

Synthesis of rapidly surface eroding polyorthoesters and polyacetals using thiol-ene click chemistry

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Supporting Information

Materials

Acetone (Fisher), Aliquat 336 (Sigma-Aldrich), basic aluminium oxide (Sigma-Aldrich), 2-bromo-1,1-dimethoxyethane (Acros Organics), cis-2-butene-1,4-diol (Sigma-Aldrich), diethyl ether (Sigma-Aldrich), 3,6-dioxo-1,8-octane-dithiol (Sigma-Aldrich), ethanol (Sigma-Aldrich), ethanethiol (Sigma-Aldrich), hexane-1,6-dithiol (Sigma-Aldrich), hydrochloric acid (Fisher), iodoacetamide (Sigma-Aldrich), Irgacure 819 (IGM Resins Ltd.), potassium carbonate (anhydrous, Sigma-Aldrich), potassium *tert*-butoxide (Sigma-Aldrich), 1,3-propanediol (Sigma-Aldrich), terephthalic acid (Sigma-Aldrich), tetrahydrofuran (Sigma-Aldrich), tributylphosphine (Sigma-Aldrich), triethylamine (Sigma-Aldrich), preparation for Dulbecco's PBS (Sigma-Aldrich) and p-toluenesulfonic acid (Sigma) were used as received from the supplier. CDCl₃ (Sigma-Aldrich) was stored over anhydrous potassium carbonate and plug filtered through basic aluminium oxide immediately before use. Furthermore, all glassware used for handling and storage of OE containing compounds was silanized by treating the inner surface with Sigmacote (Sigma-Aldrich) for five minutes, followed by rinsing with water, acetone, diethyl ether and subsequent drying under compressed air for one hour.

Methods

A Formlabs Form Cure or an NK Optik Otoflash was used for curing of polymers. Nuclear Magnetic Resonance (NMR) spectra were acquired using a Bruker Avance III 400 MHz, processed by MestReNova software using the residual solvent peak as reference (CDCl₃, ¹H: δ = 7.26 ppm, ¹³C: δ = 77.16 ppm). Mass spectra were obtained *via* a Bruker mXis plus. Elemental analysis was conducted on a CE Instruments EA1110 Elemental Analyzer. Size Exclusion Chromatograms were recorded on an Agilent Infinity II with RI detection on an Agilent PLgel MIXED-C, 7.5 \times 300 mm, 5 μ m column in THF with 2% NEt₃ and 0.01% BHT at a flow rate of 1 mL·min⁻¹ at 50 °C compared to EasiVial Polystyrene Standard. Agilent GPC/SEC software V.A.02.01 (2015) was used for data analysis. An Agilent Cary 630 FTIR Spectrometer with Agilent Resolutions Pro software V.5.0 was used for IR spectroscopy. DSC and TGA thermograms were collected on a Mettler-Toledo STARe DSC3+ system and a TA Instruments TGA Q500, respectively. Oscillatory rheometry was performed on an Anton Parr MCR-302 with PP25 plates, Omnicure S1500 UV source and RheoCompass™ V1.20.496 software at a frequency of 10 Hz, amplitude of 1% and gap width of 0.2 mm. AFM images were recorded on a JPK Nanowizard 4 in QI mode using Nanosensors PPP-NCHAuD tips and Nanowizard Control Software V.6.1.117. SEM images were obtained on a Philips XL30 ESEM-FEG Environmental SEM using Phoenix Software V.3.3 on gold-coated samples.

Bis(3-mercaptopropyl) succinate was synthesized according to established procedure within the group. Briefly, 3-mercaptopropanol (7.30 g, 0.079 mol) and succinic acid (4.40 g, 0.037 mol) are dissolved in 120 mL of a 1:1 mixture of benzene and toluene with a catalytic amount of sulphuric acid. After stirring at 120 °C overnight and collection of the distilled water, the solution was left to cool to room temperature, followed by vacuum transfer of the solvent to yield crude product. The oil was re-dissolved in chloroform, extracted with sat. NaHCO₃ solution (2 \times 200 mL) and dried over MgSO₄. Purification on a silica gel column (3:2 hexane/EtOAc) and subsequent distillation (0.2 mbar, 220 °C) yielded clear colorless oil (7.8 g, 79% yield). R_f (3:2 Hex/EtOAc) = 0.4, ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 4.21 (t, ³J_{HH} = 6.2 Hz, 4H), 2.62 (s, 4H), 2.58 (q, ³J_{HH} = 6.6 Hz, 4H), 1.40 (t, ³J_{HH} = 8.1 Hz, 2H); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 172.31, 62.94, 32.92, 29.22, 21.20; MS (ESI-QTOF +ve): (M + Na)⁺ *m/z* calculated for C₁₀H₁₈O₄S₂Na⁺: 289.1, found: 289.0; Anal. Calcd for C₁₀H₁₈O₄S₂: C 45.09; H 6.81 %. Found: C 59.70; H 4.41 %.

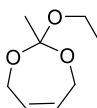
Synthesis of 2-(bromomethyl)-1,3-dioxo-5-pene (BrCKA, 1). The procedure follows a method described by Plikk *et al.*¹ Cis-2-butene-1,4-diol (33.30 g, 378 mmol) and 2-bromo-1,1-dimethoxyethane (63.89 g, 378 mmol) were weighed into a 100 mL round bottom flask, followed by p-toluenesulfonic acid (0.10 g, 0.1 wt%). A stirrer bar, vigreux condenser and distillation bridge was added and the mixture incrementally heated to 130 °C under stirring, until no more methanol was distilled over. After cooling to room temperature and gradually reducing the pressure, a residual methanol fraction was discarded and subsequently the pure product distilled at 38-42 °C and 0.05 mbar (62.1 g, 85%). Characterized as reported previously.¹ ¹H NMR

(400 MHz; 298 K; CDCl₃; ppm): δ 5.70 (t, $^3J_{\text{HH}} = 1.5$ Hz, 2H), 4.97 (t, $^3J_{\text{HH}} = 5.4$ Hz, 1H), 4.44 (dm, $^3J_{\text{HH}} = 14.7$ Hz, 2H), 4.20 (dm, $^3J_{\text{HH}} = 14.7$ Hz, 2H), 3.39 (d, $^3J_{\text{HH}} = 5.4$ Hz, 2H); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 128.81, 106.92, 63.25, 24.99.

Synthesis of 2-methylene-1,3-dioxo-5-pene (CKA, 2). Similarly to Plikk *et al.*'s method,¹ BrCKA (**1**) (40.00 g, 207 mmol) and Aliquat 336 (1.62 g, 4 mmol) were weighed into a 500 mL RBF, dissolved in 350 mL THF and cooled under stirring to 0 °C. Potassium *tert*-butoxide (46.50 g, 414 mmol) was added in small portions within one hour and the orange to yellow suspension left to stir for another two hours at 0 °C. THF was removed *in vacuo* (20 mbar, 18 °C) and the residual slurry dissolved in 200 mL diethyl ether and 200 mL distilled water, followed by separation of the layers and extraction of the aqueous phase with a further 100 mL diethyl ether. The combined organic layers were washed with 0.01M potassium carbonate solution (300 mL) for three times. The organic layer was concentrated *in vacuo* at 18 °C, followed by vacuum transfer of the residual oil at room temperature and 0.05 mbar to yield crude product. Repeat of the washing procedure, followed by drying over potassium carbonate and concentration at 30 °C and 20 mbar yielded pure product (12.50 g, 55%).
¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 5.72 (t, $^3J_{\text{HH}} = 1.7$ Hz, 2H), 4.43 (d, $^3J_{\text{HH}} = 1.7$ Hz, 4H), 3.57 (s, 2H); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 164.11, 127.83, 68.77, 68.21.

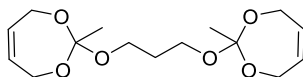
General procedure of the orthoester (OE) synthesis (3). CKA (**2**) and diol were weighed into a silanized vial in a molar ratio of 1.05 to 0.5. Terephthalic acid (1 mol eq.) was added and the mixture stirred overnight. The crude product was dissolved in diethyl ether and washed four times with equivalent volumes of 0.01M potassium carbonate solution, followed by separation and drying of the organic layer over potassium carbonate. Plug filtration through minimal amounts of basic alumina and evaporation yielded pure OE product of fruity odour (**3**). Additional distillation *in vacuo* in a silanized setup before use was performed to remove any degradation products (around ¹H NMR δ 2.00 ppm).

Synthesis of 2-ethoxy-2-methyl-1,3-dioxo-5-pene (EtOE, 3a).



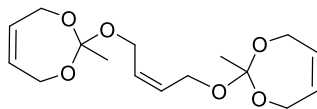
The reaction of CKA (**2**) (2.00 g, 17.84 mmol), ethanol (0.82 g, 8.92 mmol) and terephthalic acid (0.30 g, 0.18 mmol) yielded clear colourless oil (2.20 g, 78%; distillation at 0.05 mbar, 60 °C). ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 5.65 (t, $^3J_{\text{HH}} = 1.7$ Hz, 2H, -CHCH₂CO₃⁻), 4.44 (dm, $^2J_{\text{HH}} = -16.4$ Hz, 2H, -CHCH₂CO₃⁻), 4.13 (dm, $^2J_{\text{HH}} = -16.4$ Hz, 2H, -CHCH₂CO₃⁻), 3.58 (q, $^3J_{\text{HH}} = 7.0$ Hz, 2H, CH₃CH₂CO₃⁻), 1.53 (s, 3H, CH₃CO₃⁻), 1.24 (t, $^3J_{\text{HH}} = 7.0$ Hz, 3H, CH₃CH₂CO₃⁻); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 128.99 (-CHCH₂CO₃⁻), 116.08 (-CO₃⁻), 61.47 (-CHCH₂CO₃⁻), 58.89 (CH₃CH₂CO₃⁻), 19.15 (CH₃CO₃⁻), 15.49 (CH₃CH₂CO₃⁻); MS (ESI-QTOF +ve): (M + Na)⁺ *m/z* calculated for C₈H₁₄O₃Na⁺: 181.0835, found: 181.0836; Anal. Calcd for C₈H₁₄O₃: C 60.7; H 8.9%. Found: C 60.2; H 8.9; IR (neat; 298 K; cm⁻¹): 2980-2870 (-C-H), 1380 (-CH₂-), 1160-1040 (C-O), 900 (-CH₂-CH₂-), 800 (C=C), 640 (=C-H)

Synthesis of 1,3-bis(2-methyl-2-oxyl-1,3-dioxo-5-pene)-propane (OE3, 3b).



CKA (**2**) (4.00 g, 35.68 mmol), 1,3-propanediol (1.36 g, 17.84 mmol) and terephthalic acid (0.60 g, 0.36 mmol) were reacted to yield clear colourless oil (4.48 g, 84%; distillation at 0.02 mbar, 150 °C). ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 5.66 (t, $^3J_{\text{HH}} = 1.7$ Hz, 4H, -CHCH₂CO₃⁻), 4.43 (dm, 4H, $^2J_{\text{HH}} = -15.5$ Hz, -CHCH₂CO₃⁻), 4.15 (dm, 4H, $^2J_{\text{HH}} = -15.5$ Hz, -CHCH₂CO₃⁻), 3.65 (t, 4H, $^3J_{\text{HH}} = 6.3$ Hz, -OCH₂CH₂-), 1.93 (qi, 2H, $^3J_{\text{HH}} = 6.3$ Hz, -OCH₂CH₂-), 1.54 (s, 6H, -CO₃CH₃); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 128.99 (-CHCH₂CO₃⁻), 116.20 (-CO₃CH₃), 61.57 (-CHCH₂CO₃⁻), 60.42 (-CO₃CH₂CH₂-), 30.37 (-CO₃CH₂CH₂-), 19.18 (-CO₃CH₃); MS (ESI-QTOF +ve): (M + Na)⁺ *m/z* calculated for C₁₅H₂₄O₆Na⁺: 323.1465, found: 323.1468; Anal. Calcd for C₁₅H₂₄O₆: C 60.0; H 8.05%. Found: C 59.9; H 8.0; IR (neat; 298 K; cm⁻¹): 2950-2860 (-C-H), 1380 (-CH₂-), 1160-1040 (C-O), 900 (-CH₂-CH₂-), 800 (C=C), 640 (=C-H)

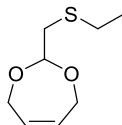
Synthesis of cis-1,3-bis(2-methyl-2-oxyl-1,3-dioxo-5-pene)-but-2-ene (OE4ene, 3c).



The reaction of CKA (**2**) (2.00 g, 17.84 mmol), cis-2-butene-1,4-diol (0.78 g, 8.92 mmol) and terephthalic acid (0.30 g, 0.18 mmol) yielded white crystals (2.25 g, 81%; recrystallisation from diethyl ether). Mp. \approx 25 °C; ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 5.71 (tm, $^3J_{\text{HH}} = 3.6$ Hz, 2H, -CHCH₂CO₃⁻ (linker)), 5.56 (t, $^3J_{\text{HH}} = 1.7$ Hz, 4H, -CHCH₂CO₃⁻), 4.43 (dm, 4H, $^2J_{\text{HH}} = -14.2$ Hz, -CHCH₂CO₃⁻), 4.15 (d, 4H, $^3J_{\text{HH}} = 3.6$ Hz, -CHCH₂CO₃⁻ (linker)), 4.13 (dm, 4H, $^2J_{\text{HH}} = -14.2$ Hz, -CHCH₂CO₃⁻), 1.54 (s, 6H, -CO₃CH₃); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 128.94 (-CHCH₂CO₃⁻), 128.64 (-CHCH₂CO₃⁻ (linker)), 116.35 (-CO₃CH₃), 61.70 (-CHCH₂CO₃⁻), 59.72 (-CHCH₂CO₃⁻ (linker)), 30.37 (-CO₃CH₂CH₂-), 19.40 (-CO₃CH₃); MS (ESI-QTOF +ve): (M + Na)⁺ *m/z* calculated for C₁₆H₂₄O₆Na⁺: 335.1465, found: 335.1468; Anal. Calcd for C₁₆H₂₄O₆: C 61.5; H 7.7%. Found: C 61.5; H 7.8; IR (neat; 298 K; cm⁻¹): 2940-2870 (-C-H), 1380 (-CH₂-), 1160-1020 (C-O), 900 (-CH₂-CH₂-), 800 (C=C), 640 (=C-H)

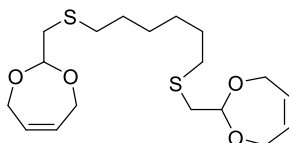
General procedure of the acetal (AT) synthesis (4). CKA (2) and thiol were weighed into a silanized vial under a nitrogen blanket in a molar ratio of 1.05 to 0.5. Irgacure 819 (0.3 wt%) was added and the mixture stirred until clear, followed by irradiation with UV light for 5 h at 60°C in a Formlabs Form Cure. Vacuum distillation yielded the pure AT product.

Synthesis of 2-((ethylthio)methyl)-1,3-dioxo-5-pene (EtAT, 4a).



CKA (2) (2.10 g, 18.73 mmol), ethanethiol (1.10 g, 8.92 mmol) and Irgacure 819 (0.01 g) were reacted to yield clear colourless oil (3.02 g, 97%; distillation at 0.02 mbar, 60 °C). ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 5.71 (t, ³J_{HH} = 1.8 Hz, 2H, -CHCH₂CHO₂-), 4.91 (t, 1H, ³J_{HH} = 5.5 Hz, -CHO₂CH₂S-), 4.42 (dm, 2H, ²J_{HH} = -15.2 Hz, -CHCH₂CHO₂-), 4.19 (dm, 2H, ²J_{HH} = -15.2 Hz, -CHCH₂CHO₂-), 2.75 (d, 2H, ³J_{HH} = 5.5 Hz, -CHO₂CH₂S-), 2.62 (d, 2H, ³J_{HH} = 7.4 Hz, -SCH₂CH₃), 1.25 (s, 3H, ³J_{HH} = 7.4 Hz, -SCH₂CH₃); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 129.58 (-CHCH₂CHO₂-), 104.35 (-CHO₂CH₂S-), 65.59 (-CHCH₂CHO₂-), 34.66 (-CHO₂CH₂S-), 26.73 (-SCH₂CH₃), 14.81 (-SCH₂CH₃); MS (ESI-QTOF +ve): M⁺ m/z calculated for C₈H₁₄O₂S⁺: 174.0715, found: 174.0716; Anal. Calcd for C₈H₁₄O₂S: C 55.1; H 8.1; S 18.4%. Found: C 55.55; H 8.1; S 18.0; IR (neat; 298 K; cm⁻¹): 2950-2850 (-C-H), 1440-1350 (-CH₂-), 1120-980 (C-O), 910 (=C-H), 740 (=C-H)

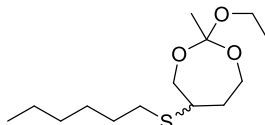
Synthesis of 1,6-bis(2-methylthiopyl)-1,3-dioxo-5-pene (AT6, 4b).



The reaction of CKA (2) (2.10 g, 18.73 mmol), 1,6-hexanedithiol (1.34 g, 8.92 mmol) and Irgacure 819 (0.01 g) yielded clear colourless oil (3.21 g, 96%; distillation at 0.02 mbar, 150 °C). ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 5.71 (t, ³J_{HH} = 1.8 Hz, 4H, -CHCH₂CHO₂-), 4.90 (t, 2H, ³J_{HH} = 5.5 Hz, -CHO₂CH₂S-), 4.42 (dm, 4H, ²J_{HH} = -15.5 Hz, -CHCH₂CHO₂-), 4.19 (dm, 4H, ²J_{HH} = -15.5 Hz, -CHCH₂CHO₂-), 2.73 (d, 4H, ³J_{HH} = 5.5 Hz, -CHO₂CH₂S-), 2.59 (d, 4H, ³J_{HH} = 7.5 Hz, -SCH₂CH₂CH₂-), 1.59 (m, 4H, -SCH₂CH₂CH₂-), 1.39 (m, 4H, -SCH₂CH₂CH₂-); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 129.60 (-CHCH₂CHO₂-), 104.38 (-CHO₂CH₂S-), 65.62 (-CHCH₂CHO₂-), 35.13 (-CHO₂CH₂S-), 32.80 (-SCH₂CH₂CH₂-), 29.54 (-SCH₂CH₂CH₂-), 28.47 (-SCH₂CH₂CH₂-); MS (ESI-QTOF +ve): (M + Na)⁺ m/z calculated for C₁₈H₃₀O₄S₂Na⁺: 397.1478, found: 397.1307; Anal. Calcd for C₁₈H₃₀O₄S₂: C 57.7; H 8.1; S 17.1%. Found: C 57.7; H 8.9; S 16.9; IR (neat; 298 K; cm⁻¹): 2920-2850 (-C-H), 1440-1350 (-CH₂-), 1120-990 (C-O), 910 (=C-H), 750 (-CH₂-)

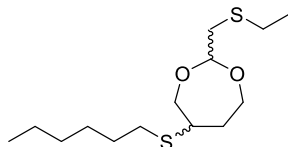
General procedure of the thiol-ene synthesis to form small molecule and chain thio-ethers (TE) (5, 6). The respective OE or AT (3, 4) and thiol were weighed into a silanized vial under a nitrogen blanket in a molar ratio of 1.0 to 0.5. Irgacure 819 (0.3 wt% for small molecules, 1.0 wt% for polymers) was added and the mixture stirred under ambient light for one day until colourless. After vigorous stirring, the viscous preparations were subjected to 24 h of UV light at 60°C in a Formlabs Form Cure. Small molecules were finally distilled *in vacuo* to yield pure product, whereas polymeric products were generally used as is for further analysis.

Synthesis of 2-ethoxy-5-(hexylthio)-2-methyl-1,3-dioxepane (EtOE-TE, 5a).



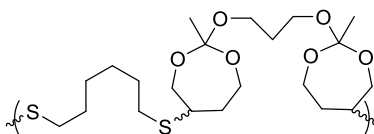
The reaction of EtOE (3a) (2.00 g, 12.64 mmol), 1-hexanethiol (1.49 g, 12.64 mmol) and Irgacure 819 (0.01 g) yielded clear oily product (3.30 g, 94%; distillation at 0.02 mbar, 150 °C). ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 3.96-3.42 (m, 4H), 3.48/3.46 (q, ³J_{HH} = 7.1 Hz, 2H), 2.80/2.72 (m, 1H), 2.46 (m, 2H), 1.95-1.55 (m, 2H), 1.55-1.45 (m, 3H), 1.37/1.35 (s, 3H), 1.34-1.18 (m, 3H), 1.16/1.14 (t, ³J_{HH} = 7.1 Hz, 3H), 0.82 (s, 3H); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 115.72/115.64, 66.60/64.99, 61.81/59.77, 58.70/58.62, 43.98/43.21, 36.61/35.69, 31.51/31.48, 31.23/31.04, 30.15/30.09, 28.71/28.68, 22.63, 20.71/20.64, 15.49, 14.13; MS (ESI-QTOF +ve): (M + Na)⁺ m/z calculated for C₁₄H₂₈NO₃SN⁺: 299.1651, found: 299.1657; Anal. Calcd for C₁₄H₂₈O₃S: C 60.8; H 10.2; S 11.6%. Found: C 60.8; H 10.3; S 11.5; IR (neat; 298 K; cm⁻¹): 2930-2860 (-C-H), 1380 (-CH₂-), 1160-1030 (C-O)

Synthesis of 2-((ethylthio)methyl)-5-(hexylthio)-1,3-dioxepane (EtAT-TE, 6a).



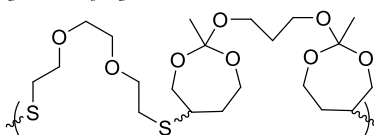
EtAT (**4a**) (2.00 g, 11.48 mmol), 1-hexanethiol (1.36 g, 11.48 mmol) and Irgacure 819 (0.01 g) were reacted to yield clear oily product (3.22 g, 95%; distillation at 0.02 mbar, 150 °C). ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 4.90-4.84 (m, 1H), 4.12-3.51 (m, 4H), 2.94-2.78 (m, 1H), 2.69-2.58 (m, 2H), 2.11-1.95 (m, 1H), 2.58-2.48 (m, 2H), 2.11-1.95 (m, 1H), 1.76-1.62 (m, 1H), 1.61-1.50 (m, 2H), 1.42-1.23 (m, 6H), 1.26 (qm, ³J_{HH} = 7.2 Hz, 2H), 0.88 (tm, ³J_{HH} = 7.2 Hz, 3H); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 102.74/102.36, 70.91/66.53, 65.53/62.11, 44.18/43.84, 36.29, 35.01/34.68, 31.54/31.50, 31.24/31.18, 30.09/30.06, 28.69, 26.73, 22.63, 14.81, 14.13; MS (ESI-QTOF +ve): (M + K)⁺ *m/z* calculated for C₁₄H₂₈O₂S₂K⁺: 331.1168, found: 331.1170; Anal. Calcd for C₁₄H₂₈O₂S₂: C 57.5; H 9.65; S 21.9%. Found: C 59.3; H 9.2; S 21.5; IR (neat; 298 K; cm⁻¹): 2920-2850 (-C-H), 1450-1340 (-CH₂-), 1120-990 (C-O), 740 (-CH₂-).

Synthesis of poly{[1,3-bis(2-methyl-2-oxyl-5-yl-1,3-dioxepane)-O-propane]-alt-(1,6-thiyl-hexane)} (**OE3-2TE6, 5b**).



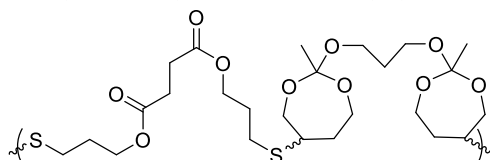
The reaction of OE3 (**3b**) (1.00 g, 3.33 mmol), 1,6-hexanedithiol (0.50 g, 3.33 mmol) and Irgacure 819 (0.015 g) yielded clear viscous product. ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 4.02-3.77 (m, 4H), 3.69-3.50 (m, 8H), 2.91-2.73 (m, 2H), 2.56-2.47 (m, 4H), 2.02-1.93 (m, 2H), 1.93-1.82 (m, 2H), 1.78-1.50 (m, 6H), 1.45-1.41 (ms, 6H), 1.41-1.34 (m, 4H); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 115.88, 66.71/65.07, 61.91/60.32, 60.26/59.86, 44.06/43.27, 36.63/35.72, 31.16/31.00, 30.30, 30.03/30.00, 28.63, 20.69; IR (neat; 298 K; cm⁻¹): 2920-2850 (-C-H), 1370 (-CH₂-), 1150-1020 (C-O), 900 (-CH₂-CH₂-); GPC (THF): *M*_n = 4400 g·mol⁻¹ (*D*_M = 2.6)

Synthesis of poly{[1,3-bis(2-methyl-2-oxyl-5-yl-1,3-dioxepane)-O-propane]-alt-(3,6-dioxo-1,8-dithiyl-octane)} (**OE3-2TEeg, 5c**).



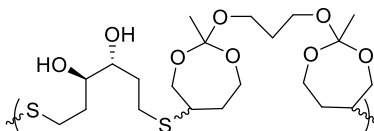
OE3 (**3b**) (1.00 g, 3.33 mmol) was reacted with 3,6-dioxo-1,8-octane-dithiol (0.61 g, 3.33 mmol) and Irgacure 819 (0.016 g) to yield clear viscous product. ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 4.16 (t, ³J_{HH} = 6.3 Hz, 4H), 3.99-3.79 (m, 4H), 3.67-3.50 (m, 8H), 2.91-2.74 (m, 2H), 2.63 (s, 4H), 2.61-2.53 (m, 4H), 2.02-1.93 (m, 2H), 1.93-1.83 (m, 6H), 1.75-1.57 (m, 2H), 1.48-1.37 (ms, 6H); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 115.87/115.78, 71.36/71.18, 70.47, 66.58/65.05, 61.70/59.76, 60.32/60.28, 44.40/43.64, 36.65/35.75, 30.62/30.51, 30.29, 20.72; IR (neat; 298 K; cm⁻¹): 2940-2870 (-C-H), 1380 (-CH₂-), 1150-960 (C-O), 900 (-CH₂-CH₂-); GPC (THF): *M*_n = 4600 g·mol⁻¹ (*D*_M = 2.3)

Synthesis of poly{[1,3-bis(2-methyl-2-oxyl-5-yl-1,3-dioxepane)-O-propane]-alt-[bis(3-thiylpropyl) succinate]} (**OE3-2TEsucc, 5d**).



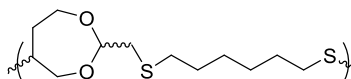
OE3 (**3b**) (1.00 g, 3.33 mmol), bis(3-mercaptopropyl) succinate (8.87 g, 3.33 mmol) and Irgacure 819 (0.019 g) were combined in the reaction to yield clear viscous product. ¹H NMR (400 MHz; 298 K; CDCl₃; ppm): δ 4.00-3.75 (m, 4H), 3.75-3.60 (m, 8H), 3.60-3.59 (s, 4H), 3.59-3.48 (m, 4H), 2.97-2.80 (m, 2H), 2.79-2.65 (m, 4H), 2.03-1.93 (m, 2H), 1.93-1.80 (m, 2H), 1.74-1.55 (m, 2H), 1.46-1.39 (ms, 6H); ¹³C NMR (400 MHz; 298 K; CDCl₃; ppm): δ 172.33, 115.88, 66.52/64.96, 63.39/63.35, 61.75/59.79, 60.32/60.26, 44.12/43.39, 36.52/35.63, 30.29, 29.19, 29.13, 27.59/27.48, 20.66; IR (neat; 298 K; cm⁻¹): 2940-2880 (-C-H), 1730 (C=O), 1380 (-CH₂-), 1150-960 (C-O), 900 (-CH₂-CH₂-); GPC (THF): *M*_n = 5400 g·mol⁻¹ (*D*_M = 2.3)

Synthesis of poly{[1,3-bis(2-methyl-2-oxyl-5-yl-1,3-dioxepane)-O-propane]-alt-(dithiylthreitol)} (**OE3-2TEdt, 5e**).



The reaction of OE3 (**3b**) (1.00 g, 3.33 mmol), dithiylthreitol (0.51 g, 3.33 mmol) and Irgacure 819 (0.015 g) yielded an oily liquid. ¹H NMR spectroscopy and SEC chromatography suggest only low conversion. GPC (THF): *M*_n = 500 g·mol⁻¹ (*D*_M = 2.5)

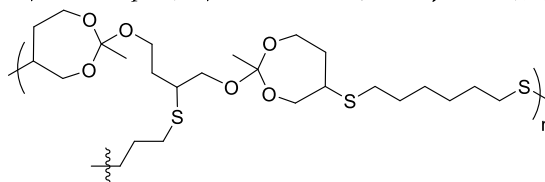
Synthesis of poly{[1,6-bis(2-methylthiyl-5-yl-1,3-dioxepane)-S-hexane]-alt-(1,6-thiyl-hexane)} (**AT6-2TE6, 6b**).



The reaction of AT6 (**4b**) (1.00 g, 3.20 mmol), 1,6-hexanedithiol (0.40 g, 2.67 mmol) and Irgacure 819 (0.014 g) yielded clear viscous product. ^1H NMR (400 MHz; 298 K; CDCl_3 ; ppm): δ 4.91-4.78 (2t, 1H), 4.13-3.95 (m, 1H), 3.91-3.70 (m, 2H), 3.66-3.50 (m, 1H), 2.93-2.76 (m, 1H), 2.67-2.60 (m, 2H), 2.60-2.47 (m, 4H), 2.10-1.95 (m, 1H), 1.73-1.63 (m, 1H), 1.63-1.48 (ms, 4H), 1.44-1.33 (ms, 4H); ^{13}C NMR (400 MHz; 298 K; CDCl_3 ; ppm): δ 102.36/102.36, 70.88/66.59, 65.52/62.15, 44.26/43.92, 36.30, 35.49/35.22, 32.83/32.81, 31.15/31.13, 31.09/29.94, 29.56/29.54, 29.53/28.49; IR (neat; 298 K; cm^{-1}): 2910-2850 (-C-H), 1450-1340 (-CH₂-), 1120-990 (C-O), 750 (-CH₂-); GPC (THF): $M_n = 5900 \text{ g}\cdot\text{mol}^{-1}$ ($\bar{M}_w = 3.8$)

Reduction and end-capping of polymer chains. Disulfide linkages were reduced to thiol groups and protected from oxidation following an adapted procedure in the style of commercially available ReadyPrep™ Reduction-Alkylation Kits. The sample was completely dissolved in THF with triethylamine (2%). Under a nitrogen blanket tributylphosphine (200 mol eq.) was added and the sealed vial shaken vigorously (300 rpm) for 4 h, followed by addition of a solution of iodoacetamide (300 mol eq.) in THF and further shaking for 4 h. Water (2 vol eq.) was added and the suspension centrifuged to form a clear organic phase. Separation, washing with water and drying in the SEC solvent over potassium carbonate yielded the final chain polymer product.

Synthesis of net-poly{[1,3-bis(2-methyl-2-oxyl-5-yl-1,3-dioxepane)-2-yl-O-butane]-co-(1,6-thioly-hexane)} (OE4ene-2TE6, 7).



A mixture of OE4ene (**3c**) (2.00 g, 6.40 mmol), 1,6-hexanedithiol (1.44 g, 9.6 mmol) and Irgacure 819 (0.034 g, 1 wt%) was stirred in a silanized brown vial under a nitrogen blanket until the solution cleared. 0.3 mL of the solution was then each deposited into a PP mold (2 mL vial cap with lowered rim) to form a smooth top surface. Subsequent curing in an Otofash G171 flash box for five times 1000 flashes with intermittent cooling, followed by extraction from the molds and a further five times 1000 flashes, yielded the polymer material in clear cylindrical shapes. $T_g = 10.2 \text{ }^\circ\text{C}$ (DSC, $10 \text{ K}\cdot\text{min}^{-1}$, heat); IR (neat; 298 K; cm^{-1}): 2910-2840 (-C-H), 1370 (-CH₂-), 1150-1000 (C-O), 900 (-CH₂-CH₂-)

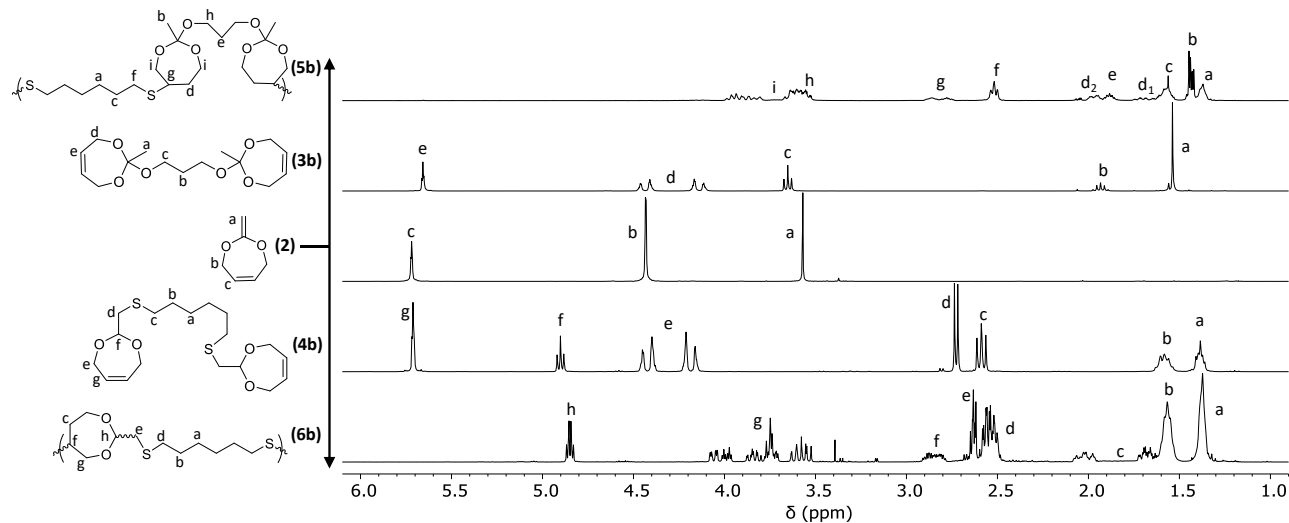


Figure S1. ^1H NMR spectra of dimeric OE (**3b**) and AT (**4b**), as well as the respective chain polymers (**5b**, **6b**) (CDCl_3 , 400 MHz, 298 K).

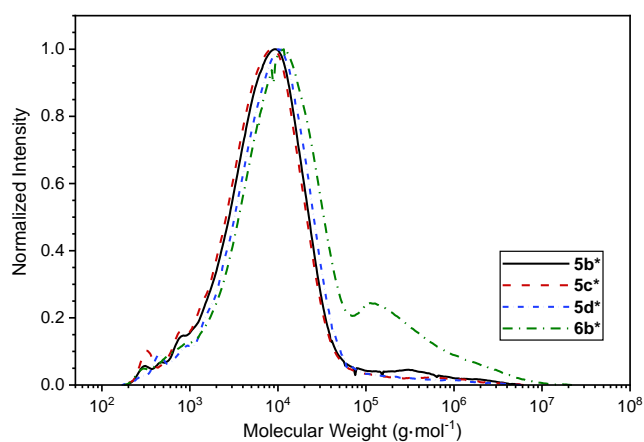


Figure S2. Size Exclusion Chromatograms of different POETE (**5b-d**) and PATTE (**6b**) chain polymers (crude, molecular weight determined in THF with 2% NEt_3 against polystyrene standards).

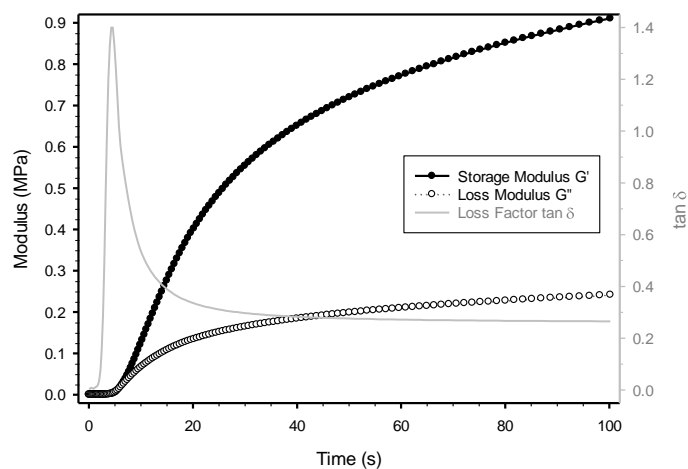


Figure S3. Progression of oscillatory storage and loss modulus during the polymerisation of P(OE4ene-2TE6) (**7**) (frequency 10 Hz, amplitude 1%, gap width 0.2 mm).

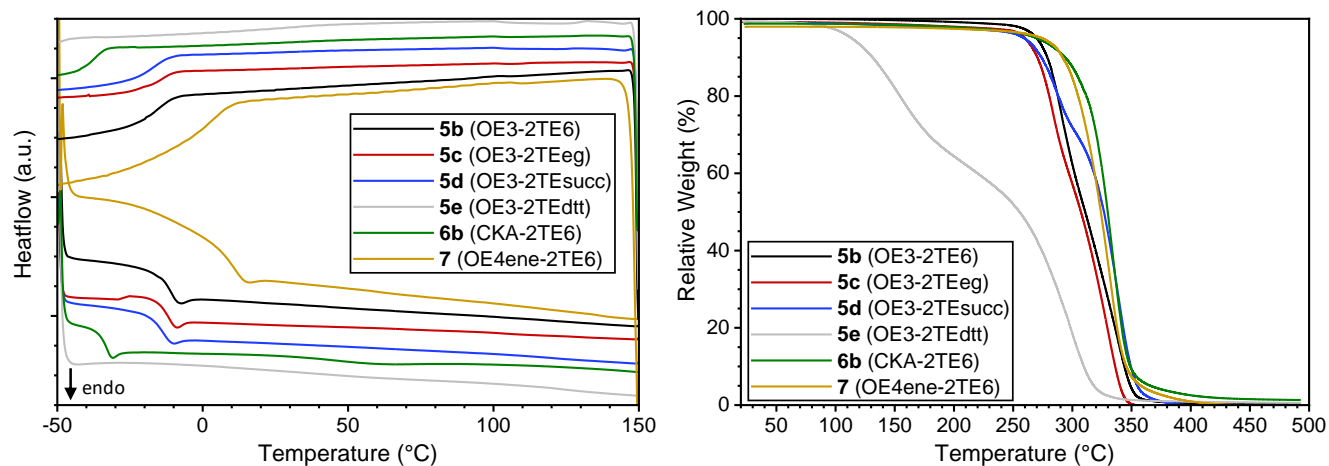


Figure S4. DSC (left, 3rd cycle) and TGA (right) thermograms of all polymeric compounds (**5b-7**). (10 K·min⁻¹).

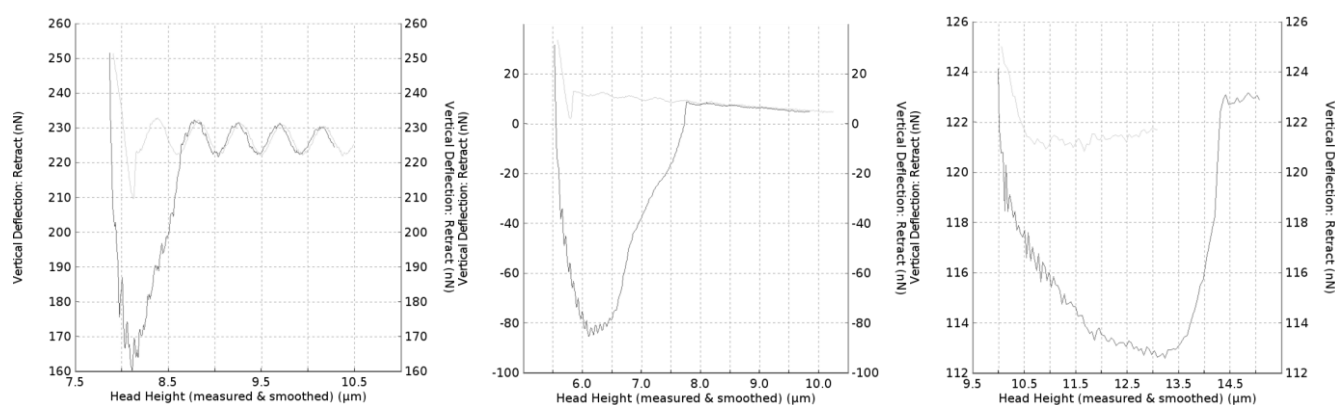


Figure S5. Exemplary AFM Force curves on degraded samples of P(OE4ene-2TE6) (**7**) at roughly 50 wt%. From left to right: crude; PBS; 0.1 M HCl (25 nN, retraction maxed at 15 μm). Grey: approach; black: retract.

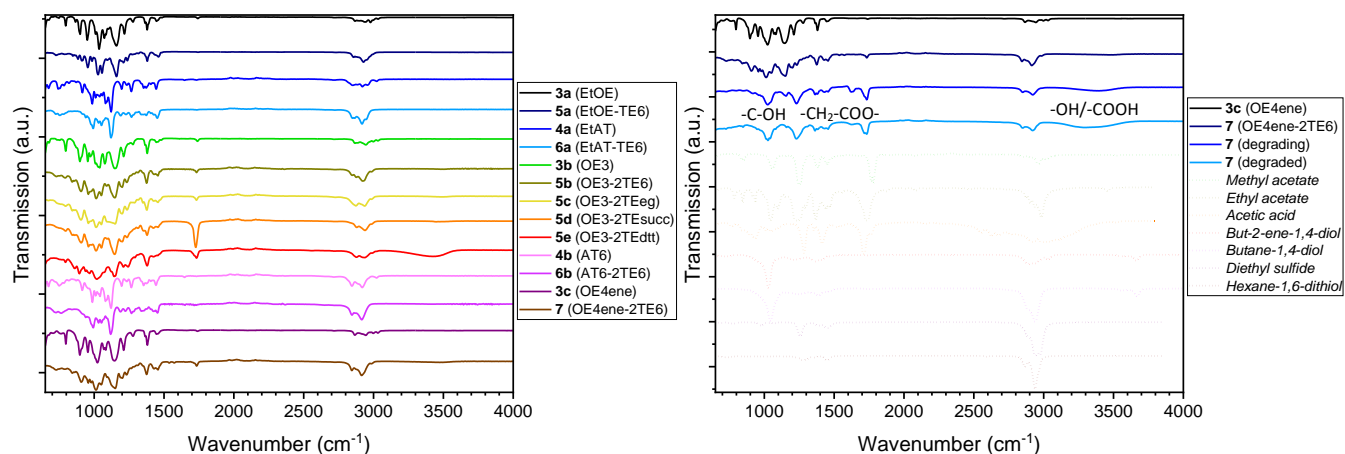


Figure S6. FT-IR spectra of all new compounds (**3a-7**, left) and degradation products of P(OE4ene-2TE6) (**7**, right) on air (neat). Spectra of reference substances (dashed, right) obtained from the NIST (National Institute of Standards and Technology) database.

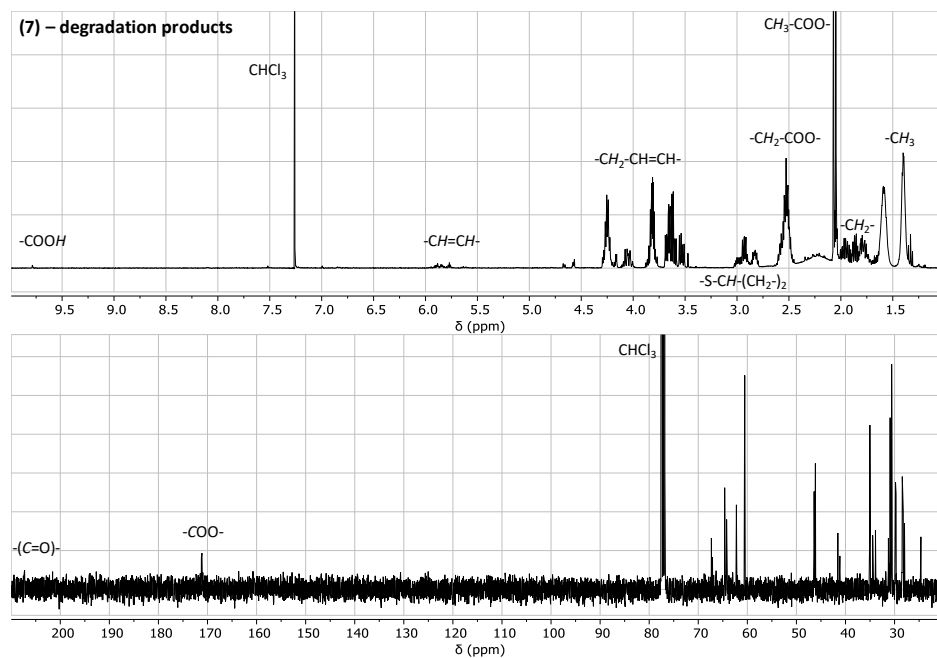


Figure S7. ^1H (top) and ^{13}C (bottom) NMR spectra of degradation products of the P(OE4ene-2TE6) (7) on air (CDCl_3 , 400 MHz, 298 K).

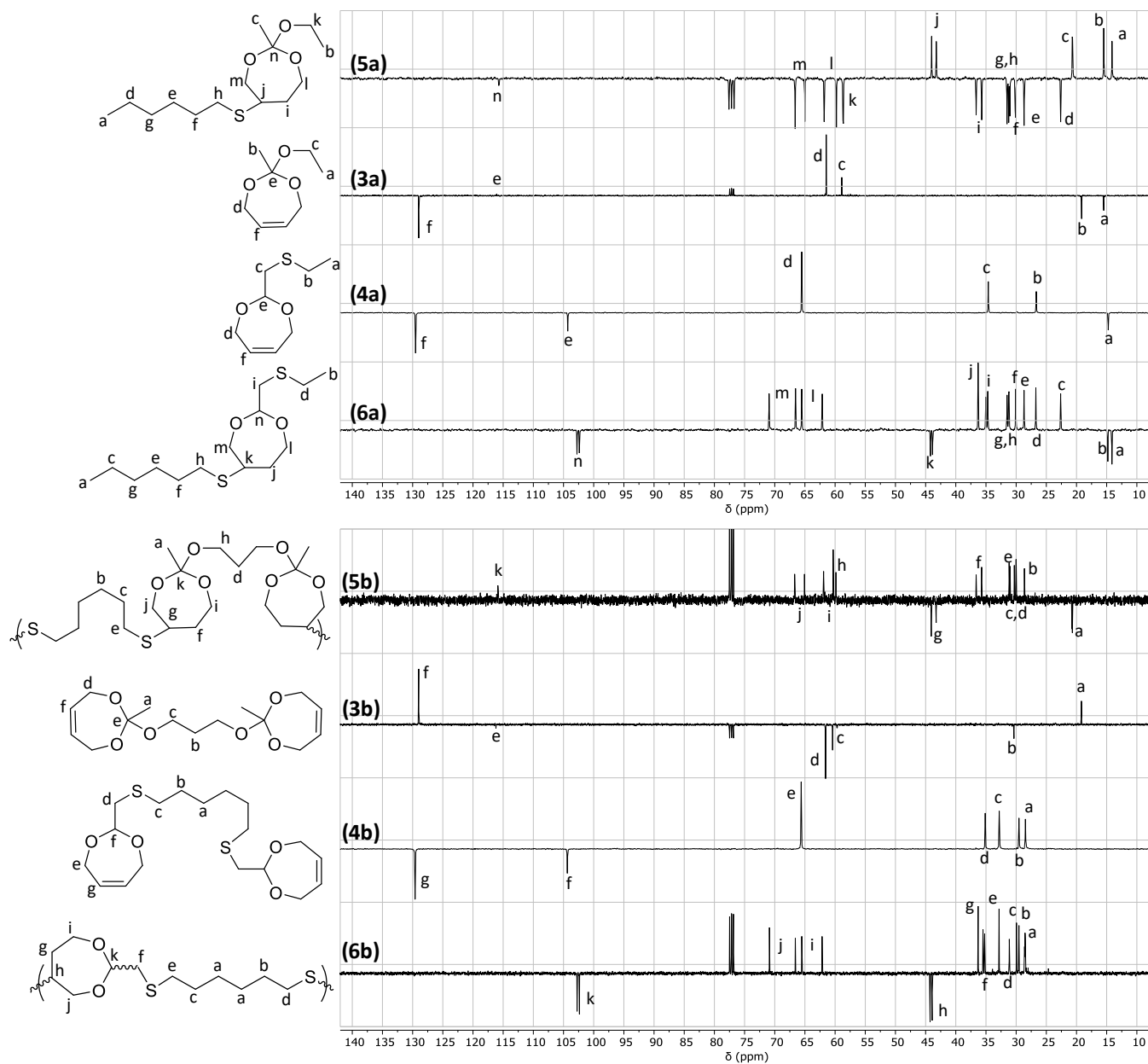


Figure S8. ^{13}C NMR spectra of selected OEs (**3a**, **3b**), ATs (**4a**, **4b**) and respective TEs (**5a**, **5b**, **6a**, **6b**) (CDCl_3 , 300 MHz, 298 K). Compounds and arrangement analogous to Figures 1 and S1.

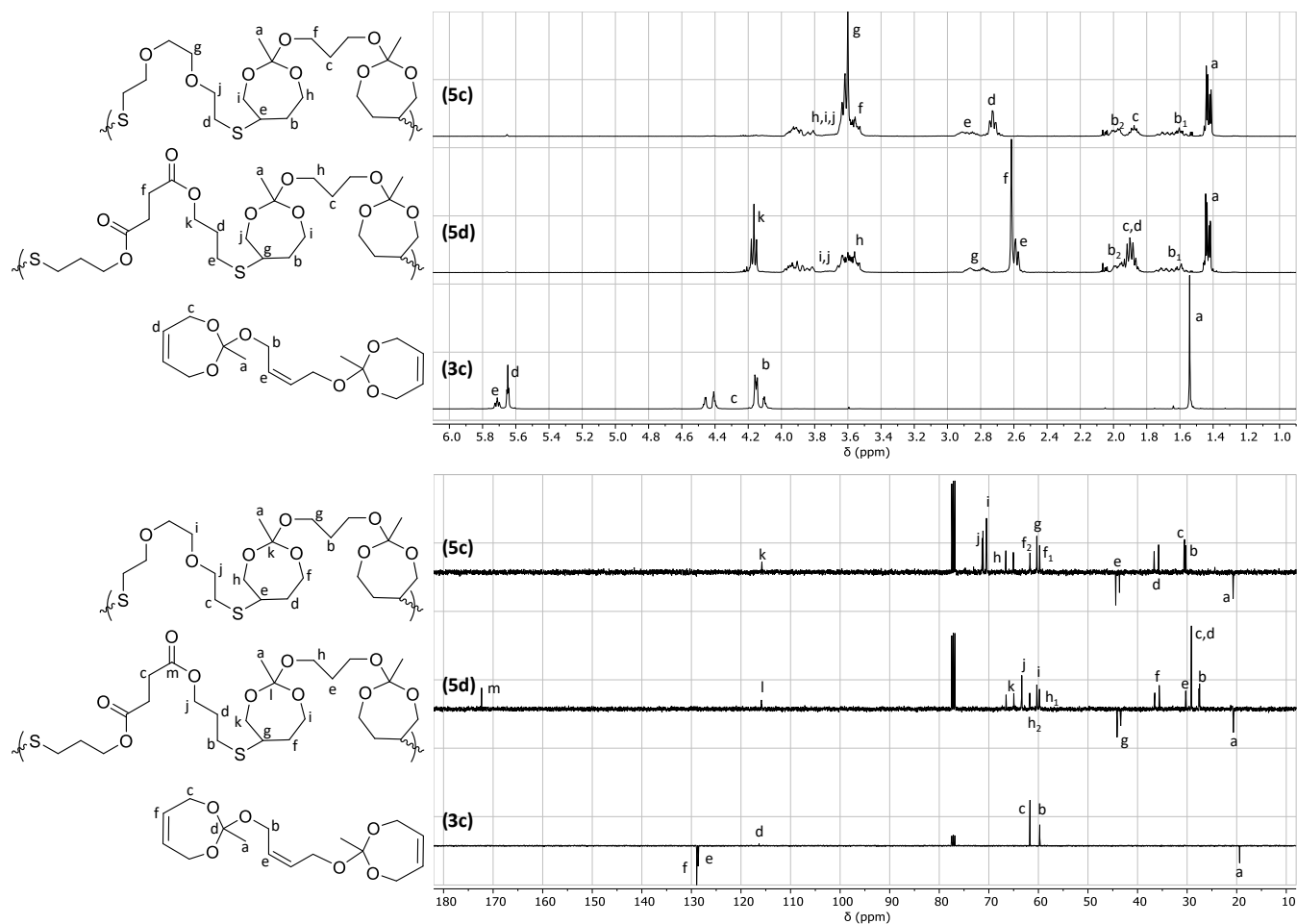


Figure S9. ^1H and ^{13}C NMR spectra of remaining polymeric compounds (**5c**, **5d**) and network precursor OE (**3c**) (CDCl_3 , 298 K). Top: ^1H NMR (400 MHz); bottom: ^{13}C NMR (300 MHz).

(1) Plikk, P.; Tyson, T.; Finne-Wistrand, A.; Albertsson, A. C., Mapping the characteristics of the radical ring-opening polymerization of a cyclic ketene acetal towards the creation of a functionalized polyester. *J. Polym. Sci. A Polym. Chem.* **2009**, 47 (18), 4587-4601. doi:10.1002/pola.23511