

APPENDIX A

Characterization of untreated and pretreated Bana grass with alkaline solution and ozone.

Table A1 Characterization of untreated and pretreated materials with NaOH solutions pretreatment

NaOH solution (%)	Time (min)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
		Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
0	0	60.2	23.8	8.2	7.8					
		60.2	23.8	8.2	7.8					
		60.2	23.8	8.2	7.8					
		60.2	23.8	8.2	7.8					
		60.2	23.8	8.2	7.8					
	Average	60.2	23.8	8.2	7.8					
0.5	60	61.7	23.9	7.8	6.7	96.5	98.9	3.2	8.7	17.4
		61.7	23.9	7.8	6.7	96.5	98.9	3.2	8.7	17.4
		61.7	23.9	7.8	6.7	96.5	98.9	3.2	8.7	17.4
		61.7	23.9	7.8	6.7	96.5	98.9	3.2	8.7	17.4
		61.7	23.9	7.8	6.7	96.5	98.9	3.2	8.7	17.4
	Average	61.7	23.9	7.8	6.7	96.5	98.9	3.2	8.7	17.4
	120	61.9	24.0	7.8	6.3	96.0	98.8	3.3	8.8	22.4
		61.9	24.0	7.8	6.3	96.0	98.8	3.3	8.8	22.4
		61.9	24.0	7.8	6.3	96.0	98.8	3.3	8.8	22.4
		61.9	24.0	7.8	6.3	96.0	98.8	3.3	8.8	22.5
		61.9	24.0	7.8	6.3	96.0	98.8	3.3	8.8	22.5
	Average	61.9	24.0	7.8	6.3	96.0	98.8	3.3	8.8	22.4
	180	62.0	24.0	7.8	6.2	96.0	98.9	3.2	8.8	23.7
		62.0	24.0	7.8	6.2	96.0	98.9	3.2	8.8	23.7
		62.0	24.0	7.8	6.2	96.0	98.9	3.2	8.8	23.7
		62.0	24.0	7.8	6.2	96.0	98.9	3.2	8.8	23.8
		62.0	24.0	7.8	6.2	96.0	98.9	3.2	8.8	23.8
	Average	62.0	24.0	7.8	6.2	96.0	98.9	3.2	8.8	23.7

Table A1 (continued)

NaOH solution (%)	Time (min)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
		Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
3	60	62.5	23.9	7.5	6.2	88.5	91.8	11.3	19.2	29.5
		62.5	23.9	7.5	6.2	88.5	91.8	11.4	19.2	29.5
		62.5	23.9	7.5	6.2	88.5	91.8	11.4	19.2	29.6
		62.5	23.9	7.5	6.2	88.5	91.8	11.4	19.2	29.6
		62.5	23.8	7.5	6.2	88.5	91.8	11.4	19.2	29.6
	Average	62.5	23.9	7.5	6.2	88.5	91.8	11.4	19.2	29.6
	120	63.2	24.1	7.5	5.2	87.0	91.3	11.9	20.4	42.0
		63.2	24.1	7.5	5.2	87.0	91.3	11.9	20.4	42.0
		63.2	24.1	7.5	5.2	87.0	91.3	11.9	20.5	42.0
		63.2	24.1	7.5	5.2	87.0	91.3	11.9	20.5	42.0
		63.2	24.1	7.5	5.2	87.0	91.3	11.9	20.5	42.0
	Average	63.2	24.1	7.5	5.2	87.0	91.3	11.9	20.5	42.0
	180	63.4	24.0	7.0	5.6	85.5	90.1	13.9	27.2	38.5
		63.4	24.0	7.0	5.6	85.5	90.1	13.9	27.2	38.5
		63.4	24.0	7.0	5.6	85.5	90.1	13.9	27.3	38.5
		63.5	24.0	7.0	5.6	85.5	90.1	13.9	27.3	38.5
		63.5	24.0	7.0	5.6	85.5	90.1	13.9	27.3	38.5
	Average	63.4	24.0	7.0	5.6	85.5	90.1	13.9	27.3	38.5
5.5	60	64.9	25.2	5.2	4.7	78.2	84.3	17.2	50.4	53.3
		64.9	25.2	5.2	4.7	78.2	84.3	17.2	50.4	53.3
		64.9	25.2	5.2	4.7	78.2	84.3	17.2	50.4	53.3
		64.9	25.2	5.2	4.7	78.2	84.3	17.2	50.4	53.3
		64.9	25.2	5.2	4.7	78.2	84.3	17.2	50.4	53.3
	Average	64.9	25.2	5.2	4.7	78.2	84.3	17.2	50.4	53.3
	120	65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.4
		65.5	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.3
		65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.3
		65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.4
		65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.4
	Average	65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.4
	180	65.9	26.1	5.3	2.7	73.4	80.3	19.6	52.6	74.6
		65.9	26.1	5.3	2.7	73.4	80.3	19.6	52.6	74.6
		65.9	26.1	5.3	2.7	73.4	80.3	19.6	52.6	74.6
		65.9	26.1	5.3	2.7	73.4	80.3	19.6	52.6	74.6
		65.9	26.1	5.3	2.7	73.4	80.3	19.6	52.6	74.6
	Average	65.9	26.1	5.3	2.7	73.4	80.3	19.6	52.6	74.6

Table A1 (continued)

NaOH solution (%)	Time (min)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)			
		Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other	
8	60	65.1	24.0	5.5	5.5	67.1	72.5	32.4	55.3	52.8	
		65.1	24.0	5.5	5.5	67.1	72.5	32.4	55.3	52.8	
		65.1	24.0	5.5	5.5	67.1	72.5	32.4	55.3	52.8	
		65.1	24.0	5.5	5.5	67.1	72.5	32.4	55.3	52.8	
		65.1	24.0	5.5	5.5	67.1	72.5	32.4	55.3	52.8	
	Average	65.1	24.0	5.5	5.5	67.1	72.5	32.4	55.3	52.8	
	120	65.9	24.2	5.4	4.5	66.0	72.3	32.8	56.7	62.0	
		65.9	24.2	5.4	4.5	66.0	72.3	32.8	56.7	62.0	
		65.9	24.2	5.4	4.5	66.0	72.3	32.8	56.7	62.0	
		65.9	24.2	5.4	4.5	66.0	72.3	32.8	56.7	62.0	
		65.9	24.2	5.4	4.5	66.0	72.3	32.8	56.7	62.0	
	Average	65.9	24.2	5.4	4.5	66.0	72.3	32.8	56.7	62.0	
	180	66.9	24.8	5.4	3.0	64.0	71.1	33.4	58.0	75.5	
		66.9	24.8	5.4	3.0	64.0	71.1	33.4	58.1	75.5	
		66.9	24.8	5.4	3.0	64.0	71.1	33.4	58.1	75.5	
		66.9	24.8	5.4	3.0	64.0	71.1	33.4	58.1	75.5	
		66.9	24.8	5.4	3.0	64.0	71.1	33.4	58.1	75.5	
	Average	66.9	24.8	5.4	3.0	64.0	71.1	33.4	58.1	75.5	
	10.5	60	67.2	21.3	6.7	4.8	47.0	52.5	58.0	61.5	71.1
			67.2	21.3	6.7	4.8	47.0	52.5	58.0	61.5	71.1
67.2			21.3	6.7	4.8	47.0	52.5	58.0	61.5	71.1	
67.2			21.3	6.7	4.8	47.0	52.5	58.0	61.5	71.1	
67.2			21.3	6.7	4.8	47.0	52.5	58.0	61.5	71.1	
Average		67.2	21.3	6.7	4.8	47.0	52.5	58.0	61.5	71.1	
120		68.5	21.7	6.5	3.3	46.0	52.3	58.1	63.5	80.6	
		68.5	21.7	6.5	3.3	46.0	52.4	58.1	63.5	80.6	
		68.5	21.7	6.5	3.3	46.0	52.4	58.1	63.6	80.6	
		68.5	21.7	6.5	3.3	46.0	52.4	58.1	63.6	80.6	
		68.5	21.7	6.5	3.3	46.0	52.4	58.1	63.6	80.6	
Average		68.5	21.7	6.5	3.3	46.0	52.4	58.1	63.6	80.6	
180		69.9	21.0	6.5	2.7	45.0	52.2	60.3	64.3	84.7	
		69.9	21.0	6.5	2.7	45.0	52.2	60.3	64.3	84.7	
		69.9	21.0	6.5	2.7	45.0	52.3	60.3	64.4	84.7	
		69.9	21.0	6.5	2.7	45.0	52.3	60.3	64.4	84.7	
		69.9	21.0	6.5	2.7	45.0	52.3	60.3	64.4	84.7	
Average	69.9	21.0	6.5	2.7	45.0	52.3	60.3	64.4	84.7		

Table A2 Characterization of NaOH solution pretreated materials with ozonolysis process

Time of ozone flow (minute)	Composition (wt.%, based on dry matter)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
	Cellulose	Hemi-cellulose	Lignin	Other			Hemi-cellulose	Lignin	Other
0	65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.4
	65.5	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.3
	65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.3
	65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.4
	65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.4
Average	65.4	25.5	5.2	3.8	76.4	83.1	18.1	51.5	62.4
10	69.8	23.2	4.2	2.8	70.9	82.2	30.8	63.6	74.6
	69.8	23.2	4.2	2.8	70.9	82.2	30.8	63.7	74.6
	69.8	23.2	4.2	2.8	70.9	82.2	30.8	63.7	74.6
	69.8	23.2	4.2	2.8	70.9	82.2	30.8	63.7	74.6
	69.8	23.2	4.2	2.8	70.9	82.2	30.8	63.7	74.6
Average	69.8	23.2	4.2	2.8	70.9	82.2	30.8	63.7	74.6
20	74.8	21.4	1.5	2.3	65.5	81.4	41.1	88.0	80.7
	74.8	21.4	1.5	2.3	65.5	81.4	41.1	88.0	80.7
	74.8	21.4	1.5	2.3	65.5	81.4	41.1	88.0	80.7
	74.8	21.4	1.5	2.3	65.5	81.4	41.1	88.1	80.7
	74.8	21.4	1.5	2.3	65.5	81.4	41.1	88.1	80.7
Average	74.8	21.4	1.5	2.3	65.5	81.4	41.1	88.0	80.7
30	75.9	20.8	0.8	2.4	62.6	78.9	45.3	93.8	80.5
	75.9	20.8	0.8	2.4	62.6	78.9	45.3	93.8	80.5
	76.0	20.8	0.8	2.4	62.6	78.9	45.3	93.8	80.5
	75.9	20.8	0.8	2.4	62.6	78.9	45.3	93.8	80.5
	75.9	20.8	0.8	2.4	62.6	78.9	45.3	93.8	80.5
Average	75.9	20.8	0.8	2.4	62.6	78.9	45.3	93.8	80.5

Table A3 Characterization of untreated and pretreated materials with NH₃ solution pretreatment

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
0			60.2	23.8	8.2	7.8					
			60.2	23.8	8.2	7.8					
			60.2	23.8	8.2	7.8					
			60.2	23.8	8.2	7.8					
			60.2	23.8	8.2	7.8					
			Average	60.2	23.8	8.2	7.8				
5	40	12	60.4	23.8	8.2	7.7	99.3	99.6	0.6	1.0	2.4
			60.4	23.8	8.2	7.7	99.3	99.6	0.6	1.0	2.4
			60.4	23.8	8.2	7.7	99.3	99.6	0.6	1.0	2.5
			60.4	23.8	8.2	7.7	99.3	99.6	0.6	1.0	2.4
			60.4	23.8	8.2	7.7	99.3	99.6	0.6	1.0	2.4
		Average	60.4	23.8	8.2	7.7	99.3	99.6	0.6	1.0	2.4
		24	60.5	23.6	8.2	7.7	98.8	99.3	2.0	1.7	2.2
			60.5	23.6	8.2	7.7	98.8	99.3	2.0	1.7	2.2
			60.5	23.6	8.2	7.7	98.8	99.3	2.0	1.7	2.2
			60.5	23.6	8.2	7.7	98.8	99.3	2.0	1.7	2.1
			60.5	23.6	8.2	7.7	98.8	99.3	2.0	1.7	2.2
		Average	60.5	23.6	8.2	7.7	98.8	99.3	2.0	1.7	2.2
	36	60.6	23.5	8.1	7.7	98.6	99.3	2.6	2.5	2.1	
		60.6	23.5	8.1	7.7	98.6	99.3	2.6	2.5	2.1	
		60.6	23.5	8.1	7.7	98.6	99.3	2.6	2.5	2.1	
		60.6	23.5	8.1	7.7	98.6	99.3	2.6	2.5	2.2	
		60.6	23.5	8.1	7.7	98.6	99.3	2.6	2.5	2.2	
		60.6	23.5	8.1	7.7	98.6	99.3	2.6	2.5	2.2	
		Average	60.6	23.5	8.1	7.7	98.6	99.3	2.6	2.5	2.1
	65	12	60.9	23.3	8.1	7.8	98.4	99.4	3.6	3.3	1.9
			60.8	23.3	8.1	7.8	98.4	99.4	3.6	3.3	1.9
			60.9	23.3	8.1	7.8	98.4	99.4	3.6	3.3	1.9
			60.8	23.3	8.1	7.8	98.4	99.4	3.6	3.3	1.9
			60.8	23.3	8.1	7.8	98.4	99.4	3.6	3.3	1.8
Average			60.8	23.3	8.1	7.8	98.4	99.4	3.6	3.3	1.9
24		61.0	23.2	8.0	7.8	98.2	99.5	4.3	4.1	1.7	
		61.0	23.2	8.0	7.8	98.2	99.5	4.3	4.1	1.7	
		61.0	23.2	8.0	7.8	98.2	99.5	4.3	4.1	1.7	
		61.0	23.2	8.0	7.8	98.2	99.5	4.3	4.1	1.7	
		61.0	23.2	8.0	7.8	98.2	99.5	4.3	4.1	1.7	
		Average	61.0	23.2	8.0	7.8	98.2	99.5	4.3	4.1	1.7
36		61.3	23.0	7.9	7.8	97.5	99.2	6.0	5.8	1.9	
		61.3	23.0	7.9	7.8	97.5	99.2	6.0	5.8	2.0	
		61.3	23.0	7.9	7.8	97.5	99.2	6.0	5.8	2.0	
		61.3	23.0	7.9	7.8	97.5	99.2	6.0	5.8	1.9	
		61.3	23.0	7.9	7.8	97.5	99.2	6.0	5.8	1.9	
		Average	61.3	23.0	7.9	7.8	97.5	99.2	6.0	5.8	2.0

Table A3 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)			
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other	
	90	12	61.5	22.8	7.8	7.9	97.3	99.3	6.9	7.0	1.5	
			61.5	22.8	7.8	7.9	97.3	99.3	6.9	7.0	1.5	
			61.5	22.8	7.8	7.9	97.3	99.3	6.9	7.0	1.5	
			61.5	22.8	7.8	7.9	97.3	99.3	6.9	7.0	1.5	
			61.5	22.8	7.8	7.9	97.3	99.3	6.9	7.0	1.5	
		Average	61.5	22.8	7.8	7.9	97.3	99.3	6.9	7.0	1.5	
		24	61.7	22.7	7.7	7.9	96.9	99.4	7.7	9.6	1.4	
			61.7	22.7	7.7	7.9	96.9	99.4	7.7	9.6	1.4	
			61.7	22.7	7.7	7.9	96.9	99.4	7.7	9.6	1.4	
			61.7	22.7	7.7	7.9	96.9	99.4	7.7	9.6	1.4	
			61.7	22.7	7.7	7.9	96.9	99.4	7.7	9.6	1.4	
		Average	61.7	22.7	7.7	7.9	96.9	99.4	7.7	9.6	1.4	
	36	61.9	22.6	7.6	8.0	96.7	99.4	8.0	10.9	1.2		
		61.9	22.6	7.6	8.0	96.7	99.4	8.0	10.9	1.2		
		61.9	22.6	7.6	8.0	96.7	99.4	8.0	10.9	1.2		
		61.9	22.6	7.6	8.0	96.7	99.4	8.1	10.9	1.2		
		61.9	22.6	7.6	8.0	96.7	99.4	8.1	10.9	1.2		
	Average	61.9	22.6	7.6	8.0	96.7	99.4	8.0	10.9	1.2		
	10	40	12	62.0	22.4	7.5	8.1	95.7	98.5	10.0	12.2	1.0
				62.0	22.4	7.5	8.1	95.7	98.5	10.0	12.2	1.0
				62.0	22.4	7.5	8.1	95.7	98.5	10.0	12.2	1.0
				62.0	22.4	7.5	8.1	95.7	98.5	10.0	12.2	1.0
				62.0	22.4	7.5	8.1	95.7	98.5	10.0	12.2	1.1
			Average	62.0	22.4	7.5	8.1	95.7	98.5	10.0	12.2	1.0
24			62.1	22.3	7.4	8.2	94.9	98.0	11.1	14.1	0.7	
			62.1	22.3	7.4	8.2	94.9	98.0	11.1	14.1	0.6	
			62.1	22.3	7.4	8.2	94.9	98.0	11.1	14.1	0.6	
			62.1	22.3	7.4	8.2	94.9	98.0	11.1	14.1	0.6	
			62.1	22.3	7.4	8.2	94.9	98.0	11.1	14.1	0.6	
Average			62.1	22.3	7.4	8.2	94.9	98.0	11.1	14.1	0.6	
36		62.3	22.2	7.3	8.2	94.1	97.4	12.3	15.9	1.0		
		62.3	22.2	7.3	8.2	94.1	97.4	12.3	15.9	1.0		
		62.3	22.2	7.3	8.2	94.1	97.4	12.3	15.9	1.0		
		62.3	22.2	7.3	8.2	94.1	97.4	12.3	15.9	1.0		
		62.3	22.2	7.3	8.2	94.1	97.4	12.3	15.9	1.1		
Average		62.3	22.2	7.3	8.2	94.1	97.4	12.3	15.9	1.0		
65		12	62.5	22.0	7.2	8.3	93.3	96.9	13.7	17.7	0.7	
			62.5	22.0	7.2	8.3	93.3	96.9	13.7	17.7	0.7	
			62.5	22.0	7.2	8.3	93.3	96.9	13.7	17.7	0.7	
			62.5	22.0	7.2	8.3	93.3	96.9	13.7	17.7	0.7	
			62.5	22.0	7.2	8.3	93.3	96.9	13.7	17.7	0.8	
Average		62.5	22.0	7.2	8.3	93.3	96.9	13.7	17.7	0.7		

Table A3 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
10	65	24	62.7	21.8	7.1	8.4	92.2	96.0	15.6	19.7	0.4
			62.7	21.8	7.1	8.4	92.2	96.0	15.6	19.7	0.4
			62.7	21.8	7.1	8.4	92.2	96.0	15.6	19.7	0.4
			62.7	21.8	7.1	8.4	92.2	96.0	15.6	19.7	0.4
			62.7	21.8	7.1	8.4	92.2	96.0	15.6	19.7	0.4
		Average	62.7	21.8	7.1	8.4	92.2	96.0	15.6	19.7	0.4
		36	62.9	21.6	6.9	8.5	91.2	95.4	17.2	22.8	0.5
			62.9	21.6	6.9	8.5	91.2	95.4	17.2	22.8	0.5
			62.9	21.6	6.9	8.5	91.2	95.4	17.2	22.8	0.5
			62.9	21.6	6.9	8.5	91.2	95.4	17.2	22.8	0.5
			62.9	21.6	6.9	8.5	91.2	95.4	17.2	22.8	0.5
		Average	62.9	21.6	6.9	8.5	91.2	95.4	17.2	22.8	0.5
	90	12	63.2	21.5	6.8	8.6	90.8	95.2	18.0	24.9	0.4
			63.2	21.5	6.8	8.6	90.8	95.2	18.0	24.9	0.4
			63.2	21.5	6.8	8.6	90.8	95.2	18.0	24.9	0.4
			63.2	21.5	6.8	8.6	90.8	95.2	18.0	24.9	0.4
			63.2	21.5	6.8	8.6	90.8	95.2	18.0	24.9	0.4
		Average	63.2	21.5	6.8	8.6	90.8	95.2	18.0	24.9	0.4
		24	63.3	21.4	6.7	8.6	89.9	94.5	19.1	27.1	0.8
			63.3	21.4	6.7	8.6	89.9	94.5	19.1	27.1	0.8
			63.3	21.4	6.7	8.6	89.9	94.5	19.1	27.1	0.8
			63.3	21.4	6.7	8.6	89.9	94.5	19.1	27.1	0.8
			63.3	21.5	6.7	8.6	89.9	94.5	19.1	27.1	0.8
		Average	63.3	21.4	6.7	8.6	89.9	94.5	19.1	27.1	0.8
36	63.4	21.3	6.6	8.8	88.6	93.3	20.8	28.8	0.7		
	63.4	21.3	6.6	8.7	88.6	93.3	20.8	28.8	0.7		
	63.4	21.3	6.6	8.8	88.6	93.3	20.8	28.8	0.7		
	63.4	21.3	6.6	8.8	88.6	93.3	20.8	28.8	0.7		
	63.4	21.3	6.6	8.7	88.6	93.3	20.8	28.8	0.7		
Average	63.4	21.3	6.6	8.8	88.6	93.3	20.8	28.8	0.7		
20	40	12	63.6	21.1	6.4	8.9	86.8	91.7	23.1	32.5	0.3
			63.6	21.1	6.4	8.9	86.8	91.7	23.1	32.5	0.4
			63.6	21.1	6.4	9.0	86.8	91.7	23.1	32.5	0.3
			63.6	21.1	6.4	8.9	86.8	91.7	23.1	32.4	0.3
			63.6	21.1	6.4	8.9	86.8	91.7	23.1	32.5	0.4
	Average	63.6	21.1	6.4	8.9	86.8	91.7	23.1	32.5	0.4	
	24	63.8	20.9	6.3	9.0	86.1	91.3	24.4	34.4	0.3	
		63.8	20.9	6.3	9.0	86.1	91.3	24.4	34.4	0.3	
		63.8	20.9	6.3	9.0	86.1	91.3	24.4	34.4	0.3	
		63.8	20.9	6.3	9.0	86.1	91.3	24.4	34.4	0.3	
		63.8	20.9	6.3	9.0	86.1	91.3	24.4	34.4	0.3	
	Average	63.8	20.9	6.3	9.0	86.1	91.3	24.4	34.4	0.3	

Table A3 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)				
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other		
20	40		64.0	20.8	6.1	9.1	85.2	90.5	25.5	36.2	0.6		
			64.0	20.8	6.1	9.1	85.2	90.5	25.5	36.2	0.6		
			64.0	20.8	6.1	9.1	85.2	90.5	25.6	36.2	0.6		
			64.0	20.8	6.1	9.1	85.2	90.5	25.6	36.2	0.6		
		36	64.0	20.8	6.1	9.1	85.2	90.5	25.5	36.2	0.6		
		Average	64.0	20.8	6.1	9.1	85.2	90.5	25.6	36.2	0.6		
	65			64.1	20.7	6.0	9.2	84.5	89.9	26.5	38.6	0.2	
				64.1	20.7	6.0	9.2	84.5	89.9	26.5	38.6	0.2	
				64.1	20.7	6.0	9.2	84.5	89.9	26.5	38.6	0.3	
				64.1	20.7	6.0	9.2	84.5	89.9	26.5	38.6	0.2	
		12		64.1	20.7	6.0	9.2	84.5	89.9	26.5	38.6	0.2	
		Average		64.1	20.7	6.0	9.2	84.5	89.9	26.5	38.6	0.2	
					64.2	20.6	5.8	9.4	83.3	88.8	27.8	40.9	0.1
					64.2	20.6	5.8	9.4	83.3	88.8	27.8	40.9	0.0
					64.2	20.6	5.8	9.4	83.3	88.8	27.8	40.9	0.0
					64.2	20.6	5.8	9.4	83.3	88.8	27.8	40.9	0.0
		24			64.2	20.6	5.8	9.4	83.3	88.8	27.8	40.9	0.0
		Average			64.2	20.6	5.8	9.4	83.3	88.8	27.8	40.9	0.0
				64.5	20.6	5.6	9.4	83.0	88.9	28.3	43.6	0.2	
				64.5	20.6	5.6	9.4	83.0	88.9	28.3	43.6	0.2	
				64.5	20.6	5.6	9.4	83.0	88.9	28.3	43.6	0.2	
				64.5	20.6	5.6	9.4	83.0	88.9	28.3	43.6	0.3	
	36			64.5	20.6	5.6	9.4	83.0	88.9	28.3	43.6	0.2	
	Average			64.5	20.6	5.6	9.4	83.0	88.9	28.3	43.6	0.2	
90			64.6	20.6	5.5	9.4	82.7	88.7	28.6	44.6	0.6		
			64.6	20.6	5.5	9.4	82.7	88.7	28.6	44.6	0.6		
			64.6	20.6	5.5	9.4	82.7	88.7	28.6	44.6	0.6		
			64.6	20.6	5.5	9.4	82.7	88.7	28.6	44.6	0.6		
	12		64.6	20.6	5.5	9.4	82.7	88.7	28.6	44.6	0.6		
	Average		64.6	20.6	5.5	9.4	82.7	88.7	28.6	44.6	0.6		
				64.7	20.5	5.4	9.4	82.3	88.4	29.1	45.7	0.7	
				64.7	20.5	5.4	9.4	82.3	88.4	29.1	45.7	0.7	
				64.7	20.5	5.4	9.4	82.3	88.4	29.1	45.7	0.7	
				64.7	20.5	5.4	9.4	82.3	88.4	29.2	45.7	0.7	
	24			64.7	20.5	5.4	9.4	82.3	88.4	29.1	45.7	0.7	
	Average			64.7	20.5	5.4	9.4	82.3	88.4	29.1	45.7	0.7	
				64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.5	0.0	
				64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.5	0.0	
				64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.4	0.0	
				64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.4	0.0	
	36			64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.5	0.0	
	Average			64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.4	0.0	

Table A4 Characterization of NH₃ solution pretreated materials with ozonolysis process

Time of ozone flow (minute)	Composition (wt.%, based on dry matter)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
	Cellulose	Hemi-cellulose	Lignin	Other			Hemi-cellulose	Lignin	Other
0	64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.5	0.0
	64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.5	0.0
	64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.4	0.0
	64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.4	0.0
	64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.5	0.0
Average	64.7	20.4	5.4	9.5	81.8	87.9	30.0	46.4	0.0
10	68.7	19.2	4.4	7.7	76.2	87.1	36.6	59.5	24.4
	68.7	19.2	4.4	7.7	76.2	87.1	36.6	59.5	24.4
	68.7	19.2	4.4	7.7	76.2	87.0	36.6	59.5	24.4
	68.8	19.2	4.4	7.7	76.2	87.1	36.6	59.5	24.4
	68.8	19.2	4.4	7.7	76.2	87.0	36.6	59.5	24.4
Average	68.7	19.2	4.4	7.7	76.2	87.1	36.6	59.5	24.4
20	78.1	16.0	1.6	4.6	64.6	85.1	55.8	89.6	74.4
	79.6	16.3	1.6	2.7	64.6	85.1	55.8	89.6	74.4
	79.6	16.3	1.6	2.7	64.6	85.1	55.8	89.6	74.4
	79.6	16.3	1.6	2.7	64.6	85.1	55.8	89.6	74.4
	79.6	16.3	1.6	2.7	64.6	85.1	55.8	89.6	74.4
Average	79.3	16.3	1.6	3.1	64.6	85.1	55.8	89.6	74.4
30	84.2	12.3	1.0	2.6	57.9	81.0	70.0	93.8	80.5
	84.2	12.3	1.0	2.6	57.9	81.0	70.0	93.8	80.5
	84.2	12.3	1.0	2.6	57.9	81.0	70.0	93.8	80.5
	84.2	12.3	1.0	2.6	57.9	81.0	70.0	93.8	80.5
	84.2	12.3	1.0	2.6	57.9	81.0	70.0	93.8	80.5
Average	84.2	12.3	1.0	2.6	57.9	81.0	70.0	93.8	80.5

Table A5 Characterization of untreated and pretreated materials with Ca(OH)₂ solution pretreatment

Ca(OH) ₂ solution (%)	Temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
0			60.2	23.8	8.2	7.8					
			60.2	23.8	8.2	7.8					
			60.2	23.8	8.2	7.8					
			60.2	23.8	8.2	7.8					
			60.2	23.8	8.2	7.8					
			Average	60.2	23.8	8.2	7.8				
20	40	12	60.4	23.8	8.2	7.6	99.5	99.7	0.6	0.6	2.6
			60.4	23.8	8.2	7.6	99.5	99.7	0.6	0.6	2.6
			60.4	23.8	8.2	7.6	99.5	99.7	0.6	0.6	2.6
			60.4	23.8	8.2	7.7	99.5	99.7	0.6	0.6	2.5
			60.4	23.8	8.2	7.7	99.5	99.7	0.6	0.6	2.5
		Average	60.4	23.8	8.2	7.6	99.5	99.7	0.6	0.6	2.6
		24	60.4	23.7	8.2	7.7	99.4	99.7	1.0	1.2	2.0
			60.4	23.7	8.2	7.7	99.4	99.7	1.0	1.2	2.0
			60.4	23.7	8.2	7.7	99.4	99.7	1.0	1.2	2.0
			60.4	23.7	8.2	7.7	99.4	99.7	1.1	1.2	1.9
			60.4	23.7	8.2	7.7	99.4	99.7	1.0	1.2	2.0
			Average	60.4	23.7	8.2	7.7	99.4	99.7	1.0	1.2
	36		60.5	23.7	8.1	7.6	99.0	99.5	1.4	1.7	3.0
		60.5	23.7	8.1	7.6	99.0	99.5	1.4	1.7	3.0	
		60.5	23.7	8.1	7.7	99.0	99.5	1.4	1.7	2.9	
		60.5	23.7	8.1	7.7	99.0	99.5	1.4	1.7	2.9	
		60.5	23.7	8.1	7.7	99.0	99.5	1.4	1.7	2.9	
	Average	60.5	23.7	8.1	7.7	99.0	99.5	1.4	1.7	2.9	
	65	12	60.6	23.6	8.1	7.7	98.8	99.4	1.9	2.4	2.7
			60.6	23.6	8.1	7.7	98.8	99.4	1.9	2.4	2.6
			60.6	23.6	8.1	7.7	98.8	99.4	1.9	2.4	2.6
			60.6	23.6	8.1	7.7	98.8	99.4	1.9	2.4	2.6
			60.6	23.6	8.1	7.7	98.8	99.4	1.9	2.4	2.6
			Average	60.6	23.6	8.1	7.7	98.8	99.4	1.9	2.4
24		60.7	23.6	8.0	7.7	98.6	99.4	2.3	3.6	2.1	
		60.7	23.6	8.0	7.8	98.6	99.4	2.3	3.6	2.1	
		60.7	23.6	8.0	7.8	98.6	99.3	2.3	3.6	2.0	
		60.7	23.6	8.0	7.7	98.6	99.3	2.3	3.6	2.1	
		60.7	23.6	8.0	7.7	98.6	99.4	2.3	3.7	2.1	
		Average	60.7	23.6	8.0	7.7	98.6	99.3	2.3	3.6	2.1
36	60.7	23.6	7.9	7.8	98.4	99.2	2.7	4.8	1.6		
	60.7	23.5	7.9	7.8	98.4	99.2	2.7	4.8	1.6		
	60.7	23.6	7.9	7.8	98.4	99.2	2.7	4.9	1.5		
	60.7	23.6	7.9	7.8	98.4	99.2	2.7	4.8	1.6		
	60.7	23.6	7.9	7.8	98.4	99.2	2.7	4.8	1.5		
Average	60.7	23.6	7.9	7.8	98.4	99.2	2.7	4.8	1.6		

Table A5 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
20	90	12	60.8	23.5	7.9	7.8	98.2	99.2	2.9	5.4	1.9
			60.8	23.5	7.9	7.8	98.2	99.2	2.9	5.4	1.9
			60.8	23.5	7.9	7.8	98.2	99.2	2.9	5.4	1.9
			60.8	23.5	7.9	7.8	98.2	99.2	2.9	5.4	1.9
			60.8	23.5	7.9	7.8	98.2	99.2	2.9	5.4	1.9
		Average	60.8	23.5	7.9	7.8	98.2	99.2	2.9	5.4	1.9
	24	60.9	23.5	7.9	7.8	98.0	99.0	3.3	6.0	2.0	
		60.9	23.5	7.9	7.8	98.0	99.0	3.4	6.0	2.0	
		60.8	23.5	7.9	7.8	98.0	99.0	3.3	6.0	2.0	
		60.8	23.5	7.9	7.8	98.0	99.0	3.4	6.0	2.0	
		60.9	23.5	7.9	7.8	98.0	99.0	3.4	6.0	2.0	
		Average	60.8	23.5	7.9	7.8	98.0	99.0	3.4	6.0	2.0
	36	61.0	23.3	7.8	7.8	97.5	98.9	4.4	7.2	2.1	
		61.0	23.3	7.8	7.8	97.5	98.9	4.4	7.1	2.2	
		61.0	23.3	7.8	7.8	97.5	98.9	4.4	7.1	2.3	
		61.0	23.3	7.8	7.8	97.5	98.9	4.4	7.2	2.2	
		61.0	23.3	7.8	7.8	97.5	98.9	4.4	7.1	2.1	
		Average	61.0	23.3	7.8	7.8	97.5	98.9	4.4	7.1	2.2
60	40	12	61.1	23.2	7.7	8.0	96.9	98.3	5.6	8.5	0.9
			61.1	23.2	7.7	8.0	96.9	98.3	5.6	8.5	1.0
			61.1	23.2	7.7	8.0	96.9	98.3	5.6	8.5	0.9
			61.1	23.2	7.7	8.0	96.9	98.3	5.6	8.5	0.9
			61.1	23.2	7.7	8.0	96.9	98.3	5.6	8.5	0.9
		Average	61.1	23.2	7.7	8.0	96.9	98.3	5.6	8.5	0.9
	24	61.3	23.1	7.7	8.0	96.5	98.2	6.4	9.0	1.6	
		61.3	23.1	7.7	8.0	96.5	98.2	6.4	9.0	1.6	
		61.3	23.1	7.7	8.0	96.5	98.2	6.5	9.1	1.6	
		61.2	23.1	7.7	8.0	96.5	98.2	6.5	9.1	1.5	
		61.3	23.1	7.7	8.0	96.5	98.2	6.4	9.1	1.7	
		Average	61.3	23.1	7.7	8.0	96.5	98.2	6.5	9.1	1.6
	36	61.4	22.9	7.7	8.0	96.1	98.0	7.7	9.6	1.5	
		61.4	22.9	7.7	8.0	96.1	98.0	7.7	9.6	1.5	
		61.4	22.9	7.7	8.0	96.1	98.0	7.7	9.6	1.4	
		61.4	22.9	7.7	8.0	96.1	98.0	7.7	9.7	1.3	
		61.4	22.9	7.7	8.0	96.1	98.0	7.7	9.7	1.4	
		Average	61.4	22.9	7.7	8.0	96.1	98.0	7.7	9.6	1.4
65	12	61.5	22.7	7.6	8.1	95.1	97.2	9.2	11.6	0.7	
		61.5	22.7	7.6	8.1	95.1	97.2	9.2	11.5	0.7	
		61.5	22.7	7.6	8.1	95.1	97.2	9.2	11.5	0.7	
		61.5	22.7	7.6	8.1	95.1	97.2	9.2	11.5	0.8	
		61.5	22.7	7.6	8.1	95.1	97.2	9.2	11.5	0.7	
	Average	61.5	22.7	7.6	8.1	95.1	97.2	9.2	11.5	0.7	

Table A5 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
60	65		61.6	22.6	7.7	8.2	94.9	97.1	9.8	11.5	0.8
			61.6	22.6	7.7	8.2	94.9	97.1	9.8	11.5	0.8
			61.6	22.6	7.7	8.2	94.9	97.1	9.8	11.5	0.8
			61.6	22.6	7.7	8.2	94.9	97.1	9.8	11.5	0.7
			61.6	22.6	7.7	8.2	94.9	97.1	9.8	11.4	0.9
		Average	61.6	22.6	7.7	8.2	94.9	97.1	9.8	11.5	0.8
		24	61.7	22.6	7.6	8.2	94.1	96.4	10.9	13.3	1.6
			61.7	22.6	7.6	8.2	94.1	96.4	10.9	13.3	1.6
			61.7	22.6	7.6	8.2	94.1	96.4	10.9	13.4	1.5
			61.7	22.6	7.6	8.2	94.1	96.4	10.9	13.4	1.6
			61.7	22.6	7.6	8.2	94.1	96.4	10.9	13.4	1.5
		Average	61.7	22.6	7.6	8.2	94.1	96.4	10.9	13.4	1.6
	90	12	62.0	22.3	7.5	8.2	93.4	96.2	12.6	14.5	1.4
			62.0	22.3	7.5	8.2	93.4	96.2	12.6	14.5	1.4
			62.0	22.3	7.5	8.2	93.4	96.2	12.6	14.6	1.4
			62.0	22.3	7.5	8.2	93.4	96.2	12.6	14.5	1.4
			62.0	22.3	7.5	8.2	93.4	96.2	12.6	14.6	1.4
		Average	62.0	22.3	7.5	8.2	93.4	96.2	12.6	14.5	1.4
		24	62.1	22.2	7.5	8.3	92.8	95.6	13.6	15.7	0.9
			62.1	22.2	7.5	8.3	92.8	95.6	13.7	15.7	0.8
			62.1	22.2	7.5	8.3	92.8	95.6	13.6	15.7	0.9
			62.1	22.2	7.5	8.3	92.8	95.6	13.6	15.7	0.9
			62.1	22.2	7.5	8.3	92.8	95.6	13.6	15.7	0.9
		Average	62.1	22.2	7.5	8.3	92.8	95.6	13.6	15.7	0.9
36	62.3	21.9	7.5	8.4	91.9	95.0	15.5	16.3	1.6		
	62.3	21.9	7.5	8.4	91.9	95.0	15.5	16.3	1.6		
	62.3	21.9	7.5	8.4	91.9	95.0	15.5	16.4	1.5		
	62.3	21.9	7.5	8.4	91.9	95.0	15.5	16.4	1.5		
	62.3	21.9	7.5	8.4	91.9	95.0	15.5	16.4	1.5		
Average	62.3	21.9	7.5	8.4	91.9	95.0	15.5	16.4	1.6		
100	40	12	62.4	21.8	7.4	8.4	91.6	94.9	16.3	17.6	0.9
			62.4	21.8	7.4	8.4	91.6	94.9	16.3	17.6	0.9
			62.4	21.8	7.4	8.4	91.6	94.9	16.3	17.7	0.9
			62.4	21.8	7.4	8.5	91.6	94.9	16.4	17.7	0.9
			62.4	21.7	7.4	8.5	91.6	94.9	16.4	17.7	0.8
		Average	62.4	21.8	7.4	8.4	91.6	94.9	16.3	17.7	0.9
	24	62.6	21.7	7.3	8.4	91.0	94.5	17.1	18.8	1.8	
		62.6	21.7	7.3	8.4	91.0	94.5	17.1	18.8	1.8	
		62.6	21.7	7.3	8.4	91.0	94.5	17.1	18.8	1.8	
		62.6	21.7	7.3	8.4	91.0	94.5	17.1	18.8	1.8	
		62.6	21.7	7.3	8.4	91.0	94.5	17.1	18.8	1.8	
		Average	62.6	21.7	7.3	8.4	91.0	94.5	17.1	18.8	1.8

Table A5 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
100	40	36	62.6	21.6	7.2	8.6	89.6	93.1	18.9	21.3	0.7
			62.6	21.6	7.2	8.6	89.6	93.1	18.9	21.3	0.7
			62.6	21.6	7.2	8.7	89.6	93.1	18.9	21.3	0.7
			62.6	21.6	7.2	8.7	89.6	93.1	18.9	21.3	0.6
			62.6	21.6	7.2	8.7	89.6	93.1	18.9	21.3	0.6
		Average	62.6	21.6	7.2	8.7	89.6	93.1	18.9	21.3	0.7
	65	12	62.6	21.5	7.2	8.7	88.7	92.3	19.9	22.4	0.9
			62.6	21.5	7.2	8.7	88.7	92.3	19.9	22.4	0.9
			62.6	21.5	7.2	8.7	88.7	92.3	19.9	22.4	0.9
			62.6	21.5	7.2	8.7	88.7	92.3	19.9	22.5	0.8
			62.6	21.5	7.2	8.7	88.7	92.3	19.9	22.4	0.9
		Average	62.6	21.5	7.2	8.7	88.7	92.3	19.9	22.4	0.9
		24	62.6	21.5	7.2	8.7	88.2	91.7	20.3	23.0	1.5
			62.6	21.5	7.2	8.7	88.2	91.7	20.3	23.0	1.5
			62.6	21.5	7.2	8.7	88.2	91.7	20.3	23.1	1.4
			62.6	21.5	7.2	8.7	88.2	91.7	20.3	23.0	1.5
			62.6	21.5	7.2	8.7	88.2	91.7	20.3	23.1	1.4
			Average	62.6	21.5	7.2	8.7	88.2	91.7	20.3	23.0
	36		62.8	21.3	7.2	8.7	88.0	91.8	21.4	23.0	1.7
		62.8	21.3	7.2	8.7	88.0	91.8	21.4	23.0	1.7	
		62.8	21.3	7.2	8.7	88.0	91.8	21.4	23.0	1.7	
		62.8	21.3	7.2	8.7	88.0	91.8	21.4	23.0	1.6	
		62.8	21.3	7.2	8.7	88.0	91.8	21.4	23.1	1.7	
	Average	62.8	21.3	7.2	8.7	88.0	91.8	21.4	23.0	1.7	
90	12	62.9	21.2	7.1	8.8	87.9	91.9	21.8	24.2	0.6	
		62.9	21.2	7.1	8.8	87.9	91.9	21.8	24.3	0.6	
		62.9	21.2	7.1	8.8	87.9	91.9	21.8	24.3	0.6	
		62.9	21.2	7.1	8.8	87.9	91.9	21.8	24.3	0.6	
		62.9	21.2	7.1	8.8	87.9	91.9	21.8	24.3	0.6	
		Average	62.9	21.2	7.1	8.8	87.9	91.9	21.8	24.3	0.6
	24	63.1	21.1	7.1	8.8	87.9	92.0	22.2	24.2	0.8	
		63.1	21.1	7.1	8.8	87.9	92.0	22.2	24.3	0.8	
		63.1	21.1	7.1	8.8	87.9	92.0	22.2	24.3	0.8	
		63.1	21.1	7.1	8.8	87.9	92.0	22.2	24.2	0.8	
		63.1	21.1	7.1	8.8	87.9	92.0	22.2	24.3	0.8	
		Average	63.1	21.1	7.1	8.8	87.9	92.0	22.2	24.3	0.8
	36	63.3	20.8	7.1	8.9	87.4	91.9	23.5	24.9	0.8	
		63.3	20.8	7.1	8.9	87.4	91.9	23.5	24.9	0.7	
		63.3	20.8	7.0	8.9	87.4	91.9	23.5	24.9	0.7	
		63.3	20.8	7.0	8.9	87.4	91.9	23.5	24.9	0.7	
		63.3	20.8	7.1	8.9	87.4	91.9	23.5	24.9	0.7	
		Average	63.3	20.8	7.1	8.9	87.4	91.9	23.5	24.9	0.7

Table A6 Characterization of Ca(OH)₂ solution pretreated materials with ozonolysis process

Time of ozone flow (minute)	Composition (wt.%, based on dry matter)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
	Cellulose	Hemicellulose	Lignin	Other			Hemicellulose	Lignin	Other
0	63.2	21.2	7.0	8.6	87.5	91.9	22.2	24.9	3.3
	63.2	21.2	7.0	8.6	87.5	91.9	22.2	24.9	3.3
	63.2	21.2	7.0	8.6	87.5	91.9	22.2	24.9	3.3
	63.2	21.2	7.0	8.6	87.5	91.9	22.2	24.9	3.3
	63.2	21.2	7.0	8.6	87.5	91.9	22.2	24.9	3.3
Average	63.2	21.2	7.0	8.6	87.5	91.9	22.2	24.9	3.3
10	63.4	21.1	7.0	8.5	87.0	91.5	22.9	25.7	4.8
	63.4	21.1	7.0	8.6	87.0	91.5	22.9	25.7	4.7
	63.4	21.1	7.0	8.5	87.0	91.5	22.9	25.7	4.8
	63.4	21.1	7.0	8.6	87.0	91.5	22.9	25.7	4.7
	63.4	21.1	7.0	8.5	86.9	91.5	22.9	25.7	4.8
Average	63.4	21.1	7.0	8.6	87.0	91.5	22.9	25.7	4.8
20	63.5	21.0	7.0	8.5	86.1	90.8	23.9	26.6	6.6
	63.5	21.0	7.0	8.5	86.1	90.8	23.9	26.6	6.5
	63.5	21.0	7.0	8.5	86.1	90.8	23.9	26.6	6.6
	63.5	21.0	7.0	8.5	86.1	90.8	23.9	26.6	6.6
	63.5	21.0	7.0	8.5	86.1	90.8	23.9	26.6	6.5
Average	63.5	21.0	7.0	8.5	86.1	90.8	23.9	26.6	6.6
30	63.6	21.0	7.0	8.4	84.9	89.8	25.1	27.6	8.7
	63.6	21.0	7.0	8.4	84.9	89.8	25.1	27.6	8.7
	63.6	21.0	7.0	8.4	84.9	89.8	25.2	27.6	8.7
	63.6	21.0	7.0	8.4	84.9	89.8	25.1	27.7	8.7
	63.6	21.0	7.0	8.4	84.9	89.8	25.1	27.7	8.7
Average	63.6	21.0	7.0	8.4	84.9	89.8	25.1	27.6	8.7

APPENDIX B

Characterization of untreated and pretreated Corn stover with alkaline solution and ozone.

Table B1 Characterization of untreated and pretreated materials with NaOH solutions pretreatment

NaOH solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)				
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other		
0			44.6	32.4	16.9	6.2							
			44.6	32.4	16.9	6.2							
			44.6	32.4	16.9	6.2							
			44.6	32.4	16.9	6.2							
			44.6	32.4	16.9	6.2							
		Average	44.6	32.4	16.9	6.2							
0.5	40		45.0	32.2	16.5	6.2	98.2	99.2	2.3	3.8	0.8		
			45.0	32.2	16.5	6.2	98.2	99.2	2.3	3.8	0.8		
			45.0	32.2	16.5	6.2	98.2	99.2	2.3	3.8	0.8		
			45.0	32.2	16.5	6.2	98.2	99.2	2.3	3.8	0.8		
			45.0	32.2	16.5	6.2	98.2	99.2	2.3	3.8	0.9		
		Average	45.0	32.2	16.5	6.2	98.2	99.2	2.3	3.8	0.8		
	60			45.1	32.3	16.4	6.2	97.8	98.9	2.5	4.7	1.5	
				45.1	32.3	16.4	6.2	97.8	98.9	2.5	4.7	1.5	
				45.0	32.3	16.4	6.2	97.8	98.9	2.5	4.8	1.4	
				45.0	32.3	16.4	6.2	97.8	98.9	2.5	4.7	1.4	
				45.1	32.3	16.4	6.2	97.8	98.9	2.5	4.7	1.5	
		Average	45.1	32.3	16.4	6.2	97.8	98.9	2.5	4.7	1.5		
		120			45.0	32.3	16.4	6.2	97.5	98.6	2.8	5.1	1.6
					45.0	32.3	16.4	6.2	97.5	98.6	2.8	5.1	1.6
					45.0	32.3	16.4	6.2	97.5	98.6	2.8	5.1	1.6
					45.0	32.3	16.4	6.2	97.5	98.6	2.8	5.0	1.5
	45.0				32.3	16.4	6.2	97.5	98.6	2.8	5.1	1.6	
	Average	45.0	32.3	16.4	6.2	97.5	98.6	2.8	5.1	1.6			
	180			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.5	
				45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4	
				45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4	
45.1				32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4		
45.1				32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4		
Average				45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4	
65			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4		
			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4		
			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4		
			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4		
			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4		

Table B1 (continued)

NaOH solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
0.5	65	60	45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.5
			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4
			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4
			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4
			45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4
		Average	45.1	32.2	16.4	6.3	97.1	98.3	3.4	5.6	1.4
		120	45.1	32.3	16.3	6.3	97.1	98.3	3.4	5.9	1.2
			45.1	32.3	16.3	6.3	97.1	98.3	3.4	5.9	1.2
			45.1	32.3	16.3	6.3	97.1	98.3	3.4	6.0	1.2
			45.1	32.3	16.3	6.3	97.1	98.3	3.4	5.9	1.2
			45.1	32.3	16.3	6.3	97.1	98.3	3.4	5.9	1.2
		Average	45.1	32.3	16.3	6.3	97.1	98.3	3.4	5.9	1.2
	180	45.3	32.2	16.3	6.2	96.8	98.3	3.7	6.3	3.2	
		45.3	32.2	16.3	6.2	96.8	98.3	3.7	6.2	3.2	
		45.3	32.2	16.3	6.2	96.8	98.3	3.7	6.3	3.2	
		45.3	32.2	16.3	6.2	96.8	98.3	3.7	6.2	3.3	
		45.3	32.2	16.3	6.2	96.8	98.3	3.7	6.3	3.2	
	Average	45.3	32.2	16.3	6.2	96.8	98.3	3.7	6.3	3.2	
	90	60	45.0	32.4	16.4	6.4	95.8	96.6	4.3	7.1	1.5
			44.9	32.4	16.4	6.4	95.8	96.6	4.3	7.1	1.4
			45.0	32.4	16.4	6.4	95.8	96.6	4.3	7.1	1.4
			44.9	32.4	16.3	6.4	95.8	96.6	4.3	7.1	1.4
			45.0	32.4	16.4	6.4	95.8	96.6	4.3	7.1	1.5
		Average	44.9	32.4	16.4	6.4	95.8	96.6	4.3	7.1	1.4
120		45.0	32.4	16.3	6.3	95.5	96.5	4.6	7.7	2.3	
		45.0	32.4	16.3	6.3	95.5	96.5	4.6	7.7	2.3	
		45.0	32.4	16.3	6.3	95.5	96.5	4.6	7.7	2.2	
		45.0	32.4	16.3	6.3	95.5	96.5	4.6	7.7	2.2	
		45.0	32.4	16.3	6.3	95.5	96.5	4.6	7.7	2.2	
Average		45.0	32.4	16.3	6.3	95.5	96.5	4.6	7.7	2.2	
180	45.1	32.3	16.2	6.4	95.3	96.5	5.1	8.3	1.9		
	45.1	32.3	16.2	6.4	95.3	96.5	5.1	8.3	2.0		
	45.1	32.3	16.2	6.4	95.3	96.5	5.1	8.3	1.9		
	45.1	32.3	16.2	6.4	95.3	96.5	5.1	8.3	1.9		
	45.1	32.3	16.2	6.4	95.3	96.5	5.1	8.3	2.0		
Average	45.1	32.3	16.2	6.4	95.3	96.5	5.1	8.3	2.0		

Table B1 (continued)

NaOH solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
5.5	40	60	59.9	23.9	8.0	8.1	68.1	91.6	49.7	67.6	10.4
			59.9	23.9	8.0	8.1	68.1	91.6	49.7	67.6	10.4
			59.9	23.9	8.0	8.1	68.1	91.6	49.7	67.6	10.4
			59.9	23.9	8.0	8.1	68.1	91.6	49.7	67.6	10.4
			59.9	23.9	8.0	8.1	68.1	91.6	49.7	67.6	10.4
		Average	59.9	23.9	8.0	8.1	68.1	91.6	49.7	67.6	10.4
		120	60.1	24.0	7.9	7.9	67.7	91.4	49.8	68.2	13.0
			60.1	24.0	7.9	7.9	67.7	91.4	49.8	68.2	13.0
			60.1	24.0	7.9	7.9	67.7	91.4	49.8	68.2	12.9
			60.1	24.0	7.9	7.9	67.7	91.4	49.8	68.2	12.9
			60.1	24.0	7.9	7.9	67.7	91.4	49.8	68.2	13.0
		Average	60.1	24.0	7.9	7.9	67.7	91.4	49.8	68.2	13.0
	180	60.1	23.9	7.9	8.1	67.5	91.0	50.3	68.2	11.2	
		60.1	23.9	7.9	8.1	67.5	91.0	50.3	68.2	11.2	
		60.1	23.9	7.9	8.1	67.5	91.0	50.3	68.2	11.2	
		60.1	23.9	7.9	8.1	67.5	91.0	50.3	68.2	11.2	
		60.1	23.9	7.9	8.1	67.5	91.0	50.3	68.2	11.2	
	Average	60.1	23.9	7.9	8.1	67.5	91.0	50.3	68.2	11.2	
	65	60	60.9	23.7	7.9	7.6	67.1	91.7	50.9	68.7	17.8
			60.9	23.7	7.9	7.6	67.1	91.7	50.9	68.7	17.7
			60.9	23.7	7.9	7.6	67.1	91.7	50.9	68.7	17.7
			60.9	23.7	7.9	7.6	67.1	91.7	50.9	68.7	17.7
			60.8	23.7	7.8	7.6	67.2	91.7	50.9	68.8	16.9
			Average	60.9	23.7	7.9	7.6	67.1	91.7	50.9	68.7
		120	61.1	23.6	7.6	7.7	66.7	91.5	51.3	70.0	17.1
			61.1	23.6	7.6	7.7	66.7	91.5	51.3	70.0	17.1
			61.1	23.6	7.6	7.7	66.7	91.5	51.4	70.0	17.1
			61.1	23.6	7.6	7.7	66.7	91.5	51.4	70.0	17.1
61.1			23.6	7.6	7.7	66.7	91.5	51.4	70.0	17.0	
Average		61.1	23.6	7.6	7.7	66.7	91.5	51.4	70.0	17.1	
180		61.0	23.6	7.7	7.7	66.0	90.4	52.0	69.7	17.8	
		61.0	23.6	7.7	7.7	66.0	90.4	52.0	69.7	17.8	
		61.0	23.6	7.8	7.7	66.0	90.4	52.0	69.7	17.8	
		61.0	23.6	7.7	7.7	66.0	90.4	52.0	69.7	17.8	
	61.0	23.6	7.7	7.7	66.0	90.4	52.0	69.7	17.7		
Average	61.0	23.6	7.7	7.7	66.0	90.4	52.0	69.7	17.8		

Table B1 (continued)

NaOH solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)				
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other		
5.5	90	60	61.0	23.3	7.9	7.9	65.1	89.1	53.2	69.7	17.2		
			61.0	23.3	7.9	7.9	65.1	89.1	53.2	69.7	17.2		
			61.0	23.3	7.9	7.9	65.1	89.1	53.2	69.7	17.2		
			61.0	23.3	7.9	7.9	65.1	89.1	53.2	69.7	17.2		
			61.0	23.3	7.9	7.9	65.1	89.1	53.2	69.7	17.3		
		Average	61.0	23.3	7.9	7.9	65.1	89.1	53.2	69.7	17.2		
		120	60.7	23.4	7.9	8.0	63.2	86.1	54.4	70.3	17.8		
			60.7	23.4	7.9	8.0	63.2	86.1	54.4	70.3	17.8		
			60.7	23.4	7.9	8.0	63.2	86.1	54.4	70.3	17.8		
			60.7	23.4	7.9	8.0	63.2	86.1	54.4	70.3	17.7		
			60.7	23.4	7.9	8.0	63.2	86.1	54.4	70.3	17.8		
		Average	60.7	23.4	7.9	8.0	63.2	86.1	54.4	70.3	17.8		
		180	60.8	23.3	7.8	8.1	62.9	85.8	54.8	70.9	17.8		
			60.8	23.3	7.8	8.1	62.9	85.8	54.8	70.9	17.8		
			60.8	23.3	7.8	8.1	62.9	85.8	54.8	70.9	17.8		
			60.8	23.3	7.8	8.1	62.9	85.8	54.8	70.9	17.8		
			60.8	23.3	7.8	8.1	62.9	85.8	54.8	70.9	17.8		
		Average	60.8	23.3	7.8	8.1	62.9	85.8	54.8	70.9	17.8		
		10.5	40	60	66.8	18.2	9.4	5.7	40.2	60.3	77.5	77.6	63.0
					66.8	18.2	9.4	5.7	40.2	60.3	77.5	77.7	63.0
					66.8	18.2	9.4	5.7	40.2	60.3	77.5	77.7	63.0
66.8	18.2				9.4	5.7	40.2	60.3	77.5	77.6	63.0		
66.8	18.2				9.4	5.7	40.2	60.3	77.5	77.6	63.0		
Average	66.8			18.2	9.4	5.7	40.2	60.3	77.5	77.7	63.0		
120	67.4			17.9	9.3	5.4	39.8	60.2	78.1	77.9	64.9		
	67.4			17.9	9.3	5.4	39.8	60.2	78.1	77.9	64.9		
	67.4			17.9	9.3	5.5	39.8	60.2	78.1	77.9	64.9		
	67.4			17.9	9.3	5.5	39.8	60.2	78.1	77.9	64.9		
	67.4			17.9	9.3	5.5	39.8	60.2	78.1	77.9	64.9		
Average	67.4			17.9	9.3	5.5	39.8	60.2	78.1	77.9	64.9		
180	67.7			17.8	9.3	5.3	39.5	60.1	78.4	78.3	66.3		
	67.7			17.8	9.3	5.3	39.5	60.1	78.4	78.3	66.4		
	67.7			17.8	9.3	5.3	39.5	60.1	78.4	78.3	66.4		
	67.7			17.8	9.3	5.3	39.5	60.1	78.4	78.3	66.4		
	67.7			17.8	9.2	5.3	39.5	60.1	78.4	78.3	66.3		
Average	67.7			17.8	9.3	5.3	39.5	60.1	78.4	78.3	66.4		

Table B1 (continued)

NaOH solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
10.5	65		67.5	17.9	9.3	5.3	38.9	58.9	78.5	78.6	66.3
			67.5	17.9	9.3	5.3	38.9	58.9	78.5	78.6	66.3
			67.5	17.9	9.3	5.4	38.9	58.9	78.5	78.6	66.3
			67.5	17.9	9.3	5.4	38.9	58.9	78.5	78.6	66.3
			67.5	17.9	9.3	5.4	38.9	58.9	78.5	78.6	66.2
		Average	67.5	17.9	9.3	5.4	38.9	58.9	78.5	78.6	66.3
		60	66.1	18.0	9.0	6.9	38.7	57.5	78.5	79.4	56.7
			66.1	18.0	9.0	6.9	38.7	57.5	78.5	79.4	56.6
			66.1	18.0	9.0	6.9	38.7	57.5	78.5	79.4	56.6
			66.2	18.0	9.0	6.9	38.7	57.5	78.5	79.4	56.7
			66.1	18.0	9.0	6.9	38.7	57.5	78.5	79.5	56.6
		Average	66.1	18.0	9.0	6.9	38.7	57.5	78.5	79.4	56.6
	120	66.7	17.8	8.9	6.7	38.4	57.5	79.0	79.7	58.6	
		66.7	17.8	8.9	6.7	38.4	57.5	79.0	79.7	58.5	
		66.7	17.8	8.9	6.7	38.4	57.5	79.0	79.8	58.5	
		66.7	17.8	8.9	6.7	38.4	57.5	79.0	79.8	58.4	
		66.7	17.8	8.9	6.7	38.4	57.5	79.0	79.7	58.5	
	Average	66.7	17.8	8.9	6.7	38.4	57.5	79.0	79.8	58.5	
	90	60	67.2	17.5	8.6	6.6	38.0	57.4	79.4	80.6	59.2
			67.2	17.5	8.6	6.6	38.0	57.4	79.5	80.6	59.2
			67.2	17.5	8.6	6.6	38.0	57.4	79.5	80.6	59.1
			67.2	17.5	8.6	6.6	38.0	57.4	79.4	80.6	59.2
			67.2	17.5	8.6	6.6	38.0	57.4	79.4	80.6	59.2
		Average	67.2	17.5	8.6	6.6	38.0	57.4	79.5	80.6	59.2
120		67.5	17.6	8.5	6.4	37.8	57.2	79.5	81.0	60.6	
		67.5	17.6	8.5	6.4	37.8	57.2	79.5	81.0	60.6	
		67.5	17.6	8.5	6.5	37.8	57.2	79.5	81.0	60.5	
		67.5	17.6	8.5	6.5	37.8	57.2	79.5	81.0	60.5	
		67.5	17.6	8.5	6.5	37.8	57.2	79.5	81.0	60.4	
Average		67.5	17.6	8.5	6.5	37.8	57.2	79.5	81.0	60.5	
180	67.5	17.3	8.5	6.7	37.7	57.1	79.9	80.9	59.0		
	67.5	17.3	8.5	6.7	37.7	57.1	79.9	80.9	58.9		
	67.5	17.3	8.5	6.7	37.7	57.1	79.9	81.0	58.9		
	67.5	17.3	8.5	6.7	37.7	57.1	79.9	81.0	58.9		
	67.5	17.3	8.5	6.7	37.7	57.1	79.9	80.9	59.0		
Average	67.5	17.3	8.5	6.7	37.7	57.1	79.9	80.9	58.9		

Table B2 Characterization of NaOH solution pretreated materials with ozonolysis process.

Time of ozone flow (minute)	Composition (wt.%, based on dry matter)				ratio	Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
	Cellulose	Hemi-cellulose	Lignin	Other				Hemi-cellulose	Lignin	Other
0	61.1	23.6	7.6	7.7	0.1	66.7	91.5	51.3	70.0	17.2
	61.1	23.6	7.6	7.7	0.1	66.7	91.5	51.3	70.0	17.12
	61.1	23.6	7.6	7.7	0.1	66.7	91.5	51.4	70.0	17.1
	61.1	23.6	7.6	7.7	0.1	66.7	91.5	51.4	70.0	17.1
	Average	61.1	23.6	7.6	7.7	0.1	66.7	91.5	51.4	70.0
10	66.2	22.0	6.2	5.6	0.1	61.0	90.5	56.7	77.5	44.5
	66.2	22.0	6.2	5.6	0.1	61.0	90.5	56.7	77.5	44.5
	66.2	22.0	6.2	5.6	0.1	61.0	90.5	56.7	77.5	44.5
	66.2	22.0	6.2	5.6	0.1	61.0	90.5	56.7	77.5	44.5
	Average	66.2	22.0	6.2	5.6	0.1	61.0	90.5	56.7	77.5
20	76.2	18.6	1.8	3.4	0.0	51.9	88.7	70.2	90.4	71.7
	76.2	18.6	1.8	3.4	0.0	51.9	88.7	70.2	90.4	71.7
	76.2	18.6	1.8	3.4	0.0	51.9	88.7	70.2	90.4	71.7
	76.2	18.6	1.8	3.4	0.0	51.9	88.7	70.2	90.4	71.7
	Average	76.2	18.6	1.8	3.4	0.0	51.9	88.7	70.2	90.4
30	83.4	13.6	1.0	2.0	0.0	45.1	84.4	80.1	99.3	85.3
	83.4	13.6	1.0	2.0	0.0	45.1	84.4	80.1	99.3	85.3
	83.4	13.6	1.0	2.0	0.0	45.1	84.4	80.1	99.3	85.3
	83.4	13.7	1.0	2.0	0.0	45.1	84.4	80.1	99.3	85.3
	Average	83.4	13.6	1.0	2.0	0.0	45.1	84.4	80.1	99.3

Table B3 Characterization of untreated and pretreated materials with NH₃ solution pretreatment

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				ratio	Solid remaining (%)	Cellulose recovery (%)	Remover (%)				
			Cellulose	Hemi-cellulose	Lignin	other				Hemi-cellulose	Lignin	Other		
0			44.6	32.4	16.9	6.2	0.4							
			44.6	32.4	16.9	6.2	0.4							
			44.6	32.4	16.9	6.2	0.4							
			44.6	32.4	16.9	6.2	0.4							
			44.6	32.4	16.9	6.2	0.4							
			Average	44.6	32.4	16.9	6.2	0.4						
5	40		44.6	32.4	16.9	6.1	0.4	99.4	99.5	0.6	0.6	2.3		
			44.7	32.4	16.9	6.1	0.4	99.4	99.5	0.6	0.6	2.2		
			44.7	32.4	16.9	6.1	0.4	99.4	99.5	0.6	0.6	2.3		
			44.6	32.4	16.9	6.1	0.4	99.4	99.5	0.6	0.6	2.3		
			44.6	32.4	16.9	6.1	0.4	99.4	99.5	0.6	0.6	2.2		
			Average	44.6	32.4	16.9	6.1	0.4	99.4	99.5	0.6	0.6	2.3	
		12			44.8	32.4	16.8	5.9	0.4	99.0	99.4	0.9	1.1	4.9
					44.8	32.4	16.8	5.9	0.4	99.0	99.4	0.9	1.1	4.9
					44.8	32.5	16.8	5.9	0.4	99.0	99.4	0.9	1.1	5.0
					44.8	32.5	16.8	5.9	0.4	99.0	99.4	0.9	1.1	5.0
					44.8	32.4	16.8	5.9	0.4	99.0	99.4	0.9	1.1	4.9
					Average	44.8	32.4	16.8	5.9	0.4	99.0	99.4	0.9	1.1
	36			44.9	32.4	16.7	6.1	0.4	97.7	98.4	2.5	3.2	4.1	
				44.9	32.4	16.7	6.1	0.4	97.7	98.4	2.5	3.2	4.0	
				44.9	32.4	16.7	6.1	0.4	97.7	98.4	2.5	3.2	4.0	
				44.9	32.4	16.7	6.1	0.4	97.7	98.4	2.5	3.2	4.0	
				44.9	32.4	16.7	6.1	0.4	97.7	98.4	2.5	3.2	4.1	
				Average	44.9	32.4	16.7	6.1	0.4	97.7	98.4	2.5	3.2	4.1
		65			45.0	32.4	16.5	6.1	0.4	97.4	98.3	2.8	4.4	3.9
					45.0	32.4	16.5	6.1	0.4	97.4	98.3	2.8	4.4	3.9
					45.0	32.4	16.5	6.1	0.4	97.4	98.3	2.8	4.4	3.9
					45.0	32.3	16.5	6.1	0.4	97.4	98.3	2.8	4.4	3.8
					45.0	32.4	16.5	6.1	0.4	97.4	98.4	2.8	4.4	3.9
					Average	45.0	32.4	16.5	6.1	0.4	97.4	98.3	2.8	4.4
24			45.6	32.4	16.4	5.6	0.4	97.9	100.1	2.1	4.7	11.4		
			45.6	32.4	16.4	5.6	0.4	97.9	100.1	2.1	4.7	11.4		
			45.6	32.4	16.4	5.6	0.4	97.9	100.1	2.1	4.7	11.5		
			45.6	32.4	16.4	5.6	0.4	97.9	100.1	2.1	4.7	11.5		
			45.6	32.4	16.4	5.6	0.4	97.9	100.1	2.1	4.7	11.3		
			Average	45.6	32.4	16.4	5.6	0.4	97.9	100.1	2.1	4.7	11.4	
	36			45.7	32.1	16.1	6.1	0.4	96.2	98.6	4.8	8.0	4.7	
				45.7	32.1	16.1	6.1	0.4	96.2	98.6	4.8	8.0	4.7	
				45.7	32.1	16.1	6.1	0.4	96.2	98.6	4.8	8.0	4.8	
				45.7	32.1	16.1	6.1	0.4	96.2	98.6	4.8	8.0	4.6	
				45.7	32.1	16.1	6.1	0.4	96.2	98.6	4.8	8.0	4.7	
				Average	45.7	32.1	16.1	6.1	0.4	96.2	98.6	4.8	8.0	4.7

Table B3 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)			
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other	
5	90	12	45.8	32.0	15.9	6.2	0.4	94.9	97.6	6.3	10.4	
			45.9	32.0	15.9	6.2	0.4	94.9	97.6	6.3	10.4	
			45.9	32.0	15.9	6.2	0.4	94.9	97.6	6.3	10.4	
			45.9	32.0	15.9	6.2	0.4	94.9	97.6	6.3	10.4	
			45.9	32.0	15.9	6.2	0.4	94.9	97.6	6.3	10.4	
		Average	45.9	32.0	15.9	6.2	0.4	94.9	97.6	6.3	10.4	
		24	46.0	31.9	15.8	6.3	0.3	93.6	96.6	7.9	12.4	
			46.0	31.9	15.8	6.3	0.3	93.6	96.6	7.9	12.4	
			46.0	31.9	15.8	6.3	0.3	93.6	96.6	7.9	12.4	
			46.0	31.9	15.8	6.3	0.3	93.6	96.6	7.9	12.4	
			46.0	31.9	15.8	6.3	0.3	93.6	96.6	7.9	12.4	
		Average	46.0	31.9	15.8	6.3	0.3	93.6	96.6	7.9	12.4	
	36	46.1	31.9	15.6	6.5	0.3	92.4	95.6	9.2	14.8		
		46.1	31.9	15.6	6.5	0.3	92.4	95.6	9.2	14.8		
		46.1	31.9	15.6	6.5	0.3	92.4	95.6	9.2	14.8		
		46.1	31.9	15.6	6.5	0.3	92.4	95.6	9.2	14.8		
		46.1	31.9	15.6	6.5	0.3	92.4	95.6	9.2	14.8		
	Average	46.1	31.9	15.6	6.5	0.3	92.4	95.6	9.2	14.8		
	10	40	Average	46.4	31.8	15.5	6.3	0.3	91.4	95.1	10.3	16.0
				46.4	31.8	15.5	6.3	0.3	91.4	95.1	10.3	16.0
				46.4	31.8	15.5	6.3	0.3	91.4	95.1	10.3	16.0
				46.4	31.8	15.5	6.3	0.3	91.4	95.1	10.3	16.0
				46.4	31.8	15.5	6.3	0.3	91.4	95.1	10.3	16.0
			Average	46.4	31.8	15.5	6.3	0.3	91.4	95.1	10.3	16.0
Average			46.5	31.6	15.3	6.6	0.3	90.3	94.1	11.9	18.3	
			46.5	31.6	15.3	6.6	0.3	90.3	94.1	11.9	18.3	
			46.5	31.6	15.3	6.6	0.3	90.3	94.1	11.9	18.3	
			46.5	31.6	15.3	6.6	0.3	90.3	94.1	11.9	18.3	
			46.5	31.6	15.3	6.6	0.3	90.3	94.1	11.9	18.3	
Average			46.5	31.6	15.3	6.6	0.3	90.3	94.1	11.9	18.3	
Average		46.6	31.5	15.2	6.6	0.3	88.8	92.9	13.6	19.9		
		46.6	31.5	15.2	6.6	0.3	88.8	92.9	13.6	19.9		
		46.6	31.5	15.2	6.6	0.3	88.8	92.9	13.6	19.9		
		46.6	31.5	15.2	6.6	0.3	88.8	92.9	13.6	19.9		
		46.6	31.5	15.2	6.6	0.3	88.8	92.9	13.6	19.9		
Average		46.6	31.5	15.2	6.6	0.3	88.8	92.9	13.6	19.9		
65		12	46.9	31.5	14.9	6.7	0.3	88.1	92.6	14.4	21.9	
			46.9	31.5	14.9	6.7	0.3	88.1	92.6	14.4	21.9	
			46.9	31.5	15.0	6.7	0.3	88.1	92.6	14.4	21.9	
			46.9	31.5	14.9	6.7	0.3	88.1	92.6	14.4	21.9	
			46.9	31.5	14.9	6.7	0.3	88.1	92.6	14.4	21.9	
		Average	46.9	31.5	14.9	6.7	0.3	88.1	92.6	14.4	21.9	

Table B3 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
10	65	24	47.1	31.4	14.8	6.7	0.3	87.7	92.6	15.1	23.1
			47.1	31.4	14.8	6.7	0.3	87.7	92.6	15.1	23.1
			47.1	31.4	14.8	6.7	0.3	87.7	92.6	15.1	23.1
			47.1	31.4	14.8	6.7	0.3	87.7	92.6	15.1	23.1
			47.1	31.4	14.8	6.7	0.3	87.7	92.6	15.1	23.1
		Average	47.1	31.4	14.8	6.7	0.3	87.7	92.6	15.1	23.1
		36	47.2	31.2	14.6	6.9	0.3	87.2	92.3	16.0	24.4
			47.2	31.2	14.6	6.9	0.3	87.2	92.3	16.0	24.4
			47.2	31.2	14.6	6.9	0.3	87.2	92.3	16.0	24.3
			47.2	31.2	14.6	6.9	0.3	87.2	92.3	16.0	24.4
			47.2	31.2	14.6	6.9	0.3	87.2	92.3	16.1	24.4
		Average	47.2	31.2	14.6	6.9	0.3	87.2	92.3	16.0	24.4
	90	12	47.4	31.1	14.6	7.0	0.3	86.6	92.0	16.8	25.2
			47.4	31.1	14.6	7.0	0.3	86.6	92.0	16.8	25.2
			47.4	31.1	14.6	7.0	0.3	86.6	92.0	16.8	25.2
			47.4	31.1	14.6	7.0	0.3	86.6	92.0	16.8	25.2
			47.4	31.1	14.6	7.0	0.3	86.6	92.0	16.8	25.2
		Average	47.4	31.1	14.6	7.0	0.3	86.6	92.0	16.8	25.2
		24	47.6	31.0	14.5	7.0	0.3	86.2	92.0	17.6	25.8
			47.6	31.0	14.5	7.0	0.3	86.2	92.0	17.6	25.8
			47.6	31.0	14.5	7.0	0.3	86.2	92.0	17.6	25.8
			47.6	31.0	14.5	7.0	0.3	86.2	92.0	17.6	25.8
			47.6	31.0	14.5	7.0	0.3	86.2	92.0	17.6	25.8
		Average	47.6	31.0	14.5	7.0	0.3	86.2	92.0	17.6	25.8
36	47.8	30.9	14.4	6.9	0.3	85.1	91.2	18.8	27.2		
	47.8	30.9	14.4	6.9	0.3	85.1	91.2	18.8	27.2		
	47.8	30.9	14.4	6.9	0.3	85.1	91.2	18.8	27.2		
	47.8	30.9	14.4	6.9	0.3	85.1	91.2	18.8	27.2		
	47.8	30.9	14.4	6.9	0.3	85.1	91.2	18.8	27.2		
Average	47.8	30.9	14.4	6.9	0.3	85.1	91.2	18.8	27.2		
20	40	12	48.0	30.7	14.3	7.0	0.3	84.3	90.6	20.2	28.4
			48.0	30.7	14.3	7.0	0.3	84.3	90.6	20.2	28.4
			48.0	30.7	14.3	7.0	0.3	84.3	90.6	20.2	28.5
			48.0	30.7	14.3	7.0	0.3	84.3	90.6	20.2	28.5
			48.0	30.7	14.3	7.0	0.3	84.3	90.6	20.2	28.4
	Average	48.0	30.7	14.3	7.0	0.3	84.3	90.6	20.2	28.4	
	24	48.2	30.7	14.1	7.0	0.3	83.4	90.2	21.0	30.2	
		48.2	30.7	14.1	7.0	0.3	83.4	90.2	21.0	30.2	
		48.2	30.7	14.1	7.0	0.3	83.4	90.2	21.0	30.2	
		48.2	30.7	14.1	7.0	0.3	83.4	90.2	21.0	30.2	
		48.2	30.7	14.1	7.0	0.3	83.4	90.2	21.0	30.2	
	Average	48.2	30.7	14.1	7.0	0.3	83.4	90.2	21.0	30.2	

Table B3 (continued)

NH ₃ solution (%)	temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)				
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other		
20	40		48.4	30.6	13.8	7.2	0.3	82.8	89.9	21.8	32.3		
			48.4	30.6	13.8	7.2	0.3	82.8	89.9	21.8	32.3		
			48.4	30.6	13.8	7.2	0.3	82.8	90.0	21.8	32.3		
			48.4	30.6	13.8	7.2	0.3	82.8	90.0	21.8	32.3		
			48.4	30.6	13.8	7.2	0.3	82.8	89.9	21.8	32.3		
		36	Average	48.4	30.6	13.8	7.2	0.3	82.8	89.9	21.8	32.3	
	65	12		48.6	30.5	13.7	7.2	0.3	82.1	89.5	22.7	33.5	
				48.6	30.5	13.7	7.2	0.3	82.1	89.5	22.7	33.5	
				48.6	30.5	13.7	7.2	0.3	82.1	89.5	22.7	33.5	
				48.6	30.5	13.7	7.2	0.3	82.1	89.5	22.7	33.5	
				48.6	30.5	13.7	7.2	0.3	82.1	89.5	22.7	33.5	
			12	Average	48.6	30.5	13.7	7.2	0.3	82.1	89.5	22.7	33.5
		24			48.8	30.3	13.6	7.4	0.3	81.9	89.5	23.6	34.1
					48.8	30.3	13.6	7.4	0.3	81.9	89.5	23.6	34.1
					48.8	30.3	13.6	7.4	0.3	81.9	89.5	23.6	34.1
					48.8	30.3	13.6	7.4	0.3	81.9	89.5	23.6	34.1
					48.8	30.3	13.6	7.4	0.3	81.9	89.5	23.6	34.1
			24	Average	48.8	30.3	13.6	7.4	0.3	81.9	89.5	23.6	34.1
	36			49.1	30.2	13.6	7.2	0.3	81.3	89.5	24.4	34.7	
				49.1	30.2	13.5	7.2	0.3	81.3	89.5	24.4	34.7	
				49.1	30.2	13.6	7.2	0.3	81.3	89.5	24.4	34.7	
				49.1	30.2	13.6	7.2	0.3	81.3	89.5	24.4	34.7	
				49.1	30.2	13.6	7.2	0.3	81.3	89.5	24.4	34.7	
		36	Average	49.1	30.2	13.6	7.2	0.3	81.3	89.5	24.4	34.7	
90	12		49.3	30.0	13.3	7.4	0.3	81.1	89.6	25.0	36.1		
			49.3	30.0	13.3	7.4	0.3	81.1	89.6	25.0	36.1		
			49.3	30.0	13.3	7.4	0.3	81.1	89.6	25.0	36.1		
			49.3	30.0	13.3	7.4	0.3	81.1	89.6	25.0	36.1		
			49.3	30.0	13.3	7.4	0.3	81.1	89.6	25.0	36.1		
		12	Average	49.3	30.0	13.3	7.4	0.3	81.1	89.6	25.0	36.1	
	24			49.6	30.0	13.1	7.3	0.3	80.5	89.7	25.5	37.3	
				49.6	30.0	13.1	7.3	0.3	80.5	89.7	25.5	37.3	
				49.6	30.0	13.1	7.3	0.3	80.5	89.7	25.5	37.4	
				49.6	30.0	13.1	7.3	0.3	80.5	89.7	25.5	37.4	
				49.6	30.0	13.1	7.3	0.3	80.5	89.7	25.5	37.3	
		24	Average	49.6	30.0	13.1	7.3	0.3	80.5	89.7	25.5	37.3	
36			49.8	29.7	13.0	7.5	0.3	80.1	89.4	26.5	38.3		
			49.8	29.7	13.0	7.5	0.3	80.1	89.4	26.5	38.3		
			49.8	29.7	13.0	7.5	0.3	80.1	89.4	26.5	38.3		
			49.8	29.7	13.0	7.5	0.3	80.1	89.4	26.5	38.3		
			49.8	29.7	13.0	7.5	0.3	80.1	89.4	26.5	38.3		
	36	Average	49.8	29.7	13.0	7.5	0.3	80.1	89.4	26.5	38.3		

Table B4 Characterization of NH₃ solution pretreated materials with ozonolysis process

Time of ozone flow (minute)	Composition (wt.%, based on dry matter)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
	Cellulose	Hemi-cellulose	Lignin	Other			Hemi-cellulose	Lignin	Other
0	49.6	30.0	13.1	7.3	80.5	89.7	25.5	37.3	5.5
	49.6	30.0	13.1	7.3	80.5	89.7	25.5	37.3	5.5
	49.6	30.0	13.1	7.3	80.5	89.7	25.5	37.4	5.5
	49.6	30.0	13.1	7.3	80.5	89.7	25.5	37.4	5.3
	49.6	30.0	13.1	7.3	80.5	89.7	25.5	37.3	5.5
Average	49.6	30.0	13.1	7.3	80.5	89.7	25.5	37.3	5.5
10	54.1	28.8	10.8	6.3	73.0	88.6	35.1	53.1	26.2
	54.1	28.8	10.8	6.3	73.0	88.6	35.1	53.1	26.2
	54.1	28.8	10.8	6.3	73.0	88.6	35.1	53.1	26.2
	54.1	28.8	10.8	6.2	73.0	88.6	35.1	53.1	26.2
	54.1	28.8	10.8	6.3	73.0	88.6	35.1	53.1	26.2
Average	54.1	28.8	10.8	6.3	73.0	88.6	35.1	53.1	26.2
20	66.5	25.9	3.6	3.1	64.6	85.1	55.8	89.6	74.4
	66.5	25.9	3.6	3.1	64.6	85.1	55.8	89.6	74.4
	66.5	25.9	3.6	3.1	64.6	85.1	55.8	89.6	74.4
	66.5	25.9	3.6	3.1	64.6	85.1	55.8	89.6	74.4
	66.5	25.9	3.6	3.1	64.6	85.1	55.8	89.6	74.4
Average	66.5	25.9	3.6	3.1	64.6	85.1	55.8	89.6	74.4
30	73.4	20.3	2.1	4.2	50.1	82.5	68.7	93.7	65.9
	73.4	20.3	2.1	4.2	50.1	82.5	68.7	93.7	65.9
	73.4	20.3	2.1	4.2	50.1	82.5	68.7	93.7	65.9
	73.4	20.3	2.1	4.2	50.1	82.5	68.7	93.7	65.9
	73.4	20.3	2.1	4.2	50.1	82.5	68.7	93.7	65.9
Average	73.4	20.3	2.1	4.2	50.1	82.5	68.7	93.7	65.9

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Table B5 Characterization of untreated and pretreated materials with Ca(OH)₂ solution pretreatment

Ca(OH) ₂ solution (%)	Temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
0			44.6	32.4	16.9	6.2					
			44.6	32.4	16.9	6.2					
			44.6	32.4	16.9	6.2					
			44.6	32.4	16.9	6.2					
			44.6	32.4	16.9	6.2					
			Average	44.6	32.4	16.9	6.2				
20	40	12	44.7	32.4	16.9	6.1	99.5	99.7	0.5	0.5	2.5
			44.7	32.4	16.9	6.1	99.5	99.7	0.5	0.6	2.5
			44.7	32.4	16.9	6.1	99.5	99.7	0.5	0.5	2.5
			44.7	32.4	16.9	6.1	99.5	99.7	0.5	0.5	2.6
			44.7	32.4	16.9	6.1	99.5	99.7	0.5	0.5	2.5
			Average	44.7	32.4	16.9	6.1	99.5	99.7	0.5	0.5
		24	44.7	32.4	16.8	6.1	98.5	98.8	1.5	1.7	2.5
			44.7	32.4	16.8	6.1	98.5	98.8	1.5	1.7	2.4
			44.7	32.4	16.8	6.1	98.5	98.8	1.5	1.8	2.4
			44.7	32.4	16.8	6.1	98.5	98.8	1.5	1.8	2.4
			44.7	32.4	16.8	6.1	98.5	98.8	1.5	1.8	2.3
			Average	44.7	32.4	16.8	6.1	98.5	98.8	1.5	1.8
	36	44.9	32.5	16.7	6.0	98.2	98.9	1.5	2.9	4.9	
		44.9	32.5	16.7	6.0	98.2	98.9	1.5	2.9	4.8	
		44.9	32.5	16.7	6.0	98.2	98.9	1.5	2.9	4.9	
		44.9	32.5	16.7	6.0	98.2	98.9	1.5	2.9	5.1	
		44.9	32.5	16.7	6.0	98.2	98.9	1.5	2.9	5.1	
		Average	44.9	32.5	16.7	6.0	98.2	98.9	1.5	2.9	4.9
	65	12	44.9	32.4	16.5	6.2	97.6	98.4	2.3	4.7	2.5
			44.9	32.4	16.5	6.2	97.6	98.4	2.3	4.7	2.5
			44.9	32.4	16.5	6.2	97.6	98.4	2.3	4.7	2.5
			44.9	32.4	16.5	6.2	97.6	98.4	2.3	4.7	2.5
			44.9	32.5	16.5	6.2	97.6	98.4	2.3	4.7	2.5
			Average	44.9	32.4	16.5	6.2	97.6	98.4	2.3	4.7
24		45.0	32.4	16.3	6.3	97.2	98.2	2.8	6.2	0.8	
		45.0	32.4	16.3	6.3	97.2	98.2	2.8	6.2	0.7	
		45.0	32.4	16.3	6.3	97.2	98.2	2.8	6.2	0.7	
		45.0	32.4	16.3	6.3	97.2	98.2	2.8	6.2	0.6	
		45.0	32.4	16.3	6.3	97.2	98.2	2.8	6.2	0.6	
		Average	45.0	32.4	16.3	6.3	97.2	98.2	2.8	6.2	0.7
36	45.2	32.4	16.2	6.3	97.0	98.3	3.1	7.1	1.5		
	45.2	32.4	16.2	6.3	97.0	98.3	3.1	7.1	1.5		
	45.2	32.4	16.2	6.3	97.0	98.3	3.1	7.1	1.5		
	45.2	32.4	16.2	6.3	97.0	98.3	3.1	7.1	1.5		
	45.2	32.4	16.2	6.3	97.0	98.3	3.1	7.1	1.5		
	Average	45.2	32.4	16.2	6.3	97.0	98.3	3.1	7.1	1.5	

Table B5 (continued)

Ca(OH) ₂ solution (%)	Temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)			
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other	
20	90		45.3	32.4	15.9	6.3	96.4	98.1	3.5	8.9	1.5	
			45.3	32.4	15.9	6.3	96.4	98.1	3.5	8.9	1.5	
			45.3	32.4	15.9	6.3	96.4	98.1	3.5	8.9	1.5	
			45.3	32.4	15.9	6.3	96.4	98.1	3.5	8.9	1.5	
		12	45.3	32.4	15.9	6.3	96.4	98.1	3.6	8.9	1.4	
		Average	45.3	32.4	15.9	6.3	96.4	98.1	3.5	8.9	1.5	
			45.5	32.5	15.7	6.3	95.8	97.9	4.0	10.7	2.4	
			45.5	32.5	15.7	6.3	95.8	97.9	4.0	10.7	2.4	
			45.5	32.5	15.7	6.3	95.8	97.9	4.0	10.7	2.3	
			45.5	32.5	15.7	6.3	95.8	97.9	4.0	10.7	2.3	
	24	45.5	32.5	15.7	6.3	95.8	97.9	4.0	10.7	2.2		
	Average	45.5	32.5	15.7	6.3	95.8	97.9	4.0	10.7	2.3		
		45.7	32.3	15.6	6.4	95.1	97.5	5.1	12.1	1.6		
		45.7	32.3	15.6	6.4	95.1	97.5	5.1	12.1	1.6		
		45.7	32.3	15.6	6.4	95.1	97.5	5.1	12.1	1.6		
		45.7	32.3	15.6	6.4	95.1	97.5	5.1	12.1	1.6		
	36	45.7	32.3	15.6	6.4	95.1	97.5	5.1	12.1	1.6		
	Average	45.7	32.3	15.6	6.4	95.1	97.5	5.1	12.1	1.6		
	60	40		45.8	32.3	15.5	6.4	94.5	97.1	5.7	13.3	1.9
				45.8	32.3	15.5	6.4	94.5	97.1	5.7	13.3	1.9
			45.8	32.3	15.5	6.4	94.5	97.1	5.7	13.3	1.8	
			45.8	32.3	15.5	6.4	94.5	97.1	5.7	13.3	1.7	
12			45.8	32.3	15.5	6.4	94.5	97.1	5.7	13.3	1.7	
Average			45.8	32.3	15.5	6.4	94.5	97.1	5.7	13.3	1.8	
			45.9	32.3	15.2	6.6	93.8	96.6	6.5	15.7	0.1	
			45.9	32.3	15.2	6.6	93.8	96.6	6.5	15.7	0.1	
			45.9	32.3	15.2	6.6	93.8	96.6	6.5	15.7	0.1	
24			45.9	32.3	15.2	6.6	93.8	96.6	6.5	15.7	0.0	
Average		45.9	32.3	15.2	6.6	93.8	96.6	6.5	15.7	0.1		
		46.1	32.3	15.2	6.5	93.2	96.3	7.2	16.0	1.8		
		46.1	32.3	15.2	6.5	93.2	96.3	7.3	16.0	1.7		
		46.1	32.3	15.2	6.5	93.2	96.3	7.3	16.0	1.7		
		46.1	32.3	15.2	6.5	93.2	96.3	7.3	16.0	1.7		
36		46.0	32.3	15.2	6.5	93.2	96.3	7.3	16.1	1.5		
Average		46.1	32.3	15.2	6.5	93.2	96.3	7.3	16.0	1.7		

Table B5 (continued)

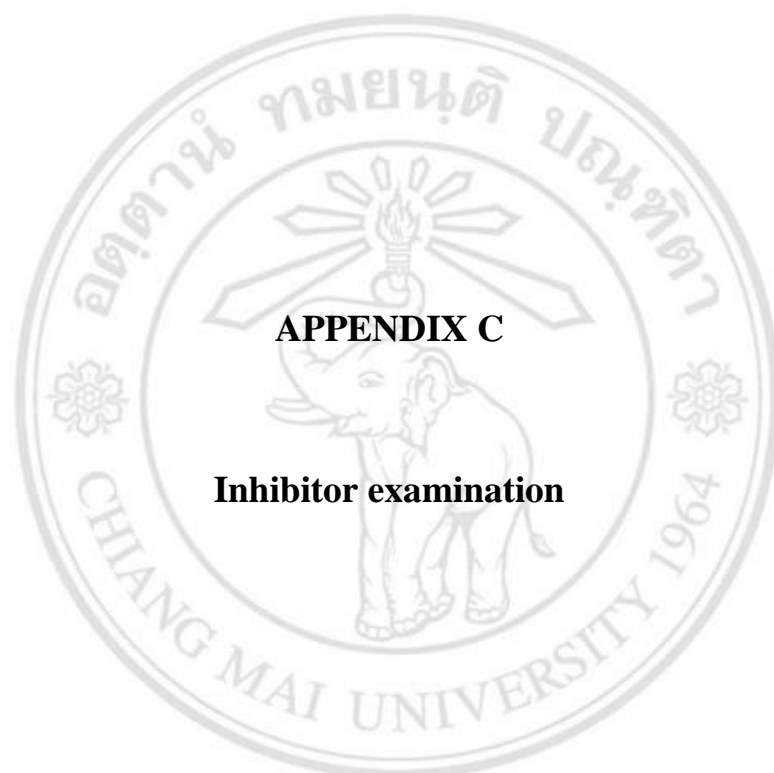
Ca(OH) ₂ solution (%)	Temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)			
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other	
60	65		46.3	32.0	15.0	6.7	92.0	95.6	9.1	18.1	0.7	
			46.3	32.0	15.0	6.7	92.0	95.6	9.1	18.1	0.7	
			46.3	32.0	15.0	6.7	92.0	95.6	9.1	18.1	0.7	
			46.3	32.0	15.0	6.7	92.0	95.6	9.1	18.1	0.7	
		12	46.3	32.0	15.0	6.7	92.0	95.6	9.1	18.1	0.7	
		Average	46.3	32.0	15.0	6.7	92.0	95.6	9.1	18.1	0.7	
			46.5	31.8	15.0	6.8	90.8	94.6	10.9	19.3	0.9	
			46.5	31.8	15.0	6.8	90.8	94.6	10.9	19.3	0.8	
			46.5	31.8	15.0	6.8	90.8	94.6	10.9	19.3	0.8	
			46.5	31.8	15.2	6.6	90.8	94.6	11.0	18.4	3.2	
		24	46.5	31.8	15.2	6.6	90.8	94.6	11.0	18.4	3.1	
		Average	46.5	31.8	15.1	6.7	90.8	94.6	10.9	18.9	1.8	
		46.1	32.4	14.8	6.8	90.9	94.0	9.1	20.5	0.6		
		46.1	32.4	14.8	6.8	90.9	94.1	9.1	20.5	0.7		
		46.1	32.4	14.8	6.7	90.9	94.1	9.1	20.4	0.8		
		46.1	32.4	14.8	6.8	90.9	94.1	9.1	20.4	0.7		
	36	46.1	32.4	14.8	6.8	90.9	94.1	9.1	20.4	0.7		
	Average	46.1	32.4	14.8	6.8	90.9	94.1	9.1	20.4	0.7		
		90		46.8	31.5	14.8	6.9	89.5	93.9	13.1	21.4	0.0
			46.8	31.5	14.8	6.9	89.5	93.9	13.1	21.4	0.0	
			46.8	31.5	14.8	6.9	89.5	93.9	13.1	21.4	0.0	
			46.8	31.5	14.8	6.9	89.4	93.9	13.1	21.4	0.0	
	12		46.8	31.5	14.8	6.9	89.5	93.9	13.1	21.4	0.0	
	Average		46.8	31.5	14.8	6.9	89.5	93.9	13.1	21.4	0.0	
	47.2		31.4	14.6	6.8	89.3	94.5	13.4	22.6	1.3		
	47.2		31.4	14.6	6.8	89.3	94.5	13.4	22.6	1.3		
	47.2		31.4	14.6	6.8	89.3	94.5	13.4	22.5	1.4		
	47.2		31.4	14.6	6.8	89.3	94.5	13.4	22.6	1.3		
24	47.2		31.4	14.6	6.8	89.3	94.5	13.4	22.6	1.3		
Average	47.2		31.4	14.6	6.8	89.3	94.5	13.4	22.6	1.3		
	47.3	31.2	14.5	7.0	88.7	94.2	14.5	23.7	0.0			
	47.3	31.2	14.5	7.0	88.7	94.2	14.5	23.7	0.0			
	47.3	31.2	14.5	7.0	88.7	94.2	14.5	23.7	0.0			
	47.3	31.2	14.5	7.0	88.7	94.2	14.5	23.7	0.0			
36	47.3	31.2	14.5	7.0	88.7	94.2	14.5	23.7	0.0			
Average	47.3	31.2	14.5	7.0	88.7	94.2	14.5	23.7	0.0			

Table B5 (continued)

Ca(OH) ₂ solution (%)	Temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)			
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other	
100	40		47.5	31.2	14.3	7.0	88.3	94.2	15.0	25.2	0.7	
			47.5	31.2	14.3	7.0	88.3	94.2	15.0	25.2	0.7	
			47.5	31.2	14.3	7.0	88.3	94.2	15.0	25.2	0.7	
			47.5	31.2	14.3	7.0	88.3	94.2	15.0	25.2	0.7	
		12	47.5	31.2	14.3	7.0	88.3	94.2	15.0	25.2	0.7	
		Average	47.5	31.2	14.3	7.0	88.3	94.2	15.0	25.2	0.7	
			47.6	31.2	14.2	7.1	87.3	93.3	16.1	26.7	0.2	
			47.6	31.2	14.2	7.1	87.3	93.3	16.1	26.7	0.3	
			47.6	31.2	14.2	7.1	87.3	93.3	16.0	26.7	0.1	
		24	47.6	31.2	14.2	7.1	87.3	93.3	16.0	26.7	0.2	
		Average	47.6	31.2	14.2	7.1	87.3	93.3	16.1	26.7	0.2	
			47.7	31.1	14.1	7.1	86.6	92.6	17.0	27.6	0.0	
		47.7	31.1	14.1	7.1	86.6	92.6	17.0	27.5	0.0		
		47.7	31.1	14.1	7.1	86.6	92.6	17.0	27.5	0.0		
		47.7	31.1	14.1	7.1	86.6	92.6	17.0	27.6	0.1		
	36	47.7	31.1	14.1	7.1	86.6	92.6	17.0	27.6	0.1		
	Average	47.7	31.1	14.1	7.1	86.6	92.6	17.0	27.6	0.0		
		65		47.8	31.0	14.1	7.2	85.7	91.9	18.1	28.4	0.7
			47.8	31.0	14.1	7.2	85.7	91.9	18.1	28.4	0.7	
			47.8	31.0	14.1	7.2	85.7	91.9	18.1	28.4	0.8	
			47.8	31.0	14.1	7.2	85.7	91.9	18.1	28.4	0.7	
	12		47.8	31.0	14.1	7.2	85.7	91.9	18.1	28.4	0.6	
	Average		47.8	31.0	14.1	7.2	85.7	91.9	18.1	28.4	0.7	
			48.0	30.8	14.0	7.2	85.2	91.8	19.1	29.0	0.8	
	48.0		30.8	14.0	7.2	85.2	91.8	19.1	29.0	0.7		
	48.0		30.8	14.0	7.2	85.2	91.8	19.1	29.0	0.8		
	48.0		30.8	14.0	7.2	85.2	91.8	19.1	29.0	0.7		
24	48.0		30.8	14.0	7.2	85.2	91.8	19.1	29.0	0.7		
Average	48.0		30.8	14.0	7.2	85.2	91.8	19.1	29.0	0.7		
	48.1	30.6	14.0	7.2	84.9	91.7	19.7	29.3	0.9			
	48.1	30.6	14.0	7.2	84.9	91.7	19.7	29.3	0.9			
	48.1	30.6	14.0	7.2	84.9	91.7	19.7	29.3	0.9			
	48.1	30.6	14.0	7.2	84.9	91.7	19.8	29.3	0.8			
36	48.1	30.6	14.0	7.2	84.9	91.7	19.7	29.3	0.8			
Average	48.1	30.6	14.0	7.2	84.9	91.7	19.7	29.3	0.9			

Table B5 (continued)

Ca(OH) ₂ solution (%)	Temp	Time (minute)	Composition (wt.%, based on dry matter after pretreatment)				Solid remaining (%)	Cellulose recovery (%)	Remover (%)		
			Cellulose	Hemi-cellulose	Lignin	other			Hemi-cellulose	Lignin	Other
100	90	12	48.2	30.6	14.0	7.3	84.6	91.4	20.2	29.9	0.0
			48.2	30.6	14.0	7.3	84.6	91.4	20.2	29.9	0.0
			48.2	30.6	14.0	7.3	84.6	91.4	20.2	29.9	0.0
			48.2	30.6	14.0	7.3	84.6	91.4	20.2	29.9	0.0
			48.2	30.6	14.0	7.3	84.6	91.4	20.2	29.9	0.0
		Average	48.2	30.6	14.0	7.3	84.6	91.4	20.2	29.9	0.0
		24	48.3	30.5	13.9	7.3	84.3	91.4	20.7	30.3	0.8
			48.3	30.5	13.9	7.3	84.3	91.4	20.7	30.3	0.7
			48.3	30.5	13.9	7.3	84.3	91.4	20.7	30.3	0.7
			48.3	30.5	13.9	7.3	84.3	91.4	20.7	30.3	0.7
			48.3	30.5	13.9	7.3	84.3	91.4	20.7	30.3	0.7
			Average	48.3	30.5	13.9	7.3	84.3	91.4	20.7	30.3
	36		48.3	30.5	13.9	7.3	83.9	91.0	21.1	30.8	1.0
		48.3	30.5	13.9	7.3	83.9	91.0	21.1	30.8	1.0	
		48.3	30.5	13.9	7.3	83.9	91.0	21.1	30.8	0.9	
		48.3	30.5	13.9	7.3	83.9	91.0	21.1	30.8	0.9	
		48.3	30.5	13.9	7.3	83.9	91.0	21.1	30.8	0.9	
		Average	48.3	30.5	13.9	7.3	83.9	91.0	21.1	30.8	0.9



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TEST REPORT

TR No. : 59/0622

Sample Code : STSC- CMU59/279(1)

Name of Customer / Organization : Wg Cdr. Jurarut Minmunin

Address : Department of Mechanical Engineering , Chiang Mai University.

Received Date : April 19, 2016

Testing Period : April 19-27 , 2016

Test Report Issued Date : April 29 , 2016

Sample Name : Sample A

The Results of Analysis

No.	Tested Items	Tested Result	Unit	LOQ	LOD	Method
1	Acetaldehyde	ND	mg/L	-	0.5	HS-GC-FID
2	Total phenolic	2.96 ± 0.14	mg/L	-	-	Spectrophotometer

Note : (a) ND = Not Detected (b) LOQ = Limit of Quantitation (c) LOD =Limit of Detection

The result is valid exclusively for the tested sample as mentioned in this report .Dissemination or alteration of any part of this test report is prohibited unless written permission is first obtained from the Director of STSC-CMU.

(Asst. Prof. Dr. Sunanta Wangkarn)
Deputy Director of STSC-CMU

(Asst. Prof. Dr. Sakunee Bovonsombut)
Director of STSC-CMU

"End of report"

Figure C 1 Test Report for $\text{Ca}(\text{OH})_2$ and Ozone pretreatment of Bana grass.



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TEST REPORT

TR No. : 59/0623

Sample Code : STSC- CMU59/279(2)

Name of Customer / Organization : Wg Cdr. Jurarut Minmunin

Address : Department of Mechanical Engineering , Chiang Mai University.

Received Date : April 19, 2016

Testing Period : April 19-27 , 2016

Test Report Issued Date : April 29 , 2016


Sample Name : Sample B

The Results of Analysis

No.	Tested Items	Tested Result	Unit	LOQ	LOD	Method
1	Acetaldehyde	ND	mg/L	-	0.5	HS-GC-FID
2	Total phenolic	3.06 ± 0.03	mg/L	-	-	Spectrophotometer

Note : (a) ND = Not Detected (b) LOQ = Limit of Quantitation (c) LOD =Limit of Detection

The result is valid exclusively for the tested sample as mentioned in this report .Dissemination or alteration of any part of this test report is prohibited unless written permission is first obtained from the Director of STSC-CMU.


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(Asst. Prof. Dr. Sunanta Wangkarn)

Deputy Director of STSC-CMU


.....

(Asst. Prof. Dr. Sakunee Bovonsombut)

Director of STSC-CMU

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Figure C 2 Test Report for Ca(OH)₂ and Ozone pretreatment of Corn stover.



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TEST REPORT

TR No. : 59/0624

Sample Code : STSC-CMU59/279(3)

Name of Customer / Organization : Wg Cdr. Jurarut Minmunin

Address : Department of Mechanical Engineering , Chiang Mai University.

Received Date : April 19, 2016

Testing Period : April 19-27 , 2016

Test Report Issued Date : April 29 , 2016

Sample Name : Sample C

The Results of Analysis

No.	Tested Items	Tested Result	Unit	LOQ	LOD	Method
1	Acetaldehyde	ND	mg/L	-	0.5	HS-GC-FID
2	Total phenolic	8.72 ± 0.26	mg/L	-	-	Spectrophotometer

Note : (a) ND = Not Detected (b) LOQ = Limit of Quantitation (c) LOD =Limit of Detection

The result is valid exclusively for the tested sample as mentioned in this report .Dissemination or alteration of any part of this test report is prohibited unless written permission is first obtained from the Director of STSC-CMU.

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Director of STSC-CMU

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Figure C 3 Test Report for NH₃ and Ozone pretreatment of Bana grass.



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TEST REPORT

TR No. : 59/0625

Sample Code : STSC- CMU59/279(4)

Name of Customer / Organization : Wg Cdr. Jurarut Minmunin

Address : Department of Mechanical Engineering , Chiang Mai University.

Received Date : April 19, 2016

Testing Period : April 19-27 , 2016

Test Report Issued Date : April 29 , 2016

Sample Name : Sample D

The Results of Analysis

No.	Tested Items	Tested Result	Unit	LOQ	LOD	Method
1	Acetaldehyde	ND	mg/L	-	0.5	HS-GC-FID
2	Total phenolic	9.83 ± 0.03	mg/L	-	-	Spectrophotometer

Note : (a) ND = Not Detected (b) LOQ = Limit of Quantitation (c) LOD =Limit of Detection

The result is valid exclusively for the tested sample as mentioned in this report .Dissemination or alteration of any part of this test report is prohibited unless written permission is first obtained from the Director of STSC-CMU.

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Deputy Director of STSC-CMU

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Director of STSC-CMU

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Figure C 4 Test Report for NH₃ and Ozone pretreatment of Corn stover.



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Fax : 053-892275 E-mail : stscmu@gmail.com

TEST REPORT

TR No. : 59/0626

Sample Code : STSC- CMU59/279(5)

Name of Customer / Organization : Wg Cdr. Jurarut Minmunin

Address : Department of Mechanical Engineering , Chiang Mai University.

Received Date : April 19, 2016

Testing Period : April 19-27 , 2016

Test Report Issued Date : April 29 , 2016

Sample Name : Sample E

The Results of Analysis

No.	Tested Items	Tested Result	Unit	LOQ	LOD	Method
1	Acetaldehyde	ND	mg/L	-	0.5	HS-GC-FID
2	Total phenolic	18.87 ± 0.56	mg/L	-	-	Spectrophotometer

Note : (a) ND = Not Detected (b) LOQ = Limit of Quantitation (c) LOD =Limit of Detection

The result is valid exclusively for the tested sample as mentioned in this report .Dissemination or alteration of any part of this test report is prohibited unless written permission is first obtained from the Director of STSC-CMU.

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Director of STSC-CMU

“End of report”

Figure C 5 Test Report for NaOH and Ozone pretreatment of Bana grass.



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TEST REPORT

TR No. : 59/0627

Sample Code : STSC- CMU59/279(6)

Name of Customer / Organization : Wg Cdr. Jurarut Minmunin

Address : Department of Mechanical Engineering , Chiang Mai University.

Received Date : April 19, 2016

Testing Period : April 19-27 , 2016

Test Report Issued Date : April 29 , 2016

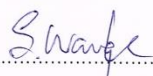
Sample Name : Sample F


The Results of Analysis

No.	Tested Items	Tested Result	Unit	LOQ	LOD	Method
1	Acetaldehyde	ND	mg/L	-	0.5	HS-GC-FID
2	Total phenolic	25.35 ± 0.79	mg/L	-	-	Spectrophotometer

Note : (a) ND = Not Detected (b) LOQ = Limit of Quantitation (c) LOD =Limit of Detection

The result is valid exclusively for the tested sample as mentioned in this report .Dissemination or alteration of any part of this test report is prohibited unless written permission is first obtained from the Director of STSC-CMU.


.....
(Asst. Prof. Dr. Sunanta Wangkarn)
Deputy Director of STSC-CMU


.....
(Asst. Prof. Dr. Sakunee Bovonsombut)
Director of STSC-CMU

"End of report"

Figure C 6 Test Report for NaOH and Ozone pretreatment of Corn stover.

APPENDIX D

Iodometric Method for the Determination of Ozone in a process gas

(International Ozone Association, Quality Assurance Committee, Revised Standardized Procedure 001/96.)

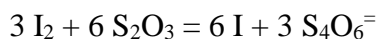
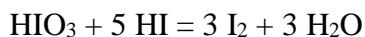
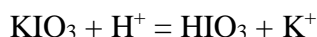
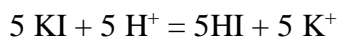
Object : The present standard method concerns the determination of ozone in air, oxygen or other process gases.

Reagents

1. Quality of the water for make-up of solutions shall comply with ISO No.3696-1987 Grade 1).
2. Buffered KI (potassium iodide) in water
3. Buffered KI (potassium iodide) in water: KI 20 g/L;Na₂HPO₄.2H₂O (disodium hydrogen phosphate) 7.3 g/L and KH₂PO₄ (monopotassium dihydrogen phosphate) 3.5g/L.
4. Sodium thiosulfate:Na₂S₂O₃ 0.1 mol/L in water.
5. Acidifying solution: H₂SO₄ (sulfuric acid):4.5 mol/L
6. Powered KIO₃ (Potassium periodate).
7. Cystalline KI.
8. HCl (hydrochloric acid) or H₂SO₄ 0.1 N.
9. Starch indicator: ZnI₂ (zinc iodide)-starch, prepared by dispersing 4 g starch into an aliquot of water. The dispersion is added to a solution of 20 g ZnCl₂ (zinc chloride) in 100ml water. The solution is boiled until the volume has been reduced to 100mL and is finally diluted to 1-Lwhile adding 2 g of ZnI₂. The indicator is stable for at least one month when stored in the dark at room temperature.

Standardization of titrant.

1. Principle



2. Procedure

2.1 To 50mL of water in a 250 conical flask are added 0.05 g KIO_3 and 0.5 g KI , followed by another volume of about 50mL water. After mixing, 10 ml of certified 0.1 N acid are added. The iodine formed is titrated with the thiosulfate solution. Normality of $\text{S}_2\text{O}_3^{2-}$ equals: Normality of acid multiplied by the volume of acid (ml) and divided by the volume of thiosulfate titrant (ml).

2.2 Determination of ozone.

2.1 200ml of KI solution are added to a gas washing bottle equipped with an open gas bubbling device (tube or diffusor) under a reagent depth of 15 cm or more; (the use of fritted glass diffusors is not recommended).

2.2 A second identical flask is connected in series as a guard detector for ozone transfer and reaction in the first flask.

2.3 Process gas containing ozone is bubbled at a flow rate of 1 l/min or less, until a total (estimated or expected) quantity of approximately 1 mM O_3 (it equals 0.048 g) has passed.

2.4 The iodine formed in the solutions of KI in the flasks, immediately after acidification with 5ml of the acidifying reagent, is titrated with a freshly standardized sodium thiosulfate solution.

2.5 After titration to a pale yellow color, optionally, 0.5mL of the starch indicator solution can be added to complete and record the final result.

2.6 Concentration of ozone in g/L equals: $24 \times$ volume of thiosulfate in L \times Normality of thiosulfate divided by the inlet volume of gas passed in L.

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