Distillation of Agarwood Oil (*Aquillaria sp*) using Photovoltaic Methods

Nelly Safitri[1], Teuku Rihayat[2], Suryani[2], Shafira Riskina[2], Rudi Saputra[1], Aida Safitri[2], Tjut Yayang Risqatia Hasnah[2], Kiki Yolanda Putri[3] and Yuhanis Yunus[3]
[1]*Departement of Electrical Engineering, Politeknik Negeri Lhokseumawe, 24301, Aceh Indonesia*
[2]*Department of Chemical Engineering, Politeknik Negeri Lhokseumawe, 24301, Aceh Indonesia*
[3]*Department of Civil Engineering, Politeknik Negeri Lhokseumawe, 24301, Aceh Indonesia*

Keywords: Agarwood, Solar Cell, Water Content, Hydro Distillation.

Abstract: The use of solar light is currently used as one of the renewable energy by utilizing sunlight, or commonly called photovoltaic (PV). One of the technologies related to the application of solar panels to energy by converting sunlight into electricity is called photovoltaic. The amount of solar energy that can be absorbed depends on the cell size and absorption of solar cells on sunlight. Solar panels are known as WP (Watt peak) where this amount is the maximum power produced by each panel unit with a capacity of 100 watts/hour, size 1200 mm x 550 mm with a thickness of 35 mm. The battery used is 12 Volt 200 Ah, and the heater used is 2000 Watt. Agarwood crust is obtained from the *Aquillaria malaccensis* tree, which is then soaked for 14, 16, 18, 20 and 22 days respectively. The best results of soaking are at 14 days, during which the immersion process has expanded and finally broken, so that water enters the cell wall through diffusion and increases turgor pressure. Soaking water becomes more acidic over time and damages the cell wall. This causes the process of increasing cell wall destruction. However, a longer immersion time causes more oil content to be wasted into soaking water. It was concluded that the most suitable immersion time for extracting agarwood oil was 14 days. The results showed that high oil yield was obtained from oil extracted with a 10 hour hydro distillation sample (0.44% analysis water content). Analysis of chemical compounds using GC-MS showed a typical compound of agarwood namely Guaiol with the highest value 4.10% (GC-FID) and 1.95% (GC-MS). Guaiol was used as a parameter to determine the quality of essential oils produced from the distillation process that has been carried out because the area produced from the test results has an area greater than other components contained in essential oils.

1 INTRODUCTION

Energy is the ability to do work. Energy is a force that can be used to carry out various processes of activities using mechanical energy, heat, and others. Therefore, almost everyone in the world, based on energy sources. There is some natural energy as alternative energy that is not polluted, safe and collected not limited to what is known as renewable energy [1]. New energy sources and resources that are renewed in the future will increasingly have a very important role in meeting energy needs. This is due to the use of fossil fuels for conventional power plants for a long time to drain oil, gas and coal sources whose reserves are depleting [2].

In Indonesia, which is located in the tropics it actually has a considerable advantage, namely receiving continuous sunlight throughout the year. Unfortunately, energy seems to be left in vain only for natural needs [3]. In addition, solar energy can be utilized with the help of other equipment, namely by converting solar radiation to other forms. There are two kinds of ways to convert solar radiation into other energy, namely through solar cells and collectors [4]. There is no doubt that solar energy is an environmentally friendly energy source and is very promising in the future because there is no pollution produced during the energy conversion process, and also many energy sources available in nature [5].

Safitri, N., Rihayat, T., Suryani, ., Riskina, S., Saputra, R., Safitri, A., Risqatia Hasnah, T., Putri, K. and Yunus, Y.
Distillation of Agarwood Oil (Aquillaria sp) using Photovoltaic Methods.
DOI: 10.5220/0008853300570062
In *Proceedings of the 1st International Conference on Chemical Science and Technology Innovation (ICOCSTI 2019)*, pages 57-62
ISBN: 978-989-758-415-2

The sun is a potential energy source for human needs, where energy can be obtained from heat that moves to the surface of the earth, or light that falls to the surface of the earth. From several studies mentioned that by changing sunlight, especially the intensity of the sun with PV can be used as a source of electrical energy for human consumption. The choice of renewable energy sources is very reasonable considering the supply of solar energy from sunlight received by the earth's surface reaches 3 x 1024 joules per year [6]. The amount of energy is equivalent to 10,000 times the energy consumption in the world today. In Indonesia, the abundance of sunlight distributed evenly and can be captured throughout the Indonesian archipelago for most of the year is a potential source of electrical energy[7]. Renewable energy has a very important role in meeting energy needs, given the abundant source [8]. This problem because the use of fuel for conventional power plants over a long period of time will deplete oil, gas, and coal sources which are running low and can also cause environmental pollution. Wrong the only effort that has been developed is the Solar Power Plant (PLTS).

Solar energy can be applied to produce heat energy through solar heat collectors (SC) and produce electrical energy through PV collectors. At present, it is common practice to install it in two separate solar collectors, one for solar thermal collectors and one for photovoltaic modules[9]. Thermal photovoltaic / hybrid (PV / T) systems are the integration of photovoltaic and solar thermal components. This produces electricity and heat from a combined system [10]. It consists of a conventional heat collector with an absorbent which is covered by a layer of PV. PV modules produce electricity, and simultaneously the heat energy absorbed is transported by the working fluid [11].

In the industrial world, distillates of essential oils are known as perfume seeds. The process of extracting and refining essential oils requires equipment at very expensive prices, so that essential oils do not become a household industry with a small scale of production. This essential oil is used in food, medicine, and cosmetics, etc. So for this reason, it is necessary to develop alternatives to develop PV technology that is environmentally friendly in the process of refining essential oils. This PV installation has many advantages, said to be an overall increase in efficiency, lower production and installation costs, and less space requirements[12].

Therefore, the purpose of this study is to improve the extraction efficiency of oil obtained from different extraction methods and to identify optimal parameters of agarwood extraction. The stages carried out in this study were materials and tools, refining techniques, photovoltaic methods, and chemical analysis using *Gas Chromatography-Flame Ionization Detector* (GC-FID) and *Gas chromatography with Mass Spectrometry* (GC-MS).

2 MATERIALS AND METHOD

2.1 Plant Material

Agarwood crust from the *Aquillaria malaccensis* stem used in this study was obtained from Keuramat, North Aceh intersection, water, and a set of hydro distillation devices.

2.2 Optimization Technique

The technique used in this distillation process is hydro distillation process. In this case, the sample size and immersion time as a control to get the maximum value from the optimal parameters. Agarwood samples are initially ground into powder using a grinding machine (FRITSCH). Agarwood samples were immersed in 1 liter glass with sample variations of 14, 16, 18, 20 and 22 days respectively. Samples were distilled using photovoltaic technology for approximately 6 hours a day.

Hydro distillation: 15-liter distilled water is poured into the kettle. 1000 g of agarwood powder is put in the kettle. Turn on the heater until it reaches 100^{o}C. After the distillation time is complete, the process is stopped. Water and essential oils from separate funnels. After the water and oil are separated 1 hour apart, the essential oil is taken above the separating funnel. Extraction is done in triplicate and the average oil is calculated. The oil is then stored in a closed container under the coolant before being analysed by chromatography.

2.3 Photovoltaic Methods

Solar panels used for distillation of essential oils are 1000 WP (peak watts) in this case 6 panels are needed. The battery capacity is 15 Volt 200 Ah, the number of batteries used for this essential oil distillation process is 11 batteries. A 2,000-watt power heater is used as a heater to agarwood oil distillation. Then an inverter (AC-DC current converter) is needed with a capacity greater than 2125 watts [13].

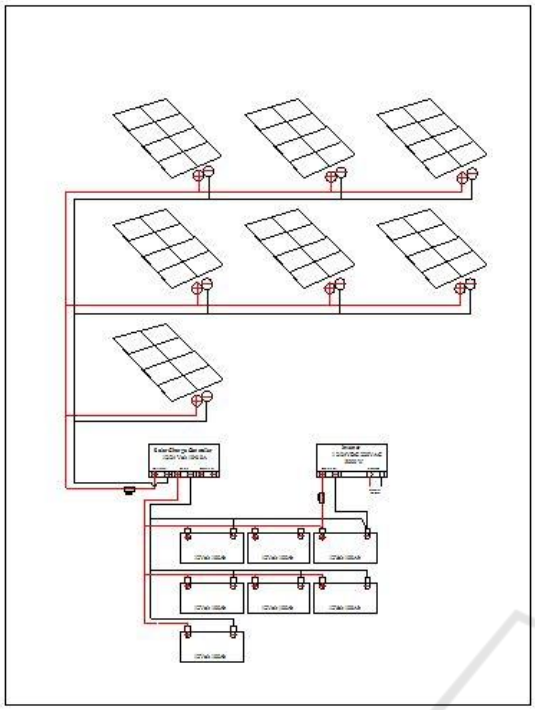

Figure 1: Photovoltaic design.

PV designs is arranged in series and is not connected to the grid. This system is installed on the rooftop of the house, PV takes energy from the sun and the inverter converts it into electrical energy. The energy is used to run equipment or charge the battery. When solar panels do not produce energy, then the battery can be used.

Grid-connected PV is a smart grid system, which includes PE, such as a DC / DC converter that can guarantee maximum solar energy harvested through maximum power point tracking control (MPPT), and converters used to connect PV to the network [14].

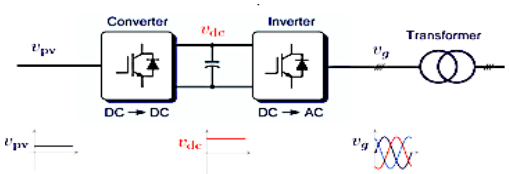

Figure 2: PE through grid-connected PV system.

Figure 1 illustrates the PE that commonly used for the grid-connected PV system. The inverter extracts as much DC voltage as possible from the PV array and converts it into clean mains AC voltage at the right frequency for feeding into the grid or for supplying domestic loads at the customer sides[15].

2.4 Chemical Analysis

Chemical constituents of agarwood oil were obtained by two GC-FID chromatographic techniques (Agilent 7890A) and GC-MS (Agilent 7890A). GC-MS was attached to a mass spectrometer (Agilent 5975C) using a DB-1MS capillary column (30 x 0.25 mm ID film thickness of 0.25µm). Both chromatographic techniques are the same in operating conditions. The temperature of the injector and detector was determined at 250°C. The temperature of the oven was programmed at 60°C for 3 minutes, increasing at 3°C / minute to 240°C and then increasing for 10 minutes. Helium as a gas carrier is determined at a flow rate of 1.2 mL / minute. The sample volume injected was 1.0µL. Components are supported by retention indices and mass spectra with disputed data [16] and are in accordance with the library of the National Standard Technology Institute (NIST). The GC-FID instrument is equipped with a flame ionization detector (FID) and detector in full scanning mode under ionization of electron concentration (EI, 70eV) used in GC-MS [17].

3 RESULT AND DISCUSSION

Pre-treatment process in extracting essential oil is an important step. Previous studies showed several methods for pre-treatment of plant samples before extraction such as immersion in water, chemical treatments, sonication, and microwave treatments [9]. This research continues the previous research that has been done. In this study, the immersion process of agarwood powder was carried out with time variations of 14,16,18,20 and 22 days and distillation times of 8, 9 and 10 hours respectively, so that the water obtained can be seen in table 1.

Table 1: Water content value of soaking agarwood oil.

Distilation time (hours)	Water content analysis (%)				
	Soaking time (days)				
	14	16	18	20	22
8	0.54	0.61	0.68	0.77	1.03
9	0.59	0.74	0.85	0.9	1.11
10	0.44	0.57	0.73	0.84	1.21

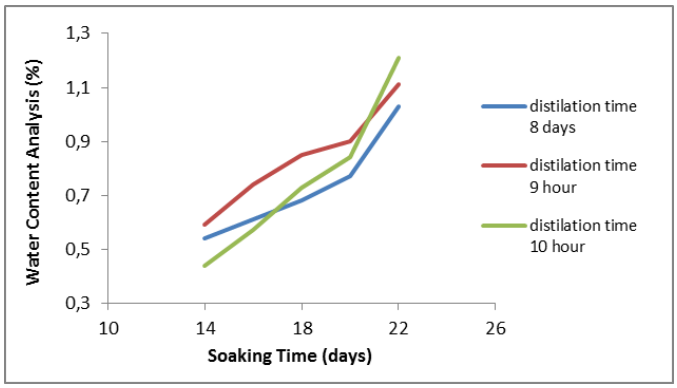

Figure 3: Graph Water Content Analysis.

From the analysis of water content shown in table 1, the highest water content was obtained at 10 hours of soaking time with 22 days which was 1.21% which identified the produced agarwood oil to be of Poor quality, while the lowest water content in distillation was 10 hours with 14 days immersion which is 0.44%. The following are the results of the graph plot of the data of agarwood immersion water content values.

During the immersion process, the cells have expanded and eventually ruptured, releasing the agarwood content into the soaking water[18]. Water enters the cell wall through diffusion and increases turgor pressure. Soaking water becomes more acidic over time and damages the cell wall. This causes a process of increasing cell wall damage. However, a longer immersion time causes more oil content to be wasted into soaking water[19].

Table 2: Chemical Components Abundances (%) From GC-MS Analysis.

No	Chemical Compounds	Abundances (%)				
		S14	S16	S18	S20	S22
1	α- Guaiene	5.8	9.79	3.49	4.41	2.8
2	β- Selinene	4.9	16.9	9.06	4.72	13.6
3	α-Muurolene	3.3	3.98	6.09	9.11	0.9
4	γ- Gurjunene	1.09	1.45	2.30	7.43	3.30
5	Guaiol	4.10	5.32	3.98	2.01	2.11

The table above is a tabulation of chemical composition analysed using GC-MS tools in agarwood oil samples using the photovoltaic method with immersion times of 14,16,18,20 and 22 days, respectively. Based on the results of analysis using GC-MS it was found that there were 5 compounds namely α- Guaiane, β-Selinene, α-Muurolene, γ-Gurjunene and Guaiol as a significant chemical composition for agarwood oil and could be used as compound markers in classifying agarwood oil [18]. Based on the table, it can be seen that oil samples with immersion times 14 days are more effective in producing better oil quality.

Indicators that can be assessed from GC-MS analysis can be seen in a line pattern that shows the intensity of detected component compounds.

Table 3: Chemical Components From GC-MS Analysis.

No	Compound	S14	S16	S18	S20	S22	Identification
1	β- maaliene	0.4	9.21	1.28	1.02	0.7	GC,FID
2	α- Guaiene	5.8	2.79	3.49	4.41	2.8	GC,FID
3	Aromsdendrene	-	3.90	2.11	3.56	0.9	GC,FID
4	Panasinsen	0.7	0.26	2.61	2.93	-	GC,FID
5	β- Selinene	4.9	6.9	9.06	4.72	13.6	GC,FID
6	α- Muurolene	3.3	2.98	6.09	9.11	0.9	GC,FID
7	γ- Guaiene	-	-	5.00	5.09	1.74	GC,FID
8	γ-Eudasmol	-	1.08	0.97	9.54	2.6	GC,FID
9	γ- Gurjunene	1.09	0.45	2.30	7.43	3.30	GC,FID
10	Guaiol	1.95	1.06	1.92	2.01	2.11	GC,FID

There are several compounds obtained through GC-FID testing namely β-maaliene, α-Guaiane, Aromadendrene, Panasinen, β-Selinene, α-Muurolene, Gu-Guaiane, γ-Eudasmol, γ-Gurjunene and Guaiol using GC-FID detectors. This fact shows that the ionization detector contains more chemical components than other methods. Soaking time in 14 days is more effective in producing better oil quality than others. All the processes carried out, photovoltaic technology was successfully carried out on refining essential oils, one of which was agarwood oil. Where data acquisition proved significant.

4 CONCLUSIONS

This study is can be concluded as follow, the best oil is obtained from the results of immersion at 14 days, which is 0.44% of the water content. Then through the results of analysis using GC-MS and GC-FID obtained 5 compounds namely α-Guaiane, β-Selinene, α-Muurolene, γ-Gurjunene and Guaiol, respectively, as a significant chemical composition for agarwood oil and can be used as a marker of compounds in classifying agarwood oil, whereas 14 days are more effective in producing better oil quality than others. All the processes carried out, throughout the photovoltaic technology was successfully carried out on refining essential oils, one of which was agarwood oil. Where data acquisition proved significant.

ACKNOWLEDGEMENTS

The author would like to thank the Directorate of Student Affairs and Education for Research and Higher Education Technology in Indonesia and the research and community center of Politeknik Negeri Lhokseumawe.

REFERENCES

N. Katayama, S. Osawa, S. Matsumoto, T. Nakano, and M. Sugiyama, “Solar Energy Materials and Solar Cells Degradation and fault diagnosis of photovoltaic cells using impedance spectroscopy,” *Sol. Energy Mater. Sol. Cells*, vol. 194, no. January, pp. 130–136, 2019.

I. Mathews, S. N. Kantareddy, T. Buonassisi, and I. M. Peters, “Technology and Market Perspective for Indoor Photovoltaic Cells,” *Joule*, pp. 1–12, 2019.

L. Hernández-callejo, S. Gallardo-saavedra, and V. Alonso-gómez, “A review of photovoltaic systems : Design , operation and maintenance,” *Sol. Energy*, vol. 188, no. June, pp. 426–440, 2019.

H. Fu, G. Li, and F. Li, “Performance comparison of photovoltaic / thermal solar water heating systems with direct-coupled photovoltaic pump , traditional pump and natural circulation,” *Renew. Energy*, vol. 136, pp. 463–472, 2019.

P. Gonçalves, V. Sampaio, M. Orestes, A. González, R. Monteiro, D. Vasconcelos, M. Aylla, J. Carlos, D. Toledo, J. Paulo, and P. Pereira, “Photovoltaic technologies : Mapping from patent analysis,” *Renew. Sustain. Energy Rev.*, vol. 93, no. May 2017, pp. 215–224, 2018.

I. Ierides, A. Zampetti, and F. Cacialli, “AC SC,” *Curr. Opin. Green Sustain. Chem.*, 2018.

E. Tatsi and G. Gri, “Solar Energy Materials and Solar Cells Polymeric materials for photon management in photovoltaics,” vol. 196, no. January, pp. 43–56, 2019.

A. Chauhan, V. V Tyagi, and S. Anand, “Futuristic approach for thermal management in solar PV / thermal systems with possible applications,” *Energy Convers. Manag.*, vol. 163, no. February, pp. 314–354, 2018.

H. Mahmoudi, S. A. Abdul-wahab, M. F. A. Goosen, and S. S. Sablani, “Weather data and analysis of hybrid photovoltaic – wind power generation systems adapted to a seawater greenhouse desalination unit designed for arid coastal countries,” vol. 222, pp. 119–127, 2008.

M. S. Elnozahy, “Technical Impacts of Grid-Connected Photovoltaic Systems on Electrical Networks — A Review Technical impacts of grid-connected photovoltaic systems on electrical networks — A review Additional information on J . Renewable Sustainable Energy,” no. May, 2013.

S. Kumar, “Urban Climate Thermal – economic analysis of a hybrid photovoltaic thermal (PVT) active solar distillation system : Role of carbon credit,” *Urban Clim.*, vol. 5, pp. 112–124, 2013.

Y. Jia, G. Alva, and G. Fang, “Development and applications of photovoltaic – thermal systems : A review,” *Renew. Sustain. Energy Rev.*, vol. 102, no. December 2018, pp. 249–265, 2019.

N. Safitri, “Different Trends of Hybrid Solar And Raindrops Energies to Generate Different Trends of Hybrid Solar And Raindrops Energies to Generate Photovoltaic,” 2019.

N. Safitri, F. Shahnia, and M. A. S. Masoum, “Stochastic Analysis Results for Coordination of Single- Phase Rooftop PVs in Unbalanced Residential Feeders,” no. July 2018, 2015.

N. Safitri and F. Abdurrahman, “Integration of DC Households System Generated by Single-Phase Rooftop PVs into Unbalanced Three-Phase Residential Feeder,” vol. 4, no. 2, 2017.

S. Seme, K. Sreden, Š. Bojan, and M. Had, “Analysis of the performance of photovoltaic systems in Slovenia,” vol. 180, no. January, pp. 550–558, 2019.

Z. Zhang, M. Yao, X. Li, Q. Deng, Q. Peng, and J. Zhong, “Solar Energy Materials and Solar Cells Simultaneous functional and structural imaging for photovoltaic

devices," *Sol. Energy Mater. Sol. Cells*, vol. 193, no. January, pp. 101–106, 2019.

T. Rihayat, "Composition on Essential Oil Extraction from Lemongrass Fragrant by Microwave Air Hydro Distillation Method to Perfume Dermatitis Production Composition on Essential Oil Extraction from Lemongrass Fragrant by Microwave Air Hydro Distillation Method to Perfume Dermatitis Production," pp. 6–11, 2019.

H. Agusnar, B. Wirjosentono, S. Salim, T. Rihayat, and T. Fauzi, "Synthesis and Characterization of Chitosan with Addition of Patchouli Oil to Improve Mechanical Properties Biofilm Synthesis and Characterization of Chitosan with Addition of Patchouli Oil to Improve Mechanical Properties Biofilm," 2018.

Jaafar, Jamiluddin., Januar, P.S·, Mohd, B.M.P., Tezara, C., Sharmiza, A., Rihayat, T. "Influence of Selected Treatment on Tensile Properties of Short Pineapple Leaf Fiber Reinforced Tapioca Resin Biopolymer Composites". Journal of Polymers and the Environment. 2018.

Rihayat, T., Suryani, T. Fauzi., H.Agusnar., B. Wirjosentono., Syafruddin., Helmi., Zulkifli., P..Alam., M.Sami. "Mechanical properties evaluation of single and hybrid composites polyester reinforced bamboo, PALF and coir fiber". IOP Conference Series: Materials Science and Engineering. Vol.334. Pp 1-8, 2018.

T. Rihayat, M. Saari, M. H. Mahmood, W. M. Z. W. Yunus, A. R. Suraya, K. Z. H. M. Dahlan, and S. M. Sapuan, "Mechanical Characterisation of Polyurethane / Clay Nanocomposites," vol. 15, no. 8, pp. 647–652, 2007

T. Rihayat, J. P. Siregar, and M. Yunus, "Synthesis and Characterization of North Aceh CEC Bentonite Determination with Methylene Blue Method and Increased D-Spacing after Addition of Surfactants CTAB-SDS Synthesis and Characterization of North Aceh CEC Bentonite Determination with Methylene Blue Method and Increased D- Spacing after Addition of Surfactants CTAB-SDS," 2019.