Electronic Supplementary Material (ESI) for Green Chemistry.

Electronic Supplementary Information

Upcycling of Waste Paper and Cardboard to Textiles

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Supporting Figures and Tables

Bleaching

Table S1. ECF bleaching conditions.

	D0	*Ep*	*D*
Temperature, °C	60	75	70
Retention time, min	60	60	120
Consistency, %	9	10	9
ClO_2 consumed, kg aCl/t	16-26	-	4.9-7.6
NaOH charge, kg/t	-	9.0	0.1
H_2O_2 consumed, kg/t	-	4.5-4.9	-

Metal analyses

Table S2. Metal content of raw and refined paper and cardboard.

	Al	Ca	Cu	Fe	Mg	Mn	Si
	[mg/kg]	[mg/kg]	[mg/kg]	[mg/kg]	[mg/kg]	[mg/kg]	[mg/kg]
fine paper		1900	< 0.5	41	290	3.1	290
P1		340	0.6	29	14	0.4	230
P2		140	1.6	37	63	0.5	210
cardboard	4100	14000	34	340	1100	32	3900
B1	550	2900	8.0	70	270	14	501
B2	86	200	7.3	29	140	1.4	140
B3	34	48	7.7	24	89	1.1	59
B4	20	29	4.2	12	82	0.3	47
B5	38	41	4.8	11	95	0.3	61

GPC-results

Table S3. Number (M_n) and weight (M_w) average molar masses and poly dispersity index (PDI=M_w/M_n) of pulps and fibers spun therefrom.

	Pulp				Fibers		
	Intrinsic viscosity	M_n	M_w	PDI	M_n	M_w	PDI
	[ml/g]	kDa	kDa		kDa	kDa	
fine paper							
P1 11.5%	470	48.5	320.3	6.6	53.1	297.7	5.7
P2 13%	428	63.4	299.1	4.7	64.3	283.4	5.6
cardboard							
B1 13%	447	52.3	158.9	3.0	40.2	133.6	3.3
B2 11.5%	500	64.7	356.0	5.6	64.7	384.2	5.9
B3 13%	470	86.9	352.9	4.1	83.6	339.7	4.1
B4 13%	460	87.5	343.2	3.9	88.7	357.6	3.9
B5 13%	436	63.8	333.9	5.2	66.8	307.7	4.6

Rheological analyses

Table S4. Rheological properties at spinning temperature.

	Spinning temperature [°C]	Zero shear viscosity [Pa s]	Dynamic modulus at COP [Pa]	Angular frequency at COP [s^{-1}]
P1 11.5%	72.9	16478	1897	0.80
P2 13%	78.5	21402	3319	2.76
B1 13%	75.0	305980	-	-
B2 11.5%	76.0	21076	2574	0.76
B3 13%	76.8	61663	3136	0.36
B4 13%	75.3	33094	4072	0.74
B5 13%	70.2	34489	3164	0.60

Mechanical properties

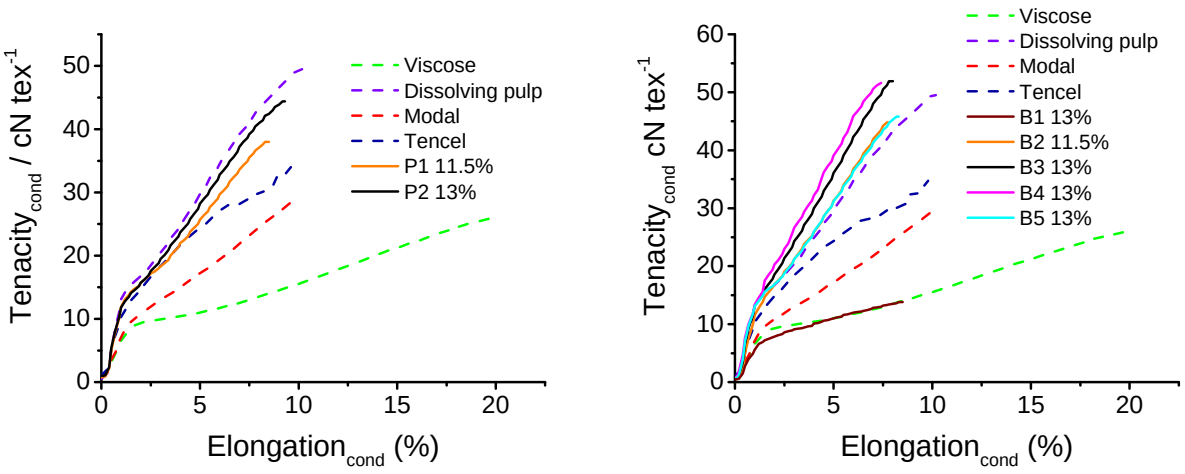

Figure S1. Stress-strain curves of fibers spun from paper (left) and cardboard (right). Dashed lines show commercial reference fibers and fibers spun with the same ionic liquid using E-PHK dissolving pulp (cond=conditioned: 23 °C, 50% relative humidity).

Table S5. Mechanical properties of P1 fibers spun at different draw ratios.

Draw ratio	Titer [dtex]	Dry tenacity [cN/tex] (MPa)	Dry elongation %	Dry modulus [GPa]	Wet tenacity [cN/tex] (MPa)	Wet elongation %	Wet modulus [GPa]	total orientation
7.1	2.62	34.66 (519.9)	8.87	20.64	22.33 (334.95)	8.84	13.35	0.678
8.8	2.22	35.28 (529.2)	8.53	19.60	23.30 (349.5)	9.27	12.87	-
10.6	1.84	37.76 (566.4)	9.00	22.77	23.86 (357.9)	8.22	15.27	0.707
12.4	1.65	38.86 (582.9)	8.80	23.21	25.94 (389.1)	9.32	13.92	0.747
14.1	1.34	37.58 (563.7)	8.60	21.73	28.56 (428.4)	9.43	16.69	0.713

Table S6. Mechanical properties of P2 fibers spun at different draw ratios.

Draw ratio	Titer [dtex]	Dry tenacity [cN/tex] (MPa)	Dry elongation %	Dry modulus [GPa]	Wet tenacity [cN/tex] (MPa)	Wet elongation %	Wet modulus [GPa]	total orientation
7.1	3.06	33.44 (501.6)	10.03	20.16	24.54 (368.1)	10.63	12.50	0.671
10.6	2.49	36.76 (551.4)	9.85	20.78	29.68 (445.2)	11.13	14.91	0.688
12.4	1.77	39.63 (594.45)	8.90	22.44	31.61 (474.15)	10.65	15.81	0.703
14.1	1.60	44.13 (661.95)	9.55	24.46	32.03 (480.45)	11.10	14.87	0.689
15.9	1.49	43.89 (658.35)	8.92	23.38	37.32 (559.8)	10.13	19.37	-
16.8	1.36	43.16 (647.4)	9.41	25.40	34.00 (510.0)	10.19	17.88	0.700

Table S7. Mechanical properties of B1 fibers spun at different draw ratios.

Draw ratio	Titer [dtex]	Dry tenacity [cN/tex] （MPa）	Dry elongation %	Dry modulus [GPa]	Wet tenacity [cN/tex] （MPa）	Wet elongation %	Wet modulus [GPa]	total orientation
0.88	16.58	11.94 (179.1)	26.51	5.33	6.61 (99.15)	31.52	1.69	-
1.8	9.01	13.97 (209.55)	13.36	5.78	9.48 (142.2)	19.1	3.14	-
3.5	5.81	13.21 (66.05)	8.06	7.39	10.11 (151.65)	12.06	4.55	-

Table S8. Mechanical properties of B2 fibers spun at different draw ratios.

Draw ratio	Titer [dtex]	Dry tenacity [cN/tex] （MPa）	Dry elongation %	Dry modulus [GPa]	Wet tenacity [cN/tex] （MPa）	Wet elongation %	Wet modulus [GPa]	total orientation
7.1	2.74	36.68 (550.2)	8.36	16.23	32.27 (484.05)	11.41	15.44	0.676
10.6	1.80	40.79 (611.85)	8.49	22.08	29.87 (448.05)	9.67	16.66	0.694
12.4	1.46	42.21 (633.15)	8.08	22.70	35.21 (528.15)	10.02	18.22	0.707
14.1	1.31	44.49 (667.35)	8.72	23.36	36.94 (554.1)	8.83	19.93	0.715
15.9	1.22	44.37 (665.55)	7.97	23.37	38.34 (575.1)	9.72	20.50	0.688

Table S9. Mechanical properties of B3 fibers spun at different draw ratios.

Draw ratio	Titer [dtex]	Dry tenacity [cN/tex] （MPa）	Dry elongation %	Dry modulus [GPa]	Wet tenacity [cN/tex] （MPa）	Wet elongation %	Wet modulus [GPa]	total orientation
7.1	3.24	37.84 (567.6)	9.22	23.78	35.23 (528.45)	12.23	15.25	0.720
10.6	2.14	45.38 (680.7)	9.25	24.79	37.98 (569.7)	11.41	17.42	0.715
12.4	1.81	45.43 (681.45)	8.16	24.92	40.03 (600.45)	9.65	21.66	0.719
14.1	1.54	48.86 (732.9)	9.45	27.69	43.85 (657.75)	10.82	22.11	0.719
15.9	1.51	50.23 (753.35)	8.61	27.41	48.22 (732.3)	9.76	26.83	-
17.8	1.23	51.38 (770.7)	8.03	27.11	43.26 (648.9)	9.55	23.92	0.738

Table S10. Mechanical properties of B4 fibers spun at different draw ratios.

Draw ratio	Titer [dtex]	Dry tenacity [cN/tex] （MPa）	Dry elongation %	Dry modulus [GPa]	Wet tenacity [cN/tex] （MPa）	Wet elongation %	Wet modulus [GPa]	total orientation
7.1	4.08	41.02 (615.3)	9.04	20.16	31.38 (470.7)	13.09	13.33	0.646
10.6	1.96	44.16 (662.4)	9.09	27.97	38.82 (582.3)	11.36	19.06	0.684
12.4	1.66	44.33 (664.95)	8.07	25.75	44.54 (668.1)	10.5	22.57	-
14.1	1.40	47.42 (711.3)	9.42	23.63	42.63 (639.45)	11.91	19.48	0.736
15.9	1.22	51.14 (767.1)	8.24	25.69	43.66 (654.9)	10.00	23.08	0.676

Table S11. Mechanical properties of B5 fibers spun at different draw ratios.

Draw ratio	Titer [dtex]	Dry tenacity [cN/tex] （MPa）	Dry elongation %	Dry modulus [GPa]	Wet tenacity [cN/tex] （MPa）	Wet elongation %	Wet modulus [GPa]	total orientation
7.1	3.16	36.66 (549.9)	9.24	21.07	29.82 (447.3)	10.28	15.37	0.710
10.6	2.12	42.64 (639.6)	8.52	23.57	33.73 (505.95)	10.32	17.24	0.716
12.4	1.84	43.52 (652.8)	9.34	21.38	33.13 (496.95)	10.94	15.41	-
14.1	1.66	45.80 (687.0)	7.50	24.06	37.42 (561.3)	10.16	19.18	0.724
14.1*	1.54	45.46 (681.9)	9.16	25.67	39.10 (586.5)	11.12	20.10	0.717
17.0*	1.32	45.62 (684.3)	9.13	27.24	38.01 (570.15)	9.75	21.86	0.722
19.8*	1.20	46.45 (696.75)	8.33	25.37	42.78 (641.7)	9.32	25.65	0.720

*Extrusion speed at 1 cm^3/min