Characterization of Liquid Smoke From Coconut Shell Based Pyrolysis Process

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Abstract: Liquid smoke produced from coconut shell by pyrolysis process. The pyrolizermade of a 12 kg gas tube that is rust resistant and can be dismantled.The aimed of this research was to explore the liquid smoke characterization of coconut shell by pyrolysis process.The result showed that yield of pyrolysis from coconut shell is 46.02%.Chemical components of liquid smoke which is produced via pyrolysis of coconut shell has been analyzedusing gas chromatography mass spectroscopy (GC-MS).The results identified as many as 48 chemical compounds that exist in the liquid smoke coconut shell.Overall, phenol, ammonium acetate and furfural were the highest concentration of chemical obtained in this research.

Keywords: Coconut Shell, Pyrolysis, Liquid Smoke, Chemical Compound.

1. Introduction

Coconut is a tropical plant that is often called "Tree of Life" or "Tree of Heaven" because this plant has many uses and most important economic value from fruit to roots. According to the data from (Dirjenbun, 2016)coconut production in Indonesia reached 2.9 million tons.In line with the increase of coconut production from year to year, on the other handalso increase the volume of waste generated.

Coconut shell is one of the waste from coconut. The smallest percentage of coconut shells is 12% of the weight of whole coconut. Coconut shells have a hard texture because of lignin, cellulose and hemicellulose as their component. Coconut shells have been widely used for the manufacture of charcoal and activated charcoal. One of the alternative technologies that can be used to treat coconut shell waste is pyrolysis method(Darmadji, 2002; Devison, 2015).

The charcoal industry in Indonesia currently only prioritizes charcoal as its product while the remaining 70-80% is in the form of vapor or gas waste dumped freely into the air as pollutants. Efforts to increase the added value of products from smoke to environmentally friendly have been done with the research utilization of changing smoke in liquid form called wood vinegar or liquid smoke(Nurhayati, T., 2005).

Pyrolysis is one of the few biofuel technologies that can handle a range of biomass feedstocks (agri-residues, forest residues, energy crops, municipal solid wastes). It is an attractive option for expanding the possibilities of using less desirable biomass. Pyrolysisis a combustion processwithout oxygen which one in the process will convert the contentoflignocellulose in biomass into liquid, charcoal and gas products (Roy and Dias,

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2017). The proportion of these three products depend on pyrolysis method, biomass characterization and reaction parameters (Hermanto and Farizy, 2014). The flexibility of pyrolysis to generate solid, liquid and gaseous as a combination of products was interesting to study about variations of operating parameters (Czajczyńska *et al.*, 2017). Typically,apyrolizer consists of a reactor, cyclone and condenser. Biomass is fed into the reactor and converted into different products via variousthermochemical reactions.

To produce a qualified liquid smoke and optimal liquid smoke yield was required a pyrolizer that can increase the quantity and quality of liquid smoke.

The pyrolizer designed by the previous researcher is in the form of a cylindrical column derived from a stainless steel plate, an oil drum that is generally easy to rusty. The previous design was madepyrolizer from stainless steel plate, tool capacity for coconut shell, coconut husk and rice husk each 1.25; 0.45; and 0.32 kg/hour (Syafri, E danNovita, S. A., 2011). Developed a liquid smoke-generating device of rice husk, 2-hour pyrolysis and produced a volume of 1,3 % of liquid smoke(Putri, Mislaini and Ningsih, 2015).

To increase the economic value of the coconut shell the researcher was interesting to process it into liquid smoke using a pyrolizer from a 12 kg gas tube and studying the chemical content of liquid smoke.

2. Materials And Methods

2.1 Raw Material

Coconut shells were obtained from Padang, West Sumatra, Indonesia. They were cleaned from the remaining coconut husk and the flesh of fruit, cut into small size ± 2x3 cm andthen sun-dried for a week.

2.2 Research Methods

The research method was done by literature study on the design of pyrolizerfrom previous researchers. The combustion process takes 5.5-6.5 hours and obtained liquid smoke yield of coconut shell 21.74% from pyrolysis design of 3 mm thick stainless steel plate with 50 cm in diameter and 80 cm in height(Syafri, E dan Novita, S. A., 2011). The performed a 60 kg pyrolysis design, 60 cm in diameter and 90 cm in height obtainedyield of liquid smoke for coconut shell was 43,93%(Devison, 2015). Based on the research results, experiments were conducted to design a liquid smoke device that is portable, and stainless. The manufacture of aliquid smoke makers consists of pyrolysis tube, smoke distribution pipes, cooling pipes, liquid water cooling drums, and liquid smoke containers.

Stagesin the manufacture of liquid smoke from various types of agricultural waste materials usingexperimentalmethods.Each treatment was performed with two replicates on each feedstock.Each raw materialfilled as much as 2/3 of the tube height and tightly sealed and pyrolysis process is done until no more condensation liquid drips.

2.3 Laboratory Analysis

Chemical analysiswas done by using Spectrofotometry and Gas Chromatography method using GC-MS brand Shimadzu QP 2010 plus with operational condition of injection temperature 210°C, column temperature 100°C, temperature rise10°C/min, helium carrier gas, pressure 111 Kpa , Rtx_5MS column type (30m x 0.25mm).

3. Results And Discussion

3.1 Design of Pyrolizer

Pyrolizer is a device to produced liquid smoke, a series of liquid smoke makers consisting of pyrolysis tubes, smoke distribution pipes, condensers, and liquid smoke containers. Pyrolizerwas modified to get a portable and stainless results. It also obtained the maximum yield of liquid smoke.

Capacity productionof pyrolizer is for 6 kg coconut shell. The specification of pyrolizer are: pyrolysis tube made from 12 kg of LPG gas tube which is cut at the top and added chimney on top. Size of tube was diameter 28 cm, tube height 38 cm and volume 23.3 liter. The condenser is a spiral pipe that was inserted into a drum containing water.The pipe used is made of 2mm thick stainless steel, 0.75 inch diameter, 35 cm spiral coil diameter and 9 spiral circumference. The smoke distribution pipes are made of stainless steel pipes 2mm thick, 0.75 inches in diameter and 1.75 m long.

3.2 Pyrolysis Results

The gas obtained is a gas thatcannot be condensed by the condenser. It was cannot be accommodated in a liquid container. Some of these gases are trapped inthe container while others go through the pipes into the atmosphere. The volatile components include CO_2, CO, CH_4 andother low-level hydrocarbons.

Table 1: Yield of Coconut Shell Pyrolysis for 5 Hours

Biomass	Weight of Material (kg)	Temp Max (ºC)	Pyrolysis Products			
			Liquid Smoke (%)	Ter (%)	Charcoal (%)	Missing Materials (%)
Coconut Shell	6	220	46,02 ± 1,37	8,34	36,71	8,93

The yield of coconut shell pyrolysis can be seen in Table 1.Liquid smoke product from this study was dark brown. Liquid smoke started out in the process of pyrolysis at minute 24 with a temperature of 95ºC, while in the 7th minute that came out only smoke with a temperature of 65ºC.

Once decanted for 1 week formed two layers in the liquid smoke liquid. The brownish top layer is a liquid smoke and a thick black undercoat is a tar. Based on Table 1, the average yield of liquid smoke produced in the process of coconut shell pyrolysis from modified gas cylinders at 220ºC for 5 hours is 46.02%. Therefore the yield of liquid smoke produced by pyrolysis from the experiment has reached the maximum yield. This result is more than previous pyrolizer design made by (Devison, 2015) with a yield of 43.39%.

3.3 Characterization of Compounds in Liquid Smoke Using GC-MS

GC-MS analysisperformed to determine the chemical content contained in coconut shell liquid smoke. The depiction of a curved chromatogram pattern as a function of time for gas chromatography and spectrogramming is in the form of line spectra for mass spectrometry showing the mass spectral pattern of fragmentation results from the sample molecules.

Figure 1 showed a chromatogram of coconut shell liquid smoke. The peak appeared at the retention time of 1.385 - 19.460 minutes and identified 48 compounds. The compounds are suspected to have the names and structures as listed in Table 2. The most common chemical content of liquid smoke is phenol followed by ammoniumacetate and furfural. The same result for the phenolic content of the palm shell is 21.02% (Haji, 2013). Phenolic compounds of liquid smoke from Lamtoro and Corn cob were: 481,2 ppm and 335 ppm (Swastawati, 2007). Identification of GC-MS of cacao shell could provide compounds that mostly derived from acetone 13.01%, acetate acid 73,86%, 2buthanone 6,60%, methyl ester 2,46%, and propanoic acid 4,07% (Hermanto and Farizy, 2014).

Phenol in smoke is one of thermal degraded results of lignin in wood. Pyrolysis of hemicellulose will produce furfural, furan and its derivatives together with long chains of carboxylic acids while hemicellulose pyrolysis together with cellulose to form acetic acid and homologous. The second pyrolysis reaction of cellulose forms acetic and homologous acids together with water and sometimes together with lignin to form furan and phenol (Darmadji, 2002).

4. Conclusions

From this study can be concluded that the design of pyrolizer from gas tubes of 12 kg can produced maximum yield for liquid smoke. Pyrolizer was modified to get a portable and stainless results. The yield of liquid smoke from coconut shell was 46,02%.

GC-MS indicated that chemical componets of coconut shell liquid smoke consists of 48 compounds. Chemical components with the highest concentration are phenol, ammonium acetate and furfural

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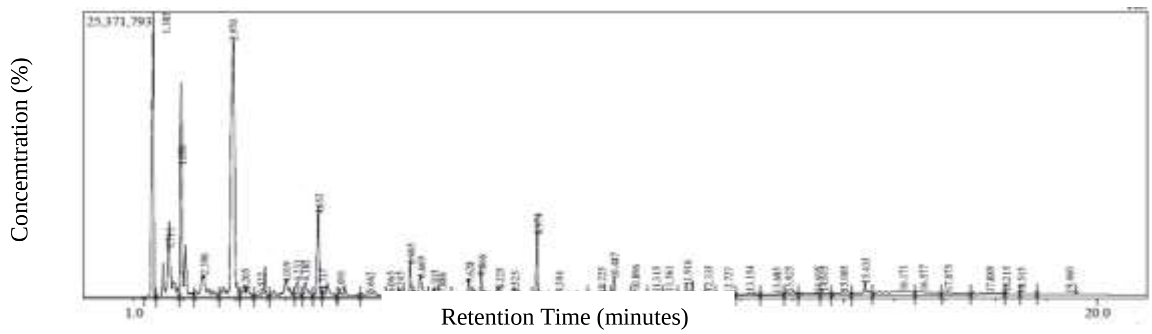

Fig. 1. Chromatogram of Liquid Smoke from Coconut Shell

Table 2. GC-MS Analysis of Liquid Smoke from Coconut Shell

Peak Number	Retention Time (minute)	Chemical Content	Concentration (%)
1	1.385	Ammonium acetate	11.19
2	1.713	1-Hydroxy-2-butanone	5.94
3	1.950	Furfural	11.05
4	2.390	V Butyrolactone	3.56
5	2.970	Phenol	21.80
6	3.205	2H-Pyran-2-one, 5,6-dihydro-3,5,5-trimethyl-	1.43
7	3.527	l-Felinine	1.60
8	4.019	Phenol, 2-methyl-	2.60

Peak Number	Retention Time (minute)	Chemical Content	Concentration (%)
9	4.233	2-Furanmethanol, tetrahydro	1.05
10	4.385	Phenol, 3-methyl-	1.17
11	4.652	Phenol, 2-methoxy-	4.10
12	4.737	2-Cyclopenten-1-one, 3-ethyl-2-hydroxy-	1.36
13	5.091	Maltol	1.06
14	5.662	Ethanone, 1-(6-methyl-7-oxabicyclo[4.1.0]hept-1-yl)-	1.09
15	6.065	Phenol, 4-ethyl-	0.55
16	6.245	Phenol, 3,4-dimethyl-	0.24
17	6.465	Phenol, 2-methoxy-4-methyl-	1.62
18	6.669	1,2-Benzenediol	1.97
19	6.935	,4:3,6-Dianhydro-.alpha.-d-glucopyranose	0.49
20	7.086	2-Furancarboxaldehyde, 5-(hydroxymethyl)-	0.45
21	7.628	1,2-Benzenediol, 3-methoxy	1.24
22	7.866	Phenol, 4-ethyl-2-methoxy-	2.14
23	8.225	1,2-Benzenediol, 4-methyl-	0.96
24	8.525	Menthyl salicylate	0.72
25	8.974	Phenol, 2,6-dimethoxy-	4.59
26	9.394	Dodecane, 1-bromo-	0.69
27	10.225	Benzoic acid, 4-methoxy-	0.14
28	10.487	Trimethoxybenzene	1.02
29	10.896	Methylparaben	0.43
30	11.315	Ethanone, 1-(4-hydroxy-3-methoxyphenyl)-	0.25
31	11.561	D-Allose	0.26
32	11.916	Benzene, 1,2,3-trimethoxy-5-methyl-	1.61
33	12.335	beta.-d-Ribopyranoside, methyl, 3-acetate	0.31
34	12.727	2H-1-Benzopyran-2-one, 8-hydroxy-	0.43
35	13.154	Phenol, 2,6-dimethoxy-4-(2-propenyl)-	0.74
36	13.685	Benzenemethanol, 2-methyl-.alpha.-phenyl-	0.61
37	13.925	2(3H)-Naphthalenone,4,4a,5,6,7,8-hexahydro-4a-	0.62
38	14.495	methyl-	0.75
39	14.615	Dihydroartemisinin, 10-O-(t-butyloxy)-	0.38
40	15.005	Phenol, 2,6-dimethoxy-4-(2-propenyl)-	0.78
41	15.435	Ethanone, 1-(4-hydroxy-3,5-dimethoxyphenyl)-	1.31
42	16.171	Desaspidinol	2.23
43	16.577	Ethanone, 1-(4-hydroxy-3,5-dimethoxyphenyl)-	1.20
44	17.075	Heptasiloxane,	0.90
45	17.889	Hexadecanoic acid, methyl ester	0.69
46	18.215	n-Hexadecanoic acid	0.21
47	18.515	Tetradecanoic acid	0.14
48	19.460	3,5-Dimethoxy-4-hydroxycinnamaldehyde	0.16
		Octasiloxane	

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