Pyrolysis Temperature Effect on Volume and Chemical Composition of Liquid Volatile Matter of Durian Shell

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Abstract---Durian shell is one of the organic waste that has not been used widely. Durian shell contains cellulose, hemicellulose and lignin thus potentially processed as liquid volatile matter (LVM). The purpose of this study are determine the effect of temperature on volume and compound of LVM durian shell. Durian shell stored from a region producer durian then dried. Farther dry durian shell heated in a pyrolysis reactor on a temperature varied at 400○C, 500○C, 600○C and 700○ C. Smoke from reactor pyrolysis condensed produce a certain volume of LVM. LVM volume durian shell was measured using a measuring cup and content of LVM has been characterized using gas chromatography (GC). Product of LVM durian shell at each temperature pyrolysis yielding different volume although the difference was not significant, respectively 52 ml, 55 ml, 57 ml and 58 ml. Type of compound and the percentage area of durian shell LVM is different at each temperature pyrolysis. LVM durian shell containing ammonia, hexane, acetic acid, propanone, cyclomethanodion, methanol and phenol.

Keywords---pyrolysis, liquid volatile matter, volume, durian shell, and gas chromatography

INTRODUCTION

Indonesia is located on the equator have biodiversity, including fruit plants. One of the fruit plants that can grow in almost all parts of the archipelago is durian. Indonesia durian production of approximately 4.34% from 19,805,977 tons of fruit crops in 2014 [1]. Southeast Sulawesi durian fruit production in the years 2011-2015 reached an average of 9.18 tons/ha/year [2]. Durian fruit consists of 20%-35% fruit pulp, seeds 5%-15%, and the skin around 60%-75% [3]. Production of durian fruit in abundance every year certainly abundant durian shell leaving anyway. Durian shell largely to waste, not fully utilized. Durian shell contains cellulose, hemicellulose, and lignin [4] which is the main component of biomass.

There are several methods of processing biomass, the direct combustion, gasification, and pyrolysis. When compared to direct combustion and gasification, more liquid products produced from pyrolysis [5]. The main components of biomass gradually degraded. Hemicellulose decomposes at a temperature range of 220°C-315°C, cellulose at 315°C-400°C temperature range, and lignin decomposes at temperatures over a wide range of 160°C-900°C [6]. Hemicellulose degraded into compounds acetic acid, furfural, furan, furanone, methanol, formaldehyde, acetone, Acetol, lactone, etc. Cellulose degraded into levoglucosan, hydroxyacetaldehyde, furfural, hydroxymethylfurfuralfuran, methanol, formaldehyde, acetone, Acetol, lactone, etc. Lignin degraded into 2-methoxyphenol, 2,6-di methoxyphenol, cathecols, phenol, alkyl phenol, methanol, furfural, acetid acid, formaldehyde, acetone, Acetol, lactone, etc [7].

Pyrolysis products include charcoal, tar, which can be condensed gas, and gas can not be condensed [8]. Gas that has been condensed hereinafter referred to as liquid volatile matter (LVM). Pyrolysis is performed at a temperature of around 500°C produce LVM as its main product [8]. Pyrolysis sago dregs at three different temperatures, 400°C, 500°C and 600°C produce LVM volume greater when the temperature gets higher, namely 25 ml, 125 ml and 160 ml. [9]. Characterization LVM durian shell using gas chromatography (GC) showed LVM containing acid compounds, furan, piran, phenol and derivatives, alcohol, nitrogen, and esters. Pyrolysis durian peel done at a temperature of 300°C-350°C [5].

The main variables that control LVM yield and characteristics are temperature, rate of heat transfer, particle size, atmosphere of pyrolysis, vapor and particle residence times, and composition of biomass [10].

RESEARCH METHOD

Durian shell taken Mowila Village, District Mowila, Konawe South, Southeast Sulawesi Province. Durian shell that has been collected is cut into pieces with a size of about 2 cm x 2 cm, and then dried under the sun to reduce the moisture content. Drying is done on a sunny day for seven days.

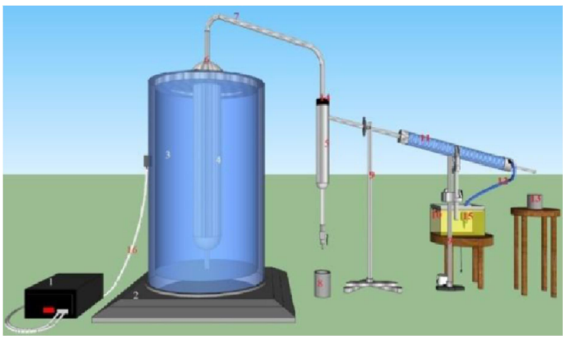

FIGURE 1. PYROLYSIS APPARATUS

Caption :
1.Regulatory currents and temperature
2. Aluminum Foil
3. The heating element
4. Reactor
5. Container tar
6. Cover reactor
7. Channels gas
8. Glass Aluminum
9. poles
10. Air
11. Condenser spiral
12. Hose
13. Glass Measure
14. Connector condenser
15. The water pump
16. Cable Connector

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Durian shell dried, then taken as much as 0.3 kg, is then inserted into the reactor and the reactor sealed. Pyrolysis reactor temperature is set to rise from room temperature to a temperature of 400℃. Once the reactor temperature reached 400℃, the temperature is maintained for 5 minutes. LVM accommodated in a measuring cup. After five minutes passed, thermocouples is set at 27℃ temperature pyrolysis reactor in order to decrease until it reaches room temperature.

LVM volume is measured using a measuring cup. Furthermore, durian shell pyrolysis carried out at a higher temperature, which is 500℃ and 600℃. The chemical composition of durian shell LVM characterized using Cromatography Gas (GC), Gilent brand, type Ms. 5975, column frontier alloy 5 ultra UA-5, column temperature of 450℃, column diameter 30 µm x 250 µm x 0:25 µm, the oven temperature of 160℃/min, injection temperature of 250℃, carrier gas such as helium carrier gas flow rate of 150 µ*l* /min.

The chromatogram shows the relationship the retention time and abundance of durian shell LVM compounds. Evaporation compounds based on their molecular weight. Small molecular weight molecules evaporate first, followed by the molecules of large molecular weight. Each type of compound has a retention time of certain characters, so this type of building blocks of durian shell LVM can be interpreted based on the retention time.

RESULT AND DISCUSSION

The condenser is integrated in the device pyrolysis. In the reactor, durian shell that has been heated to high temperatures turn into charcoal. The heating process durian shell in addition to producing charcoal, also produces tar and gas. Tar is heavier than gas so more easily trapped in tar disposed of, as shown in Figure 1. Meanwhile, the gas moves in the condenser temperature averages 29°C. Durian shell pyrolysis gases which can be condensed and there are some that can not be condensed. Gas that has been condensed out of the output condenser in liquid form.

a. Effect of Pyrolysis Temperature on LVM volume of Durian Shell

Pyrolysis durian shell has been performed three times. Whenever the pyrolysis temperature is different, each 400℃, 500℃ and 600℃. Whenever pyrolysis generates LVM with a certain volume, respectively 52 ml, 55 ml, 57 ml and 58 ml. Pyrolysis temperature graph and LVM volume is shown in Figure 2. Based on the graph, the higher the volume of pyrolysis skin durian, durian shell then LVM volume increases. High-temperature pyrolysis which causes a disconnection of hydrocarbons from the compounds making up the polymer raw material. The higher the heating temperature, the decomposition of raw materials more perfect. At high temperature the greater the LVM volume because it has generated a large amount of smoke in the process. At a temperature of 400℃, 500℃ and 600℃ durian shell get a large enough amount of heat that causes the components of durian shell more and more degraded and the smoke is condensed into LVM.

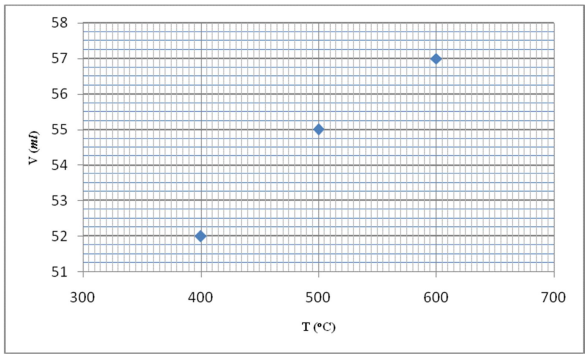

Figure 2. Plot of pyrolysis temperature vs. Volume of lvm produced by pyrolysis

b. Effect of Pyrolysis Temperature on LVM compound Durian Shell

Hemicellulose, cellulose, and lignin of durian shell degraded forming smoke. A few of smoke uncondensed and most of them condensed to be LVM. LVM characterized by gas chromatography. Result of characterization is chromatogram which plotting between retention time and abundance of compounds in durian shell LVM. Compounds of LVM produced at every temperature of pyrolysis listed in Table 1 below.

LVM resulted at pyrolysis temperature 400℃, 500℃, and 600℃ same in some types of chemistry component, although different some other in types, abundance, and amount of compound. It is suspected due to the time required to reach the maximum temperature varies. Different time allows heating rates also vary. Beside temperature, heating rates one variables that control LVM yield and characteristics.

Ammonia have been widely used as test gas in sensor gas ammonia research [12], treated be urea as fertilizer in agriculture, and cleaning up in certain doses. Acetic acid in LVM has been widely used as a preservative in fishery products [13].

LVM resulted at pyrolysis temperature 400℃ and 500℃ yielding 23 compounds, respectively, meanwhile at 600℃ yielding 21 compounds. Ammonia and acetid acid are dominan on every temperature pyrolysis, although there is a little difference in abundance. Other compound which appear in every LMV resulted are 2-propanone, 1-hydroxy, phenol and its derivatives, 2-cyclopenten-1-one, 2-hydroxy-3-methyl, 2-cyclopenten-1-one, 3-ethyl-2-hydroxy, with percentage less than 10. Acetone only appear at LVM heated at 500℃ with abundance comparable to ammonia and acetid acid. Other compounds present with a percentage of less than 10 percent .

Acetid acid content is relatively abundant in the LVM durian shell. Acetid acid can be used as an antibacterial and anti-microbial. The antimicrobial properties of LVM will increase if there is acetid acid together with phenol [11]. LVM durian shell contain some phenol and its derivatives. LVM

can used for various purpose. If pyrolysis followed by fractional distillation every compound will be obtained separately.

Table 1. Compounds of lvm produced at every temperature of pyrolysis

RT (min)	Compounds of LVM	Area (%)		
		400°C	*500°C*	*600°C*
1.92	Ammonia	29.49	17.56	23.10
1.93	methanol		7.61	
1.96	1-propanol, 2-amino			2.52
2.15	Acetone		16.84	
2.15	2-propanone	0.61		
2.65	2-pentanone	0.83		
2.73	Hexane	18.17		17.90
2.98	acetid acid	13.75	19.88	18.82
3.56	2-propanone, 1-hydroxy	8.39	9.79	10.59
6.21	1-hydroxy, 2-butanone	1.51		
8.93	2-furancarboxaldehyde	2.06		
9.77	2-furylmethanol	2.85		2.84
9.77	2-furanmethanol		2.62	
11.40	Butyrolactone	1.51		
11.40	2(3H)-furanone, dihydro		2.48	1.87
12.69	2-cyclopenten-1-one, 3-methyl-2-hydroxy	0.67		
12.69	3-methy-2-cyclopenten-1-one		0.87	1.02
13.12	Phenol	0.87	0.92	1.12
13.63	Furan, tetrahydro-2-(methoxymethyl)	1.30		0.83
13.63	hexano-dibutyrin		0.85	
14.04	2-cyclopenten-1-one, 2-hydroxy-3-methyl	1.87	2.81	3.25
14.59	phenol, 2-methyl	1.43	1.31	1.61
14.96	phenol, 3-methyl		1.14	
14.96	phenol, 4-methyl	1.95		1.37
15.24	phenol, 2-methoxy	4.28	2.33	2.47
15.30	L-Alanine	1.95		
15.30	Glutaraldehyde		2.00	
15.31	3,3-dimethyl-4-methylamino-butan-2-one			1.59
15.75	2-cyclopenten-1-one, 3-ethyl-2-hydroxy	0.93	1.37	1.41
16.97	1-hydroxy-2-methoxy-4-methylbenzen	0.36		0.61
16.97	phenol, 2-methoxy-4-methyl		0.04	
17.01	1,2-benzenediol		0.06	1.18
18.03	1,2-benzenediol, 3-methoxy		0.90	
18.27	guaiacol, 4-ethyl		1.00	
18.27	Benzeneethanol, 2-methoxy			1.19
18.41	Benzocyclooctene		2.00	
18.60	Benzeneacetid acid, 4-hydroxy-3-methoxy	1.34		
19.27	phenol, 2,6-dimethoxy	3.87	5.59	4.69
Total Area (%)		99.99	99.95	99.98

CONCLUSION

Volume of LVM durian shell tend increase from pyrolysis temperature 400 ℃ to 500℃ and 600 ℃. LVM durian shell contain some same type, some different type, and amount of compounds at pyrolysis temperature 400 ℃, 500 ℃, and 600 ℃.

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