

Supplementary information

Carbon fibers from wet spun cellulose-lignin precursors using the cold alkali process

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Number of Tables: 2 (Tables S1–S2)

Figures

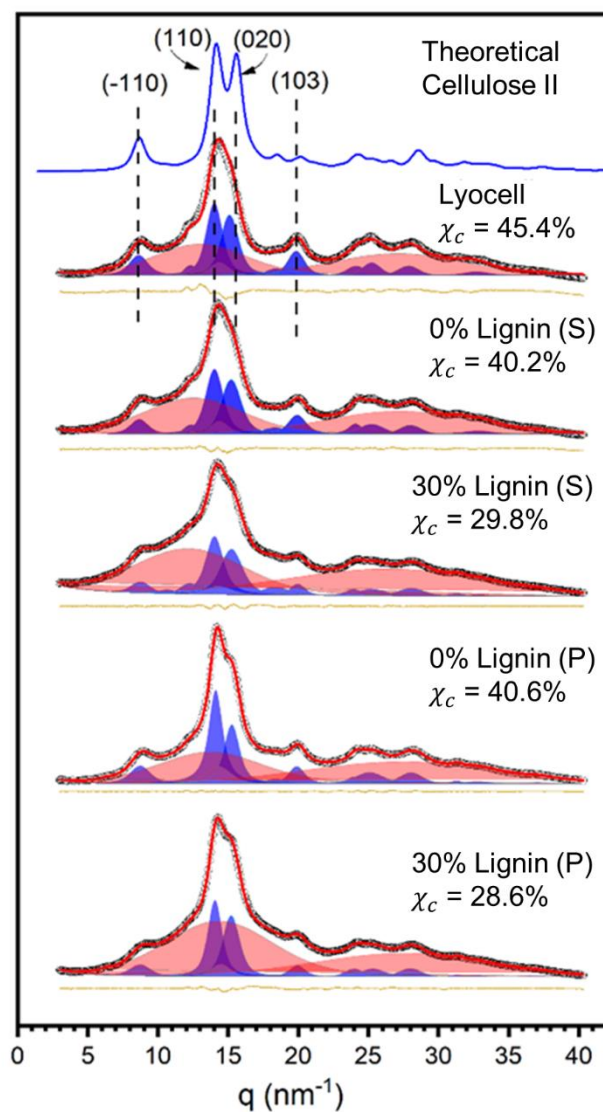


Figure S1. WAXS diffractograms (1D) of the System S and P precursors and the Lyocell reference, showing the assigned crystalline reflections of cellulose II and deconvoluted fitting procedure where the red areas indicate the amorphous contribution.

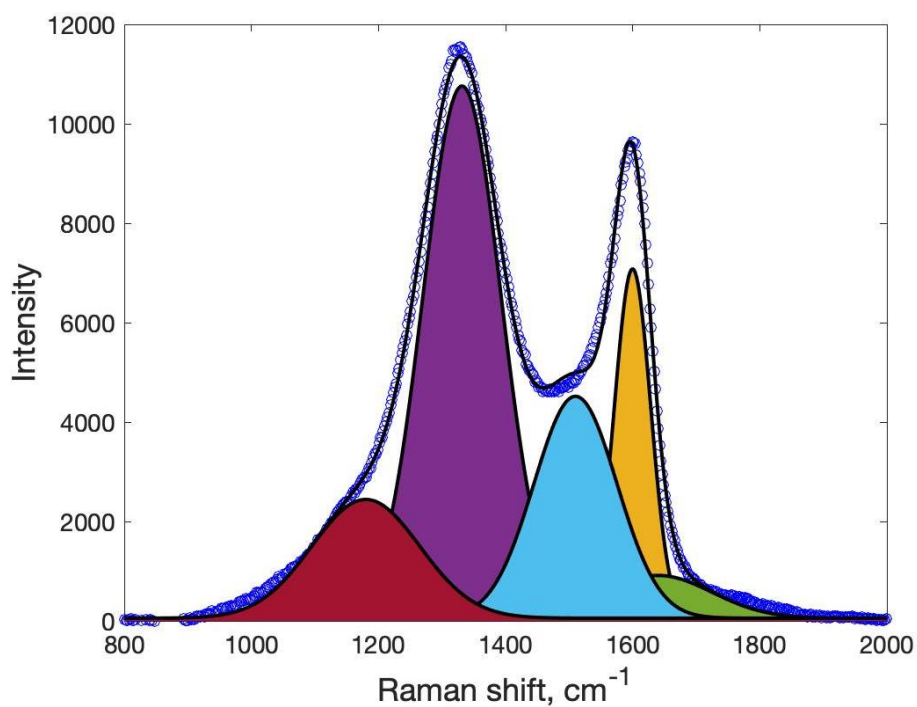


Figure S2. Example of Raman peak fitting performed on the continuously derived carbon fibre sample with stretching (1.3 cN/tex), using 5 Gaussian peaks deconvolution for calculation of I_D/I_G . Yellow = G band; Purple = D1 band; Green = D2 band; Teal = D3 band; Red = D4 band.

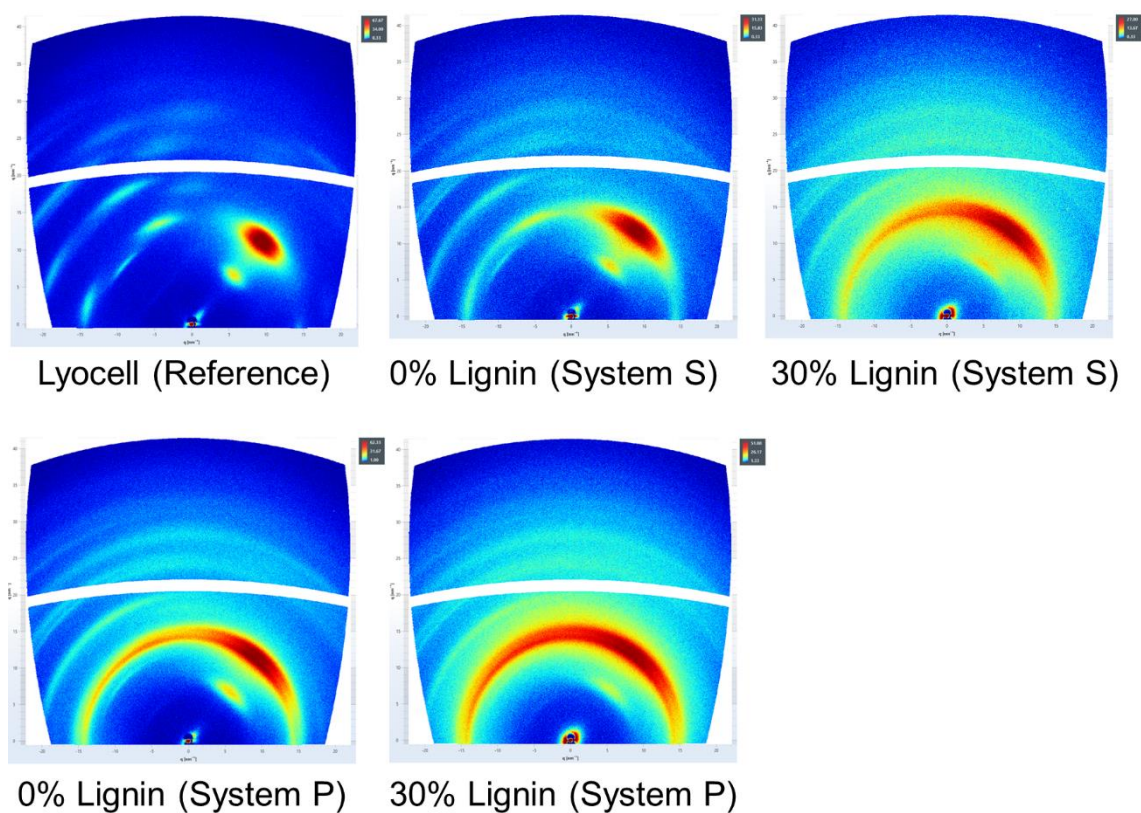


Figure S3. Scattering patterns (2D) from WAXS of the precursors and the lyocell reference.

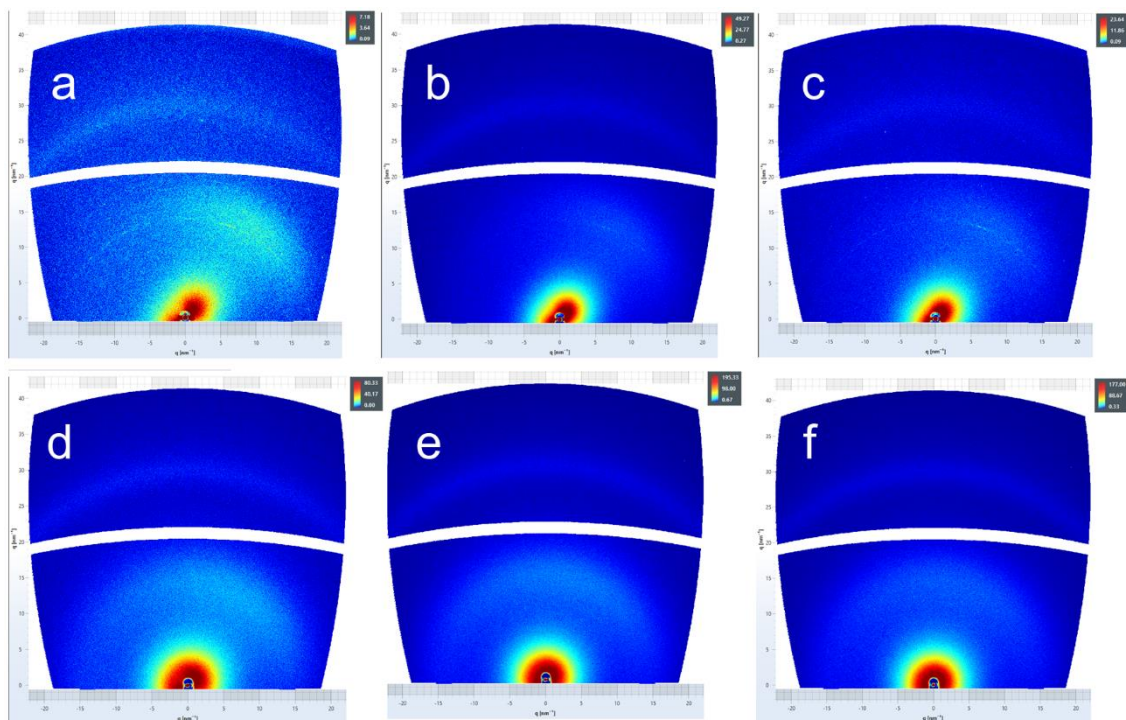


Figure S4. 2D WAXS diffraction patterns of batchwise (top) and continuously (bottom) derived CFs, showing (a) CF ($E=77$ GPa) from the System S precursor with 0% lignin, (b) CF ($E=55$ GPa) from the System P precursor with 0% lignin, (c) CF ($E=53$ GPa) from the System P precursor with 30% lignin, (d) CF ($E=46$ GPa) from the System P precursor with 0% lignin carbonised with a tension of 1.3 cN/tex, (e) CF ($E=35$ GPa) from the System P precursor with 0% lignin carbonised with a tension of 0.2 cN/tex and (f) CF ($E=33$ GPa) from the System P precursor with 30% lignin carbonised with a tension of 0.2 cN/tex.

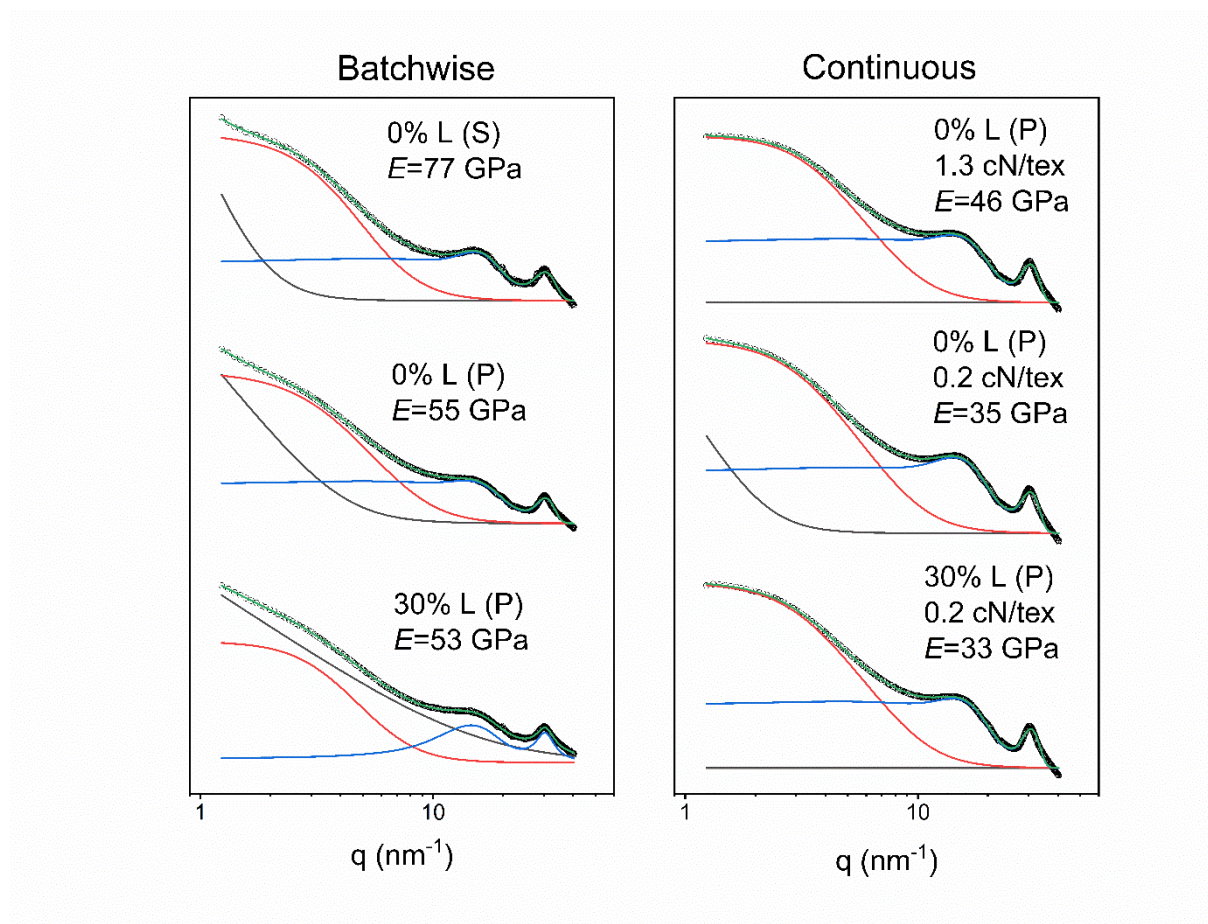


Figure S5. WAXS diffractograms (1D) of CFs prepared via batchwise and continuous conversion of System S and P precursors with different lignin content.

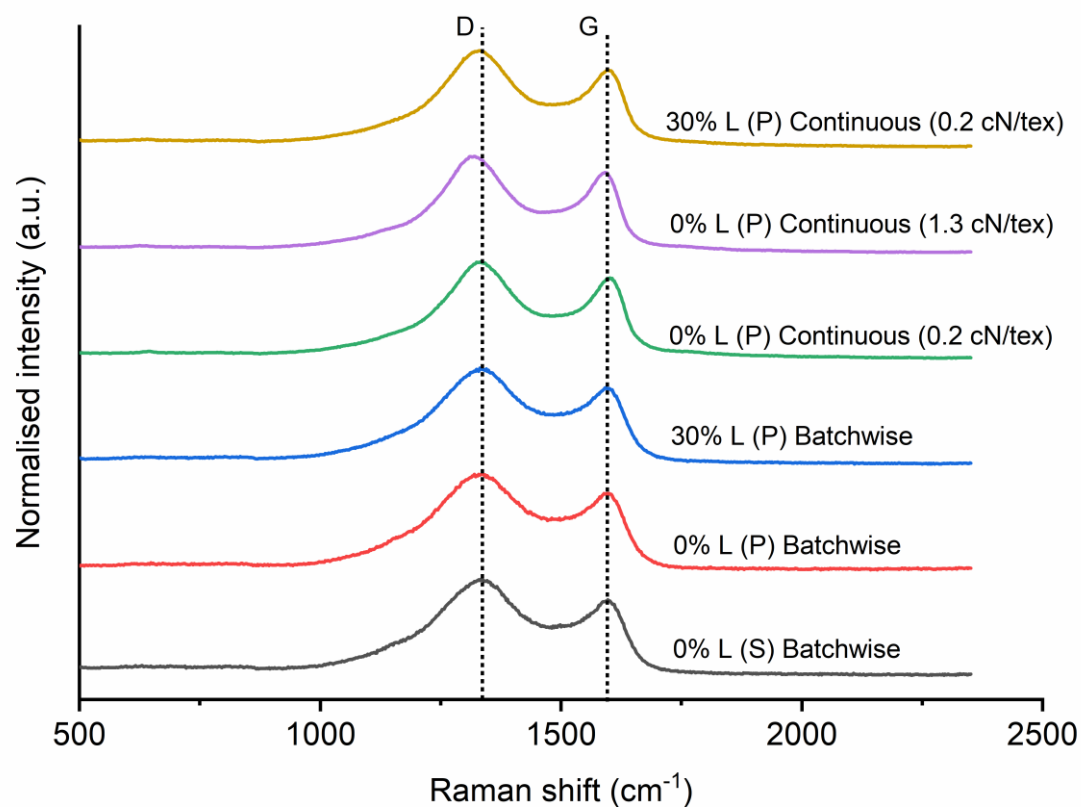


Figure S6. Raman spectra of CFs derived from cellulose-lignin precursors via batchwise and continuous conversion. L = Lignin; S = System S; P = System P.

Tables

Table S1. Gravimetric yield and elemental composition of CFs.

Conversion	Lignin	System	Stab.	Carb.	Total	Elemental composition			
mode	content		yield	yield	yield	(wt%)			
	(wt%)		(wt%)	(wt%)	(wt%)	C	O	S	P
Batchwise	0	S	98	12	12	85	14	0	0
	10	S	97	14.5	14	85	14	0.5	0
	30	S	88	34	30	87	12	1	0
	0	P	63	47	30	90	7	0	1.7
	30	P	70	55	39	90	7	0.5	2.3
Continuous	0	P	63	68	43	90	7	0	1.7
	30	P	73	60	44	90	7	0.5	2.9

Table S2. Summary of the tensile properties of the CFs prepared in this work. E = Young's modulus; σ = Tensile strength; ε = Break elongation.

Conversion mode	Lignin (wt%)	System	Tension (cN/tex)	Diameter (μm)	E (wt%)	σ (GPa)	ε (%)
Batch	0	S	— ^b	6.0 (0.8)	71 (15)	1.17 (0.29)	1.70 (0.30)
Batch ^a	0	S	— ^b	5.8 (0.7)	77 (12)	0.88 (0.20)	1.16 (0.26)
Batch	10	S	— ^b	6.8 (0.8)	71 (11)	0.96 (0.24)	1.34 (0.27)
Batch	30	S	— ^b	12.7 (0.7)	54 (6)	0.64 (0.11)	1.19 (0.18)
Batch	0	P	— ^b	9.8 (0.6)	55 (5)	0.69 (0.16)	1.27 (0.26)
Batch	30	P	— ^b	11.2 (0.8)	53 (6)	0.65 (0.12)	1.23 (0.22)
Continuous	0	P	0.2	11.4 (0.5)	35 (2)	0.57 (0.12)	1.64 (0.30)
Continuous	0	P	0.4	10.9 (0.6)	38 (3)	0.61 (0.10)	1.63 (0.25)
Continuous	0	P	1.0	9.2 (0.3)	45 (3)	0.67 (0.15)	1.49 (0.30)
Continuous	0*	P	1.3	9.2 (0.4)	46 (4)	0.68 (0.10)	1.45 (0.21)
Continuous	30	P	0.2	11.5 (0.4)	33 (2)	0.48 (0.07)	1.45 (0.21)

^a Stabilised (275 °C) and carbonised (1100 °C) with the profile used for System P fibres; ^b Mounted on graphite frames to prevent shrinkage