Electronic Supplementary Material (ESI) for RSC Advances

Supporting Information

Optimising the sustainability of crude bio-oil via reforming to hydrogen and valuable by-product carbon nanotubes **

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Table S1 Mass balance for the reforming of crude bio-oil

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
Valorization Temperature	500	500	100	178	227	500	500	500	500	100+180+230+500	100+500
Reforming Temperature	700	900	800	800	800	800	800	800	800	800	800
Catalyst	20NiCaAl	20NiCaAl	20NiCaAl	20NiCaAl	20NiCaAl	Sand	5NiCaAl	20NiCaAl	35NiCaAl	20NiCaAl	20NiCaAl
Gas yield (wt.%)	56.2	73.4	11.8	37.4	62.2	41.7	62.4	62.6	66.5	62.0	67.7
Liquid yield (wt.%)	25.8	10.3	10.6	14.6	16.2	38.4	22.8	22.3	17.9	18.3	17.6
Char yield (wt.%)*	4.6	2.6	2.0	2.3	7.3	5.6	2.6	0.7	6.6	3.0	10.0
Residue (wt.%)	7.9	8.3	65.9	38.9	7.9	6.0	15.2	8.1	15.6	12.3	4.7
Mass Balance	94.6	94.6	90.3	93.2	93.7	91.7	103.1	93.6	106.6	95.6	99.9
H_2 yield (mmol g^{-1} bio-oil)	15.6	23.5	6.0	13.7	18.9	4.9	13.4	16.0	18.6	18.6	19.9
Gas concentrations (vol.%)											
CO	33.8	41.1	11.2	32.1	35.9	42.4	37.6	34.5	38.0	40.1	39.4
H_2	46.9	49.3	68.3	54.9	48.7	25.0	39.6	48.2	47.3	49.0	48.3
CO_2	10.6	4.2	19.8	9.8	8.1	8.2	10.9	9.9	9.6	8.0	8.4
CH_4	6.2	4.4	0.8	2.8	5.7	16.5	9.0	5.4	3.4	2.5	3.4
C_2-C_4	2.6	1.0	0.0	0.4	1.7	7.9	3.0	2.0	1.8	0.5	0.5

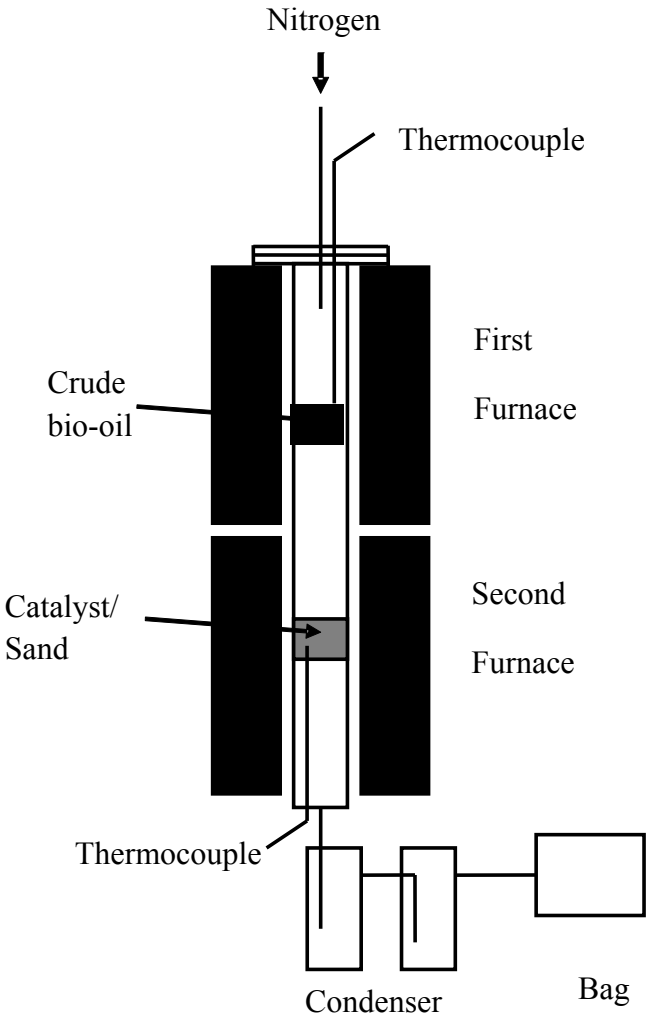
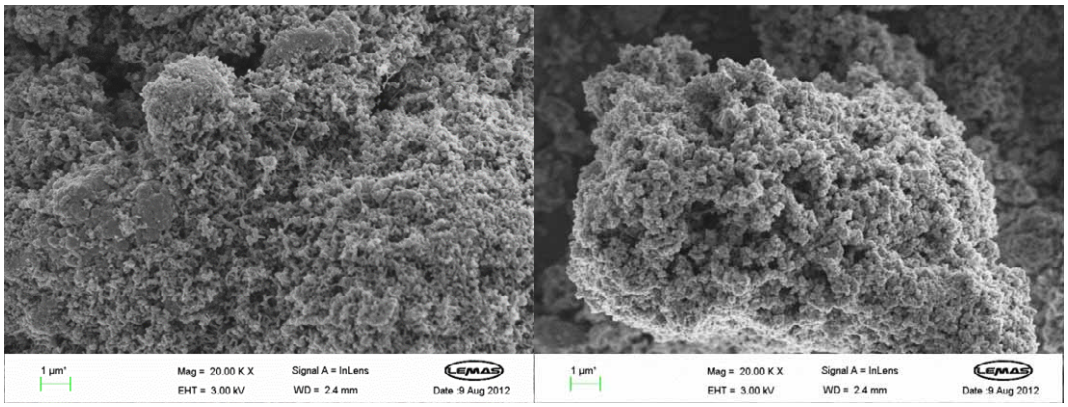


Figure S1 Schematic diagram of the reaction system.



Reacted 5NiCaAl Reacted 35NiCaAl

Figure S2 SEM analysis of the reacted 5NiCaAl and 35NiCaAl catalysts. Filamentous carbons were difficult to be observed for the reacted 5NiCaAl and 35NiCaAl catalysts compared with the reacted 20NiCaAl catalyst (Figure 2).

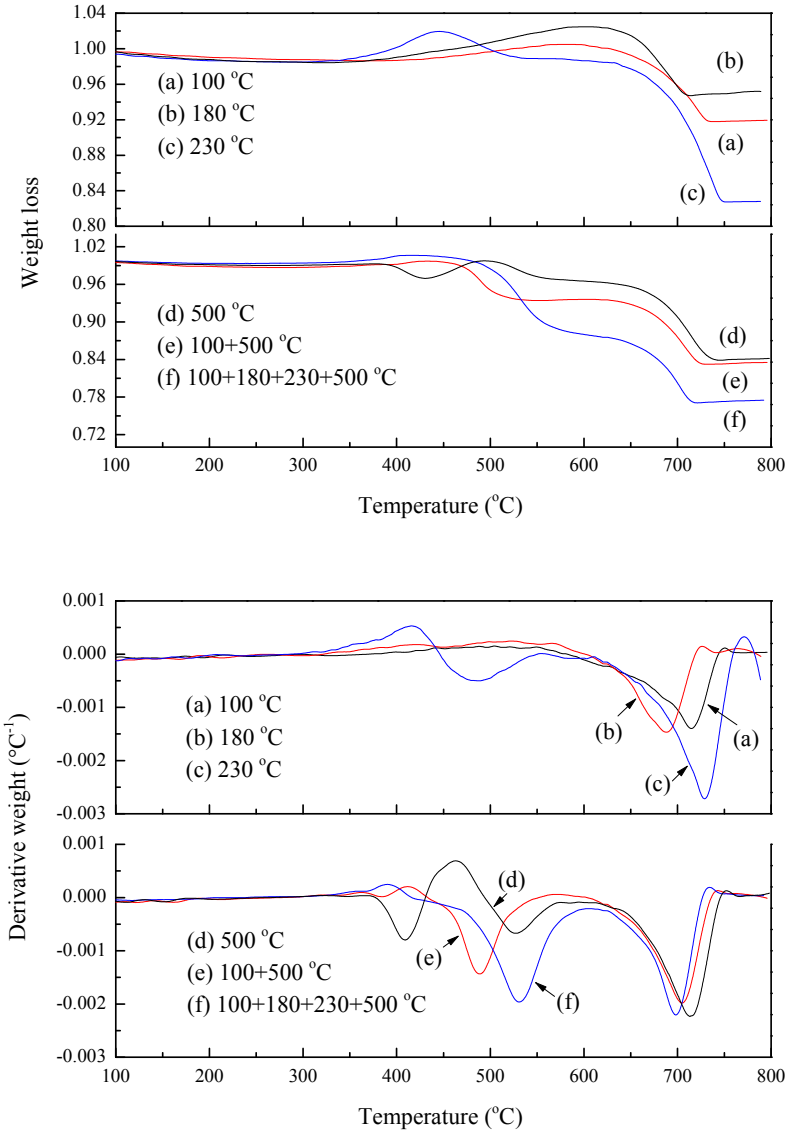


Figure S3 TGA-TPO and DTG-TPO results for reacted catalyst with different pyrolysis temperatures; gasification temperature 800 ˚C. Only one oxidation peak (around 710 ºC) was observed for the reacted 20NiCaAl catalyst with the evaporation/pyrolysis temperature of 100 or 180 ºC, while several oxidation peaks were obtained if pyrolysis temperature was 500 ºC. It is indicated that amorphous carbons or heavy hydrocarbons were produced on the surface of the reacted catalysts if the bio-oil was pyrolysed at 500 ºC

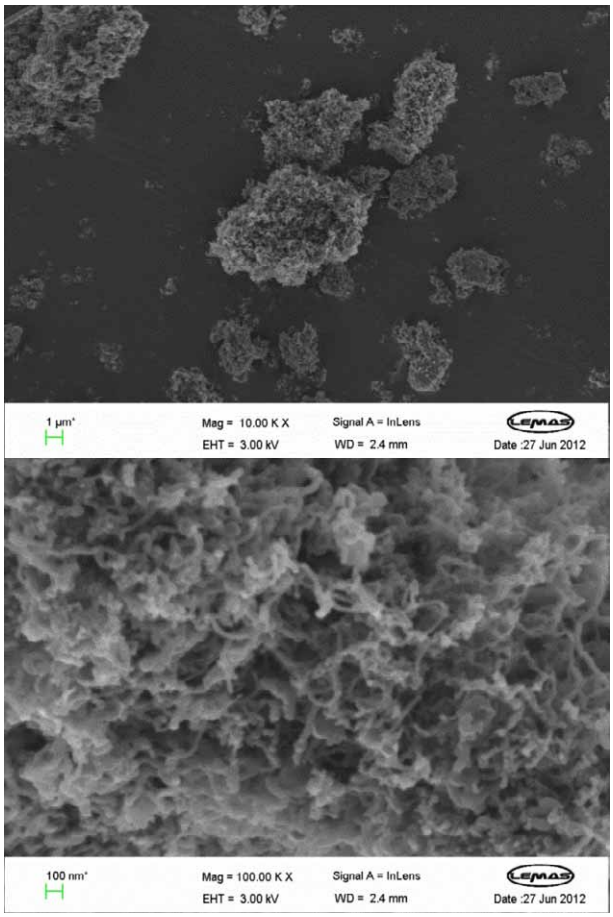


Figure S4 SEM analysis of the reacted 20NiCaAl catalyst at the evaporation/pyrolysis temperature of 100 or 180 ˚C; Filamentous carbons were obtained which corresponded to the TPO analysis in Figure S5 where a single main oxidation peak of carbons was observed at around 710 ºC

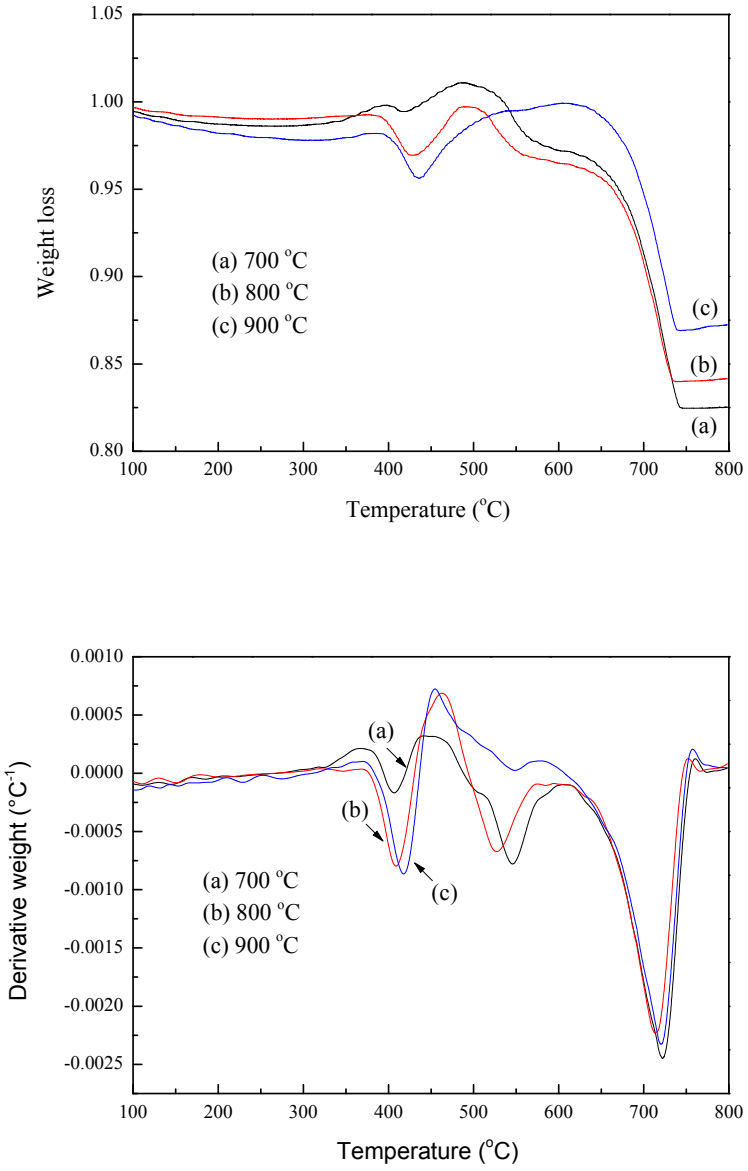


Figure S5 TGA-TPO and DTG-TPO results for reacted catalyst with different gasification temperatures; pyrolysis temperature 500 ˚C in the presence of the 20NiCaAl catalyst