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Avocado Seed Bioethanol Purification Using Zeolite Adsorbent Distillation-adsorption Process

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Abstract

Bioethanol (Ethanol or ethyl alcohol) C_2H_5OH is a clear colorless liquid, which is biodegradable, has low toxicity and does not cause major pollution when contacted in the air. However, to produce bioethanol is not enough, special treatment is needed to produce high bioethanol. Therefore, there is a need for a new method with high economic value and better in bioethanol purification, one of which is bioethanol purification using an adsorbent, In this study, bioethanol purification will be carried out using Zeolite adsorbent with Adsorption-Distillation method. With the aim of knowing the Adsorption-Distillation process by using zeolite adsorbent on bioethanol purification to obtain high bioethanol levels as well as to find out whether bioethanol purification with Adsorption-Distillation process is an efficient method and to get the results of bioethanol purity levels whether it meets the Fuel Grade Ethanol standard after purification by Adsorption-Distillation method. In this study, the optimum level of bioethanol after the adsorption-distillation process was obtained at 44.8424% at 90 minutes with a volume of 125 ml of bioethanol and the minimum level obtained after the adsorption-distillation process was 34.0570% of the previous level of 33.6977%.

Keywords: Adsorption-Distillation, Bioethanol, Natural Zeolite

1. Introduction

Given the ever-increasing demand for energy, as well as the depletion of fossil resources and the resulting impact of global warming, the search for alternative energy sources has become imperative. Biomass, as the only renewable carbon source, offers a promising solution. Bioenergy can reduce environmental pollution, help achieve climate targets, and serve as a substitute for fossil energy; thus making it the best alternative with significant potential to lower greenhouse gas emissions. By 2016, biomass had become the world's fourth largest energy source, after coal, oil and natural gas, supplying 9.5% of the total global primary energy supply and accounting for 69.5% of the world's total renewable energy supply (Christensen, 2020). As a result, biofuels have been considered a promising alternative to traditional fuels such as gasoline,

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diesel, and aerostatic fuels (Ahlgren et al., 2017; Rahman H et al., 2018). In addition, the oxygen content in bioethanol is higher than the oxygen content in gasoline fuels (Yuksel and Yuksel, 2004). As a result, the combustion of bioethanol is cleaner than that of pure gasoline. To be used as gasoline fuel additive, bioethanol must first be purified. Bioethanol produced from biomass waste such as avocado seeds is a very promising biofuel option (Dong et al., 2019; Frankowski et al., 2022; Salehi et al., 2018). Avocado seeds are rich in starch with about 30% (wet basis) of their total composition (Chel Guerrero et al, 2016). Currently, avocado seeds are still often discarded carelessly, which causes environmental pollution (Risyad et al., 2016; Sluiter et al., 2011). The main waste from avocado processing is the seed, which has a ratio of about 0.33 kg of seed per kilogram of avocado (Acevedo-García et al., 2018; Ruiz et al., 2006). With its abundant availability and significant cellulose content (Baruah et al., 2018), avocado seed is increasingly seen as a potential feedstock for bioethanol production. Bioethanol, also known as ethanol or ethyl alcohol (C_2H_5OH), is a clear, colorless liquid that is biodegradable. It has low toxicity and does not cause significant pollution when exposed to air. However, in order to produce quality bioethanol, special treatment is required to achieve the FGE (Fuel Grade Ethanol) standard of 99.55-100% v/v Bioethanol. This is important, as the presence of water in the fuel, even in small amounts, can negatively impact engine performance. (Gnansounou & Dauriat, 2005).

Therefore, it is necessary to have a new method with high economic value and better in bioethanol purification, one of which is bioethanol purification using an adsorbent. Adsorbent can separate the mixture of bioethanol and water by absorbing the water so that the level of bioethanol produced from the adsorption process followed by distillation process will be higher than purification using ordinary distillation. And the use of adsorbent in the process of purification (purification) of bioethanol is to use Zeolite adsorbent as an absorbent media. Zeolite has adsorbing properties because the colloidal particle size is very small and has a high ion capacity (Teplitskiy, 2005). Zeolite is often used as an adsorbent because it has a high adsorption capacity, is not easily saturated, has high selectivity, and is easy to regenerate (Laksmono et al., 2018)

In this research, bioethanol purification will be carried out using Zeolite adsorbent with Adsorption-Distillation method. The use of Adsorption-Distillation method is done because in this method bioethanol can contact directly with the adsorbent used. This allows for no loss of bioethanol in large quantities. So it will be more effective and efficient in terms of energy use to separate the bioethanol produced from unwanted compounds. In addition, bioethanol will be obtained which has high purity with relatively low production costs and energy use (low energy). Increasing ethanol content using zeolite has been done by Khaidir (2012) 90% to 91.22%; Rahman N.A et al (2012) 3.9% to 27.22%; Novitasari (2012) 80% to 84.34%.

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2. Research Methods

2.1. Materials and tools used

Adsorption Equipment Set Distillation, zeolite, avocado seed bioethanol, sulfuric acid and distilled water, avocado seed flour, Saccharomyces cerevisiae, NaOH

2.2. Avocado Seed Bioethanol Preparation

1) Avocado Seed Flour Preparation
   Avocado seeds are first washed thoroughly and then soaked with warm water so that the epidermis of the avocado seeds is easy to peel. Then the avocado seeds are sliced thinly and dried in the sun for 2 to 4 days. Furthermore, the dried avocado seed slices are mashed using a grinder so that avocado seed flour in the form of powder is obtained.

2) Acid Hydrolysis
   Weighing as much as 150 grams of avocado seeds that have become flour. Adding 0.3 M HCl into 1500 ml of distilled water. Mixing 150 grams of avocado seed flour into 1500 ml of distilled water which has been mixed with 0.3 M HCl, then heating for 40 minutes. Heating is done using a magnetic stirrer with a temperature of 135 °C. The hydrolysis results were filtered using filter paper to obtain a simple sugar solution (glucose). Next, measure the pH of the glucose solution by adding NaOH to obtain pH 4 - 4.5 of the glucose solution. After the hydrolysis process is complete, the material is cooled to room temperature by putting the sample in a beaker glass into a bucket of tap water until the temperature drops. Applies to the repetition of the next materials.

3) Fermentation
   The sample from the hydrolysis process was poured into 25 different fermentation bottles. After that, add tape yeast (Saccharomyces cerevisiae) weighing 10 gr for the first 5 bottles, 20 gr for the second 5 bottles, 30 gr for the third bottle, 40 gr for the fourth 5 bottles, 50 gr for the fifth 5 bottles. Each bottle was added urea and npk 1% of the total volume. Then close the lid. Perform fermentation for 3,4,5,6, and 7 days with the temperature reaching 36°C.

2.3. Purification of bioethanol from avocado seed

1) Activation Process of Natural Zeolite
   The zeolite was soaked with 1 M H_2SO_4 solution for 3 hours, then filtered, washed and soaked with distilled water for 2 hours. Then filtered again and baked at 200°C for 2.5 hours.
2) Adsorption Process of Bioethanol Distillation with Activated Zeolite
   a. The Adsorption Distillation process is carried out in several stages, namely:
   - The adsorption-distillation process was carried out simultaneously by introducing ethanol with 70% content as much as 250 ml, 300 ml, and 350 ml along with zeolite that had been

activated before into a two-neck flask and then stirring for 5 minutes so that both were evenly mixed. Next, a temporary silence was carried out for 30 minutes.

- Ethanol and zeolites that have been in the two neck flask are then carried out the distillation process, then heated until steam forms to produce pure ethanol liquid.
- Heating was stopped when the distillate obtained from adsorption-distillation was done simultaneously. The adsorption-distillation time was adjusted to a variable time (50 minutes, 70 minutes, and 90 minutes) with a constant temperature of 80°C.
- This distillate is then analyzed for its bioethanol purity percentage content using Gas Chromatography (GC).

3. Results and Discussion

Making bioethanol by using a mass of yeast 50. While the fermentation time is 3 days, 4 days, 5 days, 6 days and 7 days. The results of bioethanol content are shown in Table 3.1. Furthermore, for the Adsorption-Distillation process of bioethanol using the highest value of bioethanol content, zeolite mass of 15 g, 30 g and 45 g, while the time of 50 minutes, 70 minutes, 90 minutes and bioethanol mass of 75, 100 ml and 125 ml. The results of bioethanol content after purification are shown in table 3.2.

Table 3.1. Results of bioethanol content analysis based on the length of fermentation and mass of yeast tape on avocado seeds

Fermentation Time (days)	Yeast Mass (gr)	Bioethanol Density	Bioethanol Content (%)
3	50	0,9978	32,2807
4	50	0,9958	32,9554
5	50	0,9937	33,6977
6	50	0,9937	33,6977
7	50	0,9940	33,5627

Table 3.2 Adsorption-Distillation Process of Bioethanol with 33.9677%

Purification Time	Zeolite mass (gram)			Zeolite mass (gram)			Zeolite mass (gram)		
	15			30			45		
	Bioethanol Mass (ml)			Bioethanol Mass (ml)			Bioethanol Mass (ml)		
	75	100	125	75	100	125	75	100	125
50	34.0570	34.3289	34.6478	34.3092	34.6947	35.1050	35.3176	36.7313	38.3379
70	35.3670	35.9899	37.6508	35.4016	37.0057	38.1080	36.2049	38.2638	40.2608
90	36.0591	37.1268	37.6681	37.6261	37.7892	39.8234	39.7492	41.0023	44.4824

3.1. Influence of Variables on the Adsorption-Distillation Process

This study aims to improve the purity of ethanol. The ethanol used as feed is ethanol from avocado seeds. To obtain optimal ethanol purity, this study used one stage of the process. That is to find out the variables that affect the adsorption distillation process. The adsorption-distillation process is a process of absorption and separation carried out simultaneously where the components of a fluid phase move to the surface of the absorbing solid (adsorbent) this aims to reduce the length of operating time and the use of materials used. In the adsorption-distillation process, variable variations are carried out to determine the variables that most affect the process. The bioethanol feed used is ethanol with a content of 33.6977%. (Table 3.1.). While the desired variable variations are the weight of zeolite and the length of time of adsorption-distillation. Below are the results of research data that has been done before, then the results obtained are presented in Table 3.2. From each table presented the effect of variations in zeolite weight of 15 grams, 30 grams, 45 grams, with a volume of bioethanol 75 ml, 100 ml and 125 ml which is then combined with variations in the length of time of distillation 30 minutes, 50 minutes, and 70 minutes.

Figure 3.1. It can be seen that the best research results are taken based on the effect of 50 minutes of Adsorption-Distillation process on the increase in ethanol levels for 45 grams of zeolite weight. Where the adsorption-distillation process is carried out simultaneously at 90 ° C temperature conditions, then the optimal conditions for 45 grams of zeolite are obtained at the operating time for 50 minutes with the initial ethanol content which was originally 33.6977% increased to 38.3379%.

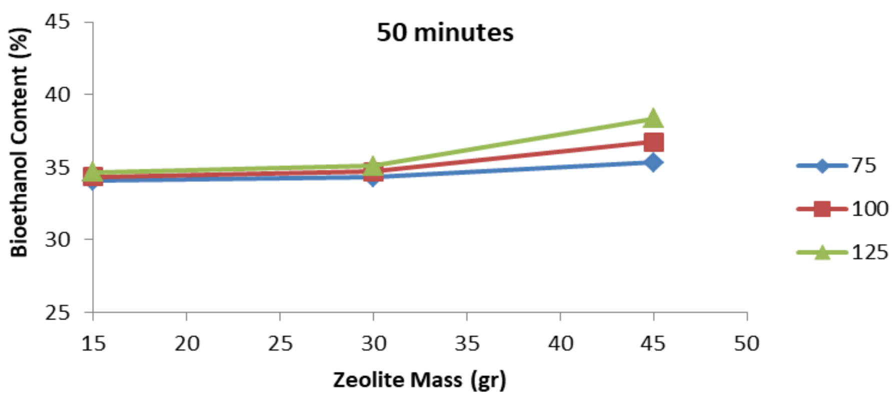

Figure 3.1. Graph of Ethanol Content (%) Relationship with Zeolite Mass (gr) and Bioethanol Mass (ml)

In Figure 3.2. can be seen the best research results taken based on the effect of time 70 minutes Adsorption-Distillation process on the increase in ethanol content for zeolite weight 45 grams. Where the adsorption-distillation process is carried out simultaneously at 80 ° C temperature conditions, then the results obtained optimal conditions for 45 grams of zeolite with an optimal volume of 125 ml of bioethanol is at the operating time for 70 minutes with the initial ethanol content which was originally 33.6977% increased to 40.2608%.

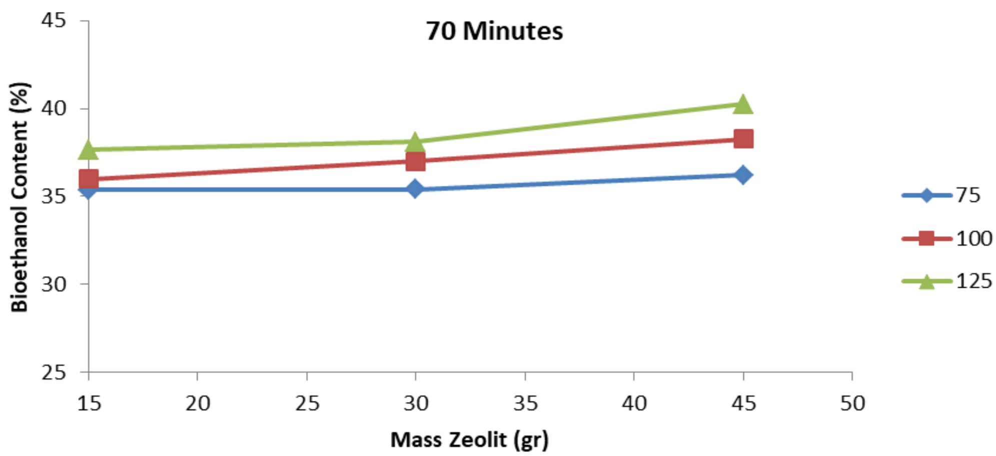

Figure 3.2. Graph of Ethanol Content (%) Relationship with Zeolite Mass (gr) and Bioethanol Mass (ml)

Figure 3.3. The best research results are taken based on the effect of 90 minutes of Adsorption-Distillation process on the increase in ethanol content for 45 grams of zeolite weight. Where the adsorption-distillation process is carried out simultaneously at 90 ° C temperature conditions, then the results obtained optimal conditions for 45 grams of zeolite with an optimal volume of 125 ml of bioethanol is at the operating time for 70 minutes with the initial ethanol content which was originally 33.6977% increased to 44.4824%.

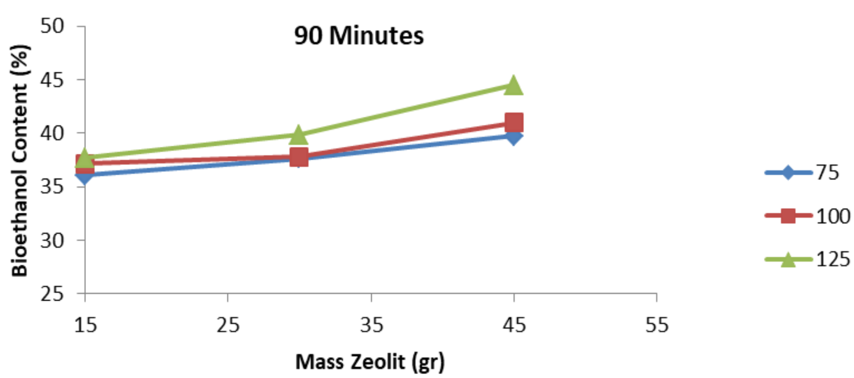

Figure 3.3. Graph of Ethanol Content (%) Relationship with Zeolite Mass (gram) and Bioethanol Mass (ml)

The results of this study influenced the most optimal zeolite weight of 45 grams with a distillation time of 90 minutes. The ethanol content produced was 44.4824%. The results showed that the more zeolite used as adsorbent, the higher the ethanol content produced. Zeolite adsorbent has a regular pore structure, which allows water to penetrate easily (Laksmono et al., 2017). This is in accordance with the theory that the greater the amount of zeolite and the presence of a fixed initial ethanol solution concentration, the more water will be absorbed. The ethanol flow rate is influenced by the volume of ethanol produced from the adsorption distillation process itself. The volume of ethanol obtained is influenced by the porosity of zeolite, the larger cross-sectional area of zeolite and the absorption capacity of zeolite to water molecules in ethanol solution (Nadzif et al., 2009).

The most optimum time in the adsorption distillation process is at 90 minutes. This is because the longer the time used for the adsorption distillation process, the greater the opportunity for ethanol and water to be absorbed by zeolites. According to Nur Ihda Farikhatin Nisa et al, 2019), to get greater ethanol levels, several treatments are needed to get maximum results. The length of distillation time is also one of the factors that can determine the efficiency of the ethanol-water separation process expressed in the concentration of overhead product and bottom product..

4. Conclusion

1. The most effective and optimal process for purification and increase in ethanol content is at a time of 90 minutes with a volume of 125 ml of bioethanol in the Adsorption-Distillation process with a temperature of 80°C.
2. The optimum level of bioethanol after the adsorption-distillation process is obtained at 44.8424% and the minimum level obtained after the adsorption-distillation process is 34.0570% from the previous level of 33.6977%.

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