

The Synergetic Reduction of the Condensation Degree of Dissolved Lignin (DL) during the Refining Process of Wheat Straw Biomass Based on the MA/O₃ System

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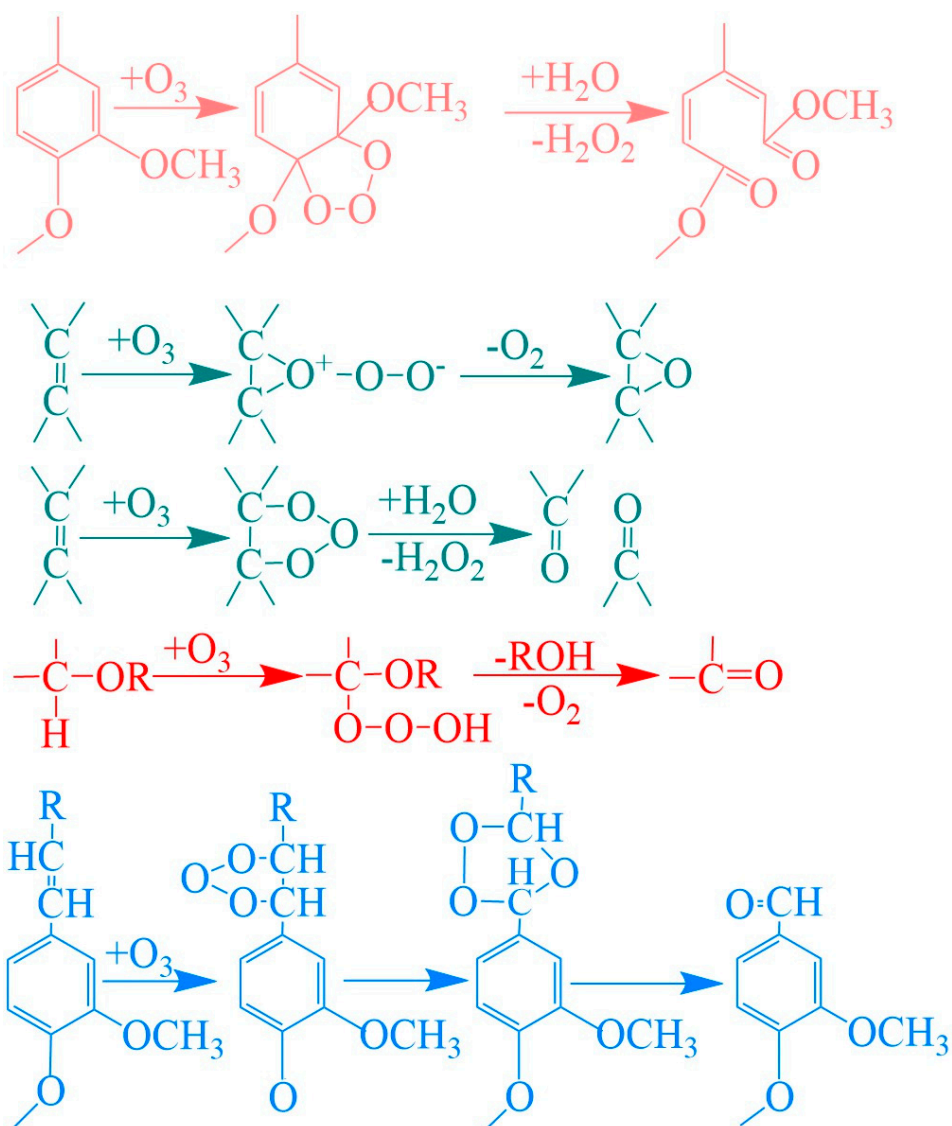


Figure S1. Reactions between O_3 and lignin

Item	Temp ^c (°C)	O ₃ holding Time (min)	Ground wheat straw				Ball-milled wheat straw					
			MA ^d	MA/O ₃	O ₃ ^e	O ₃ /H ₂ SO ₄ ^f	MA	MA/O ₃	O ₃	O ₃ /H ₂ SO ₄		
Yield (%)	50	0	85.40± 0.4		N/A ^g		64.00 ±0.5		N/A			
		3		88.60 ±0.3	93.67± 0.3	95.67±0.4		66.00± 0.5	87.67± 0.6	73.00 ±0.6		
		6	N/A	76.20 ±0.7	89.33± 0.3	93.00±0.5	N/A	65.67± 0.2	87.00± 0.1	71.67 ±0.3		
		9		80.80 ±0.4	91.33± 0.8	93.67±0.7		64.00± 0.3	84.33± 0.2	71.25 ±0.7		
		60	0	78.40± 0.3		N/A		63.66 ±0.5		N/A		
			3		85.20 ±0.4	91.00± 0.9	95.67±0.2		66.33± 0.1	82.67± 0.3	73.00 ±0.1	
			6	N/A	80.00 ±0.6	90.66± 0.7	93.37±0.5	N/A	65.67± 0.8	83.33± 0.9	72.33 ±0.5	
			9		81.20 ±0.4	92.33± 0.5	94.33±0.3		63.05± 0.3	82.67± 0.4	70.33 ±0.6	
		70	0	79.80± 0.6		N/A		64.33 ±0.8		N/A		
			3		83.40 ±0.5	94.66± 0.6	95.00±0.2		66.66± 0.3	80.33± 1.0	75.67 ±0.5	
	6		N/A	81.40± 0.4	90.66± 0.9	95.33±0.1	N/A	64.67± 0.6	78.33± 0.8	72.35 ±0.3		
	9			83.60± 0.2	91.00± 0.5	94.21±0.4		64.33± 0.9	77.87± 0.4	73.00 ±0.3		
	80		0	77.20± 0.7		N/A		63.00± 0.4		N/A		
			3		77.00± 0.9	92.66± 0.8	95.76±0.7		69.33± 0.5	96.83± 0.7	76.00 ±0.9	
			6	N/A	76.80 ±0.7	86.00± 0.8	93.47±0.6	N/A	68.00± 0.4	95.67± 0.3	75.33 ±0.2	
			9		79.14± 0.1	87.00± 0.3	92.37±0.3		70.33± 0.6	90.33± 0.8	74.67 ±0.9	
	Lignin removal ratio ^b (%)		50	0	16.58± 0.4		N/A		25.31 ±0.3		N/A	
				3		17.80 ±0.5	3.24 ±0.2	10.45±0.9		30.62± 0.6	9.90 ±0.7	20.86 ±0.9
		6		N/A	20.93 ±0.6	3.97 ±0.7	14.12±0.8	N/A	30.78± 0.5	10.54± 0.4	21.66 ±0.3	
		9			18.00	3.46	12.32±0.5		32.01±	11.96±	23.85	

			±0.8	±0.7			0.4	0.1	±0.2
Dextran removal ratio ^b (%)	60	0	18.80± 0.2	N/A		28.46 ±0.8		N/A	
		3		19.96 ±0.9	4.74 ±0.3	11.34±0.4	31.23± 0.6	14.04± 0.1	21.95 ±0.2
		6	N/A	25.21 ±1	5.74 ±0.7	16.11±0.6	N/A	31.62± 0.8	15.31± 0.3
		9		23.32 ±0.1	4.77 ±0.7	14.32±0.3		38.07± 0.2	15.78± 0.7
	70	0	20.14± 0.5	N/A		29.50 ±0.1		N/A	
		3		21.86 ±0.8	2.00 ±0.2	9.78±0.8	31.76± 0.9	7.93 ±0.6	16.56 ±0.9
		6	N/A	26.54 ±0.9	2.19 ±0.4	10.99±0.5	N/A	33.07± 0.5	9.21 ±0.4
		9		24.35 ±0.7	2.13 ±0.6	8.7±0.2		35.53± 0.7	9.45 ±0.2
	80	0	23.75± 0.6	N/A		30.53 ±0.9		N/A	
		3		24.48±1	1.08 ±0.5	8.95±0.4	32.38± 0.2	4.85 ±0.6	14.11 ±0.5
		6	N/A	26.70 ±0.3	1.91 ±0.9	9.22±0.6	N/A	34.82± 0.9	6.40 ±0.7
		9		25.88 ±0.4	1.68 ±0.8	8.52±0.8		34.98± 0.6	6.91 ±0.2
	50	0	11.10± 0.3	N/A		19.65 ±0.9		N/A	
		3		11.56 ±0.5	2.33 ±0.4	9.11±0.1	19.80± 0.8	11.84± 0.4	17.34 ±0.7
		6	N/A	13.96 ±0.7	3.25 ±0.2	10.93±0.2	N/A	20.58± 0.5	12.33± 0.6
		9		11.72 ±0.6	2.41 ±0.7	10.19±0.3		20.64± 0.1	12.56± 0.4
	60	0	13.77± 0.3	N/A		22.88 ±0.3		N/A	
		3		14.07 ±0.4	4.83 ±0.7	10.16±0.5	23.76± 0.1	13.20± 0.4	19.14 ±0.7
		6	N/A	24.78 ±0.8	5.96±0. 2	12.26±0.9	N/A	26.25± 0.3	14.85± 0.4
		9		21.53 ±0.3	5.15±0. 6	10.54±0.2		31.44± 0.1	14.95± 0.6
	70	0	15.84± 1	N/A		23.03 ±0.3		N/A	

Xylan removal ratio ^b (%)	80	3		17.71 ±0.2	0.98 ±0.8	9.28±0.4		25.86± 0.2	9.85 ±0.5	19.04 ±0.9
		6	N/A	25.51 ±0.6	1.59 ±0.3	9.71±0.1	N/A	27.97± 0.8	11.06± 0.7	22.46 ±0.3
		9		23.22 ±0.9	1.15 ±0.1	8.39±0.2		28.40± 0.9	11.51± 0.8	23.30 ±0.2
		0	20.06± 0.1		N/A		26.05 ±0.3		N/A	
	50	3		23.58 ±0.8	0.25 ±0.7	8.55±0.4		26.47± 0.2	6.24 ±0.7	12.83 ±0.4
		6	N/A	27.69 ±0.8	0.74 ±0.6	9.45±0.2	N/A	28.86± 0.5	8.73 ±0.1	13.61 ±0.2
		9		25.42 ±0.1	0.66 ±0.3	7.60±0.2		29.25± 0.9	9.11 ±0.8	15.96 ±0.7
		0	10.29± 0.3		N/A		53.58 ±0.5		N/A	
	60	3		11.60 ±0.3	5.41 ±0.7	10.42±0.6		55.79± 0.4	18.43± 0.8	52.89 ±0.9
		6	N/A	25.68 ±0.1	7.11 ±0.6	18.46±0.8	N/A	58.61± 0.3	19.56± 0.5	54.62 ±0.8
		9		20.07 ±0.2	5.91 ±0.9	17.19±0.7		62.05± 0.2	20.35± 0.7	58.29 ±0.2
		0	13.76± 0.4		N/A		55.16 ±0.4		N/A	
	70	3		15.61 ±0.5	9.11 ±0.3	16.51±0.4		57.02± 0.8	21.26± 0.9	54.36 ±0.1
		6	N/A	26.28 ±0.5	10.71± 0.1	18.73±0.2	N/A	59.49± 0.2	22.08± 0.7	56.80± 1
		9		25.35 ±0.2	10.15± 0.4	17.53±0.7		71.98± 0.1	23.37± 0.3	59.34 ±0.5
		0	16.12± 0.5		N/A		56.61 ±0.8		N/A	
	80	3		17.01 ±0.3	3.98 ±0.8	16.31±0.1		57.35± 0.9	13.74± 0.5	52.73 ±0.3
		6	N/A	30.02 ±0.7	4.44 ±0.5	17.07±0.3	N/A	62.61± 0.6	16.20± 0.4	53.93 ±0.2
		9		26.19 ±0.6	4.31 ±0.2	15.12±0.8		65.22± 0.8	16.51± 0.6	54.14 ±0.1
		0	26.94± 0.2		N/A		58.16 ±0.6		N/A	
		3		29.58 ±0.2	2.63 ±0.4	9.45±0.9		65.43± 0.1	11.08± 0.6	48.61± 0.8
		6	N/A	31.91 ±0.1	3.85 ±0.5	10.02±1	N/A	66.42± 0.2	12.90± 0.3	52.08 ±0.7

	30.17	3.22		67.22±	13.08±	53.80
9	±0.6	±0.8	8.06±0.8	0.4	0.9	±0.2

^a Water-insoluble solids. ^b The removal ratio of components is calculated based on the original content of each component in the ground wheat straw. ^c Temperature. ^d Maleic acid. ^e Ozone. ^f Sulfuric acid. ^g Not applicable.

Table S2. T_m and residual carbon of lignin

Name of sample	MWL	MA	O ₃	MA/O ₃	O ₃ /H ₂ SO ₄
T _m (°C)	374	337	262	256	265
residual carbon (%)	25.91	34.98	27.73	22.02	29.94