

Supporting information for:

Pilot scale steam explosion pretreatment with 2-naphthol to overcome high softwood recalcitrance

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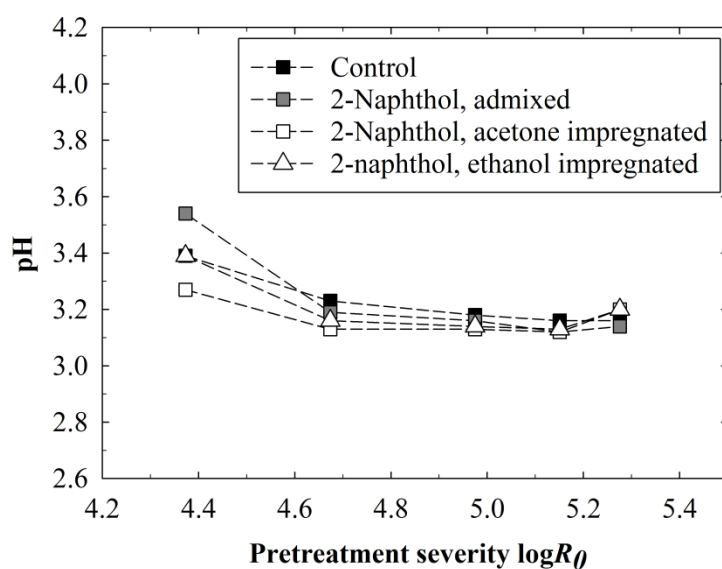


Fig. S1 pH of pretreatment liquor after steam explosion pretreatments without additive and with 2-naphthol addition by mixing and impregnation. Pretreatment conditions: $T=235\text{ }^{\circ}\text{C}$, $t=2.5\text{--}20\text{ min}$, $\Delta p\text{ explosion}=30\text{ bar}$, 1.5 kg wood chips , $35.36\text{ g 2-naphthol}$.

Table S1 Overview of biomass recovery and composition after pretreatment.

2-Naphthol addition	T / °C	t / min	log R_0 / -	Δp expl. / bar	Biomass recovered / %	Cellulose recovered / %	Biomass composition			
							Cellulose / %	Mannan / %	AIL / %	ASL / %
-	235	2.5	4.4	30	89.5	86.7	35.9±1.0	11.1±2.4	40.8±0.2	6.1±0.1
-	235	5	4.7	30	90.4	93.3	45.0±1.0	6.5±1.2	45.4±0.7	7±0.1
-	235	10	5.0	30	77.4	85.3	40.8±0.0	3.3±0.2	52.5±0.3	8.7±0.4
-	235	15	5.2	30	75.7	85.3	41.7±0.4	2.3±0.8	53.6±0.3	8.8±0.3
-	235	20	5.3	30	75	86.4	42.7±0.2	2.5±0.4	53.2±0.3	7.6±1
Mixing	235	2.5	4.4	30	87.6	82.7	35.0±0.3	10.6±0.2	42.8±0.5	8.4±0.4
Mixing	235	5	4.7	30	95.3	93.3	39.4±1.1	5.2±1.1	47.2±0.3	12.3±0.5
Mixing	235	10	5.0	30	90.8	96.5	39.3±0.7	4.3±1.1	49.9±0.7	12.9±0.3
Mixing	235	15	5.2	30	87.1	98.6	41.9±0.8	-	54.7±1.8	13.3±0.4
Mixing	235	20	5.3	30	83.3	86.7	38.5±0.2	3±0.9	52.3±0.1	13.1±0.3
Mixing	235	2.5	4.4	2.5*	79.6	75.2	35.0±0.5	10.5±2.3	44.1±0.5	8±0.3
Mixing	235	5	4.7	2.5*	92.2	98.1	39.4±1.4	4.1±0.9	45.9±0.7	8.7±0.2
Mixing	235	10	5.0	2.5*	83.8	98.9	43.7±0.5	-	47.4±0.8	12.6±0.2
Mixing	235	15	5.2	2.5*	74.2	89	44.4±1.0	-	48.5±0.9	8.4±0.2
Mixing	235	20	5.3	2.5*	80.8	88.3	40.5±0.9	2.8±2.2	50.2±0.3	7.4±0.3
Acetone imp.	235	2.5	4.4	30	90.4	88.1	34.0±0.8	10.9±0.3	41.3±0.3	12.6±0.2
Acetone imp.	235	5	4.7	30	88.4	94.1	39.4±0.5	3.9±0.9	47±0.5	12.8±1.1
Acetone imp.	235	10	5.0	30	85.2	82.9	40.2±0.2	2.9±0.3	49.5±0.5	13.3±0.4
Acetone imp.	235	15	5.2	30	82.9	88.1	39.3±0.1	2.4±0.1	52.1±0.7	13.7±0.3
Acetone imp.	235	20	5.3	30	86.9	89.9	38.3±0.3	1.9±0.4	55.5±2.7	9.5±0.8
Ethanol imp.	235	2.5	4.4	30	87.1	103.2	43.9±0.9	8.2±0.5	45.6±0.8	7.9±0.5
Ethanol imp.	235	5	4.7	30	88.1	103.2	43.3±0.3	2.9±0.3	51.6±0.1	11.3±1.1
Ethanol imp.	235	10	5.0	30	89.2	99.1	41.2±0.4	2.1±0.2	57.1±0.5	9.3±0.3
Ethanol imp.	235	15	5.2	30	85.8	92.8	40.0±0.3	1.9±0.0	56.6±0.8	10.1±0.4
Ethanol imp.	235	20	5.3	30	83.3	93.4	40.0±0.2	2.2±0.6	56.8±1.0	9.9±0.6

* Experiments with a Δp of 2.5 bar are referred to as experiments “without explosion”.

Table S2 Overview of cellulose digestibility and sugar yields. Yields are expressed as % of the raw biomass content. EH: yield in enzymatic hydrolysis (accounting for cellulose recovery from pretreatment); P: yield in pretreatment liquor; Mannose represents hemicellulosic sugars excluding glucose.

2-Naphthol addition	T / °C	t / min	logR ₀ / -	Δp expl. / bar	FPU g ⁻¹ cellulose	Digestibility cellulose / %	Yields				
							Glucose, EH / %	Mannose, EH / %	Glucose, P / %	Mannose, P / %	Total sugar / %
-	235	2.5	4.4	30	15	30.9±1.9	26.8	0	7.5±0.1	57.1±0.3	41.3
					30	42.7±3.1	37.0	0			48.4
					60	57.3±5.7	49.7	0			57.1
-	235	5	4.7	30	15	33.2±3.5	31.0	0	6.8±0.5	31.6±2.5	35.9
					30	47.9±5.7	44.7	2.4			46.1
					60	62.3±4.3	58.1	2.9			62.7
-	235	10	5.0	30	15	32.2±0.6	32.2	0	4.8±0.2	15.4±0.6	27.1
					30	57.3±3.2	48.9	3.0			42.8
					60	88.0±3.7	75.1	7.3			62.2
-	235	15	5.2	30	15	34.2±3.8	29.2	3	3.7±0.0	7±0.1	25.9
					30	58.7±4.6	50.1	4.7			40.8
					60	87.4±1.7	74.6	7.8			58.8
-	235	20	5.3	30	15	33.9±2.1	29.3	3	3.7±0.0	8.3±0.1	26.3
					30	57.4±1.8	49.6	5.4			41.1
					60	90.2±3.9	77.9	6.7			61.1
Mixing	235	2.5	4.4	30	15	21.6±1	17.9	0	6.6±0.0	52.3±0.1	33.1
					30	37.6±0.3	31.1	0			42.2
					60	51.9±4.7	42.9	0			50.4
Mixing	235	5	4.7	30	15	47.4±2.4	44.2	3.6	7.7	35.3	47.9
					30	71.9±1.6	67.1	2.2			63.3
					60	92.5±4.5	86.3	13.4			80.1
Mixing	235	10	5.0	30	15	47.1±4.1	45.4	0.1	5.8	32.9	41.1
					30	77±4	75.3	3.8			61.1
					60	92.5±4.2	89.2	8.0			73.8
Mixing	235	15	5.2	30	15	49.9±5.9	49.2	4.3	5.4	19.1	41.8
					30	78.9±6.9	77.8	7.3			62.5
					60	90.4±4.2	89.2	11.4			71.7
Mixing	235	20	5.3	30	15	52.6±2.9	45.6	4.8	4.3±0.1	10.7±0.1	39.3
					30	75.6±1.6	65.5	6.9			53.7
					60	91.3±2.3	79.1	16.6			66.1
Mixing	235	2.5	4.4	2.5*	15	27.9±4.4	19.8	1.5	4.8±0.1	37.1±0.1	29.8
					30	28.3±1.8	20.1	4.5			30.9
					60	43.7±5.9	32.9	6.5			39.5
Mixing	235	5	4.7	2.5*	15	29.7±4.2	29.1	0	7.7±0.0	35.3	34.3
					30	36.6±3.7	35.9	1.6			39.5
					60	48.1±2.7	47.2	4.1			48.1
Mixing	235	10	5.0	2.5*	15	44.7±5.1	44.2	0.3	5.8	32.9	39.6
					30	46±2.9	45.5	0.6			40.6
					60	59.1±7.6	64.3	3.1			50.3
Mixing	235	15	5.2	2.5*	15	59±3.1	52.5	1.5	4.5	19.1	43.5
					30	63.7±6.6	56.7	1.2			46.3
					60	76.6±4.6	68.1	4.8			55.4
Mixing	235	20	5.3	2.5*	15	60.3±1.4	53.3	2.8	3.1±0.1	6.9±0.0	42.0
					30	73.1±2.4	64.6	2.9			49.9
					60	86.5±1	76.4	8.9			59.9
Acetone imp.	235	2.5	4.4	30	15	47.9±3	39.7	0	4.9±0.0	15.8±0.0	44.0
					30	73.7±0.3	61.1	0.5			59.0
					60	92.5±4.1	76.7	0			69.6
Acetone imp.	235	5	4.7	30	15	71.2±3	67.0	1.1	4.9±0.0	15.8±0.0	55.0
					30	93.3±1.8	87.9	1.7			69.5
					60	98.7±1.5	92.9	1.8			73.1
Acetone imp.	235	10	5.0	30	15	83.1±4.1	76.8	1.9	4.9±0.0	15.8±0	60.1
					30	93.3±1.2	86.3	2.4			66.8
					60	100.6±2.3	93.0	3.0			71.6
Acetone imp.	235	15	5.2	30	15	80.9±5.1	71.3	2.3	3.7±0.0	6.1±0.0	54.4
					30	94.2±0.3	83.0	2.7			62.6
					60	100.3±1.7	88.3	2.4			66.3
Acetone imp.	235	20	5.3	30	15	94.7±1.3	85.20	3.1	2.5±0.0	2.8±0.0	62.4
					30	96.3±1.1	86.60	3.1			63.5
					60	94.6±1.4	85.00	2.7			62.4

Ethanol imp.	235	2.5	4.4	30	15 30 60	57.3±2.1 78±1.5 83±1.5	59.1 80.5 85.7	0 0 0	5.4±0.0	33.9±0.1	40.9 55.7 59.3
Ethanol imp.	235	5	4.7	30	15 30 60	81.2±0.9 94.6±1.7 94.8±1.2	83.8 97.6 97.8	1.1 2.4 4.9	3.3±0.1	11.8±0.2	64.2 74.2 75.1
Ethanol imp.	235	10	5.0	30	15 30 60	92.6±0.4 95.9±2.5 95.7±2.1	91.80 95.00 94.80	2.5 2.8 3.6	2.9±0.0	3.9±0.1	67.4 69.8 69.9
Ethanol imp.	235	15	5.2	30	15 30 60	105.7±0.8 107.3±0.5 96.1±3	97.6 99.6 89.20	3.3 4.4 3.7	2.7±0.0	2.8±0.0	71.2 73.0 65.5
Ethanol imp.	235	20	5.3	30	15 30 60	83.7±1.2 88.2±2.2 91.2±2	78.2 82.4 85.1	3.1 2.4 3.9	2.9±0.0	4.4±0.0	58.4 61.8 63.4

* Experiments with a Δp of 2.5 bar are referred to as experiments “without explosion”.