Supplementary materials

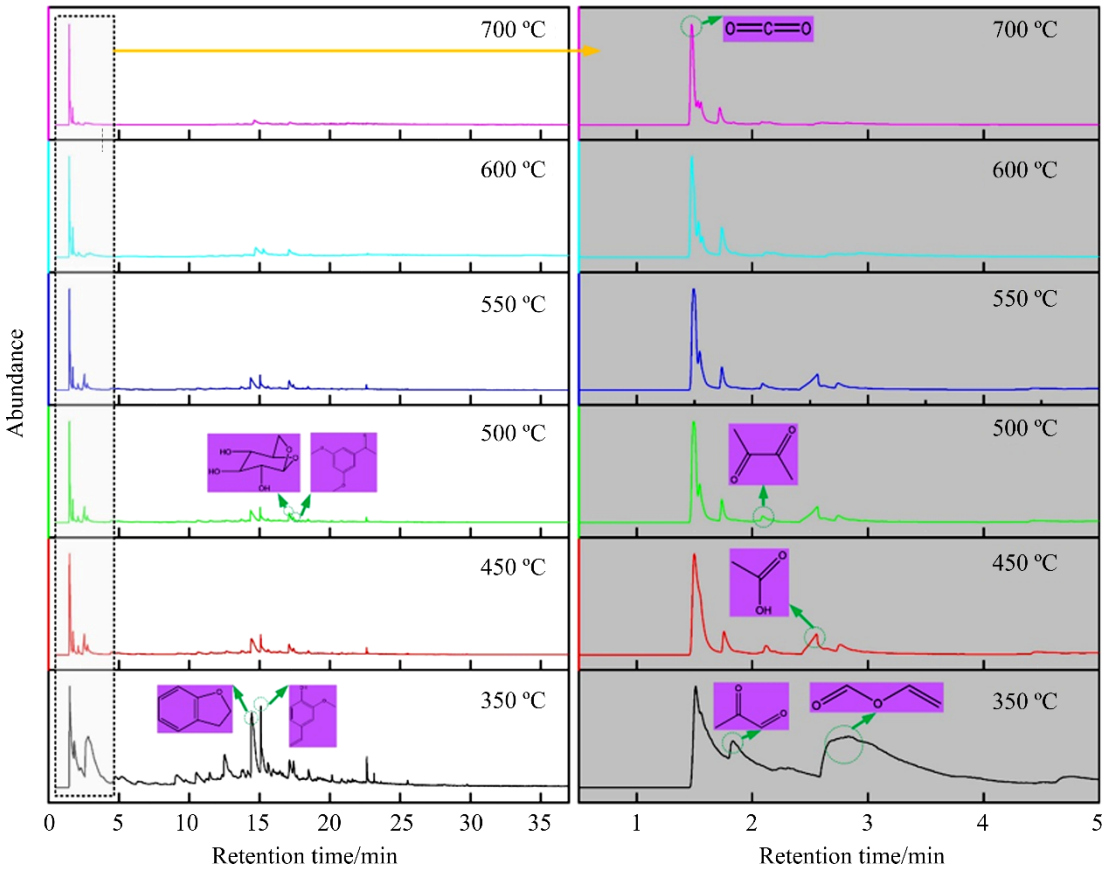

Figure S1 The revolutions of pyrolysis products at different temperatures: TIS and the corresponding enlarged diagrams

Table 1S Relative peak areas of main products for biomass and hematite mixture in Py-GC/MS

Species	Number	Retention time/min	Compound	Area					
				350 °C	450 °C	500 °C	550 °C	600 °C	700 °C
Acids	1	1.511	Carbon dioxide	9.53×10^{6}	2.42×10^{7}	2.89×10^{7}	3.33×10^{7}	2.00×10^{5}	5.36×10^{7}
			CO_2	(13.53%)	(32.7%)	(31.83%)	(37.17%)	(35.82%)	(52.19%)
	2	2.554	Acetic acid	2.16×10^{7}	5.49×10^{6}	6.24×10^{6}	5.05×10^{6}	2.55×10^{6}	2.25×10^{6}
			$C_2H_4O_2$	(30.65%)	(7.40%)	(6.89%)	(5.28%)	(2.26%)	(2.19%)
	3	9.79	2-ethylhexyl ester-2-propenoic acid	—	—	2.55×10^{6}	—	—	—
			$C_{11}H_{20}O_2$	—	—	(2.81%)	—	—	—
	4	15.165	2-oxo-butyric acid	—	1.80×10^{6}	—	—	—	—
			$C_4H_6O_3$	—	(2.43%)	—	—	—	—
	5	17.395	4-oxo-pentanoic acid	—	—	—	7.77×10^{5}	1.32×10^{6}	—
			$C_5H_8O_3$	—	—	—	(0.81%)	(1.16%)	—
	6	20.153	Hexadecanoic acid	2.50×10^{5}	2.08×10^{5}	2.43×10^{5}	—	2.00×10^{5}	—
			$C_{16}H_{32}O_2$	(0.35%)	(0.28%)	(0.27%)	—	(0.18%)	—
	7	21.265	oleic acid	—	—	—	—	—	1.49×10^{6}
			$C_{18}H_{34}O_2$	—	—	—	—	—	(1.45%)
Alkanes	8	12.66	2-methyl-heptane	5.25×10^{5}	—	—	—	—	—
			$C_{10}H_{22}$	(0.74%)	—	—	—	—	—
Olefines	9	1.855	1,3-cyclopentadiene	—	—	1.06×10^{6}	—	2.80×10^{6}	1.15×10^{6}
			C_5H_6	—	—	(1.17%)	—	(2.48%)	(1.11%)
	10	14.555	1-nonene	—	—	—	—	—	7.65×10^{5}
			C_9H_{18}	—	—	—	—	—	(0.73%)

to be continued

Continued

Species	Number	Retention time/min	Compounds	Area					
				350 °C	450 °C	500 °C	550 °C	600 °C	700 °C
Ketones	11	2.12	2,3-butanedione	—	1.80×10^{6}	1.93×10^{6}	2.59×10^{6}	1.77×10^{6}	1.32×10^{6}
			$C_4H_6O_2$	—	(2.42%)	(2.12%)	(2.72%)	(1.56%)	(1.29%)
	12	2.995	2,3-pentanedione	—	2.86×10^{5}	4.09×10^{5}	—	2.05×10^{6}	—
			$C_5H_8O_2$	—	(0.39%)	(0.45%)	—	(1.81%)	—
	13	4.745	1-hydroxy-2-propanone	4.23×10^{6}	3.20×10^{6}	2.47×10^{6}	3.66×10^{6}	3.47×10^{6}	7.13×10^{5}
			$C_3H_6O_2$	(6.01%)	(4.32%)	(2.72%)	(5.28%)	(3.06%)	(0.69%)
	14	9.17	2-methyl-cyclopentanone	3.16×10^{6}	2.53×10^{6}	—	—	—	—
			$C_6H_{10}O$	(4.49%)	(3.42%)	—	—	—	—
	15	11.46	corylone	1.00×10^{4}	1.87×10^{6}	—	—	—	—
			$C_6H_8O_2$	(0.01%)	(2.52%)	—	—	—	—
	16	11.515	3-methylycyclopentane-1,2-dione	—	—	—	1.81×10^{6}	—	—
			$C_6H_8O_2$	—	—	—	(1.99%)	—	—
	17	14.545	2-pentanone	—	6.42×10^{6}	6.15×10^{6}	—	—	—
			$C_5H_{10}O$	—	(8.66%)	(6.78%)	—	—	—
	18	17.43	3,5-dimethoxyacetophenone	9.80×10^{5}	1.27×10^{6}	2.17×10^{6}	—	—	—
			$C_{10}H_{12}O_3$	(1.39%)	(1.71%	(2.39%)	—	—	—
Alcohols	19	2.37	4-penten-2-ol	—	—	—	—	4.64×10^{5}	—
			$C_5H_{10}O$	—	—	—	—	(0.41%)	—
	20	4.74	1,3-propanediol	—	—	8.17×10^{4}	—	—	—
			$C_3H_8O_2$	—	—	(0.09%)	—	—	—
	21	14.725	Z-10-tetradecen-1-ol	—	—	—	—	—	4.99×10^{6}
			$C_{16}H_{30}O_2$	—	—	—	—	—	(4.86%)
	22	15.135	2-ethyl-2-(hydroxymethyl)-1,3-propanediol	—	—	2.69×10^{6}	—	—	—
			$C_6H_{14}O_3$	—	—	(2.97%)	—	—	—
	23	15.98	5-ethyl-2-heptanol	1.07×10^{6}	—	—			—
			$C_9H_{20}O$	(1.51%)	—	—			—
	24	16.11	1,4-anhydro-d-mannitol	—	—	—	3.85×10^{5}	-	—
			$C_6H_{12}O_5$	—	—	—	(0.40%)	-	—
	25	16.435	2,5-dimethoxybenzyl alcohol	—	1.56×10^{5}	2.80×10^{5}	—	—	—
			$C_9H_{12}O_3$	—	(0.21%)	(0.31%)	—	—	—
	26	16.445	1-O-nonyl-glucitol	—	—	—	—	—	1.69×10^{6}
			$C_{15}H_{32}O_6$	—	—	—	—	—	(1.64%)
	27	17.65	Methoxyeugenol	—	2.95×10^{5}	2.45×10^{5}	—	—	—
			$C_{11}H_{14}O_3$	—	(0.40%)	(0.27%)	—	—	—
Aldehydes	28	1.83	Methylglyoxal	3.88×10^{6}	4.38×10^{6}	4.22×10^{6}	6.80×10^{6}	9.86×10^{6}	7.61×10^{6}
			$C_3H_4O_2$	(5.51%)	(5.91%)	(4.65%)	(7.12%)	(8.71%)	(7.41%)
	29	1.91	2-methyl-propanal	—	—	—	—	—	6.75×10^{5}
			C_4H_8O	—	—	—	—	—	(0.66%)
	30	6.325	Furfural	8.48×10^{5}	—	1.05×10^{6}	—	—	—
			$C_5H_4O_2$	(1.20%)	—	(1.15%)	—	—	—
	31	12.53	Pentanal	1.96×10^{6}	1.17×10^{6}	—	1.96×10^{6}	—	—
			$C_5H_{10}O$	(2.79%)	(1.58%)	—	(0.41%)	—	—
	32	13.725	Heptanal	—	3.66×10^{5}	—	3.30×10^{6}	1.48×10^{6}	1.32×10^{6}
			$C_7H_{14}O$	—	(0.49%)	—	(3.46%)	(1.30%)	(1.29%)
	33	17.705	4-methyl-2,5-dimethoxybenzaldehyde	—	—	—	1.61×10^{6}	1.72×10^{6}	—
			$C_{11}H_{14}O_3$	—	—	—	(1.69%)	(1.52%)	—

to be continued

Continued

Species	Number	Retention time/min	Compounds	Area					
				350 °C	450 °C	500 °C	550°C	600 °C	700 °C
Phenols	34	12.32	Mequinol	2.18×10^5	3.41×10^5	—	—	—	—
			$C_7H_8O_2$	(0.31%)	(0.46%)	—	—	—	—
	35	12.365	2-methoxy-phenol	—	—	4.27×10^5	—	—	—
			$C_7H_8O_2$	—	—	(0.47%)	—	—	—
	36	13.81	3-ethyl-phenol	—	—	7.63×10^5	—	—	—
			$C_8H_{10}O$	—	—	(0.84%)	—	—	—
	37	14.10	4-ethyl-phenol	—	—	—	—	8.72×10^5	—
			$C_8H_{10}O$	—	—	—	—	(0.77%)	—
	38	15.1	2-methoxy-4-vinylphenol	3.44×10^6	2.21×10^6	2.64×10^6	7.26×10^6	8.43×10^6	—
			$C_9H_{10}O_2$	(4.88%)	(2.98%)	(2.91%)	(7.59%)	(7.45%)	—
	39	15.595	2,6-dimethoxy-phenol	8.42×10^5	8.77×10^5	1.22×10^6	2.45×10^6	9.94×10^5	—
			$C_8H_{10}O_3$	(1.19%)	(1.18%)	(1.34%)	(2.57%)	(0.88%)	—
	40	16.54	2-methoxy-4-propenyl-phenol	—	1.72×10^5	2.11×10^5	—	—	—
			$C_{10}H_{12}O_2$	—	(0.23%)	(0.23%)	—	—	—
	41	17.695	2,6-dimethoxy-4-(2-propenyl)-phenol	—	—	—	3.79×10^5	4.04×10^5	—
			$C_{11}H_{14}O_3$	—	—	—	(0.40%)	(0.36%)	—
	42	18.49	2,6-dimethoxy-4-(1E)-1-propen-1-yl-phenol	5.66×10^5	5.94×10^5	8.30×10^5	1.69×10^6	6.00×10^5	—
			$C_{11}H_{14}O_3$	(0.80%)	(0.80%)	(0.92%)	(1.77%)	(0.53%)	—
Saccharides	43	14.17	1,4:3,6-Dianhydro-α-d-glucopyranose	2.72×10^5	6.73×10^5	6.29×10^5	—	7.32×10^5	—
			$C_6H_8O_4$	(0.39%)	(0.91%)	(0.69%)	—	(0.65%)	—
	44	17.13	Levoglucosan	1.79×10^6	4.02×10^6	5.83×10^6	6.02×10^6	7.68×10^6	2.60×10^6
			$C_6H_{10}O_5$	(2.54%)	(5.42%)	(6.42%)	(6.30%)	(6.79%)	(2.53%)
Ethers	46	21.365	Hexaethylene glycol monododecyl ether	—	—	—	—	—	9.25×10^5
			$C_{24}H_{50}O_7$	—	—	—	—	—	(0.90%)
Furans	47	2.04	2,5-dihyfro-Furan	—	—	2.97×10^5	—	8.63×10^5	6.10×10^5
			C_4H_6O	—	—	(0.33%)	—	(0.76%)	(0.59%)
	48	2.18	2-methyl-furan	—	—	—	—	2.89×10^6	1.58×10^6
			C_5H_6O	—	—	—	—	(2.56%)	(1.54%)
	49	2.625	2,3-dihydro-furan	—	—	1.36×10^6	—	1.13×10^6	7.04×10^5
			C_4H_6O	—	—	(1.50%)	—	(1.00%)	(0.69%)
	50	3.125	2,5-dimethyl-furan	—	—	7.19×10^4	—	—	—
			C_6H_8O	—	—	(0.08%)	—	—	—
	51	14.445	2,3-dihydro-benzofuran	9.77×10^6	4.81×10^6	6.27×10^6	1.44×10^7	1.75×10^7	4.19×10^6
			C_8H_8O	(13.87%)	(6.49%)	(6.92%)	(15.11%)	(15.51%)	(4.08%)
N-containing compounds	52	10.505	2-methyliminoperhyro-1,3-oxazine	1.78×10^6	1.90×10^6	—	—	—	—
			$C_5H_{10}N_2O$	(2.53%)	(2.56%)	—	—	—	—
	53	20.85	Oleanitrile	—	—	1.36×10^5	—	2.86×10^5	—
			$C_{18}H_{33}N$	—	—	(0.15%)	—	(0.25%)	—
	54	21.605	Tetradecanamide	8.29×10^5	9.24×10^4	—	—	—	—
			$C_{14}H_{29}NO$	(1.18%)	(0.12%)	—	—	—	—
	55	22.635	Oleic acid amide	7.87×10^5	8.14×10^5	8.67×10^5	1.21×10^6	5.35×10^5	8.02×10^5
			$C_{18}H_{35}NO$	(1.12%)	(1.10%)	(0.96%)	(1.26%)	(0.47%)	(0.78%)

Table S2 In-situ analysis of gaseous composition analysis of CO, CO_2, H_2 and CH_4 at different temperatures

Temperature/ °C	Gas	T_{in}/s	T_{max}/s	V_{max}/%	S_{max}				
					0−600 s	600−1200 s	1200−1800 s	1800−2400 s	Total
250	CO	352	1412	0.04	2.03 (0.38%)	10.46 (1.98%)	18.19 (3.45%)	18.43 (3.49%)	49.11 (9.31%)
	CO_2	470	841	0.37	10.97 (2.08%)	187.98 (35.64%)	130.50 (24.74%)	76.76 (14.55%)	406.20 (77.01%)
	CH_4	281	967	0.03	3.70 (0.70%)	9.72 (1.84%)	8.75 (1.66%)	8.34 (1.58%)	30.49 (5.78%)
	H_2	482	827	0.04	1.75 (0.33%)	17.65 (3.35%)	9.60 (1.82%)	12.70 (2.41%)	41.68 (7.90%)
350	CO	186	1024	1.13	70.93 (2.10%)	551.78 (16.36%)	200.91 (5.96%)	28.52 (0.85%)	852.14 (25.26%)
	CO_2	219	732	2.31	416.48 (12.34%)	837.46 (24.82%)	666.75 (19.76%)	187.28 (5.55%)	2107.97 (62.48%)
	CH_4	257	947	0.09	11.29 (0.33%)	43.78 (1.30%)	38.56 (1.14%)	25.20 (0.75%)	118.83 (3.52%)
	H_2	219	1087	0.3	35.15 (1.04%)	157.36 (4.66%)	78.56 (2.33%)	23.73 (0.70%)	294.80 (8.74%)
450	CO	141	414	2.84	748.73 (14.92%)	200.74 (4.00%)	22.68 (0.45%)	11.22 (0.22%)	983.36 (19.59%)
	CO_2	170	420	5.99	1761.00 (35.09%)	1092.49 (21.77%)	254.04 (5.06%)	82.72 (1.65%)	3190.24 (63.57%)
	CH_4	176	584	0.44	99.90 (1.99%)	157.68 (3.14%)	60.78 (1.21%)	36.72 (0.73%)	355.07 (7.08%)
	H_2	168	497	0.69	201.93 (4.02%)	199.88 (3.98%)	61.37 (1.22%)	26.65 (0.53%)	489.82 (9.76%)
550	CO	117	282	5.33	1163.35 (16.63%)	51.38 (0.73%)	11.41 (0.16%)	7.37 (0.11%)	1233.50 (17.63%)
	CO_2	131	296	9.37	2724.79 (38.95%)	837.46 (11.97%)	324.17 (4.63%)	160.16 (2.29%)	4046.57 (57.84%)
	CH_4	143	319	1.49	450.35 (6.44%)	200.69 (2.87%)	45.51 (0.65%)	17.02 (0.24%)	713.56 (10.20%)
	H_2	133	385	2.57	728.35 (10.41%)	201.62 (2.88%)	51.43 (0.74%)	21.18 (0.30%)	1002.58 (14.33%)

to be continued

Continued

Temperature/ °C	Gas	T_{in}/s	T_{max}/s	V_{max}/%	S_{max}				
					0−600 s	600−1200 s	1200−1800 s	1800−2400 s	Total
600	CO	70	220	5.92	1243.60 (14.02%)	50.79 (0.57%)	18.93 (0.21%)	13.41 (0.15%)	1326.73 (14.95%)
	CO_2	102	257	11.21	3430.96 (38.67%)	999.25 (11.26%)	397.31 (4.48%)	203.06 (2.29%)	5030.57 (56.70%)
	CH_4	96	295	2.24	676.74 (7.63%)	183.10 (2.06%)	42.48 (0.48%)	24.37 (0.27%)	926.68 (10.45%)
	H_2	104	336	4.61	1226.27 (13.82%)	218.99 (2.47%)	87.12 (0.98%)	55.42 (0.62%)	1587.79 (17.90%)
650	CO	48	182	7.67	1306.49 (13.03%)	75.73 (0.76%)	32.71 (0.33%)	22.86 (0.23%)	1437.78 (14.34%)
	CO_2	90	220	13.41	3870.10 (38.60%)	1103.17 (11.00%)	420.76 (4.20%)	210.49 (2.10%)	5604.52 (55.89%)
	CH_4	83	234	3.26	854.50 (8.52%)	106.86 (1.07%)	24.72 (0.25%)	15.09 (0.15%)	1001.16 (9.98%)
	H_2	98	261	6.27	1569.74 (15.65%)	247.00 (2.46%)	103.52 (1.03%)	63.72 (0.64%)	1983.97 (19.79%)
700	CO	44	158	8.91	1393.40 (12.20%)	149.61 (1.31%)	71.58 (0.63%)	52.32 (0.46%)	1666.90 (14.59%)
	CO_2	71	190	16.36	4354.81 (38.12%)	1073.50 (9.40%)	381.96 (3.34%)	190.22 (1.67%)	6000.49 (52.53%)
	CH_4	77	195	4.51	980.79 (8.59%)	70.63 (0.62%)	21.94 (0.19%)	14.44 (0.13%)	1087.80 (9.52%)
	H_2	73	219	8.90	2112.79 (18.49%)	336.08 (2.94%)	136.03 (1.19%)	83.98 (0.74%)	2668.87 (23.36%)
800	CO	34	125	11.34	1918.12 (12.51%)	668.71 (4.36%)	501.20 (3.27%)	374.42 (2.44%)	3462.44 (22.58%)
	CO_2	65	161	19.53	4886.72 (31.88%)	1517.24 (9.90%)	750.55 (4.90%)	415.01 (2.71%)	7569.51 (49.37%)
	CH_4	68	155	6.79	1112.29 (7.26%)	48.30 (0.32%)	20.42 (0.13%)	15.59 (0.10%)	1196.59 (7.81%)
	H_2	65	182	11.35	2606.51 (17.00%)	282.26 (1.84%)	131.68 (0.86%)	81.76 (0.53%)	3102.21 (20.24%)
900	CO	20	123	13.09	4171.76 (16.22%)	2807.61 (10.91%)	1195.76 (4.65%)	691.37 (2.69%)	8866.50 (34.47%)
	CO_2	58	144	25.72	6889.74 (26.78%)	2095.97 (8.15%)	873.89 (3.40%)	482.87 (1.88%)	10342.48 (40.20%)
	CH_4	59	153	10.03	1472.11 (5.72%)	80.34 (0.31%)	40.80 (0.16%)	27.09 (0.11%)	1620.35 (6.30%)
	H_2	21	175	14.38	3014.76 (11.72%)	604.41 (2.35%)	623.62 (2.42%)	652.61 (2.54%)	4895.39 (19.03%)