

Supporting Information

From Glucose-Based Carbohydrates to Phenol-rich Bio-oil Integrated with Syngas Production via Catalytic Pyrolysis over Activated Carbon Catalyst

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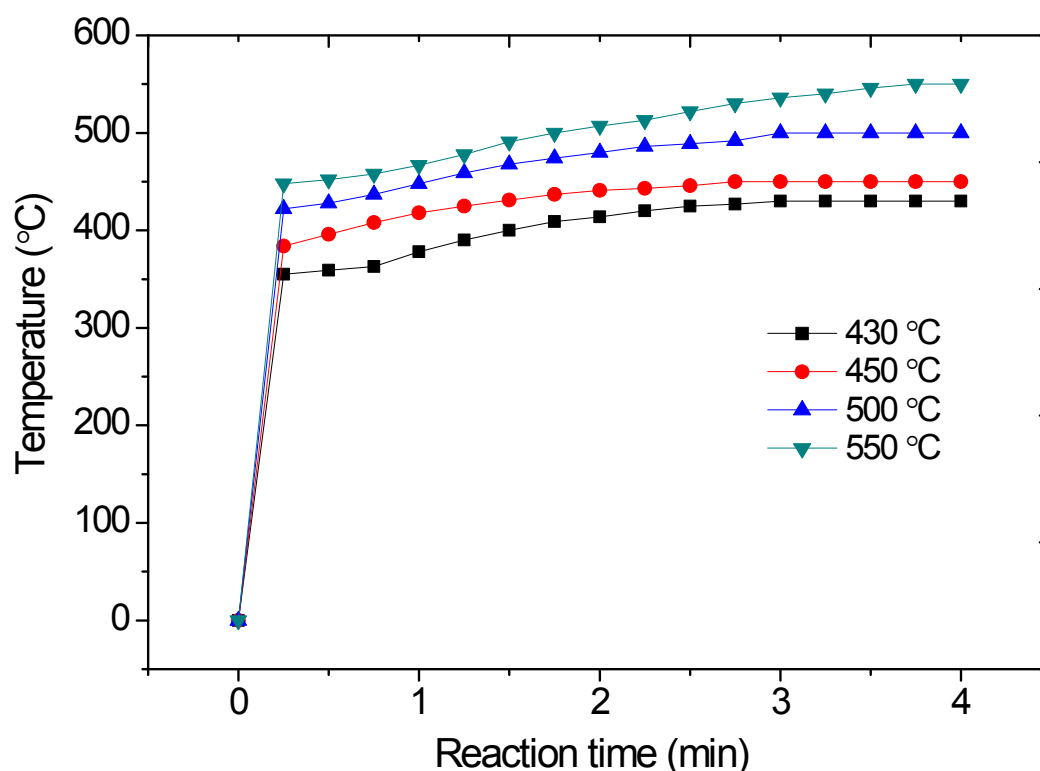


Figure S1. The temperatures change along with the initial 4 min of the reaction time.

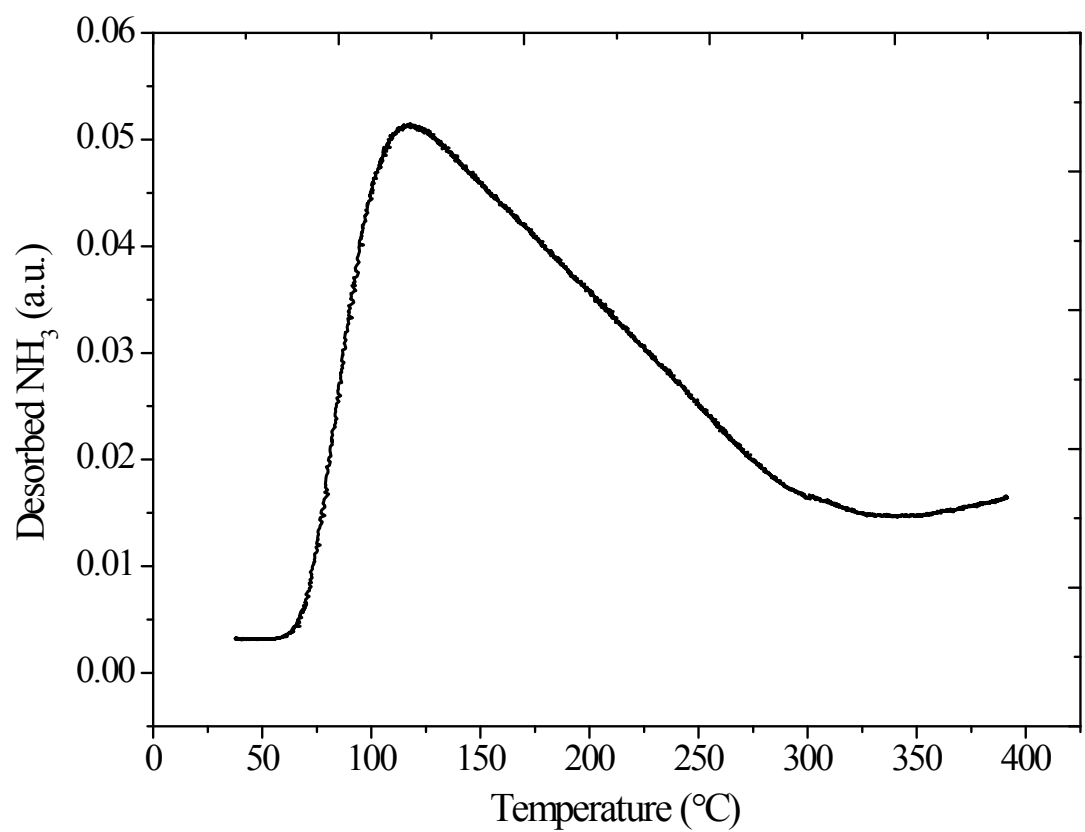


Figure S2 NH₃-TPD curve of the phosphoric acid activated ACC.

Table S1. The compositions of obtained oils in each run of catalytic pyrolysis of glucose.

RT (min)	Compound name	Category	Peak area (%)						
			R-1	R-2	R-3	R-4	R-5	R-6	R-7
4.6368	2(5H)-Furanone	Ketones			0.34	0.53		0.55	0.84
4.97	3-Furaldehyde	Aldehydes	1.02	-	0.47	0.97	-	0.81	1.74
5.35	Furfural	Furans	31.7 4	-	27.0 3	25.8 5	8.82	27.9 9	31.5 8
6.36	2-Hexanone, 3,4-dimethyl-	Ketones	-	-	1.87	-	-	-	-
6.45	2(3H)-Furanone, 5-methyl-	Furans						1.08	-
6.56	4-Hexen-2-one	Ketones				0.54	-	-	0.52
6.92-7.0	Cyclopent-4-ene-1,3-dione	Ketones			1.12	-	-	1.76	1.38
7.17	4-Cyclopentene-1,3-dione	Ketones	0.85	-	-	0.99	--	-	-
7.31	2,4-Dimethylfuran	Furans			2.79	-	-		1.87
7.45	Ethanone, 1-(2-furanyl)-	Ketones	3.89	-	4.51	5.83	-	3.73	-
8.01	2-Cyclopenten-1-one, 2-methyl-	Ketones					6.10	2.18	-
8.10-8.19	1,2-Cyclopentanedione	Ketones	-	-	3.30	0.95	-	1.44	1.12
8.89-8.77	2-Furancarboxaldehyde, 5-methyl-	Aldehydes	6.77	-	10.1 6	6.53	-	8.42	8.24
9.17	2-Cyclohexen-1-one	Ketones						1.25	1.30
9.319-9.4	Phenol	Phenols	48.1 7	10 0	15.3	30.5 4	77.5 7	23.5 2	32.9 1
10.34-10.43	2-Cyclopenten-1-one, 2-hydroxy-3-methyl-	Ketones			4.89	-	-		-
10.52	Cyclooctene	Hydrocarbons				2.93	--	3.5	3.43
10.93	Phenol, 2-methyl-	Phenols			0.74	1.34	-	0.84	1.28
11.36-11.43	Oxetane, 2-propyl-	Ketones			2.12	0.89	-	0.95	0.72
11.71-11.65	Levogluconone	Anhydrosugar			15.3 4	20.2 5	-	18.4 5	11.2 0
12.167	Phenol, 3-methyl-	Phenols	5.87	-	-	-	7.51	-	-
13.58	1,4:3,6-Dianhydro- α -D-glucopyranose	Anhydrosugar			5.17	1.52	-	1.51	-
14.47	1H-Inden-1-one, 2,3-dihydro-	Ketones			1.5	-	-	-	-
15.46	2-Acetyl cyclohexanone	Ketones						0.70	0.66
16.07-16.18	Phenol, 2-methoxy-4-propyl-	Guaiacols		-	-	-	-	0.66	0.75
17.04	Ethanone, 1-(4,5-diethyl-2-methyl-1-cyclopenten-1-yl)-	Ketones						0.67	0.46
17.34	1,2-Dimethoxy-4-n-propylbenzene	Guaiacols				0.34	-	-	
19.77	Bicyclo[3.2.2]nona-2,6-dien-5-ol-4-	Phenols			0.32	-	-	-	-

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Table S1. The compositions of obtained oils in each run of catalytic pyrolysis of glucose (continue).

RT (min)	Compound name	Category	Peak area (%)						
			R-8	R-9	R-10	R-11	R-12	R-13	R-14
4.6368	2(5H)-Furanone	Furans	0.71	0.67	0.43			0.51	0.43
4.97	3-Furaldehyde	Aldehydes	1.09	0.87	0.36	0.73		0.97	0.65
5.35	Furfural	Furans	23.68	25.47	25.78	27.93	19.54	24.01	28.6
6.36	2-Hexanone, 3,4-dimethyl-	Ketones	-	-	2.28	1.49			
6.56	4-Hexen-2-one	Ketones							1.84
6.45	2(3H)-Furanone, 5-methyl-	Ketones	0.85	1.38				1.13	
6.92-7.0	Cyclopent-4-ene-1,3-dione	Ketones	0.69	1.58	1.07	0.96	-	0.92	1.82
7.31	2-Cyclopenten-1-one, 2-methyl-	Ketones	1.44	1.86	2.36	2.73	-	1.22	2.48
7.45	Ethanone, 1-(2-furanyl)-	Ketones	2.61	3.02	4.07	2.98	2.62	2.91	4.79
7.87	2(5H)-Furanone	Ketones				0.65			
8.10-8.19	1,2-Cyclopentanedione	Ketones	0.94	1.77	3.54	2.05	-	0.91	2.64
8.89-8.77	2-Furancarboxaldehyde, 5-methyl-	Aldehydes	6.97	7.75	9.71	8.38	-	8.39	9.98
9.17	2-Cyclohexen-1-one	Ketones		1.0	1.73	3.96		0.99	
9.319-9.4	Phenol	Phenols	28.51	25.74	4.75	12.95	74.7	19.51	19.79
10.34-10.48	2-Cyclopenten-1-one, 2-hydroxy-3-methyl-	Ketones			4.99	4.13	-	3.31	4.32
10.52	Cyclooctene	Hydrocarbons	3.07	3.51			--	-	
10.93	Phenol,2-methyl-	Phenols	0.96	0.86	1.15	0.76	0.8	0.94	0.4
11.36-11.43	Oxetane, 2-propyl-	Ketones	0.69	1.0	1.61	1.69	-	0.86	1.92
11.71-11.65	Levoglucosenone	Anhydrosugar	25.71	20.32	18.76	17.06	-	29.97	10.23
12.167	Maltol	Ketones	-	-	1.89	-	-	-	1.37
12.66	4H-Pyran-4-one, 5-hydroxy-2-methyl-	Ketones			0.41				0.86
12.84	3,6-Dimethyl-1-heptyn-3-ol	Ketones	-			0.64	-	-	
13.95-13.86	1,4:3,6-Dianhydro-.alpha.-d-glucopyranose	Anhydrosugar	1.32	1.45	8.70	5.62	-	2.66	3.78
14.47	1H-Inden-1-one, 2,3-dihydro-	Ketones			1.55	2.58	-	0.39	-
14.61	Catechol	Phenols							1.27
14.86	2-(3'-Oxo-butyl)-cyclopentanone	Ketones			1.48				
15.04	Benzoic acid	Acids					2.34		

15.59	2(5H)-Furanone, 5-(1-methylethyl)-	Ketones	0.35	0.5					
16.07-16.18	3,5-Octadiene, 4,5-diethyl-, (E,Z)-	Ketones		0.74	0.34	-	-		-
16.83	2(5H)-Oxepinone, 6,7-dihydro-	Ketones			0.87				
17.04	Ethanone, 1-(4,5-diethyl-2-methyl-1-cyclopenten-1-yl)-	Ketones	0.39	0.53	0.39			0.39	-
17.34	5,7-Dodecadiene, (Z,Z)-	Ketones			0.5		-		

Table S1. The compositions of obtained oils in each run of catalytic pyrolysis of glucose (continue).

RT (min)	Compound name	Category	Peak area (%)						
			R-15	R-16	R-17	R-18	R-19	R-20	R-21
3.2	2-Pentene, 4-methyl-, (E)-	Hydrocarbons	2.11	0.90					
4.57	2(5H)-Furanone	Ketones			0.77	0.71	0.52	0.66	0.79
4.97	3-Furaldehyde	Aldehydes	0.56	0.78					
5.35	Furfural	Furans	28.83	23.12	31.80	31.55	30.29	32.30	31.28
6.36	2-Hexanone, 3,4-dimethyl-	Ketones	2.58						
6.40	4-Hexen-2-one	Ketones		4.95					
6.45	2(3H)-Furanone, 5-methyl-	Ketones			5.39	5.63	4.68	5.03	4.42
6.92-7.0	Cyclopent-4-ene-1,3-dione	Ketones	0.97	0.73	0.67	0.84	0.88	0.86	0.75
7.17	2(3H)-Furanone, dihydro-4-hydroxy-	Ketones		-	-			-	0.62
7.31	2-Cyclopenten-1-one, 2-methyl-	Ketones				0.55	0.6	0.64	0.8
7.45	Ethanone, 1-(2-furanyl)-	Ketones	4.4	5.20	5.05	4.38	3.97	4.02	3.68
8.01	2-Cyclopenten-1-one, 2-methyl-	Ketones	3.6	3.58					-
8.06	2-Pentenal, 2-methyl-	Aldehydes		2.01					
8.10-8.19	1,2-Cyclopentanedione	Ketones	4.18		1.06	1.12	1.27	1.24	1.51
8.31	2(5H)-Furanone, 5-methyl-	Ketones			1.63	1.8	1.77	1.61	1.53
8.49	2,3-Dimethyl-4-hydroxy-2-butenic lactone	Ketones		2.29					
8.89-8.77	2-Furancarboxaldehyde, 5-methyl-	Aldehydes	10.17	11.69	7.89	8.46	8.06	8.11	7.79
9.38	3-Methyl-3-cyclohexen-1-one	Ketones		1.69					
9.17	2-Cyclohexen-1-one	Ketones	0.96						
9.319-9.4	Phenol	Phenols	15.72	8.99					
9.81	3,4-Hexanedione	Ketones			2.38	2.58	2.67	2.69	2.76
10.34-10.48	2-Cyclopenten-1-one,2-hydroxy-3-methyl-	Ketones	4.96	5.53	6.18	6.38	6.34	5.93	5.83

10.93	Phenol,2-methyl-	Phenols	1.15	0.68			0.69	0.75	0.75
11.36- 11.43	Oxetane, 2-propyl-	Ketones	2.56	1.54	4.53	5.02	5.04	4.75	4.56
11.71- 11.65	Levogluosenone	Anhydrosu ger	7.0	13.4 2	4.92	4.62	4.13	4.67	4.46
12.35	Maltol	Ketones	1.04	0.83	1.66	1.19	1.04	0.97	1.03
12.59	4H-Pyran-4-one, 5-hydroxy-2- methyl-	Ketones		0.41					
12.66	2-Propenoic acid, 2-methyl-, oxiranylmethyl ester	Acids			1.02	0.88	0.66	0.64	0.72
12.84	Phenol, 3,4-dimethyl-	Phenols	0.87						
13.58	4H-Pyran-4-one, 3,5-dihydroxy-2- methyl-	Ketones	-	0.93		-	-	-	-
13.68	1,4:3,6-Dianhydro-.alpha.-d- glucopyranose	Anhydrosu ger	5.75	5.54	14.8	14.1 6	15.9 8	14.8 9	16.2
14.44	1H-Inden-1-one, 2,3-dihydro-	Ketones	1.35	0.94					
14.47	5-Hydroxymethylfurfural	Aldehydes			5.56	5.38	6.06	4.44	4.81
14.86	2(5H)-Furanone, 5-(1- methylethyl)-	Ketones	0.56	1.04					
15.56	3,5-Octadiene, 4,5-diethyl-, (E,Z)-	Ketones		0.5	0.75	0.55	0.58	0.57	0.81
16.44	Ethanone, 1-(4,5-diethyl-2-methyl- 1-cyclopenten-1-yl)-	Ketones		0.98	0.49	0.43	0.54	0.56	0.6
16.83	2(5H)-Oxepinone, 6,7-dihydro-	Ketones		0.80	2.14	2.01	2.33	2.23	2.33
17.34	5,7-Dodecadiene, (E,Z)-	Ketones		0.26	0.44	0.39	0.43	0.45	0.43

Table S2. The main compositions of obtained oils with fresh, spent, regenerated, and HZSM-5 catalysts, respectively.

RT (min)	Compound name	Category	Peak area (%)						
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			Fresh	Spent	Regenerated	HZSM-5
4.08	Cyclopentanone	Ketones	-	-	5.29	-
4.55	Carbonocyanidic acid, ethyl ester	Other				1.63
4.6368	2(5H)-Furanone	Ketones		1.36	-	-
4.97	3-Furaldehyde	Aldehydes	-	0.84	-	-
5.35	Furfural	Furans	8.82	8.82	-	14.45
5.61	3-Cyclopentene-1-acetaldehyde, 2-oxo-	Ketones			7.46	
6.36	2-Hexanone, 3,4-dimethyl-	Ketones	-	7.49	-	-
6.45	2(3H)-Furanone, 5-methyl-	Furans		-	-	8.52
6.56	4-Hexen-2-one	Ketones	-	-	-	-
6.92-7.0	Cyclopent-4-ene-1,3-dione	Ketones	-	0.58	-	0.66
7.17	4-Cyclopentene-1,3-dione	Ketones	--	-	-	1.85
7.31	2,4-Dimethylfuran	Furans	-	1.55		-
7.45	Ethanone, 1-(2-furanyl)-	Ketones	-	4.9	-	3.63
8.01	2-Cyclopenten-1-one, 2-methyl-	Ketones	6.10	6.10	2.11	-
8.10-8.19	1,2-Cyclopentanedione	Ketones	-	2.09	-	1.22
8.89-8.77	2-Furancarboxaldehyde, 5-methyl-	Aldehydes	-	7.43	-	6.23
9.17	2-Cyclohexen-1-one	Ketones			-	2.35
9.319-9.4	Phenol	Phenols	77.57	3.45	62.3	-
10.34-10.43	2-Cyclopenten-1-one, 2-hydroxy-3-methyl-	Ketones	-		-	-
10.52	Cyclooctene	Hydrocarbons	--	8.75	-	3.43
10.93	Phenol, 2-methyl-	Phenols	-	-	3.28	1.28
11.36-11.43	Oxetane, 2-propyl-	Ketones	-	2.47	-	0.72
11.71-11.65	Levogluosenone	Anhydrosug er	-	12.89	-	14.78
12.167	Phenol, 3-methyl-	Phenols	7.51	7.51	11.25	-
13.58	1,4:3,6-Dianhydro-.alpha.-d-glucopyranose	Anhydrosug er	-	16.96	-	17.94
14.47	1H-Inden-1-one, 2,3-dihydro-	Ketones	-	1.15	-	-
14.97	Phenol, 3,4-dimethyl-	Phenols			8.58	
15.46	2-Acetyl-cyclohexanone	Ketones		2.02	-	0.66
16.07-16.18	Phenol, 2-methoxy-4-propyl-	Guaiacols	-	-	-	0.75
17.04	Ethanone, 1-(4,5-diethyl-2-methyl-1-cyclopenten-1-yl)-	Ketones		0.52	-	0.46
17.34	1,2-Dimethoxy-4-n-propylbenzene	Guaiacols	-	1.92-	-	
19.77	Bicyclo[3.2.2]nona-2,6-dien-5-ol-4-one	Phenols	-	-	-	-