

PYROLYSIS OF BIO OIL

LUCAS FERRARI DE CARVALHO COSTA¹, CAIO GLAUCO SÁNCHEZ²

1- PhD student in Mechanical Engineering, Department of Energy, Faculty of Mechanical Engineering - UNICAMP (lucas.prk@gmail.com)

2- Professor at the Faculty of Mechanical Engineering, Department of Energy - UNICAMP (caio@fem.unicamp.br)

Abstract: The fast pyrolysis is a process applied to biomass in order to densify it. One of the resulting products is named bio-oil. The bio-oil can serve as a feedstock for the biorefinery, this compound can be transformed into synthesis gas through pyrolysis at higher temperatures. During this process polymerization reactions can occur, forming coke inside the reactor. The coke can clog the reactor and/or deactivate catalysts that are in the process. This work has the objective to reduce coke formation in the reactor by previous distillation of the bio-oil. The procedure used was positive and minimize coke formation during the pyrolysis of the distilled bio-oil.

Keywords: Pyrolysis, bio-oil, synthesis gas, coke

Introduction

Among the renewable energy sources the most prominent is the biomass because carbon, hydrogen and oxygen are present in this being a sustainable source for production of fuels and chemicals.

One of the disadvantages of using biomass as a feedstock for power generation is its low density, hampering transport and endearing its use. As soon an interesting way for the use of this raw material is densify it, or increase its mass per volume for easier transportation.

One of the ways found to densify biomass is turn it into liquid by fast pyrolysis at 500 °C, which is a thermal degradation of the material. For liquid raw material there is a whole logistics available. Another advantage is the best accommodation because large spaces isn't necessary to store it, due to increased the energy density. The bio-oil may serve as an intermediate in the biorefinery concept, in which the oil produced in small and medium-sized decentralized pyrolysis units can be carried to a large and centralized unit (the biorefinery). In this unit the bio-oil can go through various processes, including those of thermo-conversion to produce synthesis gas, composed of CO and H₂.

The thermo-conversion can also be called gasification and/or pyrolysis and can be applied for the production of synthesis gas from bio-oils. This conversion is studied through two pathways: non-catalytic or catalytic conversion. In this work the non-catalytic pyrolysis of bio-oils were made.

The process of thermal degradation of the bio-oil is illustrated in Figure 1 The process was analyzed by Wornat, Porter and Yang (1994) and the Figure were developed by Chhiti et al. (2011).

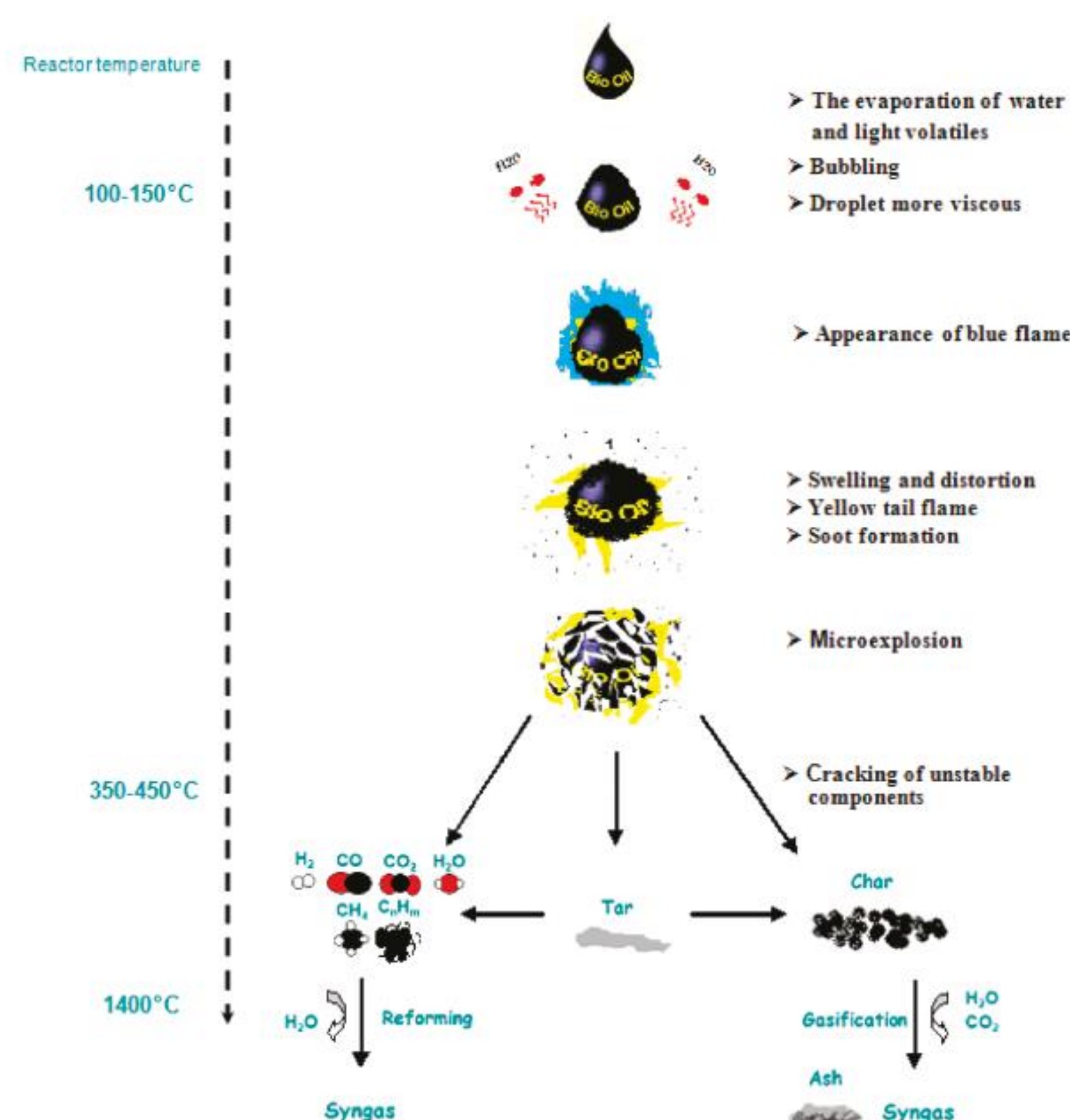


Figure 1: Scheme for the gasification of bio-oil per Chhiti et al. (2011)

Materials and Methods

In this work a blended bio-oil with ethanol (BPL) was used. The composition in mass of the blended oil was 80% of bio-oil and 20% of ethanol. It was also used a fraction obtained from a distillation to a temperature of 260 °C from BPL and named as BPLD. This temperature was used because above this temperature the formation of solid material within the retort at a rate of about 1 : 1 occurs, as also observed by Krumdieck and Daily (1998). The information of bio-oils are shown in Table 1.

A entrained flow reactor with electric heating in the outer wall at a temperature of 900 °C was used, the inner core temperature of the reactor was around 700 °C.

Table 1: Characterization of Bio-oils

Samples	BPL	BPLD
Relative density (g/g)	1,202 ± 0,001	0,948 ± 0,001
Viscosity at 40 °C (cP)	201,8 ± 5,8	4,9 ± 0,1
Water content (%)	13,75 ± 0,15	27,5 ± 0,3
Elemental Analysis (% g/g)	C	49 ± 2
	H	8 ± 1
	N	0,29 ± 0,07
	O*	43 ± 2

* per difference

Results

In Figures 2, 3 and 4 are the graphics of the gas concentrations without N₂, the mass balance and the heat value in dry basis obtained after three trials with each sample.

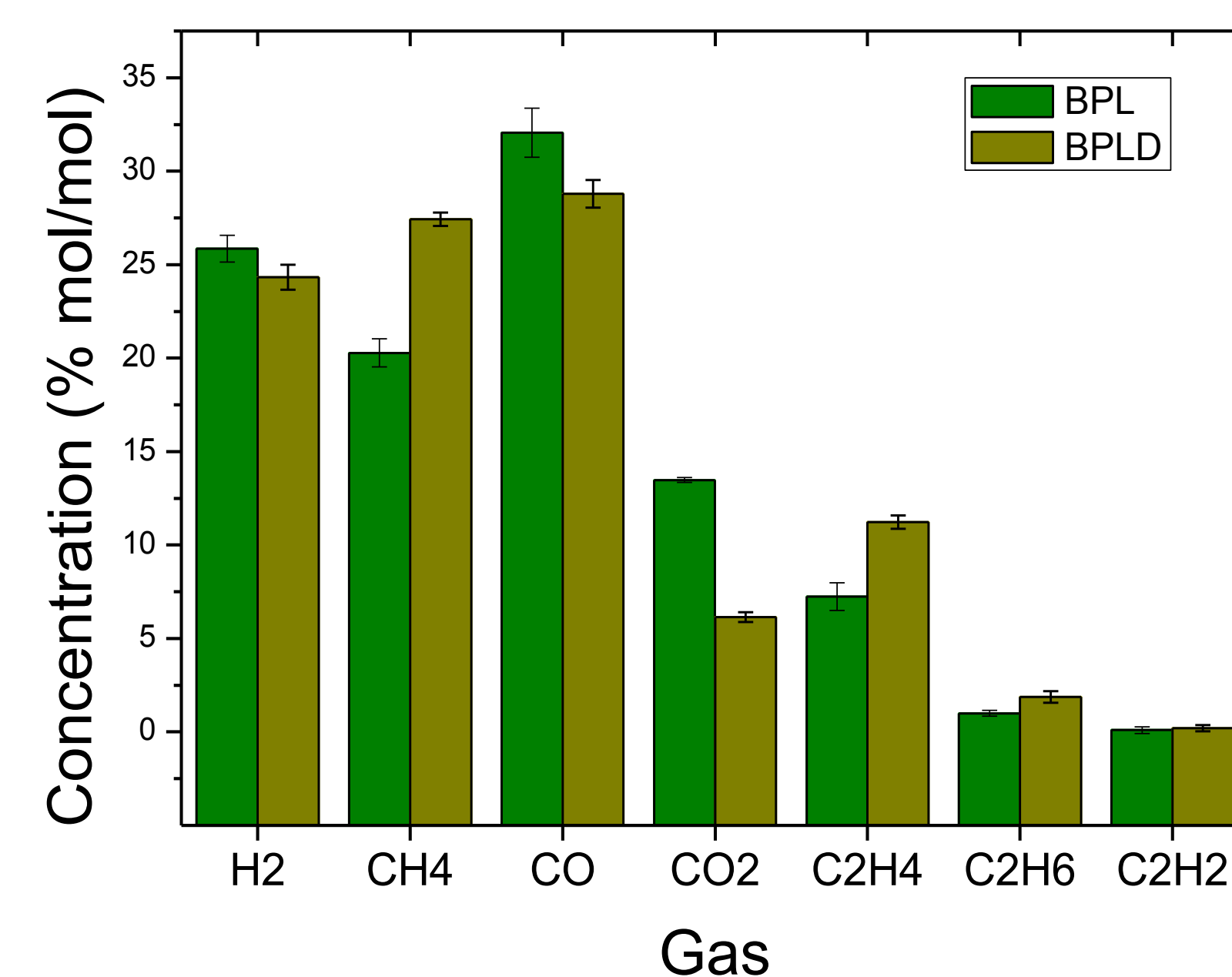


Figure 2: Composition of gases

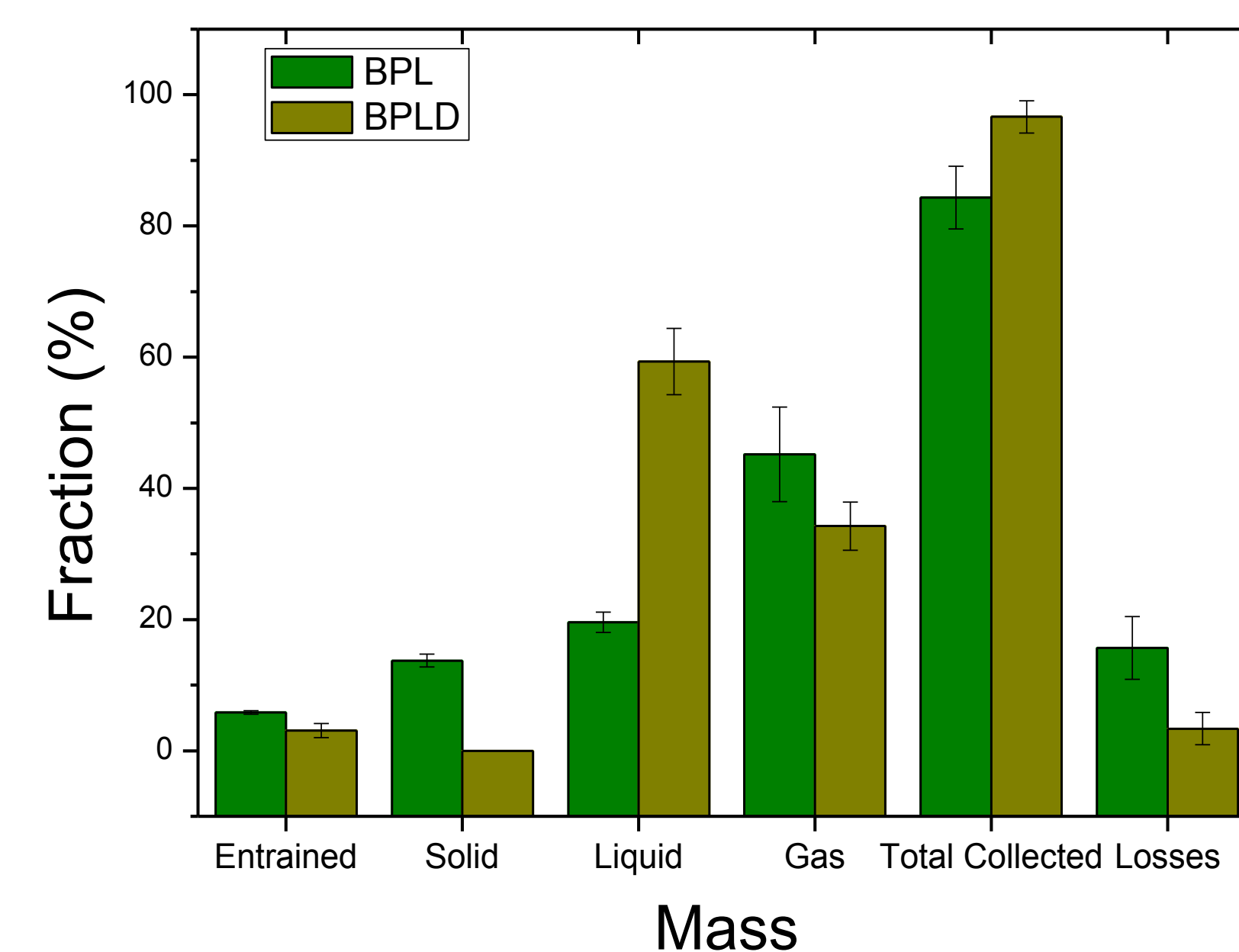


Figure 3: Mass balance

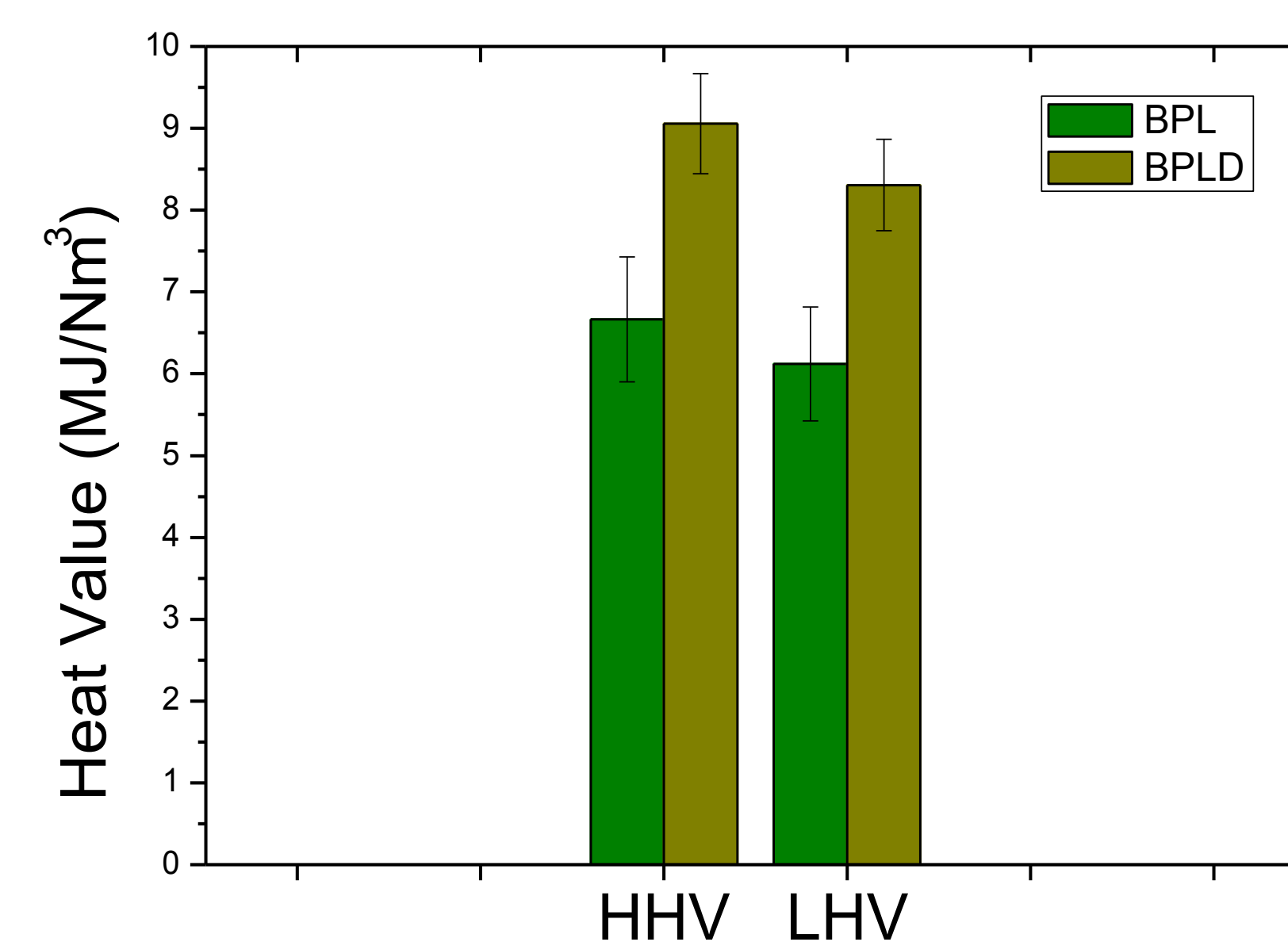


Figure 4: Heat value of pyrolysis gases in dry basis

Conclusions

The solid materials removed in the distillation process prevented the formation of coke in the reactor during pyrolysis of BPLD. Consequently decreased the formation of CO₂ and CO in the pyrolysis process of this sample.

The decreased content of carbon dioxide and carbon monoxide led to increasing the concentration of light hydrocarbons, increasing the heat value of the pyrolysis gas from BPLD in relation to the pyrolysis gas from BPL.

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References

- ADEBANJO, A. Production of fuels and chemicals from biomass derived oil and lard. *Thesis* (MS in Chemical Engineering) University of Saskatchewan, Saskatoon, Saskatchewan. 2005.
- CHHITI, Y. et al. Wood bio-oil noncatalytic gasification: influence of temperature, dilution by an alcohol and ash content. *Energy Fuels*. 2011. 25. p. 345-351.
- KRUMDIECK, S. P. e DAILY, J. W. Evaluating the Feasibility of Biomass Pyrolysis Oil for Spray Combustion Applications. *Combustion Science and Technology*. 1998. 134. p. 351-365.
- PANIGRAHI, S. et al. Synthesis gas production from steam gasification of biomass-derived oil. *Energy and Fuels*. 2003. 17. p. 637-642.
- PEREZ, G.; DAS, K. C.; ADAMS, T. T.. Conversão termoquímica de biomassa em biorrefinarias. In TEIXEIRA, W. G. et al. As Terras Pretas de Índio da Amazônia: Sua caracterização e uso deste conhecimento na criação de novas áreas. Manaus: Embrapa Amazônia Ocidental. 2009. cap. 26. p. 328-335
- RENNARD, D. et al.. Production of synthesis gas by partial oxidation and steam reforming of biomass pyrolysis oils. *International Journal of Hydrogen Energy*. n.35. 2010. p. 4048-4059
- ROSSUM, G.; KERSTEN, S. R. A.; SWAAIJ, W. P. M. Catalytic and Noncatalytic Gasification of Pyrolysis Oil. *Industrial & Engineering Chemistry Research*. 2007. 46. p. 3959-3967.
- WANG, Y. et al. Formation of Aromatic Structures during the Pyrolysis of Bio-oil. *Energy and Fuels*. 2012. 26. p. 241-247.
- WANG, Y. et al. Formation of Coke During the Pyrolysis of Bio-oil. *Fuel*. 2013. 108. p. 439-444.
- WORNAT, M. J.; PORTER, B. G.; YANG, N. Y. C. Single Droplet Combustion of Biomass Pyrolysis Oils. *Energy & Fuels*. v.8, p.1131-1142, 1994.