Supplementary Information (SI) for Soft Matter.

SUPPORTING INFORMATION

Novel amphiphilic copolymers as stabilizers for glyceryl monooleate-based lipid-polymer hybrid nanoparticles

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1. NMR

^{1}H NMR (600 MHz) spectra of copolymers were recorded at r.t. in $CDCl_3$ using a Bruker-Avance II 600 MHz (Fremont, CA, USA) equipped with Ultrashield Plus Magnets, with tetramethylsilane (TMS) as the internal standard.

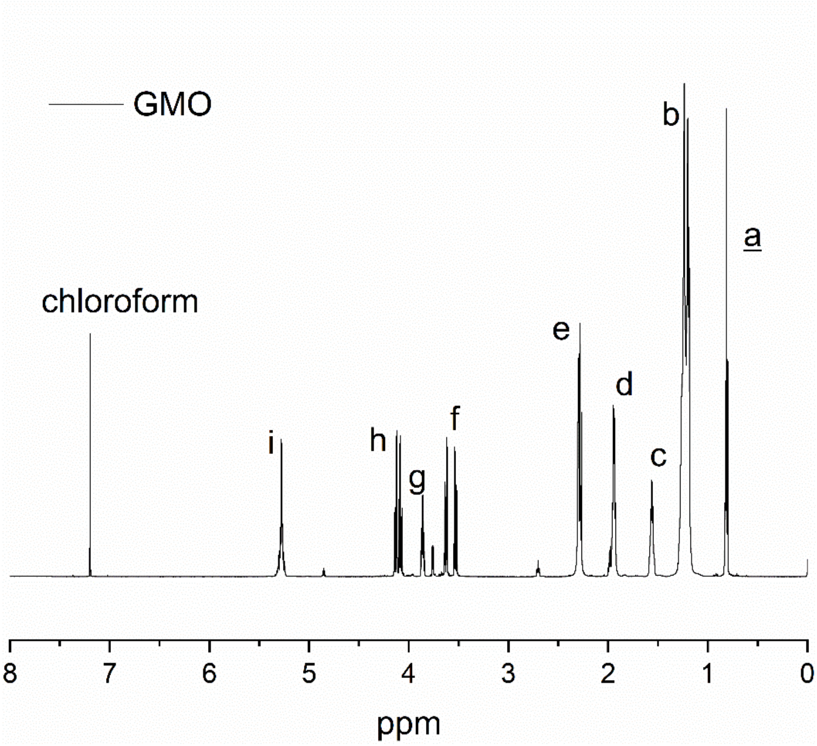

Figure S1. ^{1}H NMR spectrum of Glyceryl Monooleate

The molar mass of the copolymers was calculated as the sum of the molar masses of the hydrophilic and hydrophobic blocks. The m olar mass of the hydrophilic block was known to be 5000 g/mol (determined by SEC and ^{1}HNMR). The molar mass of the hydrophobic block was determined based on the integral ratio between the signal from the methoxy end group protons (-OC**H**$_3$) and the methylene protons of the carbonate units (-C(O)OC**H**$_2$-).

$$M_{HNMR} = 5000 + \frac{3 I_{C(O)OCH_2}}{4 \ I_{CH_3O}} \cdot M_{monomer}$$

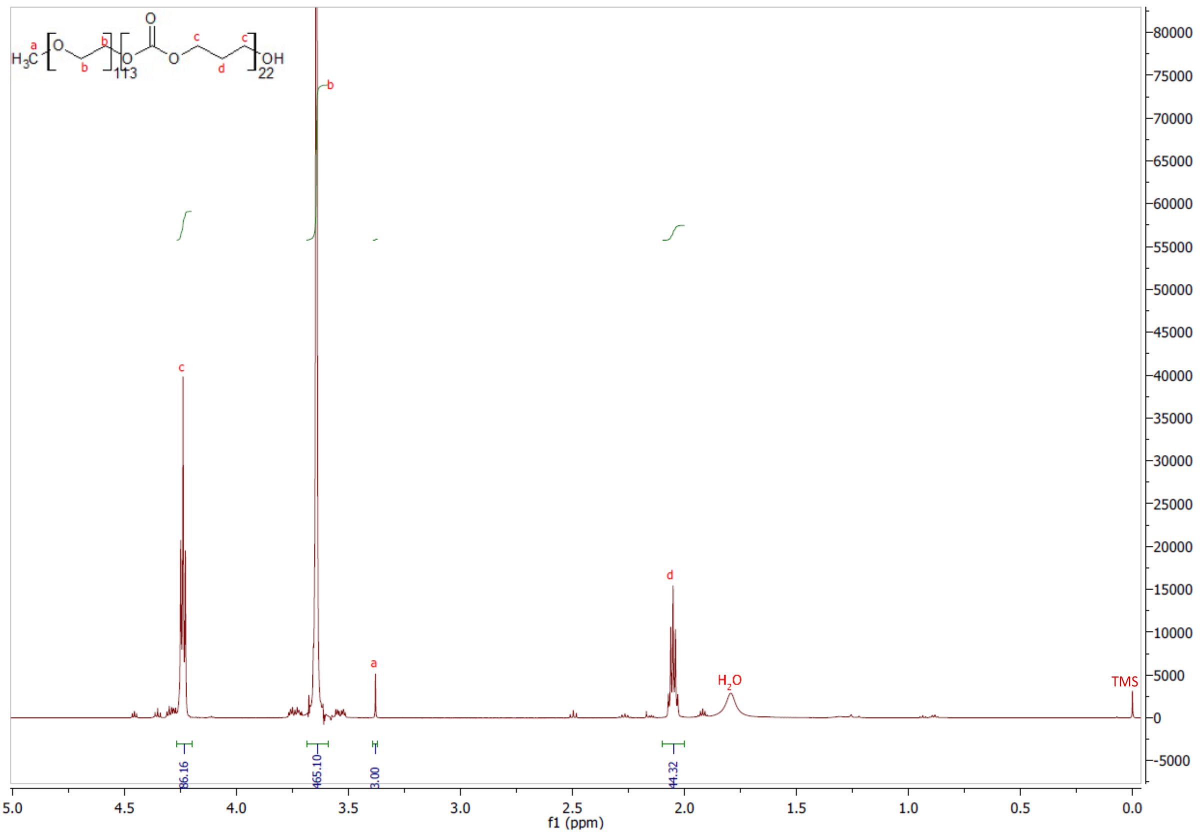

Figure S2. ^{1}H NMR spectrum of PEG-*b*-PTMC

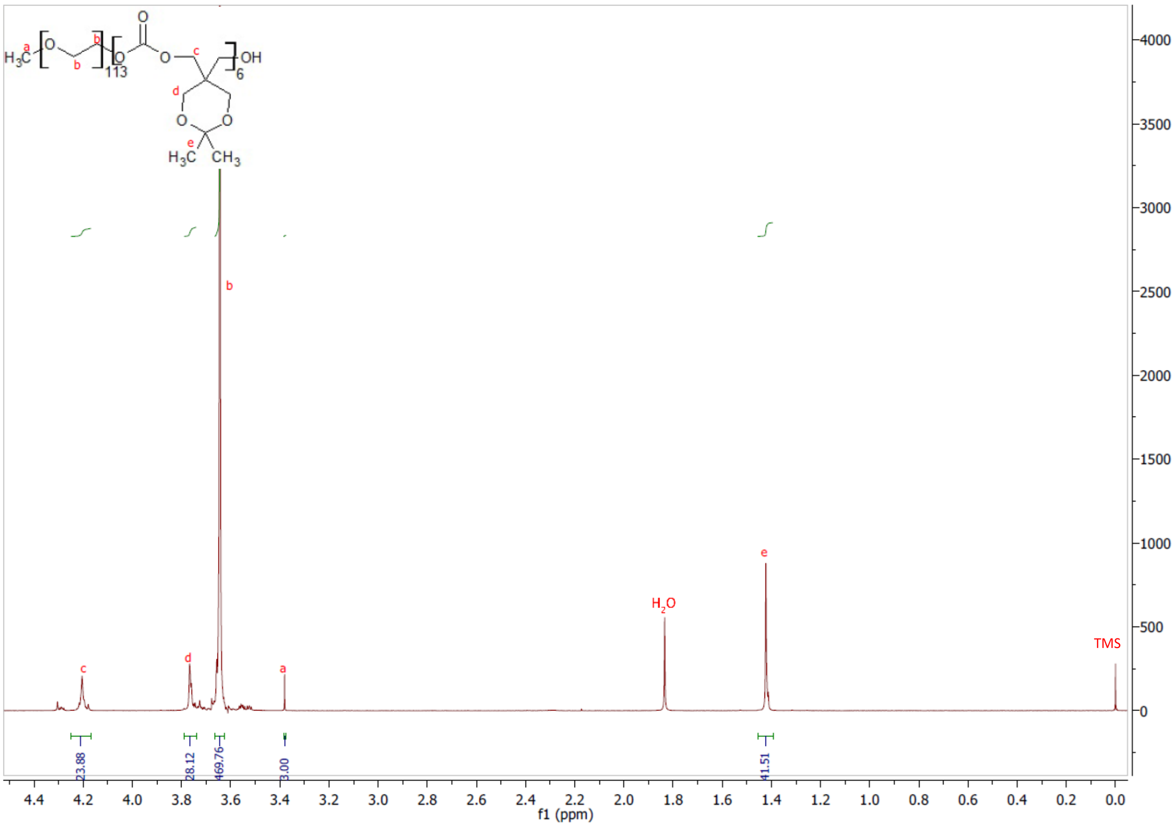

Figure S3. ^{1}H NMR spectrum of PEG-*b*-PKPC

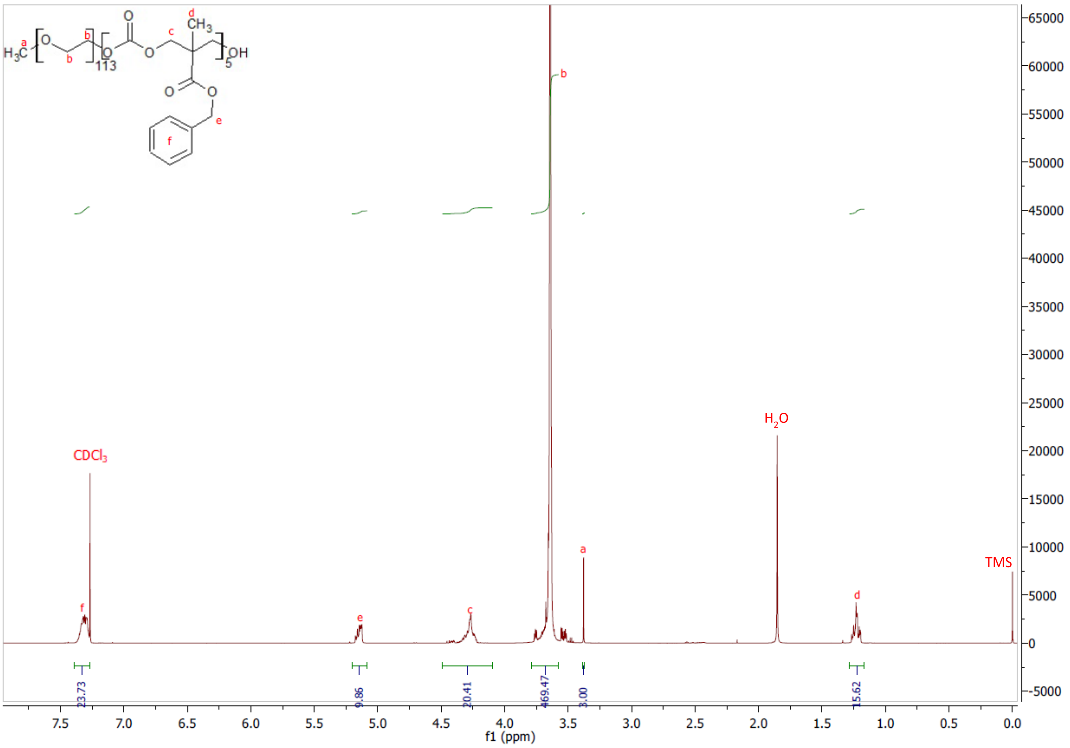

Figure S4. ^{1}H NMR spectrum of PEG-*b*-PMBC

The OEGMA$_{300}$ monomer showed complete (100%) conversion, as confirmed by HPLC analysis. The degree of polymerization of EMA units was calculated from the ^{1}H NMR spectrum by comparing the integration peak g (integral value 0.13, 1.2 ppm), corresponding to the methyl protons of the ethyl ester in the EMA unit, to peak e integration (integral value 0.92, 3.4 ppm), corresponding to the methyl protons of the methoxy group in the OEGMA$_{300}$ side chain, $DP_{EMA}=DP_{OEGMA}* Ig/Ie$.

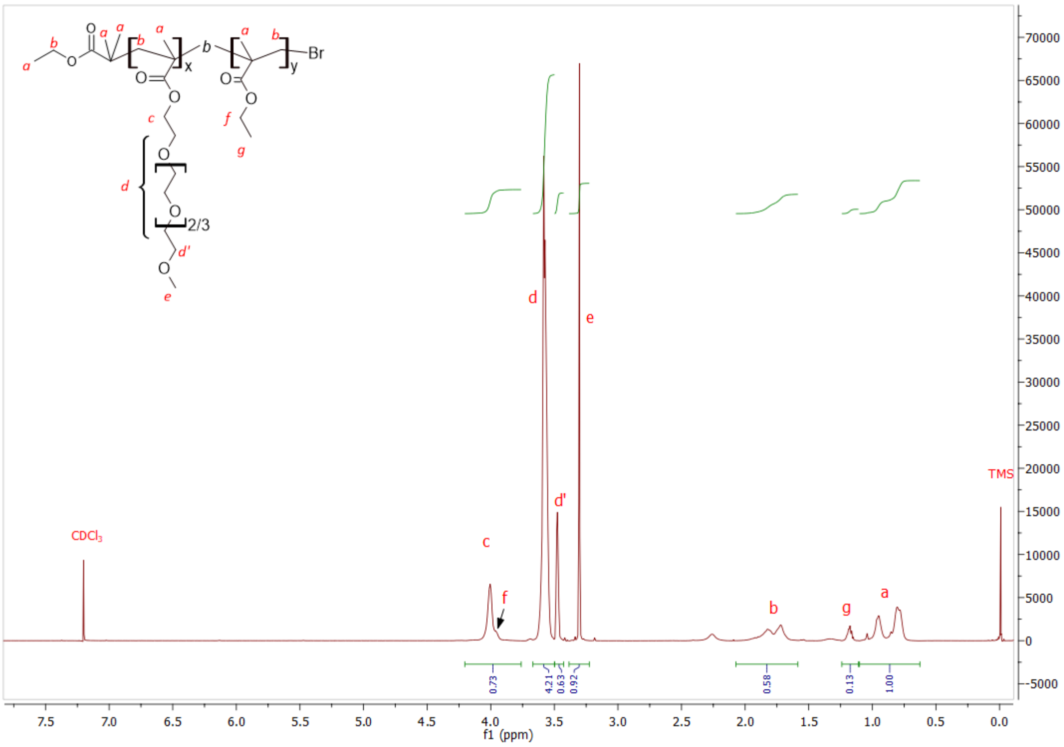

Figure S5. ^{1}H NMR spectrum of POEGMA-*b*-PEMA

2. Size exclusion chromatography (SEC)

SEC measurements were performed at 45°C using DMF containing 5 mmol L^{-1} LiBr as the eluent, at a nominal flow rate of 1 mL min^{-1}. The chromatography system consistent of a refractive index detector (Dn-2010RI, WGE Dr Bures) and a column system (the PSS gel GRAM guard column and three analytical columns PSSGRAM 100 Å, 1000 Å, and 3000 Å). Molar mass and dispersity were evaluated using ASTRA 5.3.4.10 software from Wyatt Technologies. Poly(ethylene glycol) standards with a low dispersity mass distribution (M_n values ranging from 1010 to 29,600 g mol^{-1}, Polymer Laboratories) were used to generate a calibration curve.

Chromatograms are presented in Figures S6-S10.

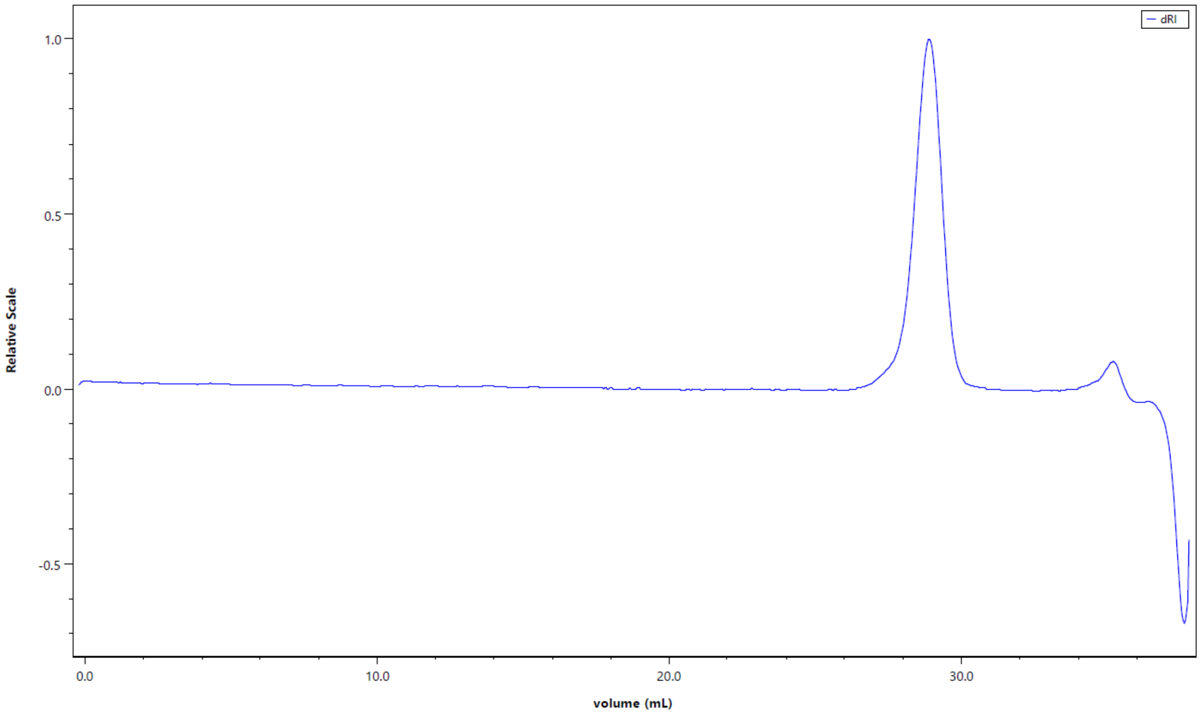

Figure S6. GPC chromatogram for PEG-*b*-PTMC

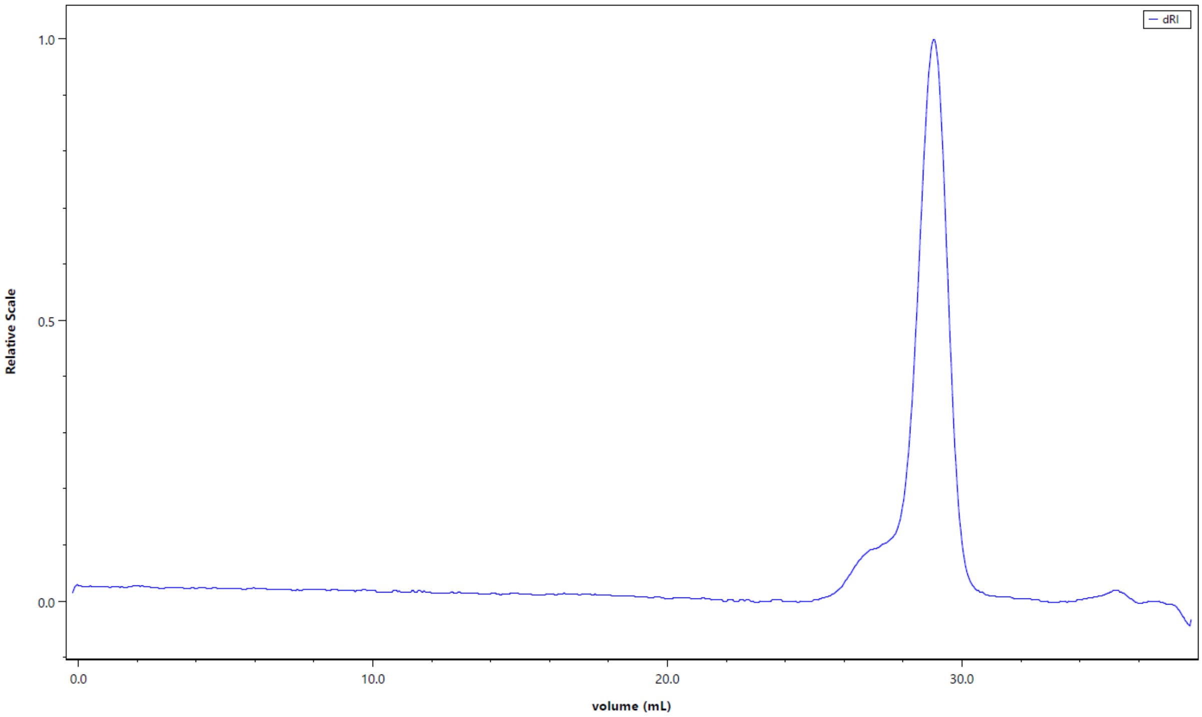

Figure S7. GPC chromatogram for PEG-*b*-PKPC

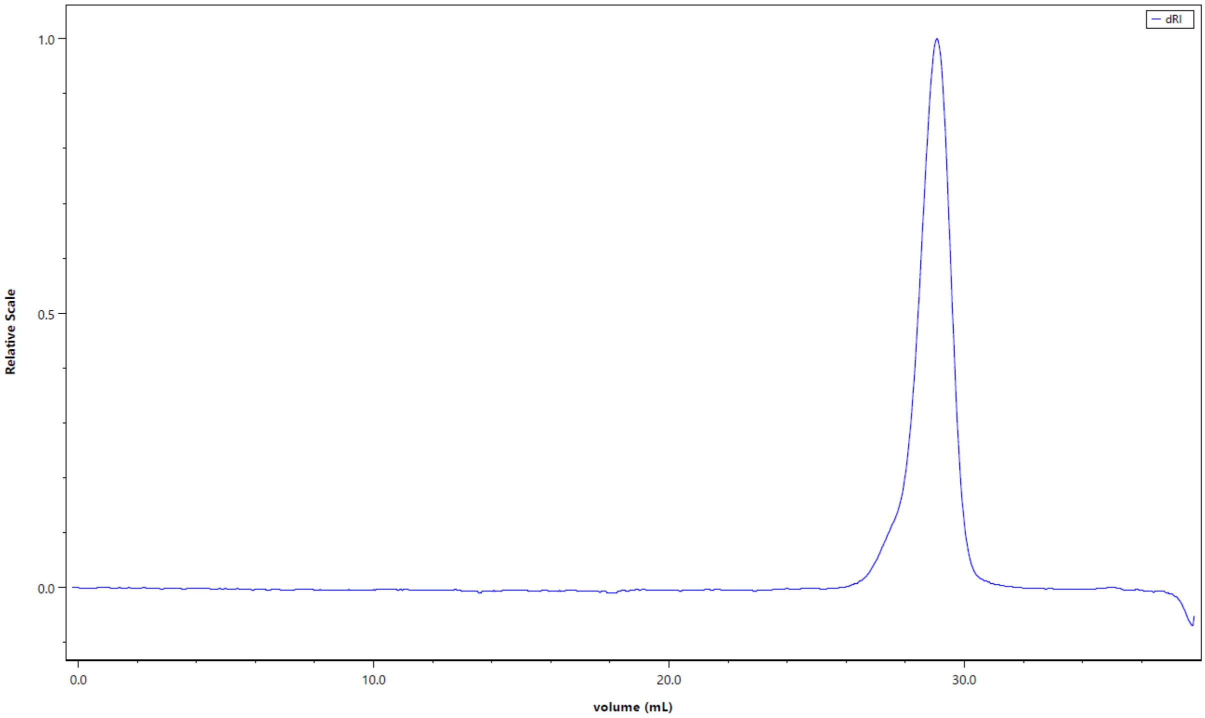

Figure S8. GPC chromatogram for PEG-*b*-PMBC(1)

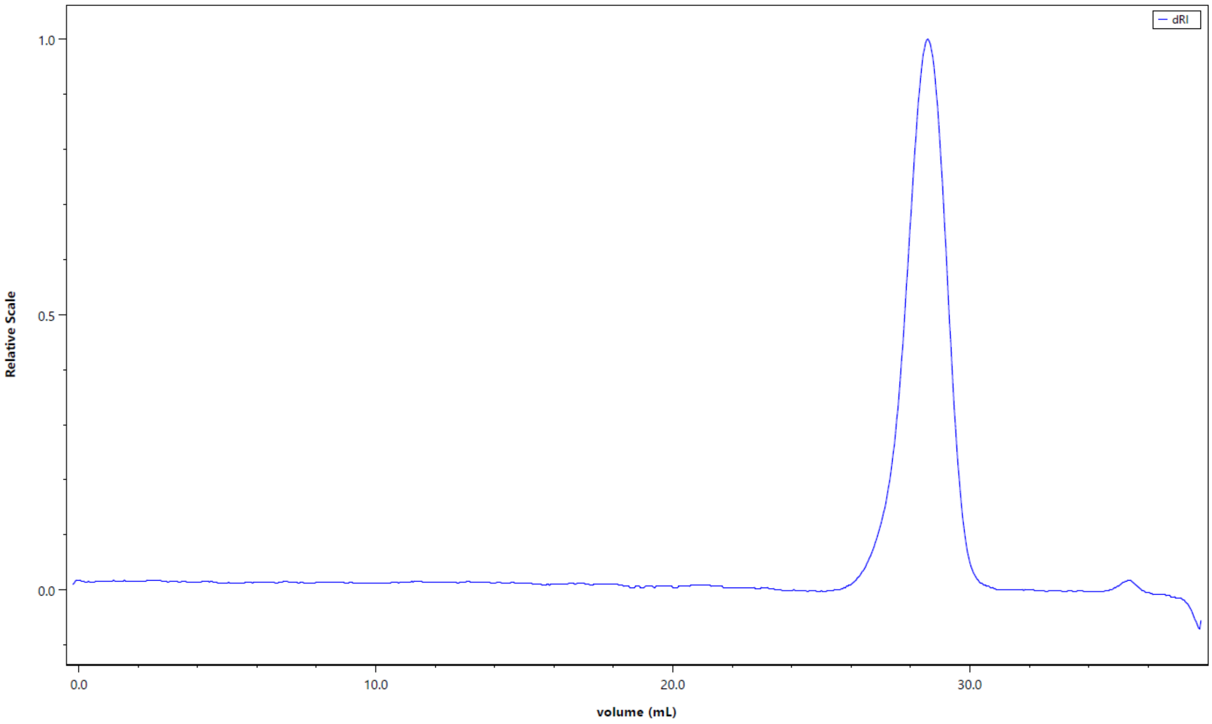

Figure S9. GPC chromatogram for PEG-*b*-PMBC(2)

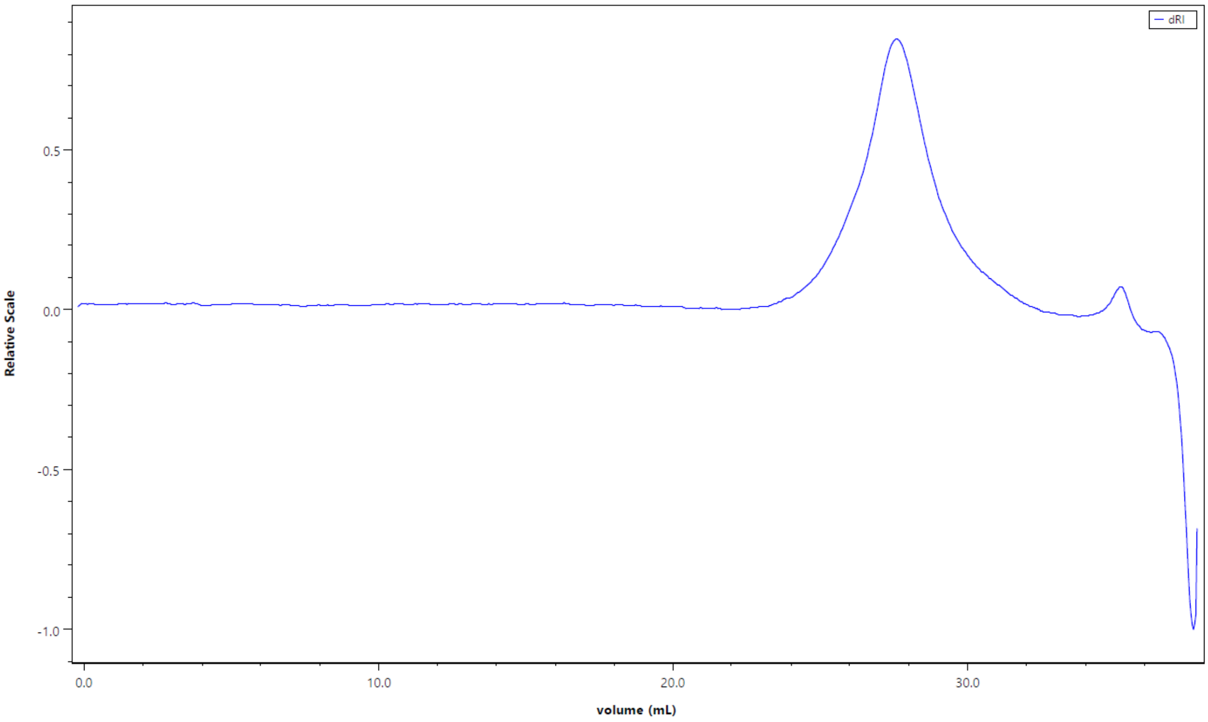

Figure S10. GPC chromatogram for POEGMA-*b*-PEMA

3. Dynamic light scattering distributions and cryo-TEM histograms

DLS measurements were performed in triplicate for each formulation and values reported in Table 2 represent mean ± standard deviation. For each cryo-TEM histogram, 200 particles from 20 micrographs were measured; reported sizes are given as mean ±1 nm.

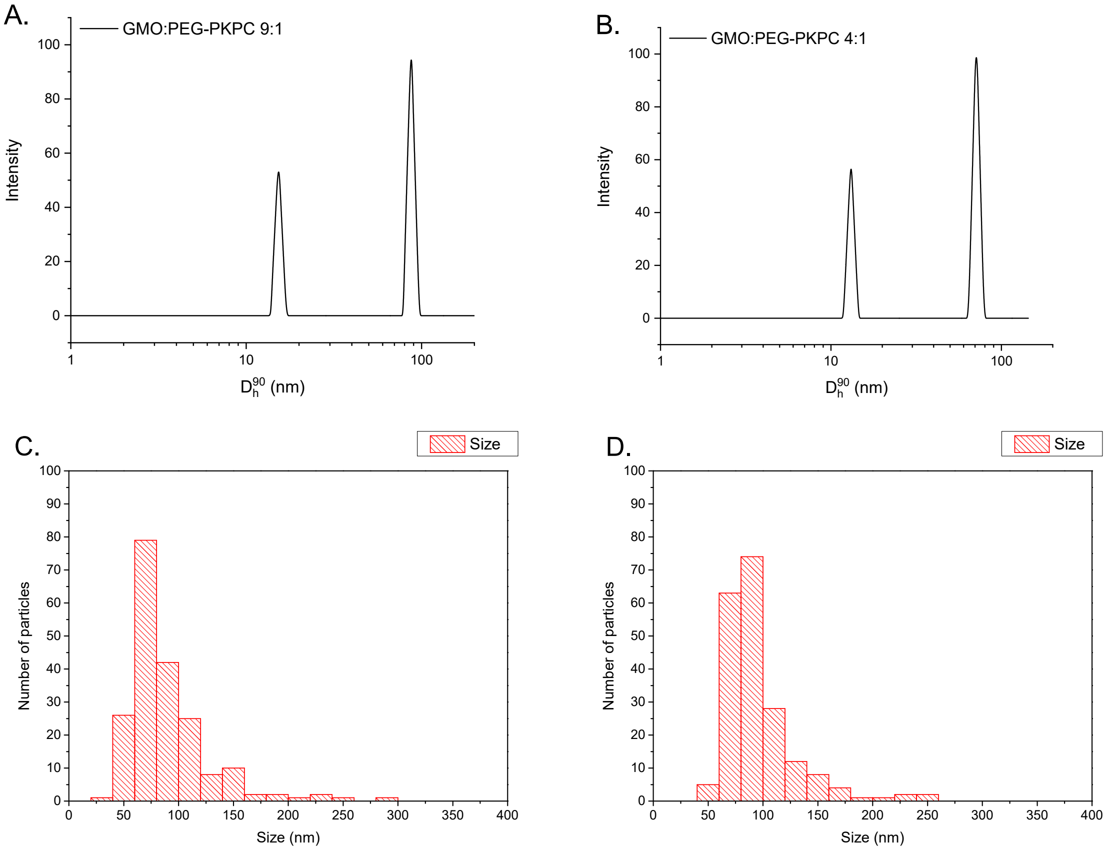

Figure S11. Dynamic light scattering distributions (by intensity) of **A.** GMO:PEG-*b*-PKPC 9:1, **B.** GMO:PEG-*b*- PKPC 4:1 and cryo-TEM histograms of sponges **C.** and **D.,** respectively

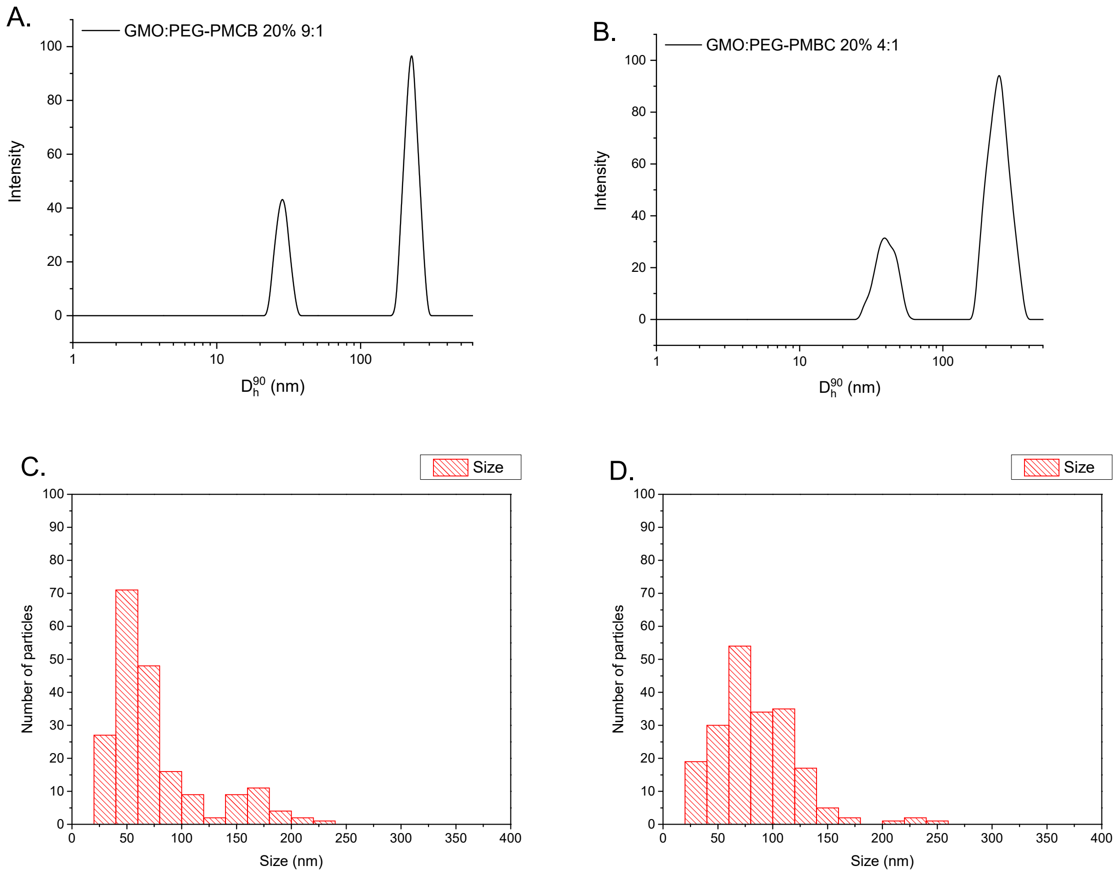

Figure S12. Dynamic light scattering results (by intensity) of **A.** GMO:PEG-*b*-PMBC(1) 9:1, **B.** GMO:PEG-*b*- PMBC(1) 4:1 and cryo-TEM histograms of sponges **C.** and **D.,** respectively

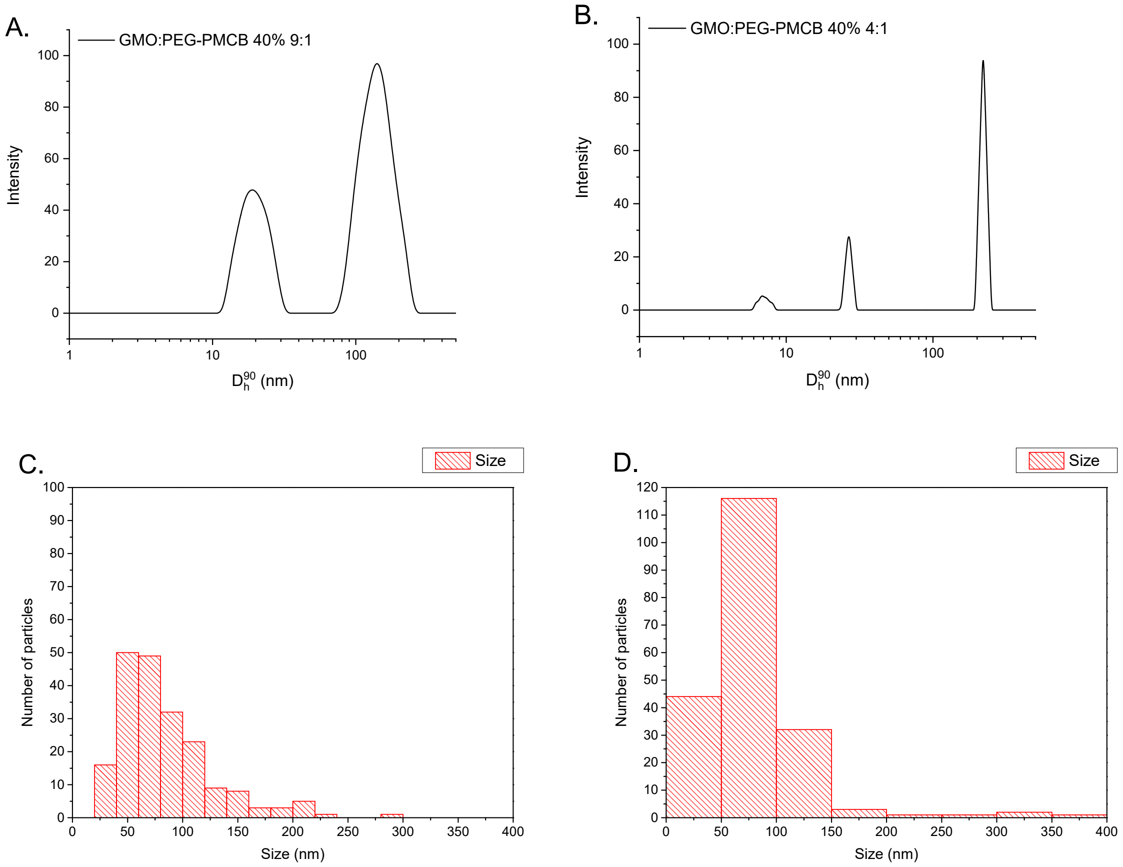

Figure S13. Dynamic light scattering distributions (by intensity) of **A.** GMO:PEG-*b*-PMBC(2) 9:1, **B.** GMO:PEG-*b*-PMBC(2) 4:1 and cryo-TEM histograms of sponges **C.** and **D.,** respectively

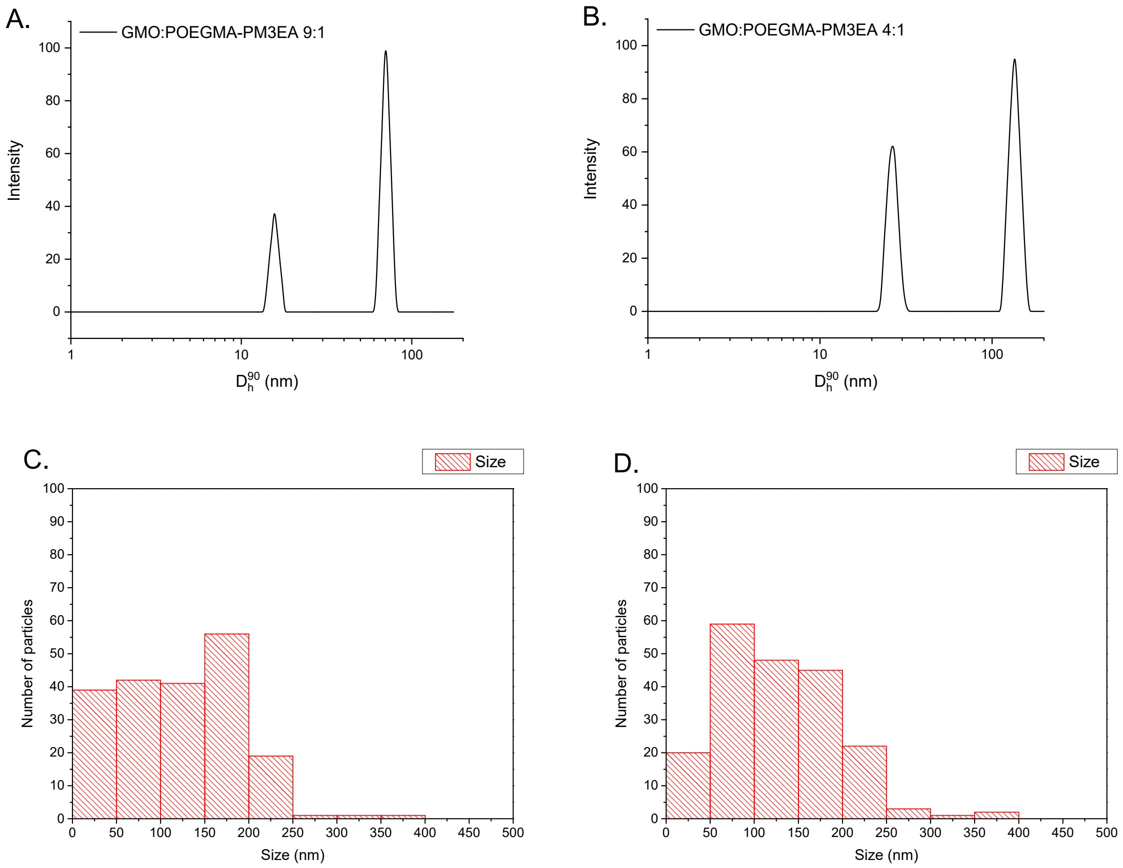

Figure S14. Dynamic light scattering distributions (by intensity) of **A.** GMO:POEGMA-*b*-PEMA 9:1, **B.** GMO: POEGMA-*b*-PEMA 4:1 and cryo-TEM histograms of sponges **C.** and **D.,** respectively

4. Phase transitions of copolymers studied by Differential Scanning Calorimetry (DSC)

The thermal transitions of diblock copolymers, including the glass transition temperature (T_g), melting temperature (T_m), and melting enthalpy (ΔH_m) were determined using a differential scanning calorimeter (DSC 2920, TA Instruments, New Castle, USA). Baseline calibration was performed in the temperature range from 0 °C to 300 °C, and a temperature calibration was carried out using an indium standard. Samples of polymers (2 to 4 mg) were weighed into the aluminum pans and placed in the DSC cell with a nitrogen flow rate of 50 mL/min. The first DSC runs were conducted by heating from -60 °C to 200 °C, at a rate of 10 °C/min. After holding 5 min. at 200 °C, the samples were cooled at the same rate of 10 °C/min. The third runs, i.e. the reheating of samples were carried out by subsequent heating from -60 °C to 200 °C at 10 °C/min. The DSC curves of PEG, PEG-*b*-PTMC, PEG-*b*-PKPC, PEG-*b*-PMBC(1) and PEG-*b*-PMBC(2) are shown in Figure S14.

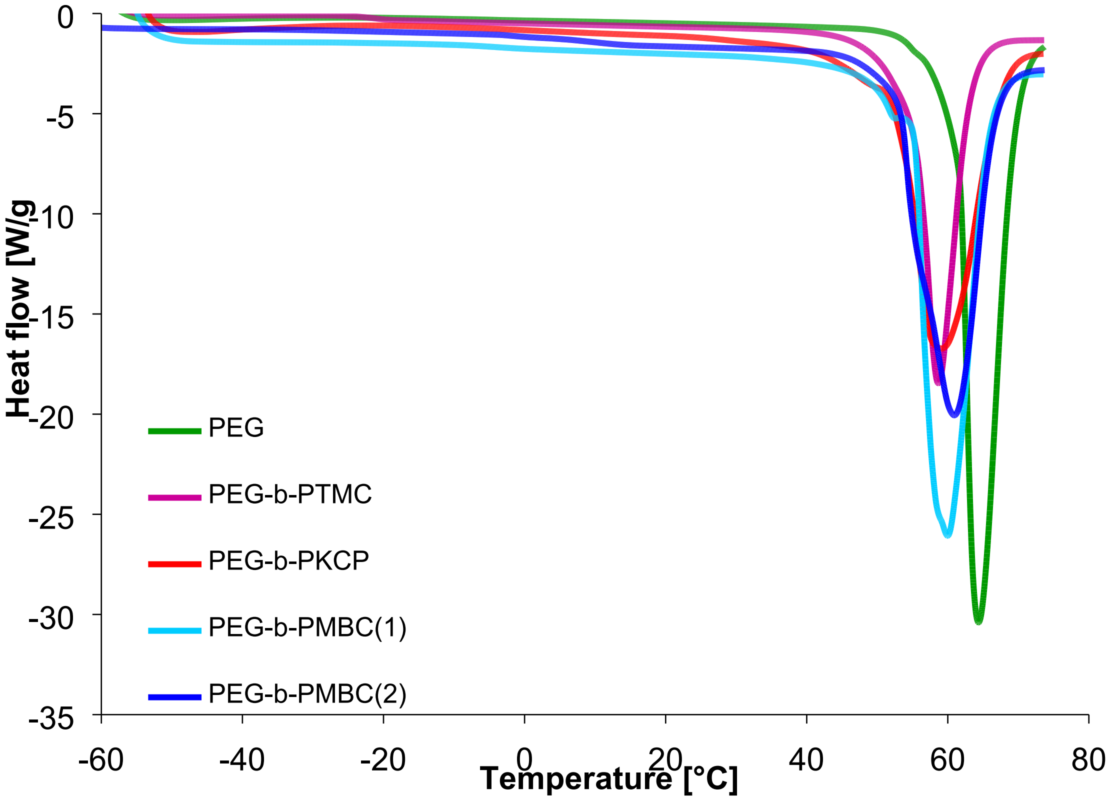

Figure S15. The heat flow curves as a function of temperature in the third run (re-heating) for pure PEG and its copolymers

The melting of PEG is characterized by single endothermic peak with a small shoulder preceding the main melting peak at ~60 °C. The melting peaks obtained for copolymers are symmetrical. The endotherm temperature shifts for all copolymers towards lower temperatures with respect to the peak maximum observed for PEG at ~60 °C. For the copolymers PEG-*b*-PMBC(1) and PEG-*b*-PMBC(2) the melting temperatures decreased with increasing PMBC content, reaching 57 °C and 54 °C, respectively. A reduction in the enthalpy of melting is observed for all copolymers. Generally, the lower melting enthalpy for PEG chains in copolymers can be attributed to the partial encapsulation of PEG chains by the other polymer blocks, which restricts their ability to crystallize and melt freely.

The table 1 presents DSC data from the re-heating experiments, including the initial PEG and its copolymers PEG-*b*-PTMC, PEG-*b*-PKPC, PEG-*b*-PMBC(1), PEG-*b*-PMBC(2).

Table 1. Comparison of the melting temperature, melting enthalpy of PEG, and the glass transition temperatures of the amorphous polymer blocks in the copolymers studied.

	T_g [°C]	Melting	
		T_m [°C]	ΔH_m [J/g]
PEG 5K	-	60.2	217
PEG-*b*-PTMC	-24.0	56.7	125
PEG-*b*-PKPC	-23	58.1	123
PEG-*b*-PMBC(1)	-11.2	57.1	157
PEG-*b*-PMBC(2)	-2.2	54.3	114

All the copolymers are semi-crystalline. The glass-transition temperature of the diblock copolymers reflects the presence of a second component in the copolymer, in addition to PEG, i.e. PKCP, PKBC and PTMC.