Physicochemical of Bio-Oil from Three Residual Plants Produced by Continuous Pyrolysis Reactor

Kittiphop Promdee, Tharapong Vitidsant, Supot Vanpetch, and Peerapon Ruengvilairat

***Abstract*—Continuous pyrolysis process to produce bio-oil from three residual plants, conducted at a temperature range of 450-600 ℃, were to study the quality of bio-oil extracted from different residual plants were, 1) Oil palm empty fruit bunch [Rpt-1], 2) Water hyacinth [Rpt-2], and 3) Manila grass [Rpt-3]. The preliminary analyses of three residual plants found that the yield of bio-oil was averaging of medium range standard, and The proximate analysis of three residual plants extracted from three residual plants had good qualities because of low moisture content and high fixed carbon and high volatile matter. The element contents of three residual plants found that high carbon content. The analysis of bio-oil can found the heating values averages of bio-oil from [Rpt-2] and [Rpt-3] were difference from bio-oil obtained from [Rpt-1], both [Rpt-2] and [Rpt-3] held that there was in the Heating Value of high-level or better standards, especially bio-oil obtained from [Rpt-2] have a highest value averaging of 30.5 MJ/Kg. The amount of carbon in the bio-oil obtained from [Rpt-1], [Rpt-2] and [Rpt-3] were 55.91, 55.57, and 55.03 wt.%., respectively., carbon was relatively high in three residual plants. Hence; In this research are concerns the feeding rate, velocity of screw feeders, the control nitrogen flow, the temperatures in reactor and reactor operate for produce the hi quality of bio-oil with three residual plants.**

***Index Terms*—Pyrolysis, bio-oil, oil palm empty fruit bunch, manila grass, water hyacinth.**

I. Introduction

Fuel energy have important role in out way of life. The shortage of the fuel is being concerned in every country. Now we are looking at the fuel which synthesized from natural matter, especially; residual plant, by using the pyrolysis method. The fuels from natural matter have a good solve and can reduce a waste in widespread areas of several provinces of Thailand and wasted area have found a dispersions of residual plant on lowland. The experiment was conducted by using [Rpt-1], [Rpt-2] and [Rpt-3] transformed to bio-oil and their product by continuous pyrolysis reactor on standard criteria and analysis the properties of material and products.

Continuous pyrolysis reactor is a one of technology for synthesized the bio-oil from several biomass, such as, biomass waste, residual plants, agricultural residual and weed plants to be considered for high potential and high yield of bio-oil by control the criteria of reactor for an generate the alternative energy source. The wastes produced by agriculture become problem i.e. rice hays and cut grass. Farmers usually get rid of them by burning which emits the toxic pollutants [1], [2] - [5]. These wastes can become useful if they can be reformed into the petroleum products which ultimately help reduce the residual wastes and also cut down the cost of fuel for the farmers, etc.

The using of continuous pyrolysis process to produce bio-oil gives good qualities similarly to fuel oil [2], [3]. Therefore, the purpose of this experiment was to study the some physicochemical of bio-oil derived from the local residual plant (3 types; [Rpt-1], [Rpt-2] and [Rpt-3]) which would lead to the feasibility to utilize and improve the quality of the by product and evaluate the bio-oil from three residual plant.

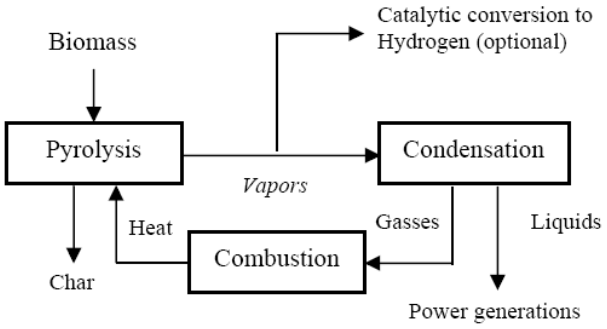

Fig. 1. The simple of pyrolysis processes to produce bio-oil.

Pyrolysis gives high oil yields, but the technical efforts needed to process pyrolytic oils mean that this energy generating system does not seem very promising at the present stage of development [4], [5]. However, pyrolysis as a first stage in two-stage gasification for grass, straw, plant and other agricultural materials does deserve consideration.

II. Procedure

A. Sample Preparation

Preparation of [Rpt-1], [Rpt-2] and [Rpt-3], crust and bring to oven at 85 ^{o}C for 2 hr until it is completed dry or less than 5 percent moisture. The samples were separated through a sieve to the approximate 450-1,000 microns. And then, control the N_2 flow rate around 0, 50, 100, 150, 200, 400 ml/hr and feed samples approximately 1.3 - 1.8 kg/hr. The samples were fed to continuous reactor for pyrolysis process at 450-600 ^{o}C. Controlling a feeding rate with 150 - 350 rpm (r min^{-1}) for test

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K. Promdee is with the Inter-Department of Environmental Science, Chulalongkorn University, Bangkok, 10330, Thailand., and Department of Environmental Science, Chulachomklao Royal Military Academy, Nakorn Nayork, 26001, Thailand (e-mail: nuumensci@hotmail.com).

T. Vitidsant, S. Vanpeth, and P. Ruengvilairat are with the Department of Chemical Technology, Chulalongkorn University, Bangkok, 10330, Thailand. (e-mail: tharapong.v@chula.ac.th; penut9@hotmail.com; peera030127@hotmail.com).

a received oil yield and reaction time of 0.5 to 2 seconds. The bio-oil product were analyzed by Ultimate analyzer, Proximate analyzer and Heating value analyzer. Which could be evaluated by the standard criteria.

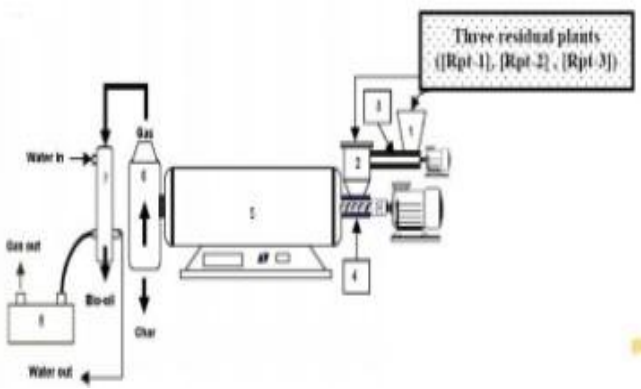

Fig. 2. Schematic diagram of experiment setup: 1. Hopper 1 2. Hopper 2 3. Screw feeder 1 4. Screw feeder 2 5. Tube furnace 6. Separator 7.Condenser 8. Vacuum pump

B. Proximate Analysis

Proximate analysis is the most often used analysis for characterizing coals in connection with their utilization, this experiment was analysis by ASTM D 3173-3175. The process are determined the distribution of products obtained when the sample is heated under specified conditions [4]. Proximate analysis separates the products into four groups: (1) moisture, (2) volatile matter, consisting of gases and vapors driven off during pyrolysis, (3) fixed carbon, the nonvolatile fraction of char, and (4) ash.

C. Ultimate Analysis

In the experiment was analysis form of element components of bio-oil concerned with determination of only Carbon (C), Hydrogen (H) and Nitrogen (N) in a sample, these analyzed by Ultimate analyzer [6],[7].

D. Gross Calorific Value (GCV) or Heating Value

The GCV are defined as the quantity of heat generated by the combustion and subsequent cooling of the exhaust gases to 25 ℃. Both the energy required to heat the combustion air and the exhaust gases, and the heat generated by the evaporation or condensation of liquid, particularly water are taken into account in this parameter [8]. this experiment was analysis by ASTM D1826.

III. Results and Discussion

The properties of bio-oil by during pyrolysis, which takes place at temperatures in the range 450-600 ℃, using a particle size of 450-1,000 microns, and feed rate of 1.3 - 1.8 kg/hr [150 - 350 rpm (r min^{-1})], for compare the three types of plants, [Rpt-1], [Rpt-2] and [Rpt-3]. Preliminary calculate of the product oil yield of three plants, the result showed that the liquid average of [Rpt-1] was highest 42.5 %, [Rpt-2] was 35.3 % and the lowest of liquid yield was [Rpt-2] averaging 22.5 %, and the results found that the gas average and the solid average of [Rpt-1], [Rpt-2] and [Rpt-3] were 26.2, 47.4, and 34.7 % respectively., showed that in the Fig. 3.

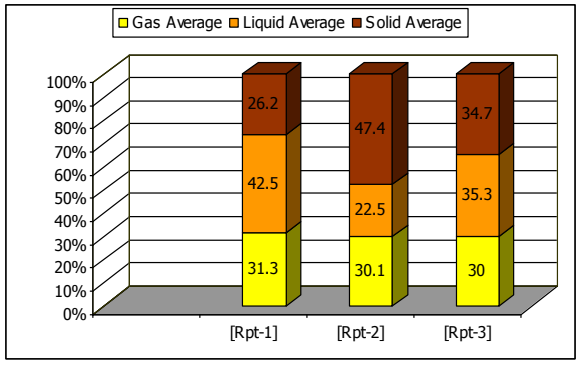

Fig. 3. The product yield averages in 3 phases of [Rpt-1], [Rpt-2] and [Rpt-3] to feeding rate 1.3 - 1.8 kg/hr or 150 - 350 rpm (r min^{-1}).

The analysis of biomass used in the three species was found that the proximate analysis of [Rpt-1], [Rpt-2] and [Rpt-3] showed in the Fig. 4, that composed of a fixed carbon, volatile matter, ash, and moisture**.**

The proximate analysis showed that the fixed carbon of [Rpt-2] and [Rpt-3] over 20 wt.%, was higher than the [Rpt-1] was about 10.48 wt.%, which will have a major effect on the quality of bio-oil as well. The other three proximate analysis were following; The volatiles of the [Rpt-1], [Rpt-2] and [Rpt-3] were 70.03, 60.10 and 59.25 wt.%, respectively., the ashes of [Rpt-1], [Rpt-2] and [Rpt-3] were 13.65, 19.00 and 18.68 wt.%, respectively., the moisture content of the [Rpt-2] and [Rpt-3] less than 1.00 wt.% (0.60 and 0.52 wt.%). The results of the analysis found that the low moisture content and high fixed carbon of [Rpt-2] and [Rpt-3], which were likely to have a good quality bio-oil. In addition, the analysis of raw algae biomass [9] and safflower seed [10],[11] founded that the volatile matter were 79.14 and 83.0 wt.% respectively., and fixed carbon were 15.24 and 14.0 wt.% respectively., indicated that the difference natural material have received the difference value contents by proximate analysis.

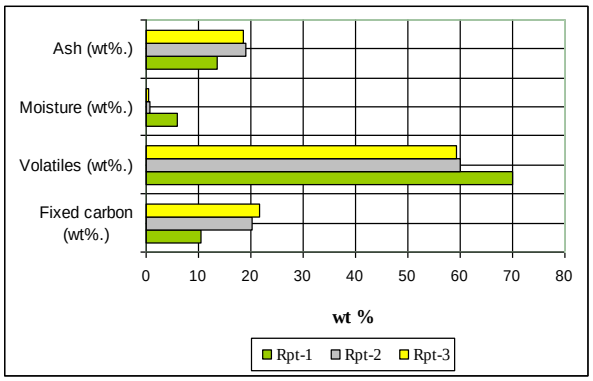

Fig. 4. The proximate analysis of [Rpt-1], [Rpt-2] and [Rpt-3].

However, the results showed that a stability for the range of material compound in [Rpt-1], [Rpt-2] and [Rpt-3], can be synthesized bio-oil in high efficiency on next step, because consist of the high fixed carbon and volatile matter, and low ash and moisture., especially; in the [Rpt-2] and [Rpt-3].

The ultimate analysis of biomass showed that the element contents of [Rpt-1], [Rpt-2] and [Rpt-3] composed of carbon, hydrogen, oxygen, nitrogen and sulfur, [Rpt-1] was found that the carbon content was 53.22 % over the [Rpt-2] and [Rpt-3] which were 30.77 and 29.70 %, respectively., The other

elements can be found the hydrogen in [Rpt-1] was 6.25 % as same the results of [Rpt-2] and [Rpt-3], and the oxygen content in [Rpt-1], [Rpt-2] and [Rpt-3] were 39.28, 63.30 and 64.60 %, respectively. Fig. 5 according to the result of safflower seed showed the carbon, hydrogen, nitrogen, and oxygen of 49.5, 6.9, 3.0, and 40.6, respectively [10].

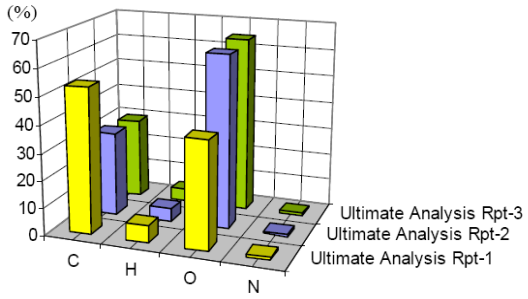

Fig. 5. The element contents of [Rpt-1], [Rpt-2] and [Rpt-3].

The heating value average of bio-oil obtained from [Rpt-2] was 30.50 MJ/Kg, higher than that bio-oil obtained from [Rpt-2] and [Rpt-3] were 27.64 and 29.00 MJ/Kg, respectively., (Figure 6). Indicating that the rate of heat, the bio-oil obtained from the [Rpt-2] was higher to release the heat as much as possible. Studies on the Heating value of biomass as well as three examples of this residual plants. Determination of the optimal conditions for the heat of the bio-oil has a specific temperature [12],[13]-[14].

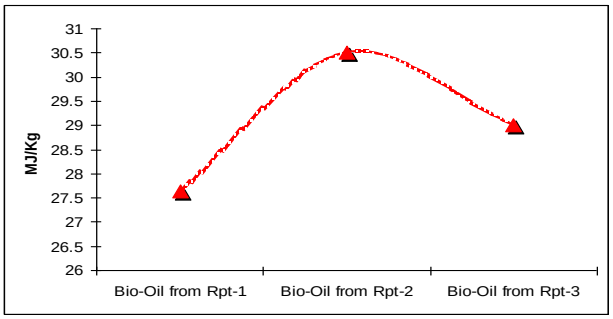

Fig. 6. The heating value average of bio-oil obtained from [Rpt-1], [Rpt-2] and [Rpt-3].

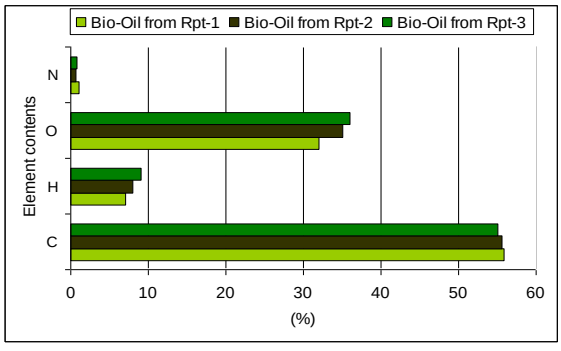

Fig. 7. The element analyses of bio-oil obtained from [Rpt-1], [Rpt-2] and [Rpt-3].

This is one factor that was used in determining the quality of bio-oil obtained from this research in conjunction with other factors in physical and chemical of the compound to be analyzed [7]-[15],[16].

According to the analyzed oil palm stone founded that the heating value average was about 24.93 MJ/Kg [15]., be similar to the result of [Rpt-2] and [Rpt-3].

The element analyses of bio-oil showed that the amount of carbon in the bio-oil obtained from the [Rpt-1], [Rpt-2] and [Rpt-3] same as a result were 55.91, 55.57 and 55.03 %, respectively., that is a good result rather than bio-oil obtained from raw algae biomass about 46.16 % [8], similar a result have been analyzed safflower seed founded that the value of bio-oil components were averaged 63.56 and 23.32 %, of carbon and oxygen, respectively [10],[11]., that moderate to high value. Conversely, the pyrolysis result of safflower founded that carbon was 43.17 wt.%, and oxygen was 48.89 wt.%. Indicating that the bio-oil in this study presented high efficiency for produce the fuel on next step by fractional distillation, because the bio-oil showed the high carbon value [17] and consist of oxygen and hydrogen values on the appropriate standard range, both the element from three residual plants and the element from bio-oil.

IV. Conclusion

Continuous pyrolysis process of biomass for three samples of residual plants of Thailand were analyzed. The element contents of [Rpt-1], [Rpt-2] and [Rpt-3] presented a high carbon content. The heating value of bio-oil from [Rpt-2] was higher than that bio-oil obtained from [Rpt-1] and [Rpt-3], both held that there was in the heating value of high-class or better standards. Of course, the amount of the elemental composition of the oils derived from three residual plants, the concentration of carbon was relatively high in three residual plants. The amount which may be a minor problem in the management of the trial in order to obtain products from biomass, both of which are higher quality. For the purpose that, the bio-oil in three residual plants of resist in Thailand can be used to generate the fuel energy, however; we would like to concern and consider the properties of proximately analysis, reactor temperatures, control the continuous reactor, velocity of screw feeders and elemental compounds for improving a quality of bio-oil and the overall qualities of the continuous pyrolysis reactor is superior to pyrolysis bio-oils.

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Kittiphop Promdee was born in Ubonrachathani Province, Thailand, in 1975. He received the M.S. degree in environmental science from the school of environmental science, Kasetsart University, Bangkok, Thailand, in 2004. He is currently an lecturer with Department of Environmental Science, Chulachomklao Royal Military Academy, Nakorn Nayork, Thailand . His research interests include agricultural residuals, renewable energy, fuel, environmental energy, green and biomass technology and catalytic pyrolysis processes. He is currently pursuing the Ph.D. degree with Inter- Department of Environmental Science, Chulalongkorn University, Bangkok, Thailand.

Tharapong Vitidsant received the B.S. degree and the M.S. degree in chemical engineering from Chulalongkorn University, Bangkok, Thailand. He received the Ph.D. degree from . Institut National Polytechnique de Toulouse (INPT), France, in 1999. He is currently an associate professor with Department of Chemical Technology, Chulalongkorn University. His research interests include renewable energy, fuel energy, catalytic pyrolysis processes and reaction engineering**.**

Supot Vanpeth was born in Nakorn Sri Thammarat Province, Thailand, in 1982. He received the B.S. degree in industrial chemistry from King Mongkut's University of Technology North Bangkok, in 2005 and the M.S. degree in chemical technology from Chulalongkorn University, in 2007. His research interests include renewable energy, fuel energy, slow and fast pyrolysis processes and industrial chemistry**.**

Peerapon Ruengvilairat. was born in Bangkok, Thailand, in 1985. He received the B.S. degree in biology from Mahidol University, Bangkok, in 2010 and the M.S. degree in chemical technology from Chulalongkorn University, in 2012. His research interests include renewable energy, bioenergy and green chemistry**.**