Production of bio-oil from palm kernel shell in a newly developed two-stage pyrolyzer

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The extensive use of fossil fuel-derived chemicals along with the decline of fossil fuel reserves has forced researchers to find new chemical resources (Francesco, 2010). The use of renewable biomass to produce chemicals is a good option from the economic and environment viewpoint. In particular, lignocellulosic biomass which mainly consists of cellulose, hemicelluloses and lignin, has been using the major feed material through various method. Each component of lignocellulosic biomass produces valuable chemicals through pyrolysis (Collard and Blin, 2014). Pyrolysis, one of the thermochemical conversion technologies, can convert biomass into liquid product. The liquid product named to bio-oil is composed of various valuable chemicals such as acetic acid, furfural and phenol. However, bio-oil has demerit for application of multidisciplinary due to bio-oil characteristics. Meaningful studies have been performed to produce bio-oils enriched with special chemicals.

In this study, palm kernel shell (PKS) was pyrolyzed to investigate the effect of newly developed two-stage pyrolysis process. PKS is one of the largest current sources of biomass from agricultural residues. PKS is generated from palm oil milling process. Approximately 2.4 million tons of PKS is produced annually in Malaysia (Zhang *et al.*, 2007).

Pyrolysis experiments were conducted using two types of pyrolysis processes: one-stage pyrolysis having a fluidized bed reactor and two-stage pyrolysis having an auger and fluidized bed reactors in series. A diagram of the two-stage pyrolysis process is shown in Fig. 1.

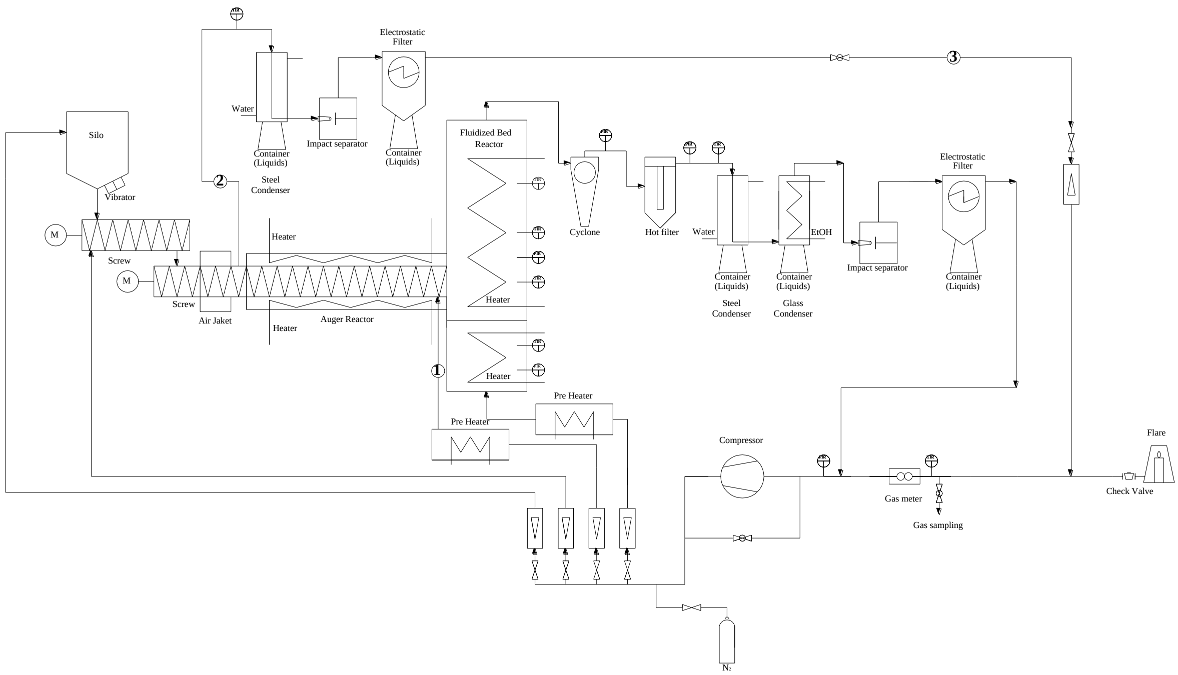

Fig. 1. Diagram of the two-stage pyrolysis process

The main reaction conditions are shown in Table 1. OS1 to OS2 were conducted at the fluidized bed reactor temperatures of ~ 350 and 500 °C, respectively. TS1 to TS5 were performed with the two-stage pyrolysis process. The intended reaction temperature for the fluidized bed reactor of the two-stage pyrolysis was 500 °C, although some deviation from this temperature occurred in the experiments. The comparison of results from TS1 to TS3 was performed to reveal the effect of auger reactor temperature on the bio-oil compositions, while that from TS3 to TS5 was performed to determine the influence of the residence time of the feed material in the auger reactor. Additionally, the comparison between the results of OS1 and OS2 and those of TS2 was conducted to determine the characteristics of the two-stage pyrolysis.

Table 1. Reaction conditions of two-stage pyrolysis.

Parameters	One-stage		Two-stage				
	OS1	OS2	TS1	TS2	TS3	TS4	TS5
Reaction temperature (ºC)	-	-	293(AR)	342(AR)	384(AR)	379(AR)	378(AR)
	353(FBR)	512(FBR)	520(FBR)	519(FBR)	517(FBR)	519(FBR)	521(FBR)
Solid residence time in AR (min)	-	-	2	2	2	2.5	3.5
Flow rate of fluidizing gas (Nl/min)	43	32	29	29	29	29	29

AR: Auger reactor, FBR: Fluidized bed reactor

References

[1] Francesco C. The biorefinery concept: Using biomass instead of oil for producing energy and chemicals. Energy convers and Manag 2010;51:1412–21.

[2] Collard FX, Blin J. A review on pyrolysis of biomass constituents: Mechanisms and composition of the products obtained from the conversion of cellulose, hemicelluloses and lignin.Renew Sustain Energy Rev 2014;38:594–608.

[3] Zhang Q, Chang J, Wang T, Xu Y. Review of biomass pyrolysis oil properties and upgrading research. Energy convers and Manag 2007; 48; 87-92.