Electronic Supplementary Material (ESI) for Chemical Science.

Supporting Information

Continuous and Scalable Synthesis of a Porous Organic Cage by Twin Screw Extrusion (TSE)

Benjamin D. Egleston,[a] Michael C. Brand,[a] Francesca Greenwell,[a] Michael E. Briggs,[a] Stuart L. James,[b] Andrew I. Cooper[a], Deborah E. Crawford[c*] and Rebecca L. Greenaway[a,d*]

[a] Department of Chemistry and Materials Innovation Factory, University of Liverpool, 51 Oxford Street, Liverpool, L7 3NY, UK; [b] School of Chemistry and Chemical Engineering, Queen's University Belfast, 39 – 123 Stranmillis Road, Belfast, BY9 5AG, Northern Ireland, UK; [c] School of Chemistry and Biosciences, University of Bradford, Richmond Road, Bradford, BD7 1DP, UK; [d] Department of Chemistry, Imperial College London, White City Campus, Wood Lane, London, W12 0BZ, UK.

Email: *r.greenaway@imperial.ac.uk; d.crawford@bradford.ac.uk*

1. General synthetic and analytical methods

Materials: 1,3,5-Triformylbenzene was purchased from Manchester Organics, (*S,S*)-1,2-cyclohexanediamine was purchased from TCI-UK, and sodium hydrogen carbonate and TFA were purchased from Sigma-Aldrich. Solvents were reagent or HPLC grade purchased from Fisher Scientific. All chemicals and solvents were used as received.

Twin-Screw Extrusion: Extrusion was carried out using a Three-Tec 12 mm, 40:1 L:D co-rotating twin screw extruder with six heating zones.

NMR spectra: ^{1}H Nuclear magnetic resonance (NMR) spectra were recorded using an internal deuterium lock for the residual protons in $CDCl_3$ (δ = 7.26 ppm) at ambient probe temperature using either a Bruker Avance 400 (400 MHz) or Bruker Avance 300 (300 MHz) instrument.

NMR data are presented as follows: chemical shift, integration, peak multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad, app = apparent), coupling constants (*J* / Hz). Chemical shifts are expressed in ppm on a δ scale relative to δ_{CDCl3} (7.26 ppm) and coupling constants, *J*, are given in Hz.

HPLC: HPLC was conducted on a Dionex UltiMate 3000 equipped with a diode array UV detector using a Thermo-Scientific Syncronis C8 column, 150 x 4.6 mm, 3 µm (SN 10136940, Lot 12459). The mobile phase was isocratic MeOH at a flow rate of 1 mL/min for a 10 minute run time. The injection volume was 10 µL and the sample concentration was approximately 1 mg/mL. Detection for UV analysis was conducted at 254 nm.

HRMS: Electrospray ionisation mass spectrometry (ES-MS) was carried out using an Agilent Technologies 6530B accurate-mass QTOF Dual ESI mass spectrometer (MeOH + 0.1% formic acid, capillary voltage 4000 V, fragmentor 225 V) in positive-ion detection mode.

LCMS: High-resolution liquid chromatography mass spectrometry (LCMS) was carried out using an Agilent Technologies 6530B system, using a Thermo-Scientific Syncronis C8 column, 150x50mm, 5 µm (SN 97205-159370, Lot 12105), with mass detection using an accurate mass QTOF Dual ESI mass spectrometer (capillary voltage 4000 V, fragmentor 225 V) in positive ion detection mode. The mobile phase was isocratic MeOH containing 0.1% formic acid at a flow rate of 0.25 mL/min for a 5 minute run time.

PXRD: Laboratory powder X-ray diffraction data were collected in transmission mode on samples held on thin Mylar film in aluminium well plates on a Panalytical X'Pert PRO MPD equipped with a high throughput screening (HTS) XYZ stage, X-ray focusing mirror and PIXcel detector, using Ni-filtered Cu Kα radiation. Data were measured over the range 4–40° in ~0.013° steps over 60 minutes.

TGA: Thermogravimetric analysis was carried out using a Q5000IR analyser (TA instruments) with an automated vertical overhead thermobalance. The sample was heated in platinum pans under nitrogen at a rate of 10 °C/min.

DSC: Differential scanning calorimetry (DSC) was carried out using a Q2000 analyser (TA instruments). The samples were heated at the rate of 20 °C/min to the required specified temperature in Tzero sealed-aluminium pans under a nitrogen flow (50 mL/min).

Gas sorption analysis: Surface areas were measured by nitrogen sorption at 77 K. Powder samples were degassed offline at 90 °C for 15 hours under dynamic vacuum (10^{-5} bar) before analysis, followed by degassing on the analysis port under vacuum. Nitrogen isotherms were measured using Micromeritics ASAP 2420 volumetric adsorption analyser. Carbon dioxide isotherms were measured using Micromeritics ASAP 2020 volumetric adsorption analyser. Gas uptake measurements for nitrogen were taken at a temperature of 77 K, and for carbon dioxide measurements were performed at 273 K using a circulating water chiller.

2. Optimisation of cage formation using TSE

2.1. General optimisation screening method for CC3

For the standard screw (Figure S1, top): 1,3,5-Triformylbenzene was briefly mixed with (*S,S*)-1,2-cyclohexanediamine (required quantity of solid ~ 3 g) before being manually fed into the extruder at different temperatures and with different screw speeds – see Table S1, entries 1-7. The extruded sample and that collected from within the barrel was collected for subsequent analysis by ^{1}H NMR, HRMS, HPLC, and PXRD.

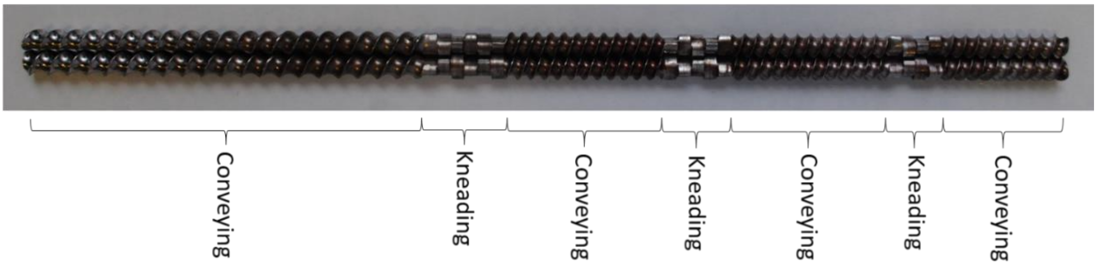
For the reverse screw (Figure S1, bottom):

No LAG: 1,3,5-Triformylbenzene was briefly mixed with (*S,S*)-1,2-cyclohexanediamine (required quantity of solid ~ 8 g) before being manually fed into the extruder with a temperature gradient and a screw speed of 200 rpm – see Table S1, entry 8. The extruded sample and that collected from within the barrel was collected for subsequent analysis by ^{1}H NMR, HRMS, HPLC, and PXRD.

LAG: (*S,S*)-1,2-cyclohexanediamine was dissolved in either $CHCl_3$ or water (1:1, 1:4, or 1:8 molar ratio) and added a rate of 0.25 mL/min by syringe pump prior to the solid addition hopper, where 1,3,5-triformylbenzene was manually fed. A temperature gradient was used with a screw speed of 200 rpm – see Table S1, entries 9-18. The extruded sample and that collected from within the barrel was collected for subsequent analysis by ^{1}H NMR, HRMS, HPLC, and PXRD.

LAG/Additives: (a) (*S,S*)-1,2-cyclohexanediamine was dissolved in $CHCl_3$ (1:1 molar ratio) and 2 drops of TFA were added to the solution, before continuing with the LAG method – see Table S1, entry 12; (b) 1,3,5-Triformylbenzene (1.0 eq.) was mixed with $NaHCO_3$ (0.4 eq.), before continuing with the LAG method – see Table S1, entry 13.

Standard Screw Configuration:



Reverse Screw Configuration:

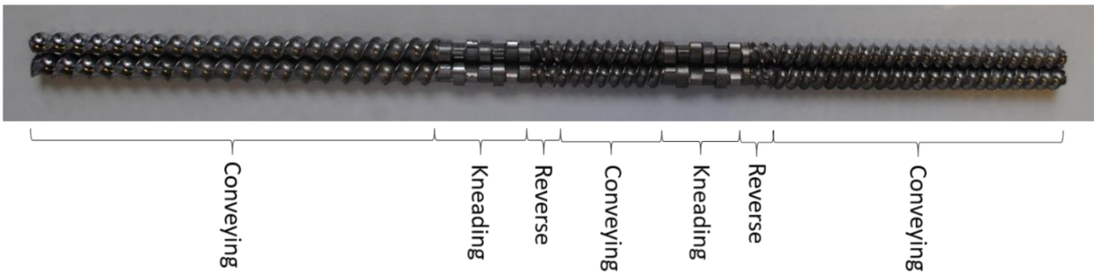


Figure S1: Photos of the standard screw (top) configuration used, containing kneading and conveying sections at angles of 30° and 60°, and the reverse screw configuration (bottom), containing additional reverse conveying segments.

Table S1: Summary of conditions screened, with reagent quantities, during the optimisation of **CC3** formation using twin-screw extrusion.

Entry	TFB: CHDA Ratio	TFB (g)	CHDA (g)	Temp (°C)	Speed (rpm)	LAG	Solvent	Solvent: CHDA Ratio	Screws	Fully Dissolved?	Comments
1	4:7	1.4	1.72	RT	55	×	×	-	Standard	✓	-
2	4:7	1.4	1.72	60	55	×	×	-	Standard	✓	-
3[a]	4:7	1.4	1.72	100	55	×	×	-	Standard	-	Torque limit exceeded
					100	×	×	-	Standard	✓	-
4	4:7	1.4	1.72	160	75	×	×	-	Standard	×	Insoluble polymer formed
5	4:7	1.4	1.72	Gradient[b]	75-100	×	×	-	Standard	-	Torque limit exceeded[e]
6	4:6	1.5	1.58	60	55	×	×	-	Standard	✓	
7	4:8	1.3	1.83	60	55	×	×	-	Standard	✓	
8	4:8	3.25	4.57	Gradient[c]	200	×	×	-	Reverse	✓	
9	4:8	3.9	5.49	Gradient[c]	200	✓	$CHCl_3$	1:1	Reverse	✓	
10	4:8	3.9	5.49	Gradient[c]	200	✓	H_2O	1:1	Reverse	✓	
11	4:8	3.9	5.49	Gradient[c]	100	✓	$CHCl_3$	1:1	Reverse	×	Torque limit exceeded
12	4:8	1.73	2.43	Gradient[c]	200	✓	$CHCl_3$	1:1	Reverse	×	2 drops TFA mixed with CHDA:$CHCl_3$ mixture
13	4:8	3.9	5.49	Gradient[c]	200	✓	$CHCl_3$	1:1	Reverse	×	0.4 eq. $NaHCO_3$ mixed with TFB
14	4:8	4	5.63	Gradient[d]	200	✓	$CHCl_3$	1:4	Reverse	×	Insoluble polymer formed[e]
15	4:8	4	5.63	Gradient[d]	200	✓	$CHCl_3$	1:8	Reverse	×	Torque limit exceeded[e]
16	4:6.2	3.9	4.25	Gradient[c]	200	✓	$CHCl_3$	1:1	Reverse	✓	
17	4:10	4	7.04	Gradient[d]	200	✓	$CHCl_3$	1:1	Reverse	×	Insoluble polymer formed[e]

[a] Reaction carried out twice: first run at 55 rpm and torque limit was exceeded, so second run carried out at 100 rpm; [b] Gradient along extruder barrel used: H1 = ambient, H2 = 60 °C, H3-H6 = 100 °C; [c] Gradient along extruder barrel used: H1-H2 = 60 °C, H3-H6 = 80 °C; [d] Gradient along extruder barrel used: H1-H4 = 60 °C, H5-H6 = 80 °C; [e] Only insoluble material formed and therefore not all solution based characterisation carried out.

Table S2: Summary of the solution-based characterisation of each extruded sample from the optimisation of **CC3** formation using twin-screw extrusion.

Entry	**Characterisation**							**Species Formed?**
	^{1}H NMR ($CDCl_3$)		**QTOF-MS**				**HPLC**	
	CC3 Formed?	**Residual TFB?**	**CC3 Formed?**	**Mass ion?**	**Other species?**	**Mass ion?**	**[4+6]:[3+5] Percentage Ratio (a/a)**	
1	×	✓	×	-	×	-	-	-
2	✓	✓	✓	[M+H]$^+$ 1117.7086 [M+2H]$^{2+}$ 559.3586	✓	[M+H]$^+$ 895.5927 [M+2H]$^{2+}$ 448.3005	70:30	[4+6], [3+5]
3	✓	×	✓	[M+H]$^+$ 1117.7106 [M+2H]$^{2+}$ 559.3590	✓	[M+H]$^+$ 895.5933 [M+2H]$^{2+}$ 448.3011	69:31	[4+6], [3+5]
4	✓	×	✓	[M+H]$^+$ 1117.7092 [M+2H]$^{2+}$ 559.3596	✓	[M+H]$^+$ 895.5943 [M+2H]$^{2+}$ 448.3014	69:31	[4+6], [3+5]
5	-	-	-	-	-	-	-	-
6	✓	✓	✓	[M+H]$^+$ 1117.7097 [M+2H]$^{2+}$ 559.3585	✓	[M+H]$^+$ 895.5925 [M+2H]$^{2+}$ 448.3009	69:31	[4+6], [3+5]
7	✓	✓	✓	[M+H]$^+$ 1117.7101 [M+2H]$^{2+}$ 559.3591	✓	[M+H]$^+$ 895.5937 [M+2H]$^{2+}$ 448.3010	67:33	[4+6], [3+5]
8	✓	×	✓	[M+H]$^+$ 1117.7101 [M+2H]$^{2+}$ 559.3588	✓	[M+H]$^+$ 895.5933 [M+2H]$^{2+}$ 448.3013	77:23	[4+6], [3+5]
9	✓	×	✓	[M+H]$^+$ 1117.6929 [M+2H]$^{2+}$ 559.3502	✓	[M+H]$^+$ 895.5791 [M+2H]$^{2+}$ 448.2932	85:15	[4+6], [3+5]
10	✓	×	✓	[M+H]$^+$ 1117.6911 [M+2H]$^{2+}$ 559.3504	✓	[M+H]$^+$ 895.5786 [M+2H]$^{2+}$ 448.2920	69:31	[4+6], [3+5]
11	✓	×	✓	[M+H]$^+$ 1117.6922 [M+2H]$^{2+}$ 559.3496	✓	[M+H]$^+$ 895.5790 [M+2H]$^{2+}$ 448.2928	90:10	[4+6], [3+5]
12	✓	×	✓	[M+H]$^+$ 1117.6921 [M+2H]$^{2+}$ 559.3493	✓	[M+H]$^+$ 895.5783 [M+2H]$^{2+}$ 448.2926	70:30	[4+6], [3+5]
13	✓	×	✓	[M+H]$^+$ 1117.6920 [M+2H]$^{2+}$ 559.3499	✓	[M+H]$^+$ 895.5774 [M+2H]$^{2+}$ 448.2921	72:28	[4+6], [3+5]
14	✓	×	-	-	-	-	-	[4+6] + oligomers
15	-	-	-	-	-	-	-	-
16	✓	×	✓	[M+H]$^+$ 1117.6914 [M+2H]$^{2+}$ 559.3503	✓	[M+H]$^+$ 895.5777 [M+2H]$^{2+}$ 448.2929	78:22	[4+6], [3+5]
17	-	-	-	-	-	-	-	-

Table S3: Summary of the solid-based characterisation of each extruded sample from the optimisation of **CC3** formation using twin-screw extrusion.

Entry	**PXRD**		
	Bulk Crystallinity?	**TFB?**	**CC3α?**
1	Crystalline	✓	×
2	Predominantly Amorphous	✓	×
3	Amorphous	×	×
4	Amorphous	×	×
5	-	-	-
6	Predominantly Amorphous	✓	×
7	Predominantly Amorphous	✓	×
8	Amorphous	×	×
9	Predominantly Amorphous	×	✓
10	Predominantly Amorphous	×	✓
11	Crystalline	×	✓
12	Some Crystallinity	✓	✓
13	Predominantly Amorphous	×	✓
14	Some Crystallinity	×	✓
15	Some Crystallinity	×	✓
16	Predominantly Amorphous	×	✓
17	-	-	-

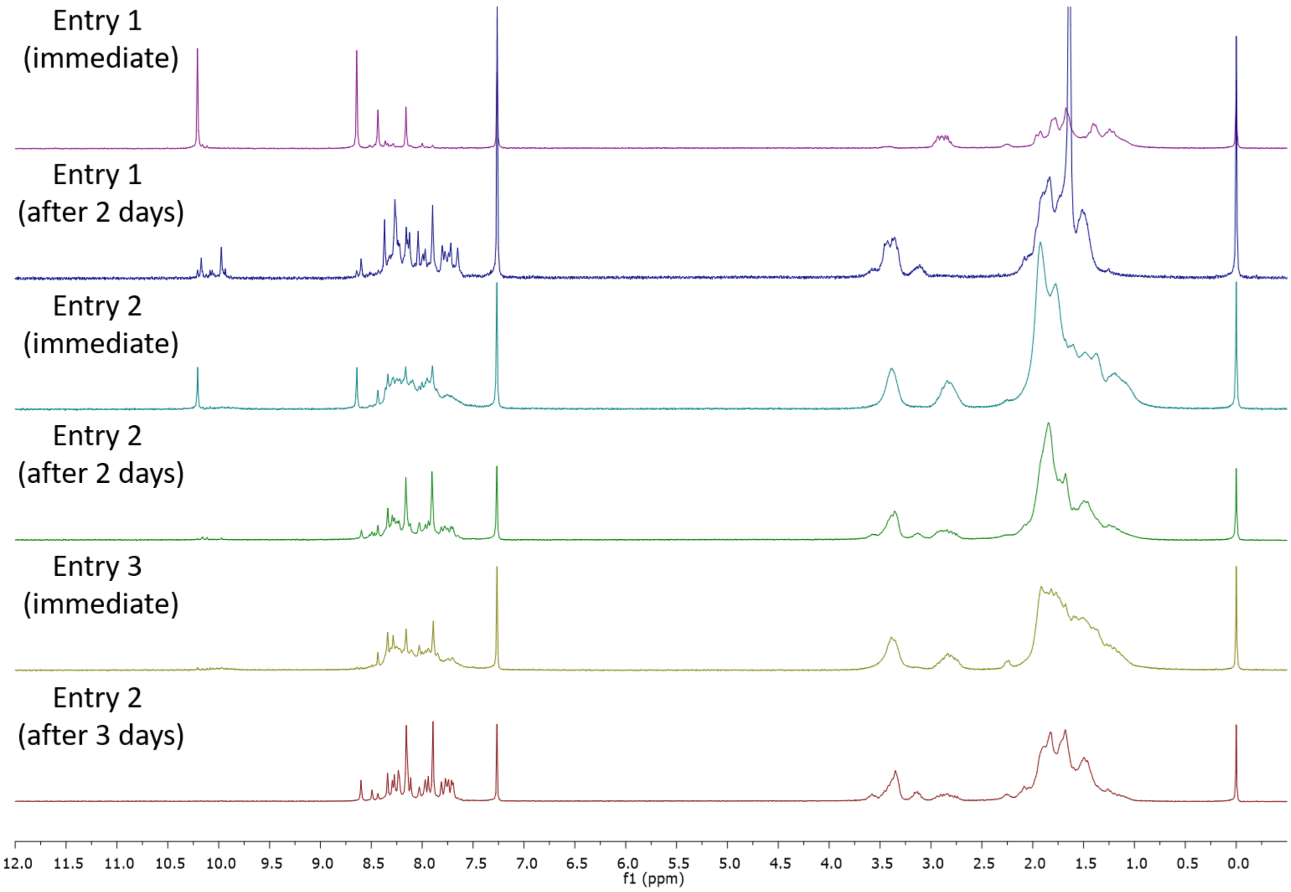


Figure S2: Stacked ^{1}H NMR ($CDCl_3$) spectra of extruded samples during the optimisation of **CC3**, immediately after sample preparation and after leaving the sample in $CDCl_3$ for 2 days, showing equilibration to **CC3** occurs over time.

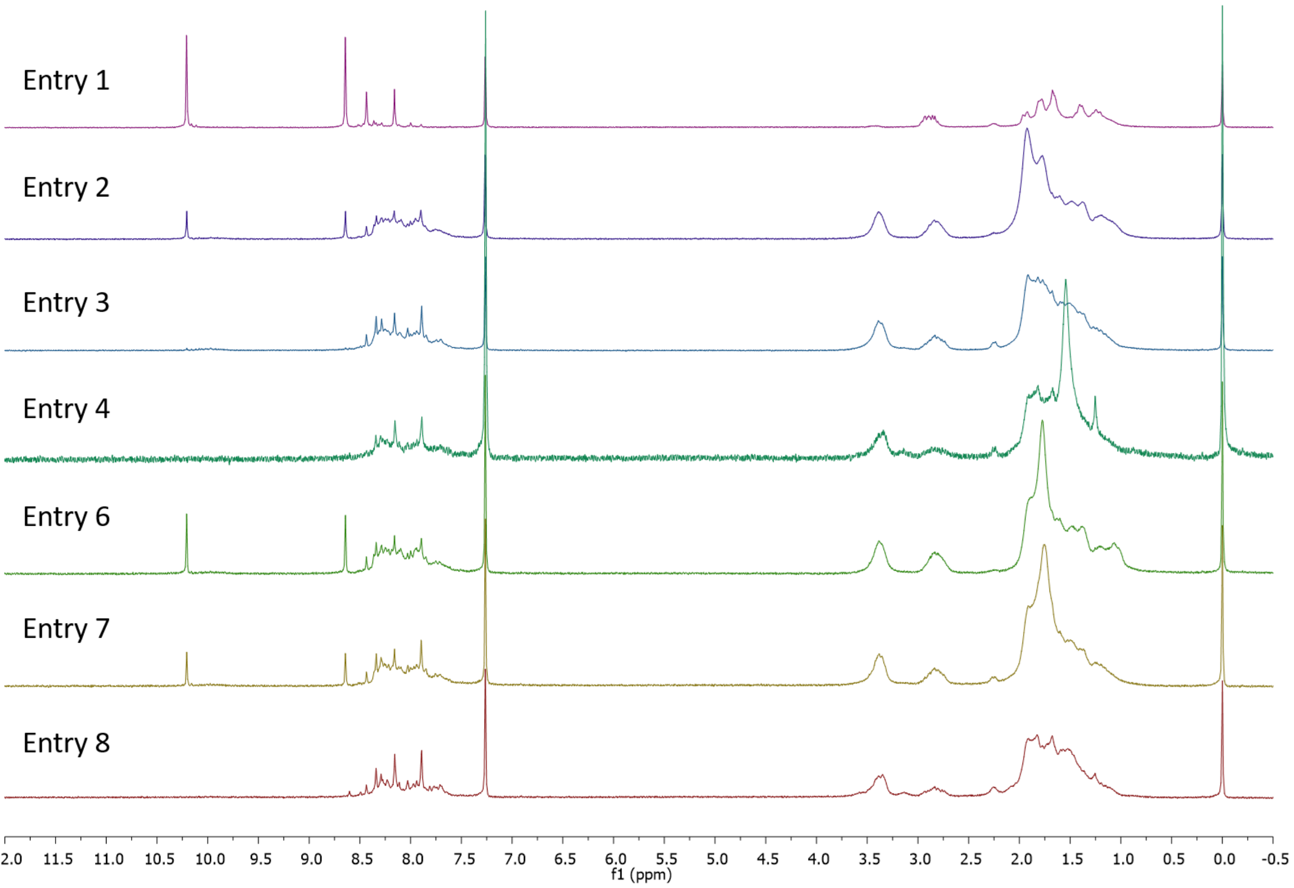


Figure S3: Stacked ^{1}H NMR ($CDCl_3$) spectra of extruded samples during the optimisation of **CC3** formation using no LAG during twin-screw extrusion (Table S1, Entries 1-8).

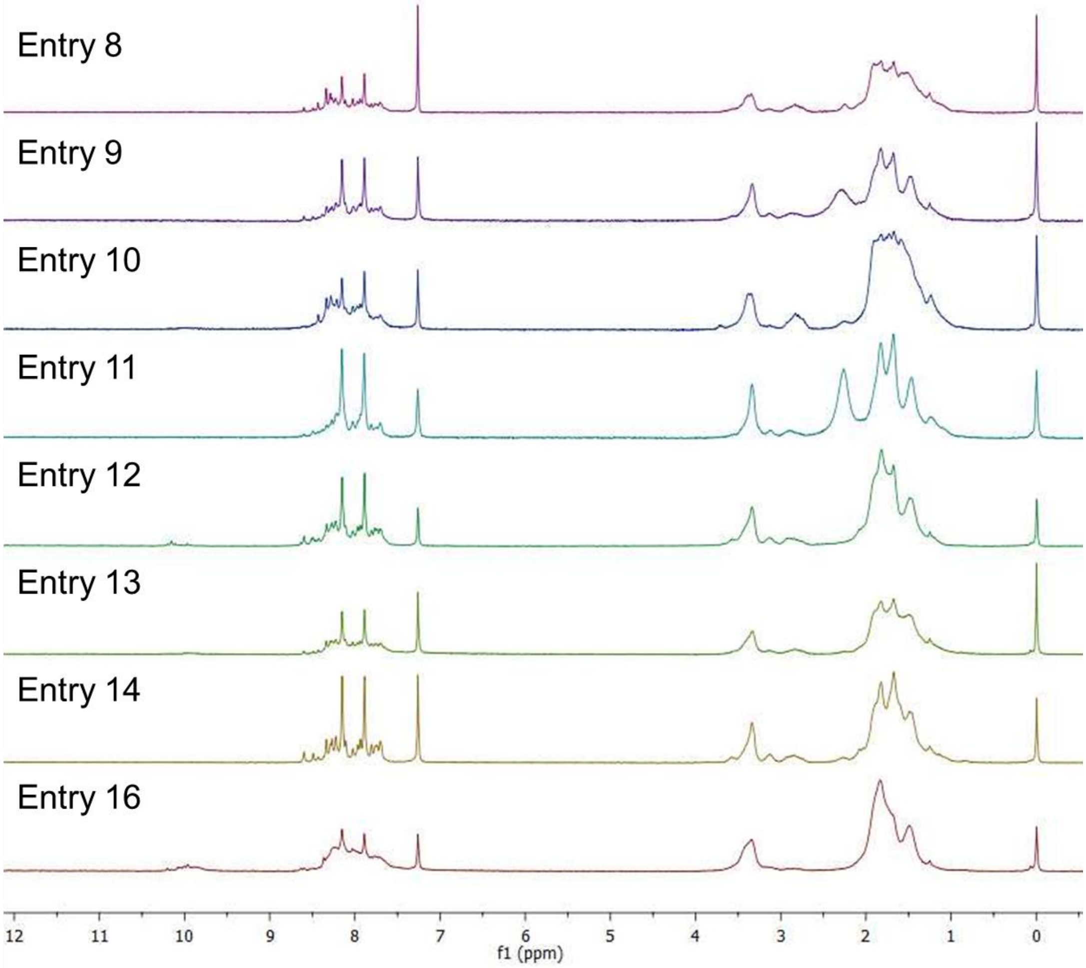


Figure S4: Stacked ^1H NMR ($CDCl_3$) spectra of extruded samples during the optimisation of **CC3** formation using the reverse screw configuration during twin-screw extrusion (Table S1, Entries 8-17).

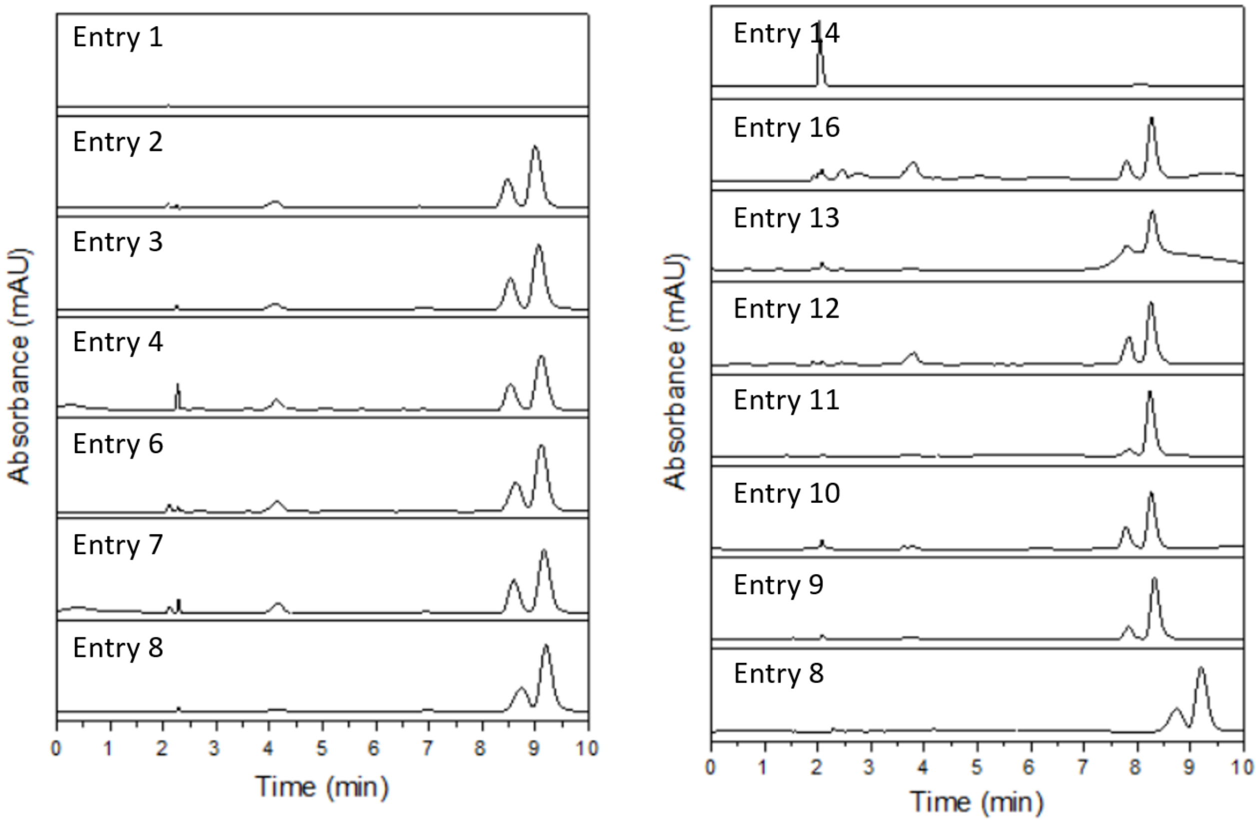


Figure S5: Stacked HPLC traces of extruded samples during the optimisation of **CC3** formation using twin-screw extrusion.

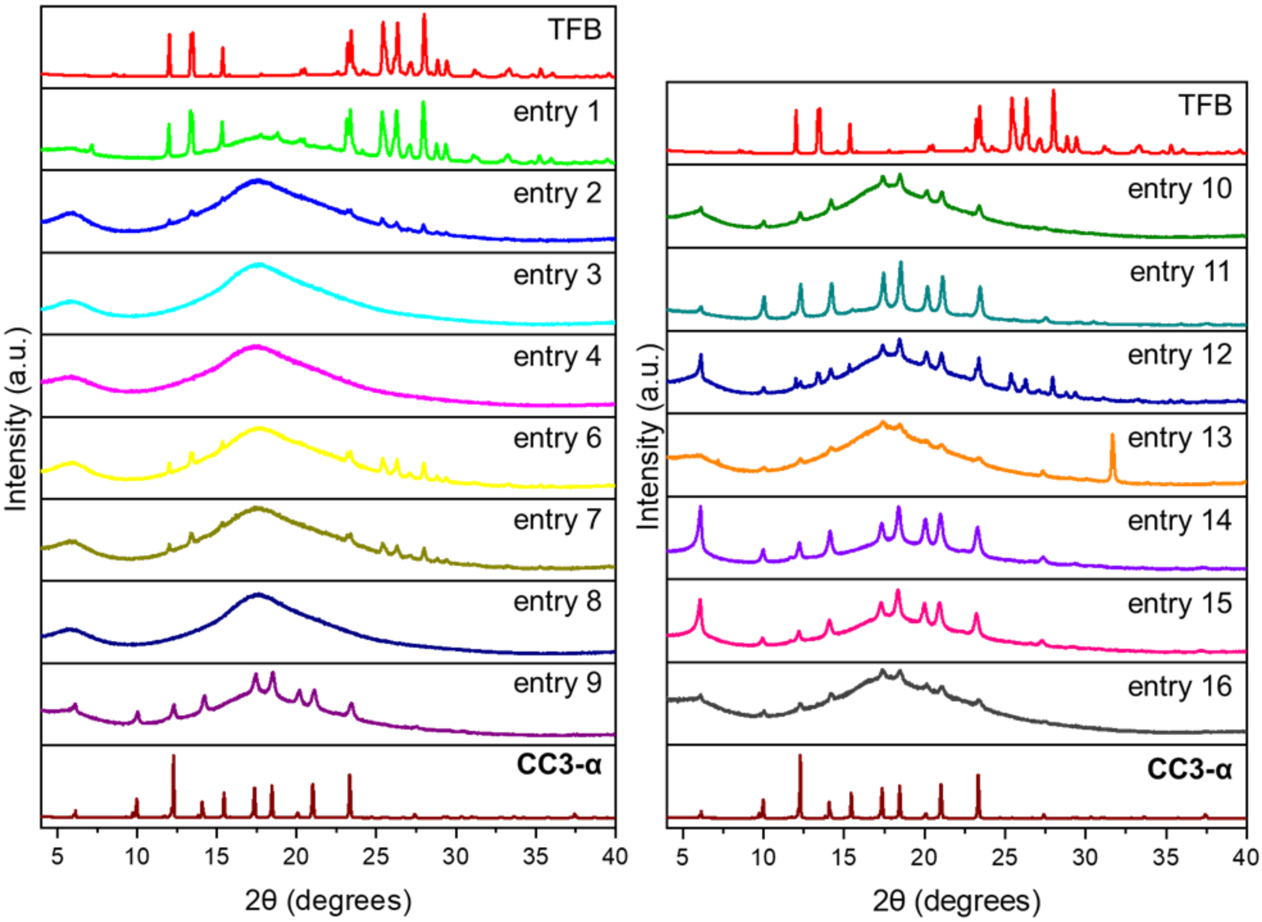


Figure S6: Stacked PXRD traces of extruded samples during the optimisation of **CC3** formation using twin-screw extrusion.

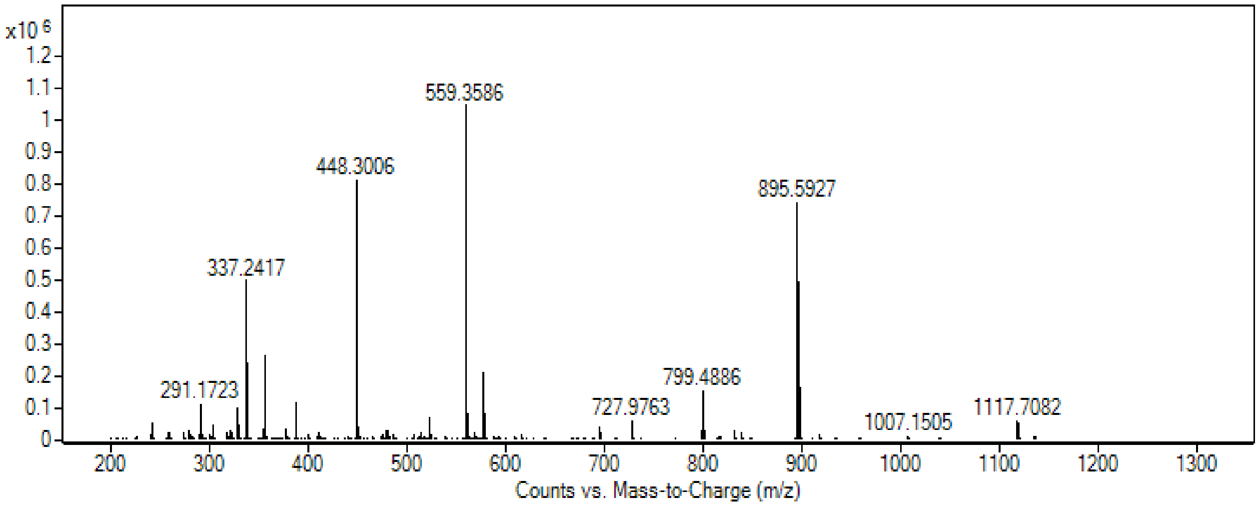


Figure S7: Example HRMS spectra of one of the extruded samples during the optimisation of **CC3** formation using twin-screw extrusion, showing the corresponding mass ions for the [3+5] ($[M+H]^+$ 895.5927, $[M+2H]^{2+}$ 448.3006) and **CC3** ($[M+H]^+$ 1117.7082, $[M+2H]^{2+}$ 559.3586) species.

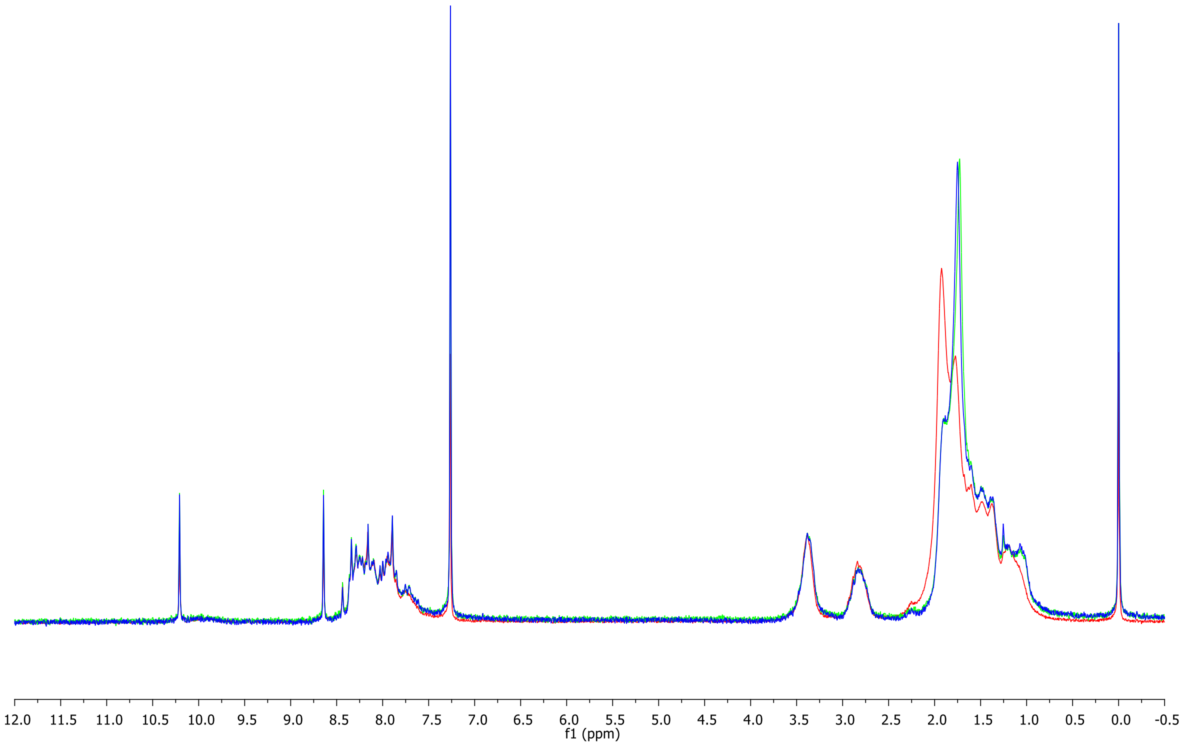


Figure S8: Overlaid ^{1}H NMR ($CDCl_3$) spectra of the optimisation reaction passed through the extruder a further two times (red = initial reaction, green = 2nd pass, blue = 3rd pass) using the standard screw configuration at 60 °C and 55 rpm (Table S1, Entry 2), showing no further conversion to **CC3**.

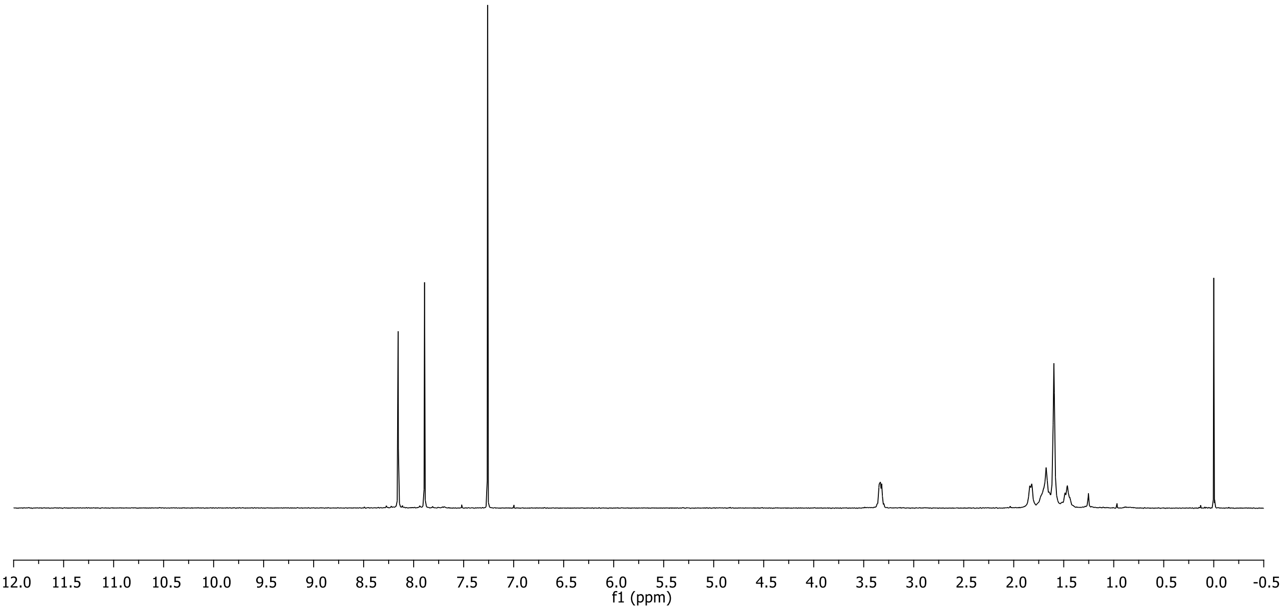


Figure S9: ^{1}H NMR ($CDCl_3$) spectra of pure **CC3**, pre-formed using standard solution based batch conditions, after processing in the extruder (reverse screw configuration, 200 rpm, temperature gradient: 60-80 °C) showing no conversion to any side-products.

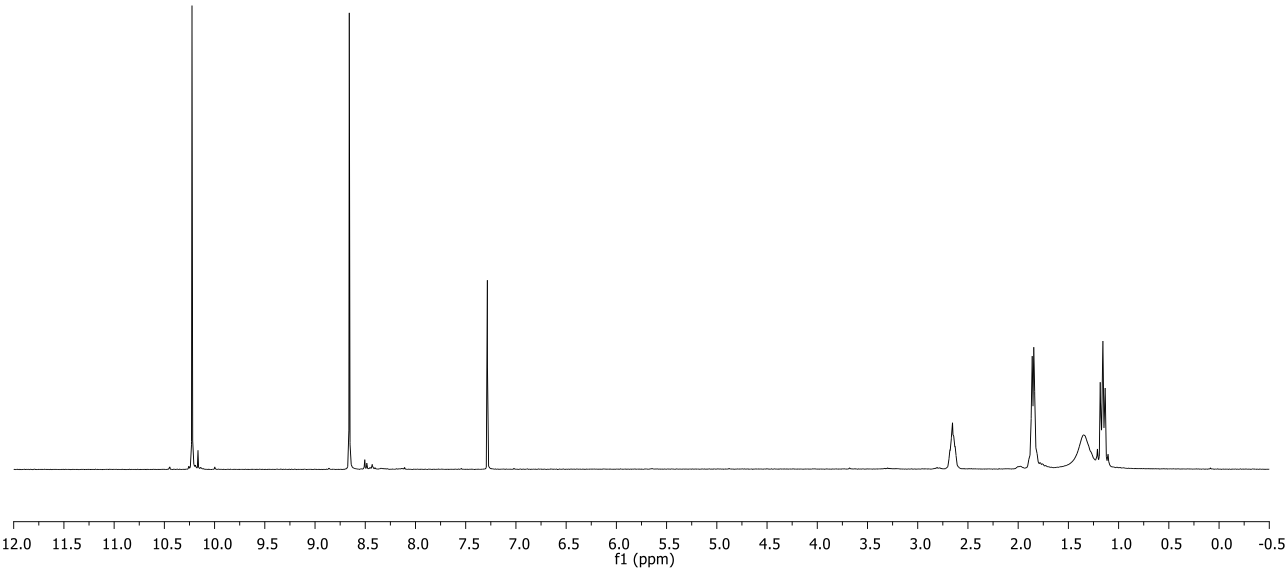


Figure S10: ^{1}H NMR ($CDCl_3$) spectra of the solid after mixing TFB (4 eq.) and CHDA (8 eq.) neat at room temperature, indicating no formation of **CC3** and only the unreacted precursors being present.

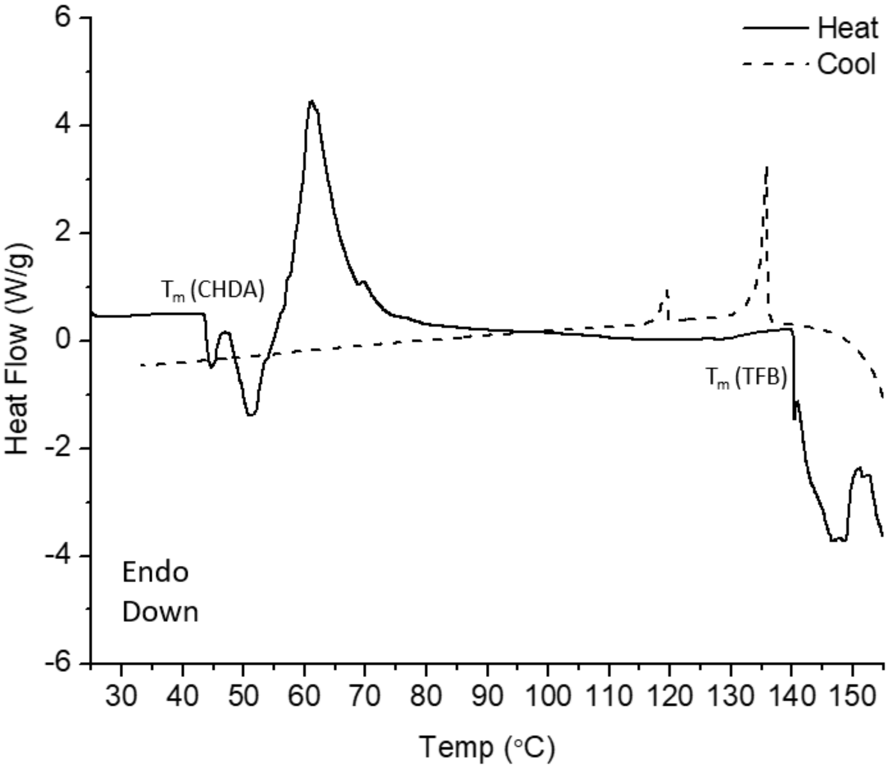


Figure S11: DSC trace of a mixture of TFB (4 eq.) and CHDA (8 eq.) heated neat to 160 °C and then cooled, showing the endotherms correlating with the melting points of both, and an exotherm between 60 and 75 °C which is thought to correlate with polymer formation.

3. Scale-up of CC3 formation by TSE

Table S4: Average TFB Addition rate (0.4% rotation speed on volumetric feeder) – dispensed mass over an extended time period measured to get an average dispensing rate

	Total Mass Dispensed (g)	Total Time (min)	Dispensing Rate (mg/min)
1	4.87	53.5	91
2	3.95	44.9	88
3	4.97	60.1	83
4	3.9	47	83
Average dispensing rate (mg/min)			**86**
Standard deviation			**3.5**

Preparation of CHDA stock solution: To *S,S*-CHDA (31.5 g, 275.86 mmol, 1.0 eq.) was added $CHCl_3$ (22.1 mL, 275.86 mmol, 1.0 eq.) and the mixture sonicated until completely dissolved. The stock solution was loaded into syringes ready for addition to the extruder *via* syringe pump.

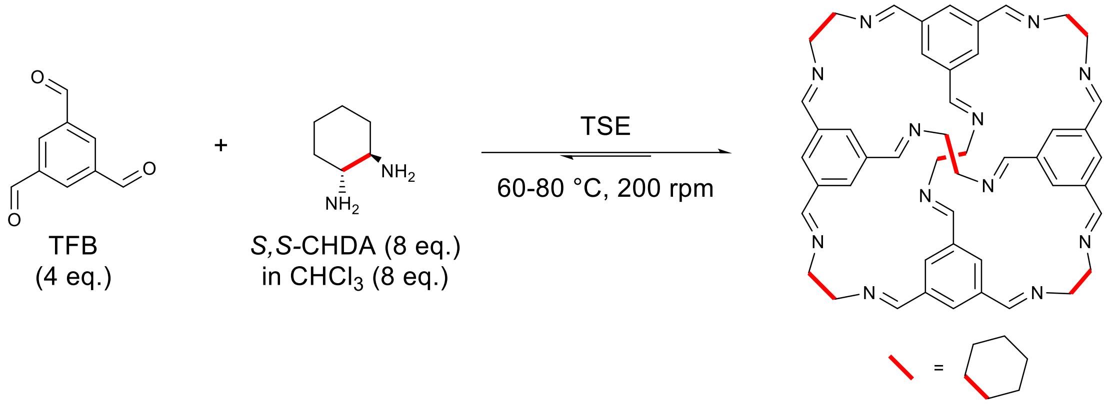
Table S5: Density of stock solution – 1 mL measured 5 times to calculate an average density of the stock solution

	Mass of 1 mL sample (g)
1	1.1753
2	1.1696
3	1.1718
4	1.1714
5	1.1655
Average density (g/mL)	**1.17**
Standard deviation	**0.0036**

Table S6: Calculated addition rates for scale-up of **CC3** by TSE, based on the maximum amount of TFB that could be added to ensure a 4:8 ratio of TFB:CHDA is maintained throughout the preparation.

	Addition Rate (mg/min)	Addition Rate (mmol/min)	Addition Rate (mL/min)	Equiv.
TFB (based on maximum mass addition)	**89.5**	0.55	-	4.0
S,S-CHDA required	126	1.10	-	8.0
$CHCl_3$ required	131	1.10	-	8.0
CHDA in $CHCl_3$ (1:1)	257	-	**0.22**	-

Scale-up procedure of CC3:



CC3-*S*

Heating zones 1-4 were heated to 60 °C and heating zones 5-6 to 80 °C, with a screw speed of 200 rpm, employing the configuration consisting of reverse screw segments. A volumetric feeder was used to feed TFB into the barrel at a feed rate of 0.4%, equating to an average feed rate of 5.16 g/h. A syringe pump was used to feed a stock solution of CHDA in $CHCl_3$ (1:1 based on molar equivalents) before the solid TFB feed at a rate of 13.2 mL/h. Under these conditions, complete consumption of TFB was determined in the bulk material by ^1H NMR spectroscopy ($CDCl_3$), with the bulk extruded material (~16.3 g/h) showing an 88:12 ratio of **CC3**:[3+5] with an overall 95% purity as determined by HPLC analysis. For data see Figures S11-S21 and Table S7.

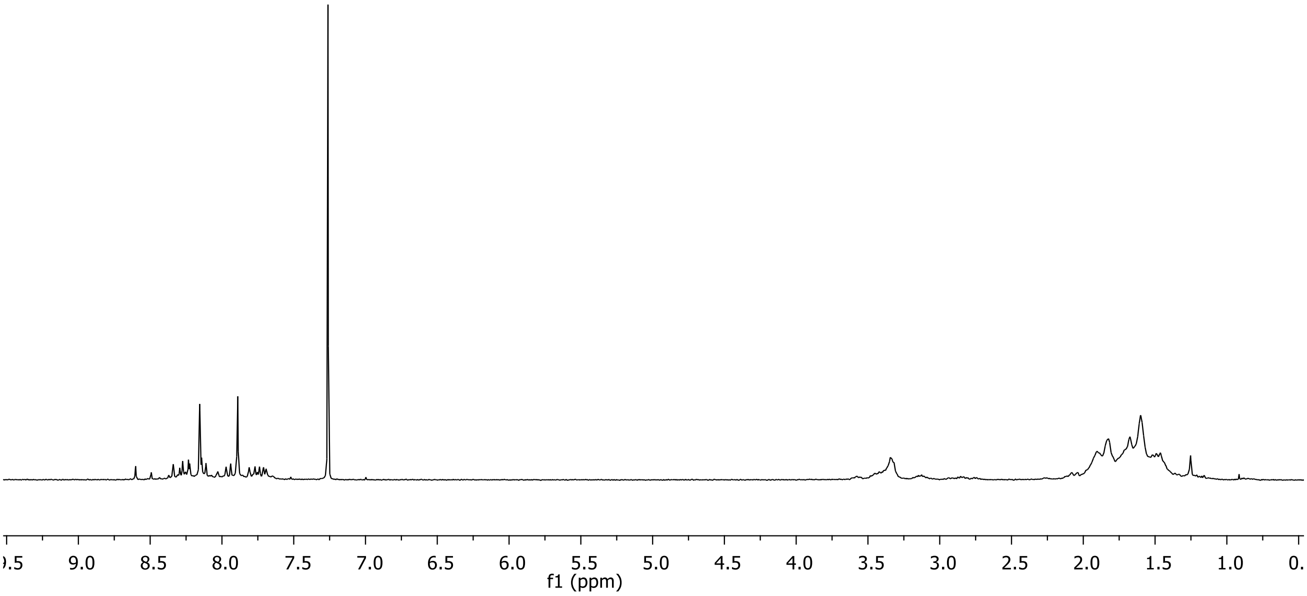


Figure S12: ^1H NMR ($CDCl_3$) spectra of bulk extruded material from the scale-up

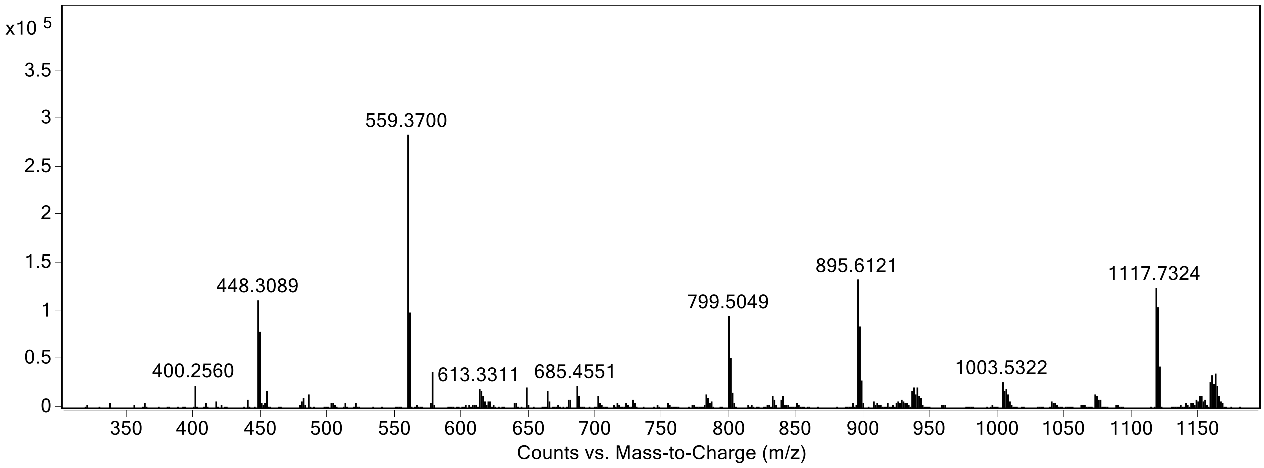


Figure S13: HRMS spectra of bulk extruded material from the scale-up, showing the corresponding mass ions for the [3+5] ([M+H]$^+$ 895.6121, [M+2H]$^{2+}$ 448.3089) and **CC3** ([M+H]$^+$ 1117.7324, [M+2H]$^{2+}$ 559.3700) species.

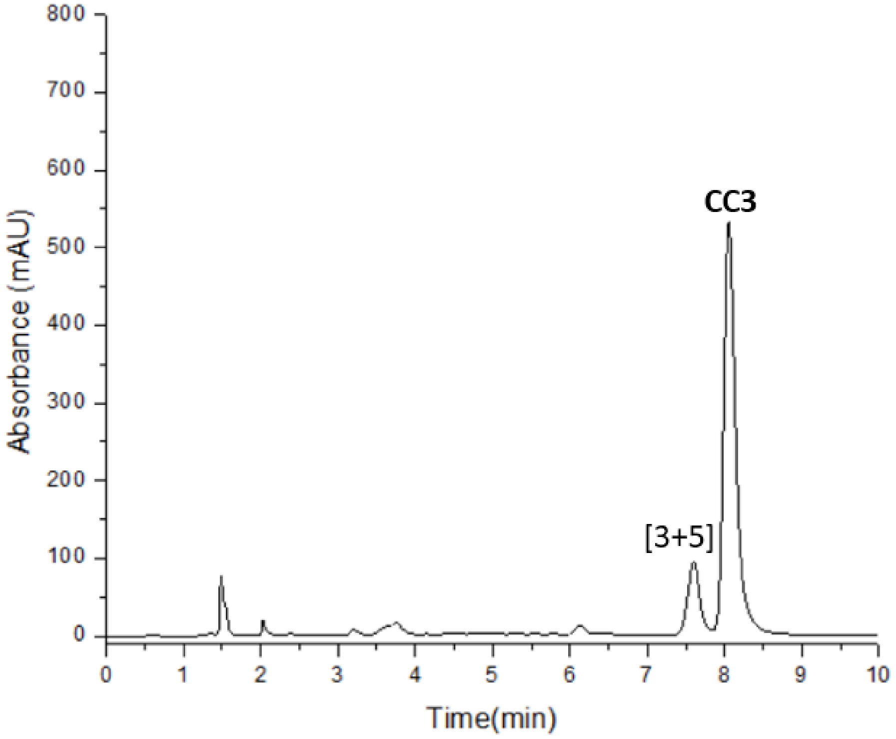


Figure S14: HPLC trace of bulk extruded material from the scale-up, showing an 88:12 ratio of **CC3**:[3+5] and an overall 95% purity based on relative peak areas. The solvent front is visible at ~1.5 min.

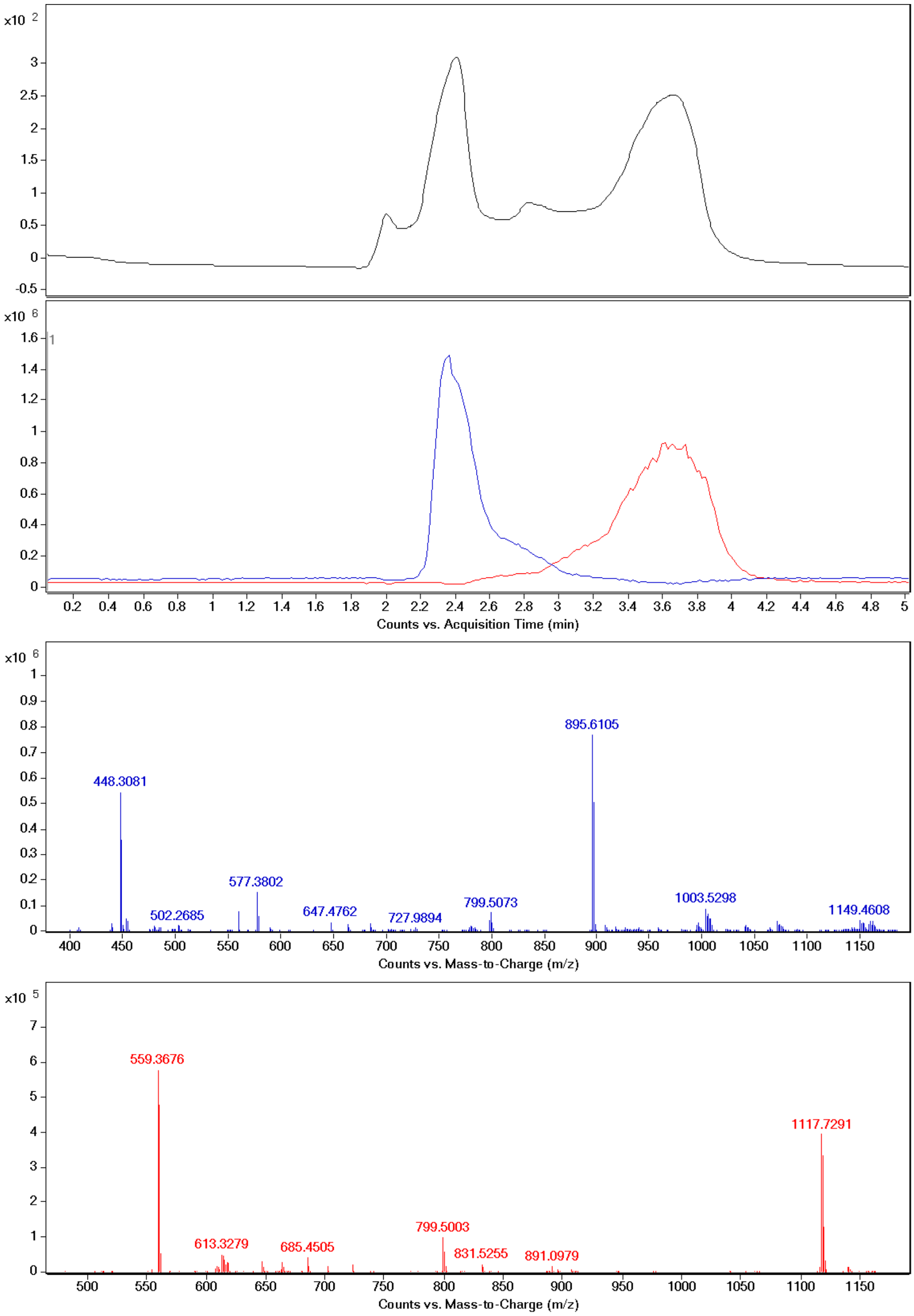


Figure S15: LCMS of the as extruded material from the scale-up, with traces for the UV spectra (black), and extracted ion counts (EIC) for each of the [3+5] species (blue) and **CC3** (red), with the corresponding mass spectra below – [3+5] species, peak at ~ 2.4 min, $[M+H]^+$ 895.6105 and $[M+2H]^{2+}$ 448.3081; **CC3**, peak at ~ 3.6 min, $[M+H]^+$ 1117.7291 and $[M+2H]^{2+}$ 559.3676

Table S7: Measured cumulative mass of extruded material over a 3 hour period during the scale-up of **CC3**, compared to the calculated masses of feed ratios and the maximum theoretical mass of **CC3** than could be formed.

Time (min)	Cumulative Extruded Mass (g)	Feed of TFB+CHDA+$CHCl_3$ Cumulative Mass (g)	Cumulative Mass of TFB+CHDA-$CHCl_3$ (g)	Maximum Mass of Generated Water (g)	Theoretical Maximum Mass of CC3 formation = TFB+CHDA-$CHCl_3$-H_2O-excess CHDA (g)
0	0	0.00	0	0.00	0.00
5	4.56	1.71	1.06	0.14	0.76
10	5.09	3.43	2.12	0.29	1.52
15	5.46	5.14	3.17	0.43	2.27
20	6.34	6.86	4.23	0.57	3.03
25	7.95	8.57	5.29	0.72	3.79
30	9.1	10.29	6.35	0.86	4.55
35	10.35	12.00	7.41	1.00	5.30
40	12.39	13.72	8.46	1.15	6.06
45	13.97	15.43	9.52	1.29	6.82
50	15.69	17.15	10.58	1.43	7.58
55	16.34	18.86	11.64	1.58	8.34
60	18.04	20.58	12.70	1.72	9.09
65	18.85	22.29	13.75	1.86	9.85
70	19.3	24.00	14.81	2.01	10.61
75	20.22	25.72	15.87	2.15	11.37
80	21.57	27.43	16.93	2.29	12.12
85	22.94	29.15	17.99	2.44	12.88
90	24.32	30.86	19.04	2.58	13.64
95	24.65	32.58	20.10	2.72	14.40
100	26.29	34.29	21.16	2.87	15.15
105	28.3	36.01	22.22	3.01	15.91
110	29.55	37.72	23.28	3.15	16.67
115	31.26	39.44	24.34	3.30	17.43
120	32.8	41.15	25.39	3.44	18.19
125	33.89	42.87	26.45	3.58	18.94
130	36.11	44.58	27.51	3.73	19.70
135	37.66	46.30	28.57	3.87	20.46
140	37.92	48.01	29.63	4.01	21.22
145	38.17	49.72	30.68	4.16	21.97
150	39.15	51.44	31.74	4.30	22.73
155	41.01	53.15	32.80	4.44	23.49
160	42.6	54.87	33.86	4.59	24.25
165	44.32	56.58	34.92	4.73	25.01
170	45.97	58.30	35.97	4.87	25.76
175	48.81	60.01	37.03	5.02	26.52
180	49.01	61.73	38.09	5.16	27.28

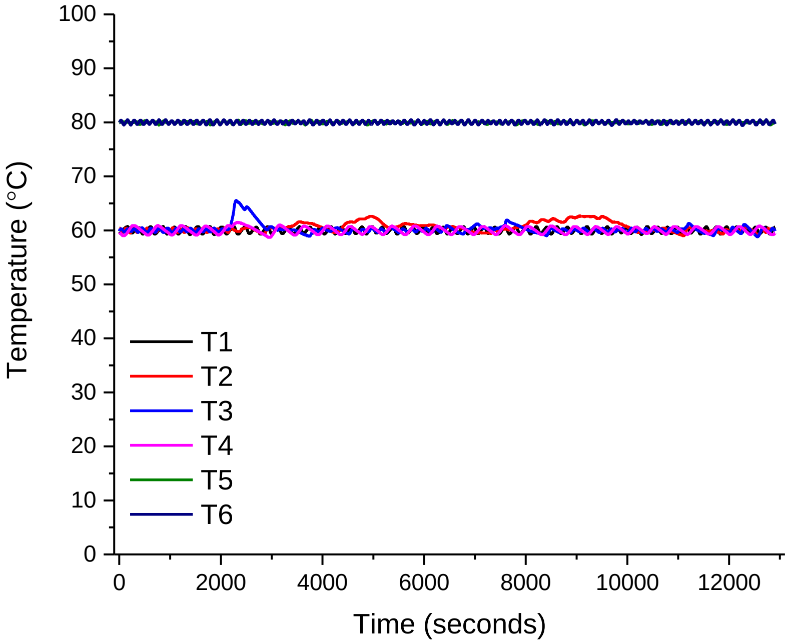


Figure S16: Temperature monitoring for each of the heating zones during the scale-up of **CC3** by TSE. Some small exotherms are observed in zones 2 and 3 where the first kneading section is located – this is likely due to the cage formation reaction occurring, which was shown to have occurred at this section (see Figure S19).

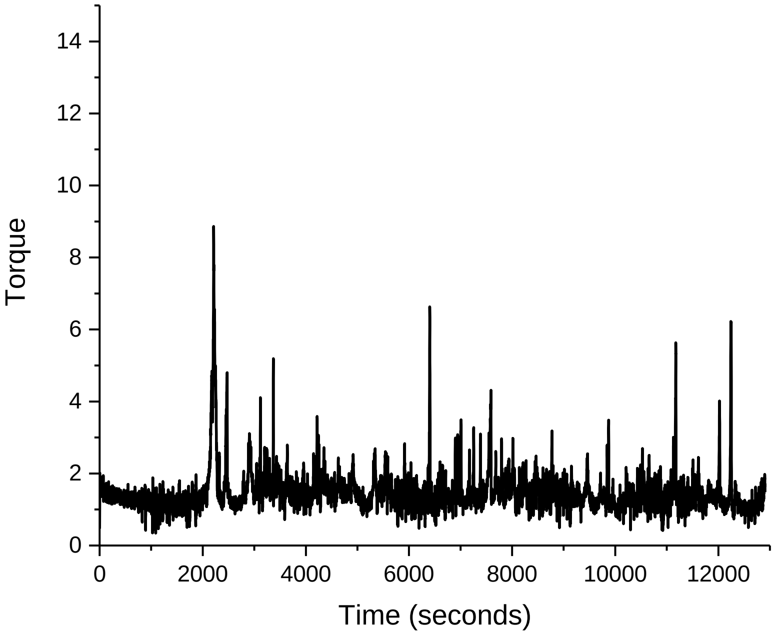


Figure S17: Torque monitoring during the scale-up of **CC3** by twin-screw extrusion.

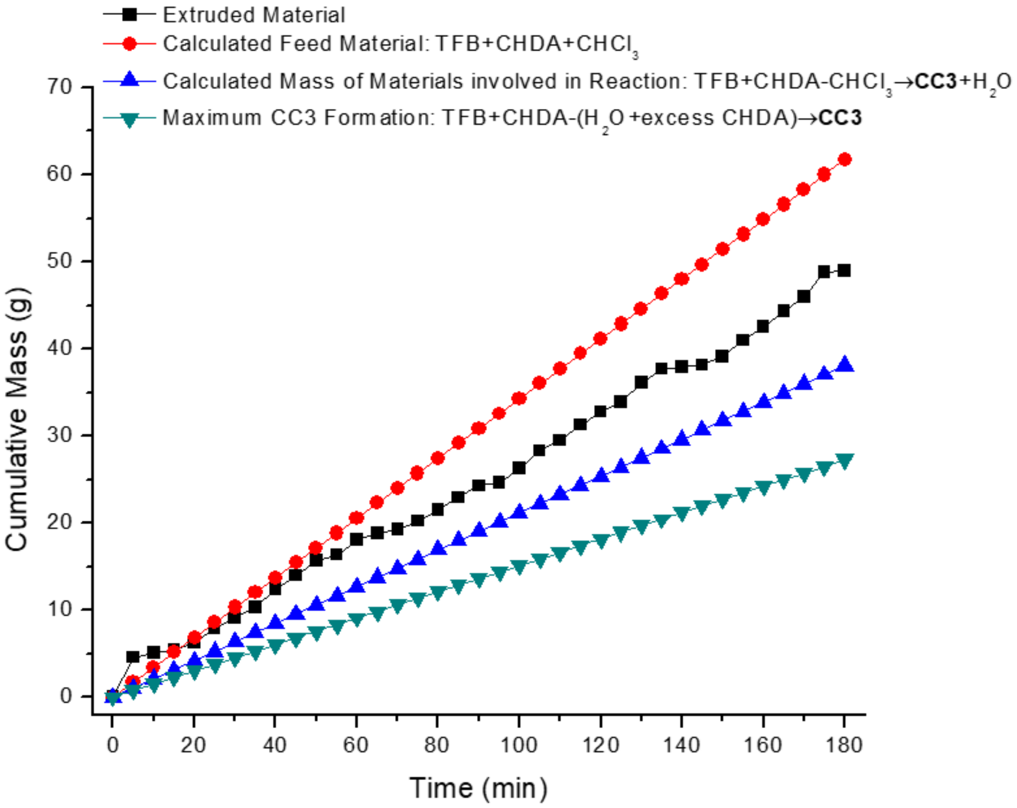


Figure S18: Comparison of calculated feed quantities with the cumulative measured mass of the extruded material over a 3 hour run.

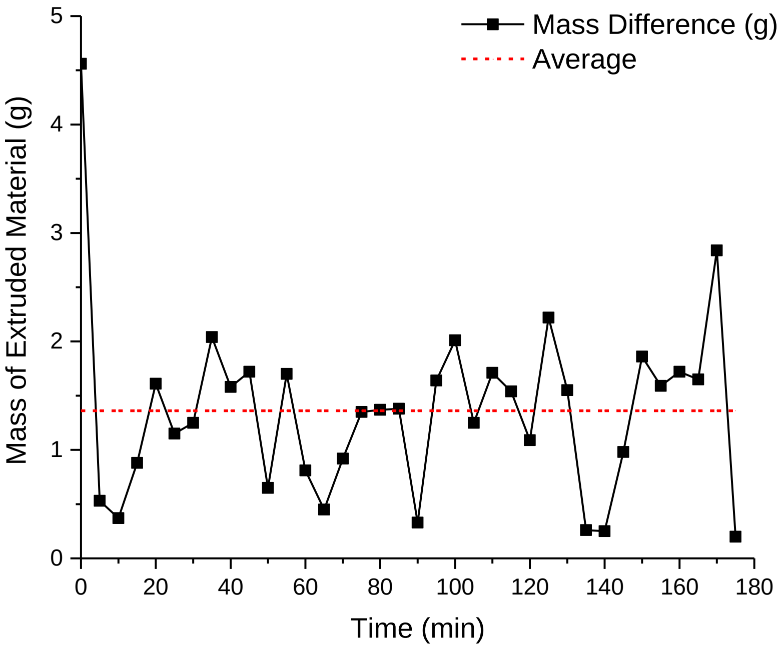


Figure S19: Differential mass of extruded material showing reliable and continuous cage formation over a 3 hour run.

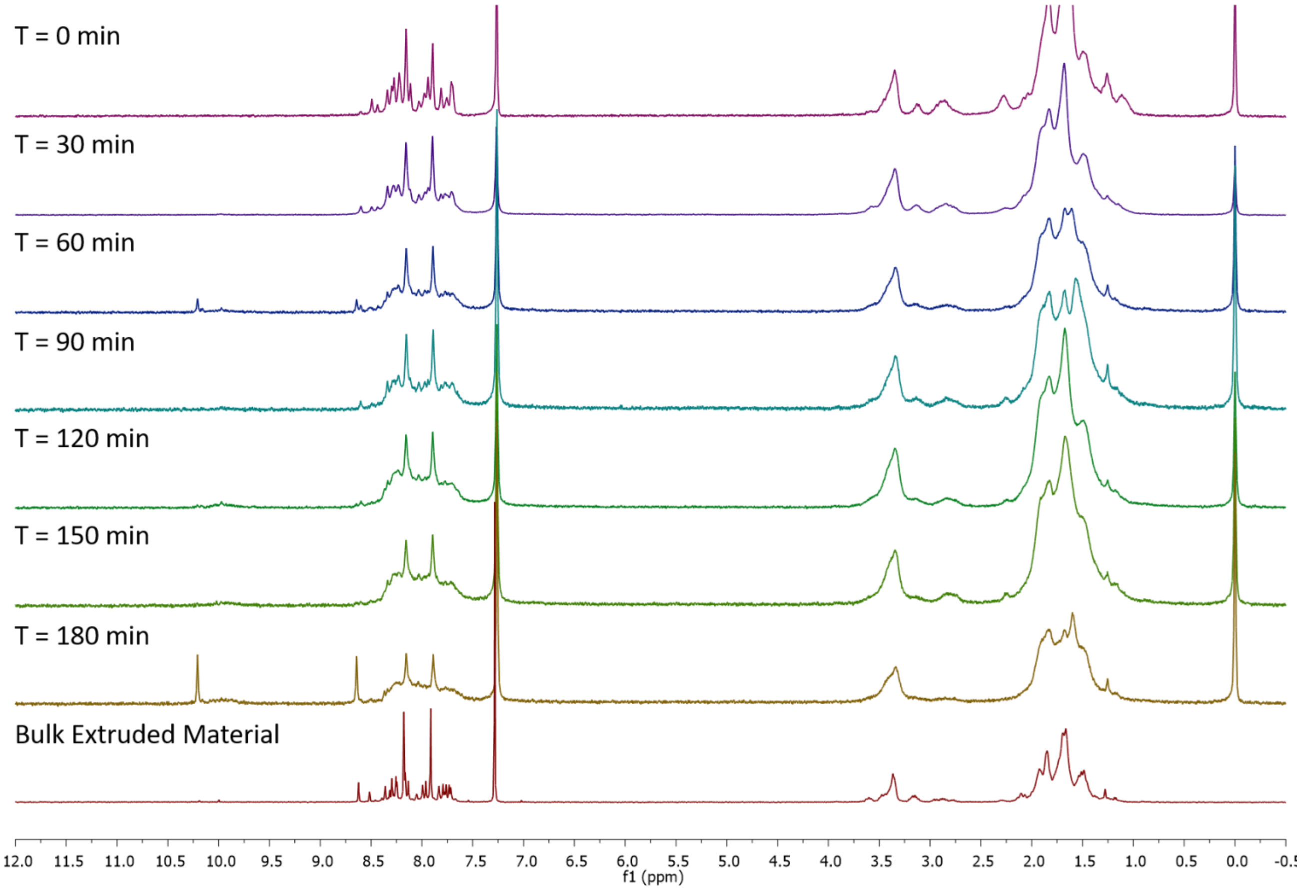


Figure S20: Stacked ^{1}H NMR ($CDCl_3$) spectra of samples of the bulk extruded material at different time points during continuous processing.

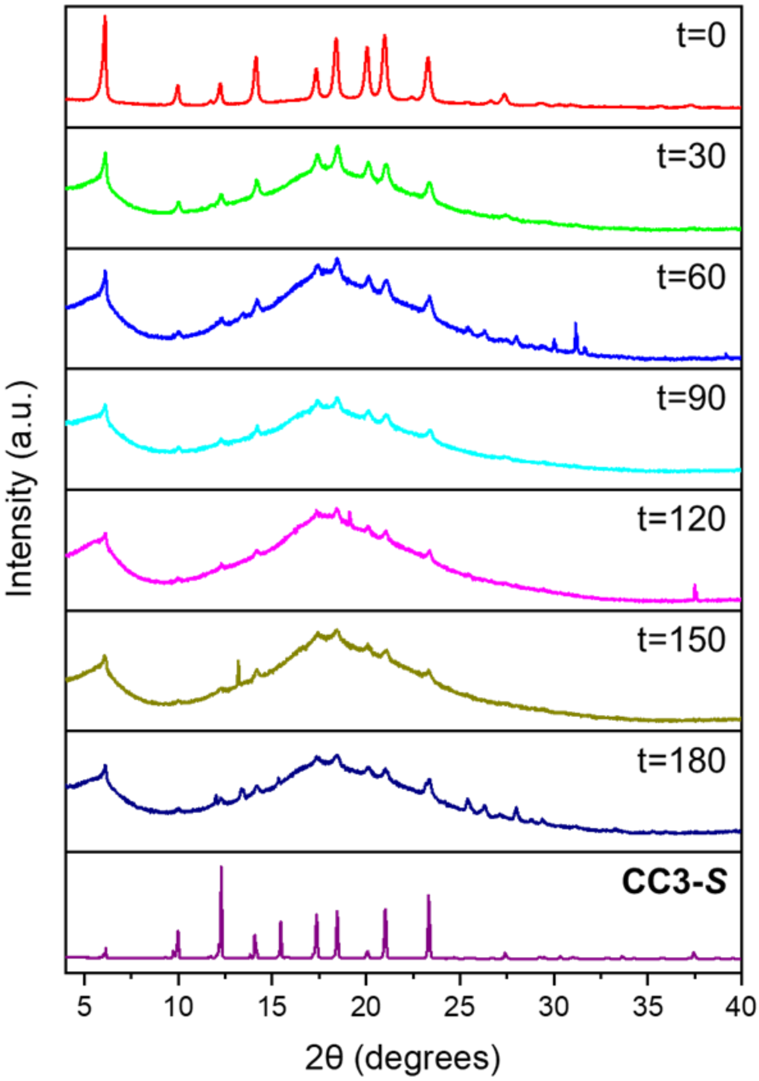


Figure S21: Stacked PXRDs of samples of the bulk extruded material at different time points during continuous processing.

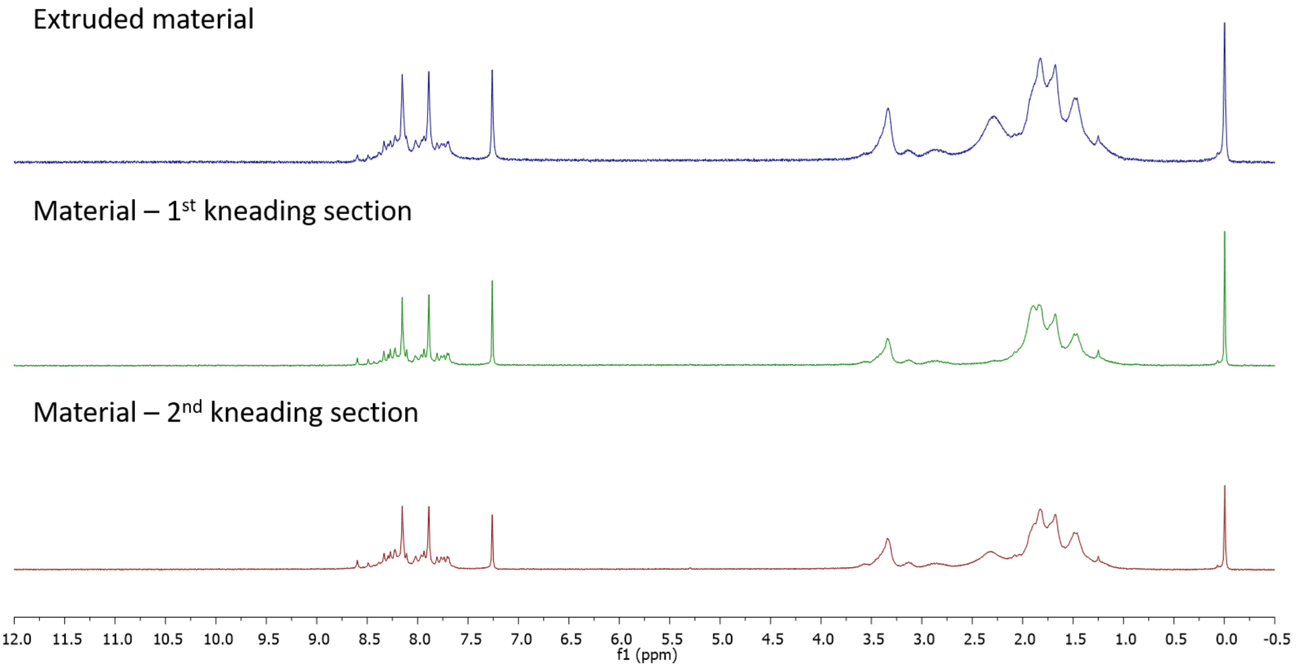


Figure S22: Stacked ^{1}H NMR ($CDCl_3$) spectra of the extruded material compared to that found at the 1st and 2nd kneading sections, during **CC3** formation by twin-screw extrusion under the optimised conditions, confirming the reaction had already occurred at the first section.

Purification by Soxhlet extraction: A 5 g sample of the extruded material was loaded into a Soxhlet cellulose thimble and refluxed overnight with 100 mL of one of EtOH, EtOAc, water, or hexane, to extract the impurities. The resulting solids, including a 5 g sample of the as-extruded material to calculate percentage mass recoveries, were dried under vacuum and then in the vacuum oven at 90 °C overnight, to yield beige solids – see Table S8, and Figures S22-S28 for characterisation data.

For the sample after purification with EtOH – ^{1}**H NMR** (400 MHz, $CDCl_3$) δ_H 8.15 (12H, s), 7.89 (12H, s), 3.32 (12H, m), 1.77–1.64 (12H, m), 1.82–1.1.46 (60H, m). Data in accordance to literature values.[1]

Table S8: Summary of the mass recovery, product distribution, and overall purity of the bulk extruded material purified by Soxhlet extraction in a range of solvents.

Sample	Mass Recovery	CC3:[3+5] (based on HPLC relative peak areas)	Overall Purity of CC3:[3+5] mixture (%)
Soxhlet treated - EtOH	3.88 g / 94%	95:5	98
Soxhlet treated - EtOAc	3.76 g / 91%	91:9	97
Soxhlet treated - Water	4.10 g / 99%	88:12	90
Soxhlet treated - Hexane	3.99 g / 97%	84:16	91
As extruded	4.12 g	88:12	95

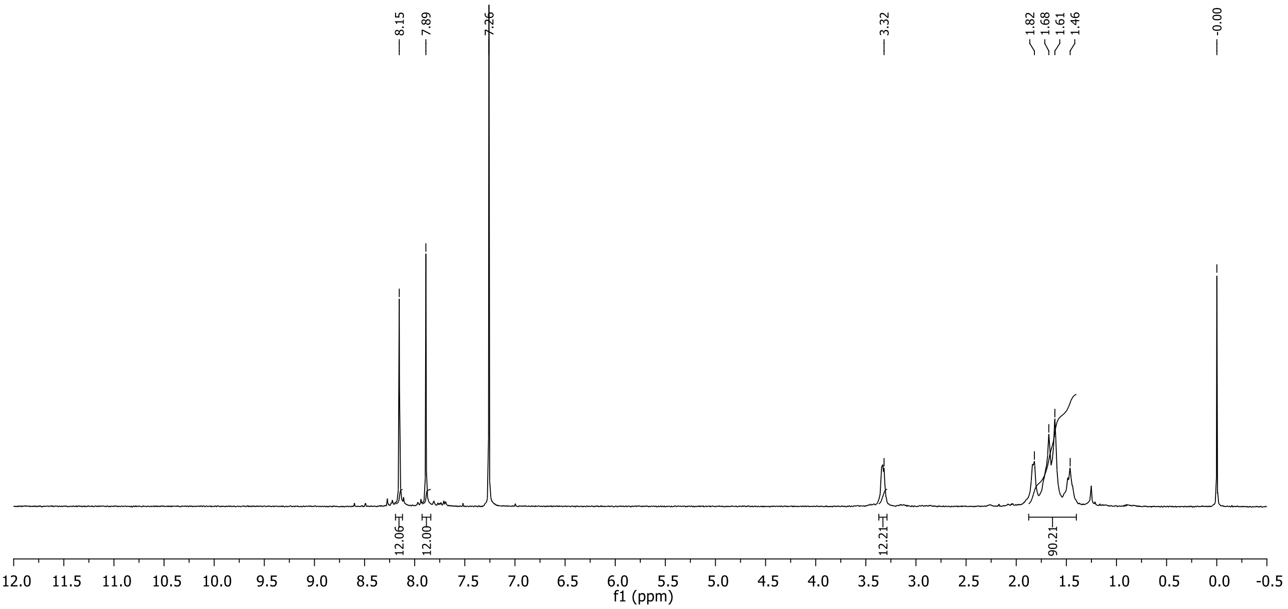


Figure S23: ^{1}H NMR ($CDCl_3$) spectra of **CC3** purified by Soxhlet extraction with EtOH.

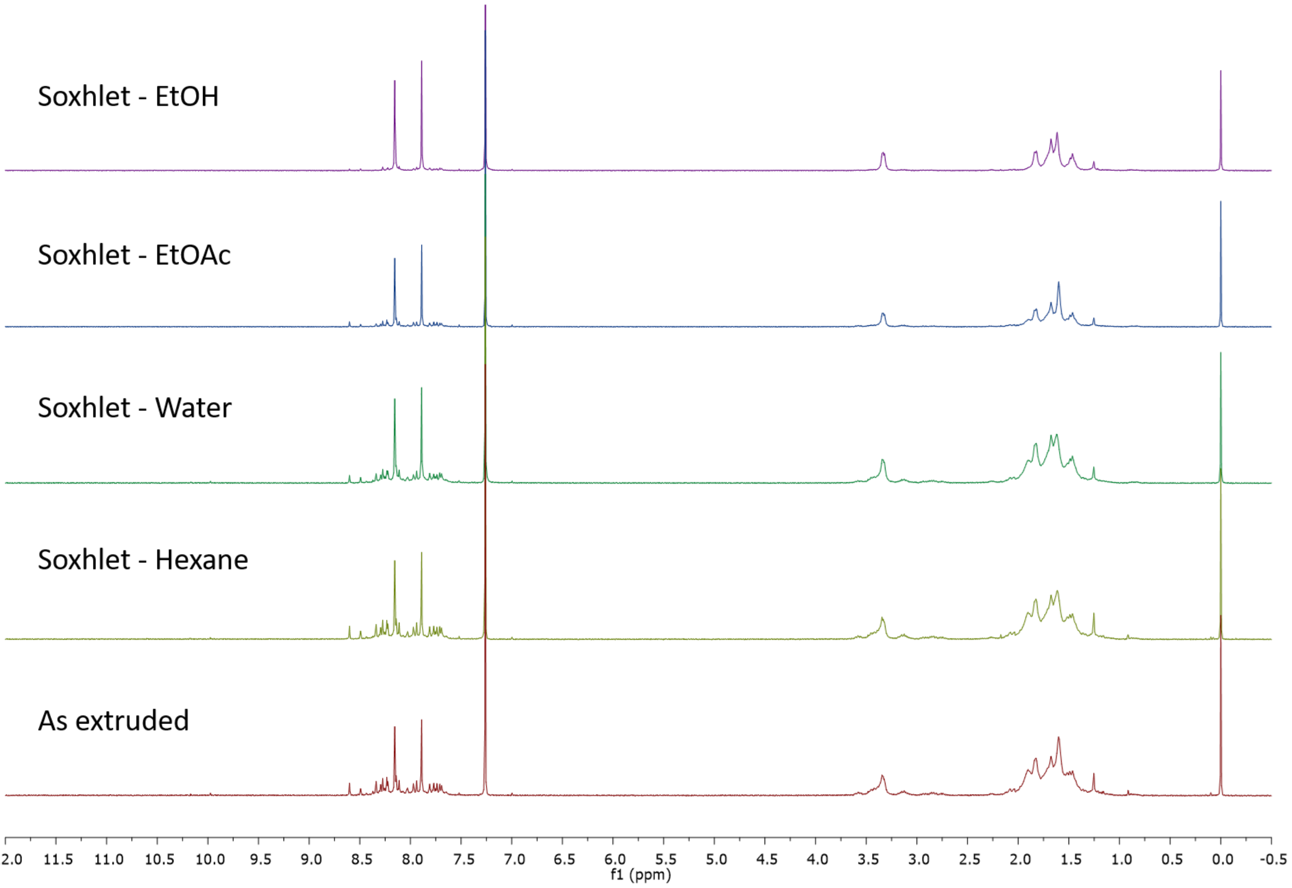


Figure S24: Stacked ^{1}H NMR ($CDCl_3$) spectra of bulk extruded material purified by Soxhlet extraction in a range of solvents.

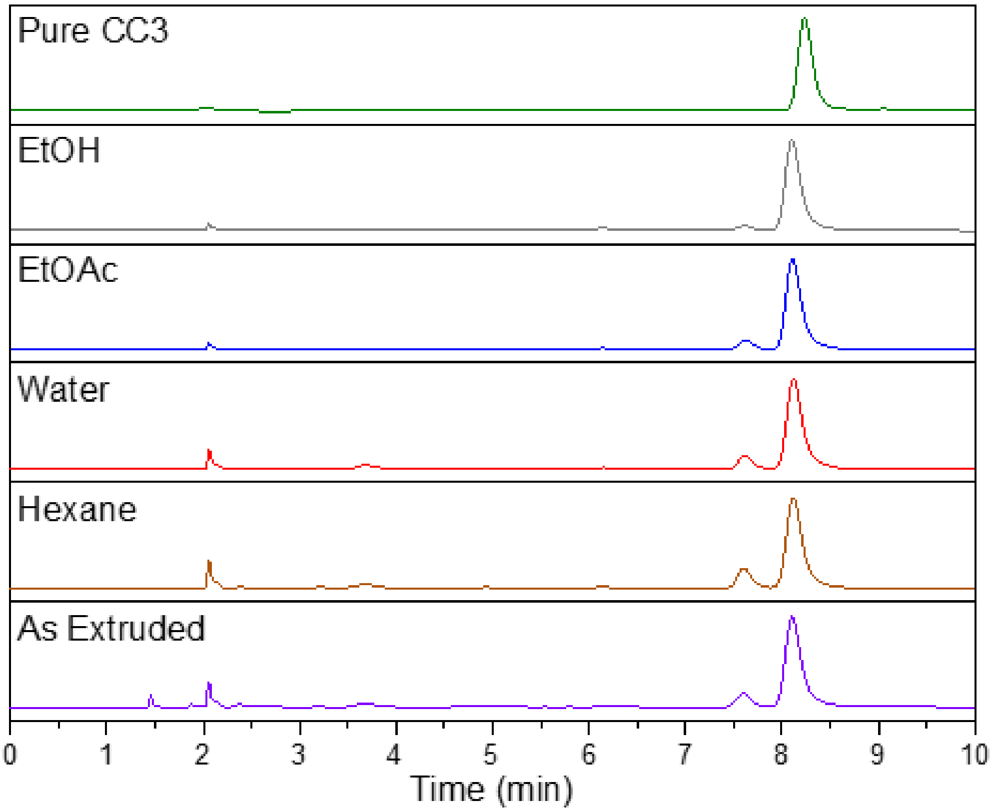


Figure S25: Stacked HPLC traces of samples of the bulk extruded material purified by Soxhlet extraction in a range of solvents.

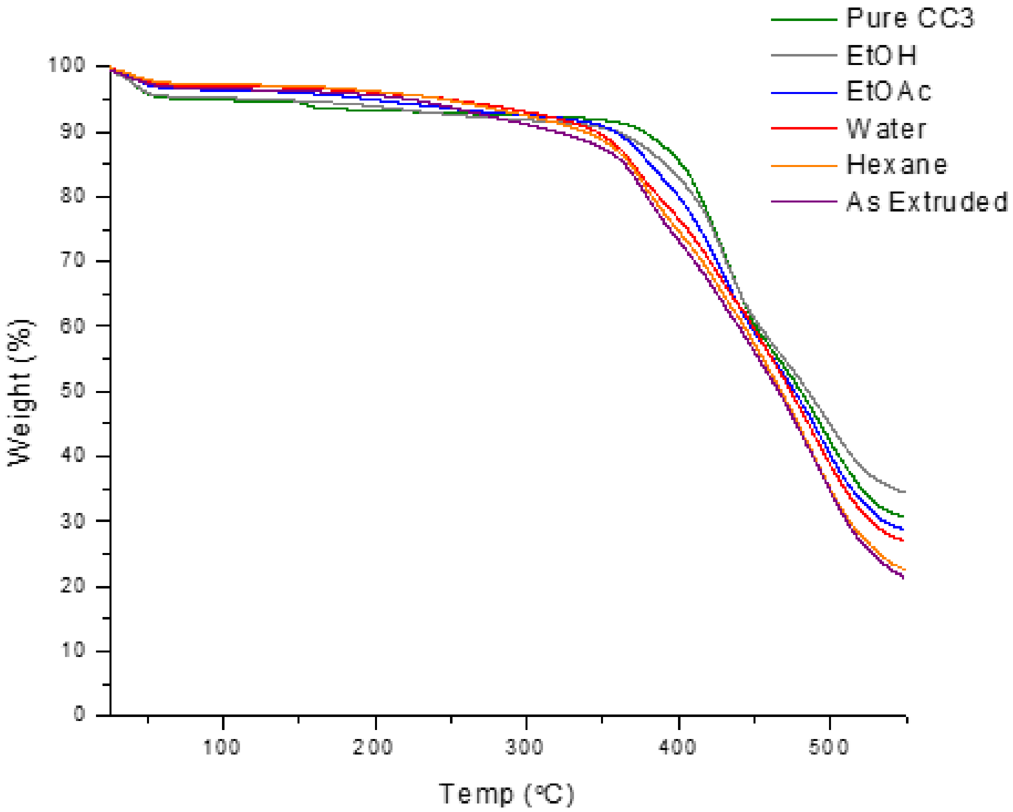


Figure S26: Overlaid TGA of samples of the bulk extruded material purified by Soxhlet extraction in a range of solvents.

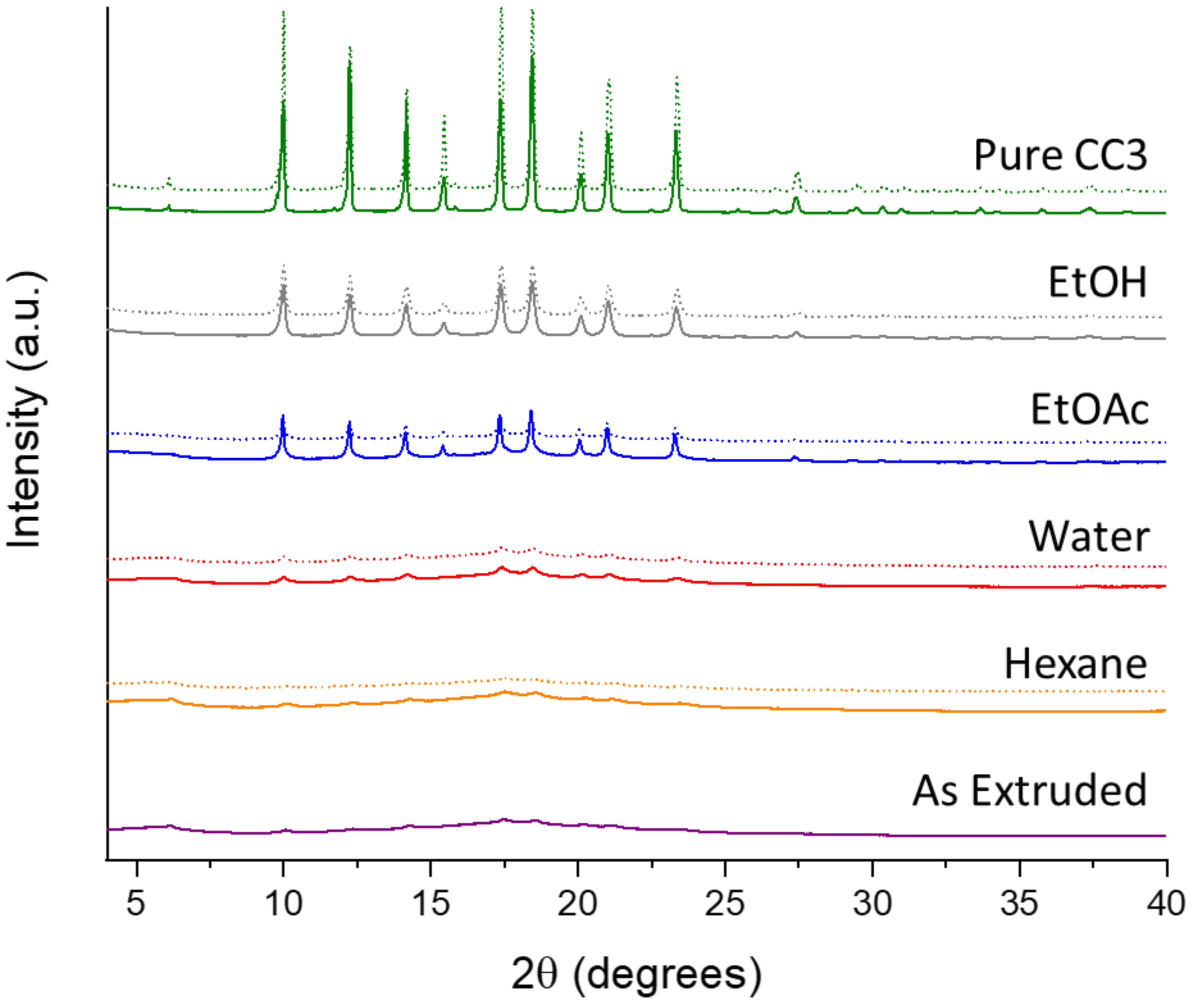


Figure S27: Stacked PXRD of samples of the bulk extruded material purified by Soxhlet extraction in a range of solvents, pre- (solid lines) and post- (dotted lines) sorption.

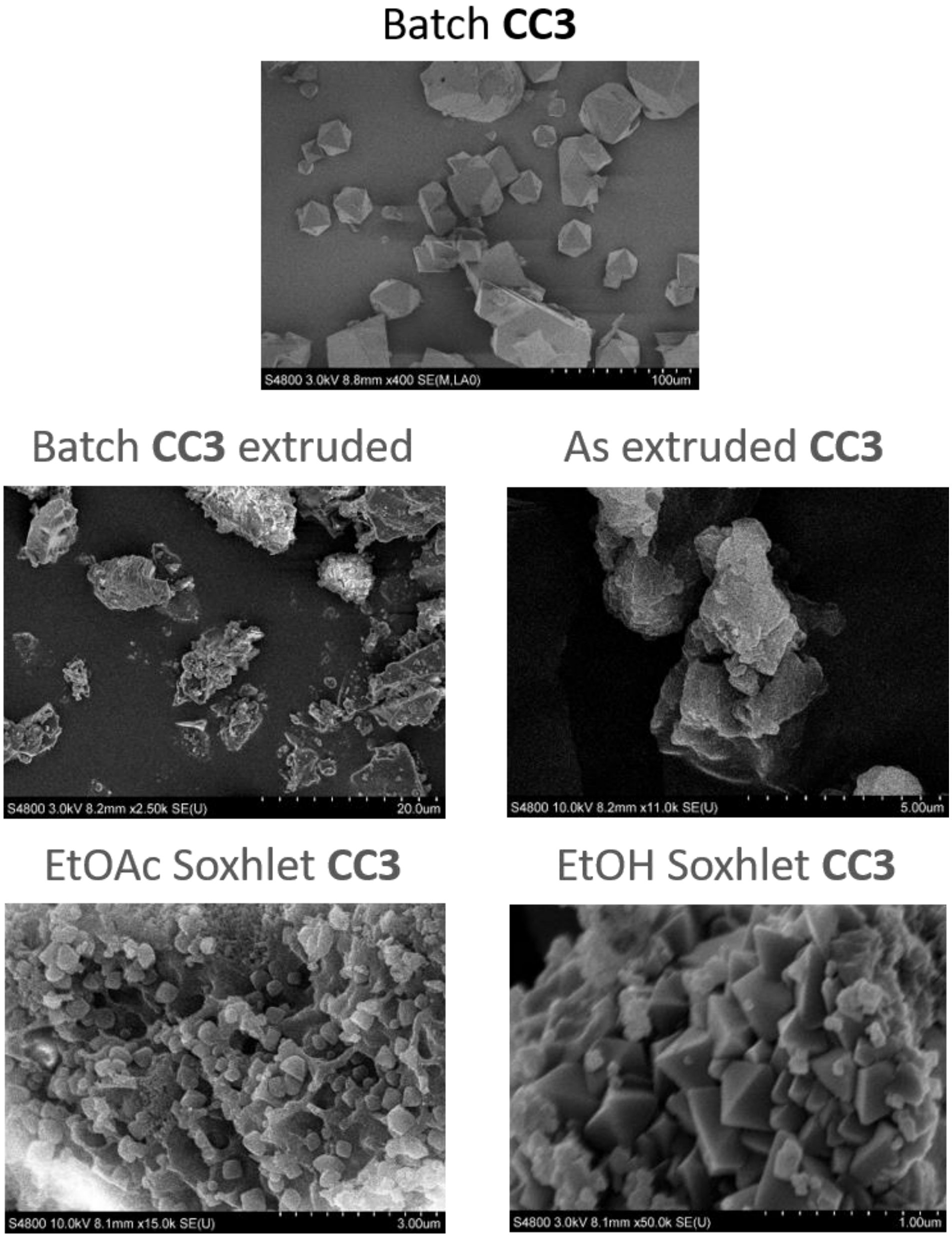


Figure S28: SEM images of samples of the bulk extruded material before and after purification by Soxhlet extraction in EtOH and EtOAc, compared to pure **CC3** pre-formed using standard solution based batch conditions, before and after processing in the extruder.

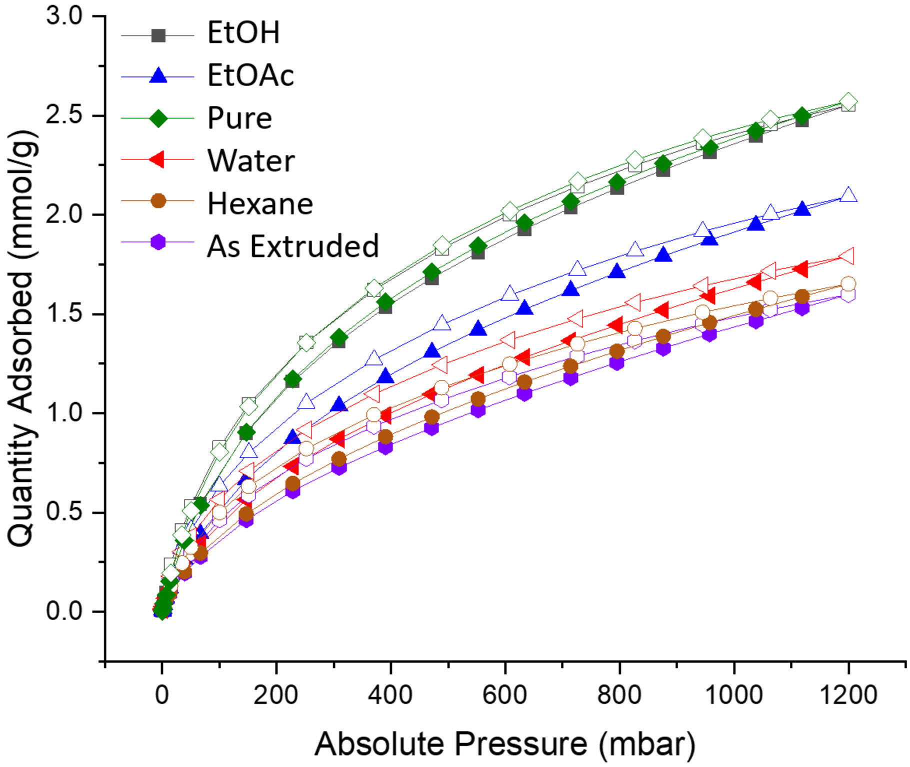


Figure S29: CO_2 adsorption (filled) and desorption (empty) isotherms for different pure **CC3**, the as-extruded material, and samples of the bulk extruded material purified by Soxhlet extraction in a range of solvents.

4. References

1 T. Hasell, S. Y. Chong, K. E. Jelfs, D. J. Adams and A. I. Cooper, *J. Am. Chem. Soc.*, 2012, **134**, 588–598.