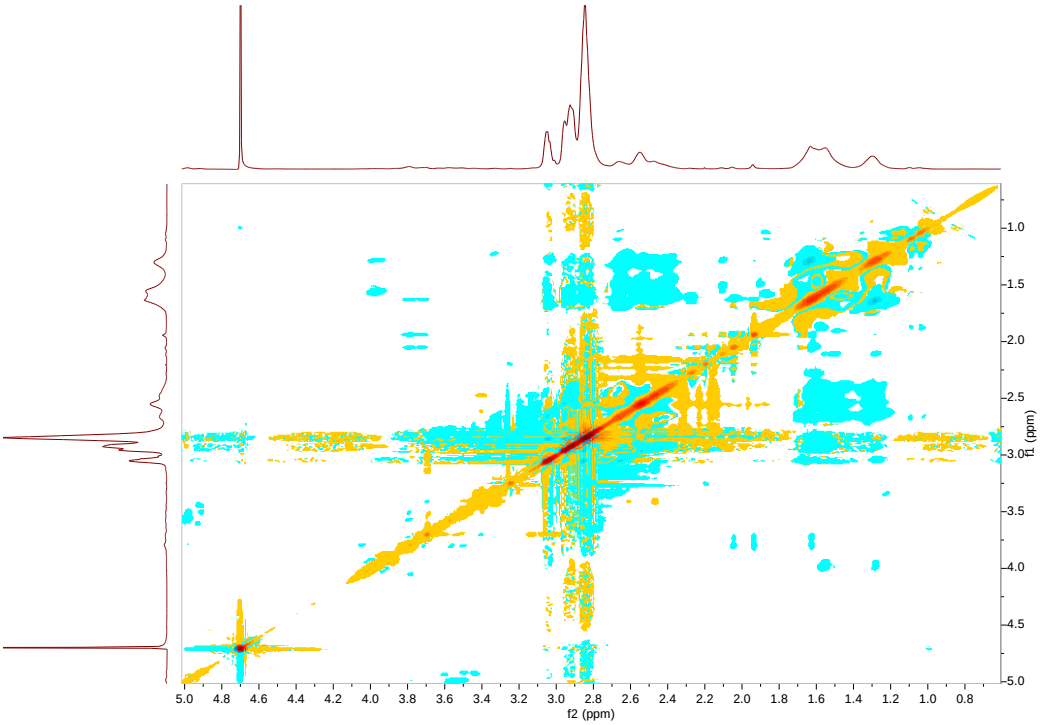

Figure S16. 2D ROESY NMR spectrum of a 3:1 molar mixture of an adamantyl-functionalized PDMAAm (M_{nGPC} = 14600 g·mol^{-1}, $Đ_M$ = 1.12) polymerized with **CTA1** and the β-CD_3 core in D_2O at 25 °C.

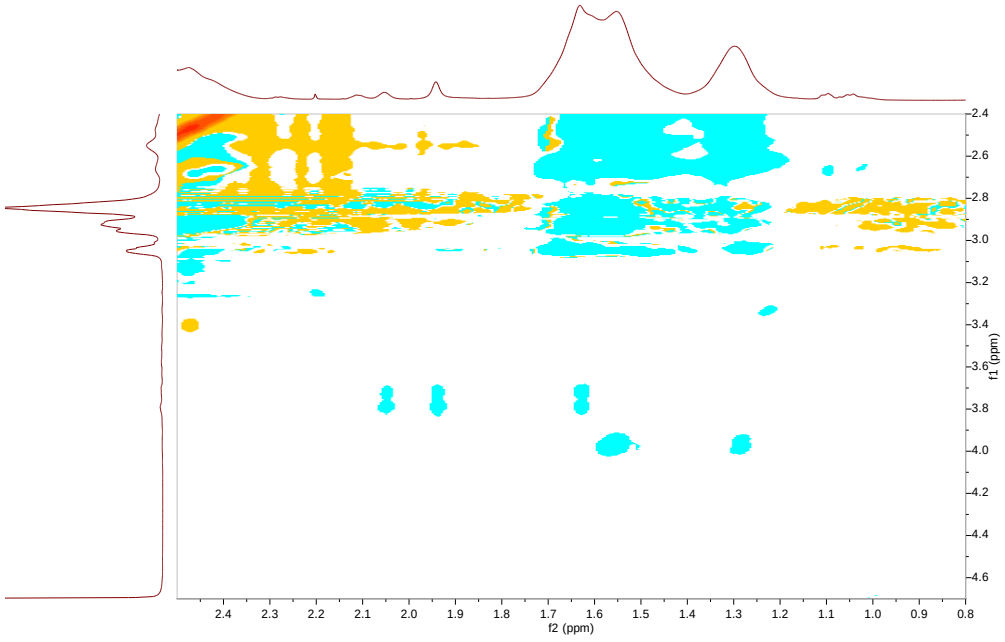

Figure S17. Magnification of the 2D ROESY NMR spectrum of a 3:1 molar mixture of an adamantyl-functionalized PDMAAm (M_{nGPC} = 14600 g·mol^{-1}, $Đ_M$ = 1.12) polymerized with **CTA1** and the β-CD_3 core in D_2O at 25 °C.

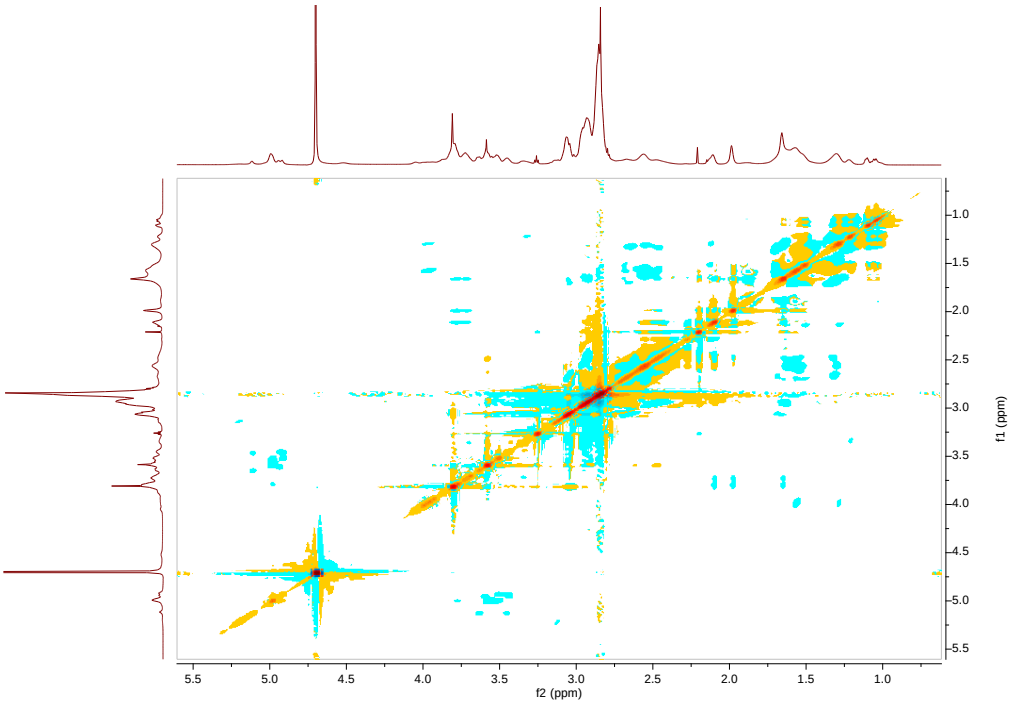

Figure S18. 2D ROESY NMR spectrum of a 3:1 molar mixture of an adamantyl-functionalized PDMAAm (M_{nGPC} = 3900 g·mol^{-1}, $Đ_M$ = 1.07) polymerized with **CTA1** and the β-CD_3 core in D_2O at 25 °C.

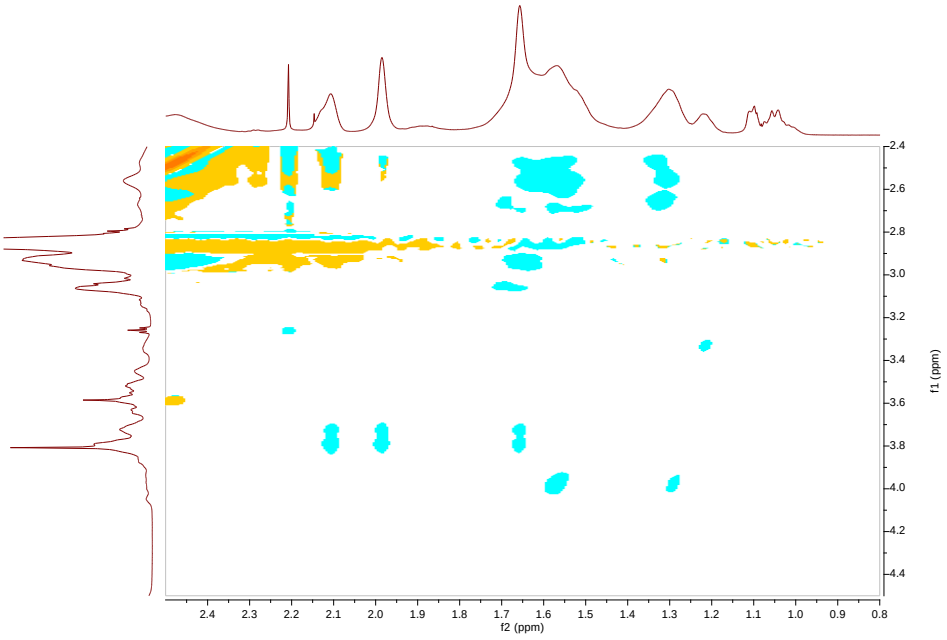

Figure S19. Magnification of the 2D ROESY NMR spectrum of a 3:1 molar mixture of an adamantyl-functionalized PDMAAm (M_{nGPC} = 3900 g·mol^{-1}, $Đ_M$ = 1.07) polymerized with **CTA1** and the β-CD_3 core in D_2O at 25 °C.

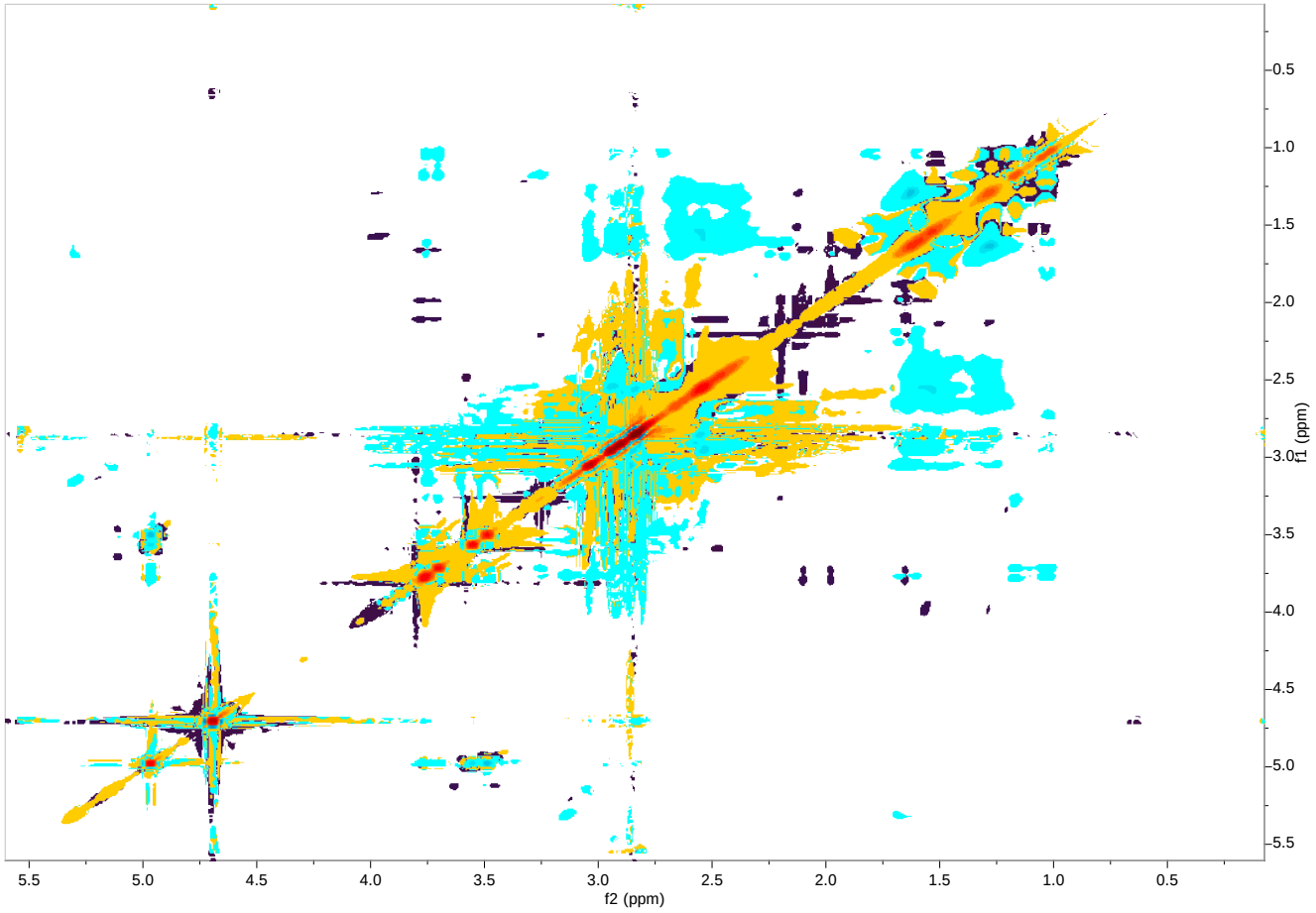

Figure S20. Overlay of the 2D ROESY NMR spectra in D_2O at 25 °C. Violet: 3:1 molar mixture of an adamantyl-functionalized PDMAAm (M_{nGPC} = 3900 g·mol^{-1}, $Đ_M$ = 1.08) polymerized with **CTA1** and the β-CD_3 core. Turquoise: 1:1.1 molar mixture of PDMAAm (M_{nGPC} = 12800 g·mol^{-1}, $Đ_M$ = 1.10) polymerized with EMP and β-CD.

References

1. Z. Yu, A. R. Sawkar, L. J. Whalen, C.-H. Wong and J. W. Kelly, *Journal of Medicinal Chemistry*, 2006, **50**, 94-100.