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OPTIMIZATION OF CARBONIZATION TEMPERATURE IN THE PRODUCTION OF COCONUT PULP-BASED ACTIVATED CARBON FOR THERMOELECTRIC MATERIALS

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ABSTRACT

A thermoelectric generator is one of the power plants capable of converting thermal energy into electrical energy. Thermoelectricity can be derived from materials based on metal oxide composites with carbon materials, one example is the use of Copper (II) Oxide with activated carbon. Using activated carbon can help reduce thermal conductivity, which will be beneficial in its utilization as a thermoelectric material. Activated carbon comes from biomass waste that has not been fully utilized, such as coconut pulp waste. Utilization of coconut pulp waste can reduce environmental pollution and can add economic value to the waste. The goal of this research is to produce coconut pulp activated carbon at the ideal temperature for usage as thermoelectric materials. The research method used was the carbonization method. Coconut pulp activated carbon was obtained through dehydration, carbonization and activation stages. The carbonization temperature variation used is at a temperature of 250ºC, 300ºC, 350ºC, 400ºC, and 450ºC. According to the results of the characterization, the yield, ash content, and bound carbon content of activated carbon decrease with increasing carbonization temperature, while the values of water content and ash content of activated carbon increase. This indicates that the activated carbon made from coconut pulp has met the requirements SNI 06-3730-1995. XRD characterization results show that coconut pulp activated carbon is amorphous and does not show sharp diffraction peaks (significant). For producing activated carbon, coconut pulp is carbonized at a temperature of 300ºC to get the optimum temperature.

Keywords : *Carbonization temperature; Activated carbon; Coconut pulp; Thermoelectric.*

I. INTRODUCTION

Electrical energy can be generated by converting heat into electricity using a thermoelectric generator. Thermoelectrics are usually made of Bi_2Te_3 and GeTe materials, However, these substances are hazardous and unstable at high temperatures, which may harm the substance's thermoelectric capabilities [1][2]. Materials used as thermoelectric manufacturing materials are expected to produce clean energy without causing adverse effects on the environment. As a result, non-toxic materials are required. One example is the usage of transition metal oxides, which are very common in nature and can be simply and cheaply manufactured. One example is Copper (II) Oxide (CuO) which has several advantages such as being environmentally friendly, abundant, and has a low price [3]. A p-type semiconductor is CuO. This material, which has a energy gap of 1.2 eV, is frequently used to create thermoelectric materials, microelectronic circuits, sensors, batteries, and solar cells [4].

Maximum purity CuO has a large thermal conductivity but a high Seebeck coefficient [5]. The Seebeck effect is a condition that can convert temperature differences into electrical energy, so CuO can be used as a thermoelectric material. On the other hand, CuO has high thermal conductivity. This situation can be overcome by making composites that aim to reduce thermal conductivity. CuO thermoelectric materials can be made by compositing with carbon-based materials. [6]. One example of carbon-based materials is using activated carbon.

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The surface area of activated carbon, which ranges from 300 m^2/g to 3500 m^2/g, is made up of covalently bound C atoms organized in flat hexagonal structures that have one C atom at each corner [7]. Activated carbon is the result of processing carbon-based compounds that produce a high degree of porosity and large surface area [8]. Charcoal that has undergone further processing in the form of an activation step utilizing physical or chemical activators is known as activated carbon or activated charcoal. A porous solid composed of carbon-containing materials and heated at high temperatures to produce a high-carbon content product is called "activated carbon" [9]. Activated carbon can be made from agricultural and forestry waste containing lignocellulose because it has a high carbon content (usually more than 45%) [10].

The thermal conductivity value of a thermoelectric material can be decreased by using activated carbon as a composite [11][12]. The utilization of CuO as a thermoelectric material with activated carbon derived from biomass waste has been carried out previously by [13] using coconut shell waste, cocoa shell waste [14], cassava skin waste [15], and durian skin waste [16] and coconut fiber [17]. From some of these studies, no one has used activated carbon derived from coconut pulp biomass waste. Therefore, this research will utilize coconut pulp waste in the manufacture of activated carbon which can later be utilized for the manufacture of thermoelectric materials.

Coconut pulp is a waste derived from grated coconut meat from which coconut milk has been extracted for food and coconut oil production. The pulp from coconut milk is usually discarded immediately, because it is considered to have no benefits anymore and will eventually produce solid waste. In the long run, coconut pulp waste can pollute the surrounding environment such as polluting groundwater sources and air pollution from the foul odor it causes [18]. Therefore, there needs to be an effort to reuse coconut pulp waste so that it does not become waste that can pollute the environment. Utilization of dried coconut pulp into activated carbon will increase economic value, reduce material disposal costs and provide cheap materials for the manufacture of activated carbon [19].

Dried coconut pulp consists of galactomannan as much as 61% and manan as much as 13% of total polysaccharides, the remaining 26% consists of fractions that cannot be extracted [20]. In a study also mentioned that coconut pulp has a lignin content of 1.88%, hemicellulose 1.13%, cellulose 72.67% and insoluble pectin 4.32% [21]. Because it contains cellulose, manan, lignin, and galactomannan, coconut pulp can be utilized as a raw material to make activated carbon. Each of these compounds decomposes at different temperatures. Hemicellulose compounds which are polymers of several monosaccharides such as pentosan and hexosan decompose the earliest at a temperature of 200ºC-260ºC (characterized by the release of thin white smoke from the furnace chimney), then followed by the decomposition of cellulose at 240ºC-350ºC (characterized by the release of thicker and darker colored smoke, brownish black), and lignin decomposes the last at 280ºC-500ºC (in this process the color of the smoke produced is again white and thin, and gradually disappears) [7][22].

The coconut pulp activated carbon that will be made will undergo three stages. The first stage is dehydration, carbonization, and chemical activation. Components from organic sources are transformed into carbon during the carbonization stage. In this study, variations in carbonization temperature will be used. Giving this temperature variation can be useful for changing electrical properties and thermal properties in its utilization as a thermoelectric material [22][23].

In the research entitled "Preparation of Activated Carbon from Desiccated Coconut Residue by Chemical Activation with NaOH*",* Coconut pulp activated carbon was made using temperature variations of 400ºC, 500ºC, and 600ºC. The highest carbon yield (final product) in this investigation was obtained at a carbonization temperature of 400°C, where it was discovered that activated carbon from coconut pulp decreased in specific surface area at a temperature of 600°C [24]. Another study with the title "Preparation of Activated Carbon from Coconut Dregs with Variations in the Type and Amount of Concentration of Activator Substance Compounds", discovered that coconut dregs could be carbonized at 300°C for 15 minutes to produce activated carbon with a water content of 3.8% and an ash concentration of 2.42% [25].

from research that has been done before by [24] [25], obtained differences in carbonization temperatures used in the manufacture of coconut pulp activated carbon, so in this study the manufacture of activated carbon is carried out with temperature variations of 250ºC, 300 ºC, 350 ºC, 400 ºC and 450ºC in the coconut pulp carbonization process with a carbonization time of 15 minutes. Therefore, from the above background, a problem formulation can be taken, namely what is the optimum temperature of coconut pulp carbonization to produce the best activated carbon based on the requirements of SNI O6-3730-1995 which can later be utilized in the manufacture of activated carbon and CuO composites for thermoelectric materials.

II. METHOD

The experimental approach was employed in this study to ascertain how changes in carbonization temperature affected the properties of activated carbon made from coconut pulp. The independent variable, control variable, and dependent variable are the three variables that make up this study. The carbon yield value, moisture content, ash content, vapor content, bound carbon content, and X-ray diffraction (XRD) diffraction patterns on coconut pulp activated carbon are the dependent variables of this study. The carbonization temperature of coconut pulp is the independent variable, while the carbonization time is the control variable.

The first step was to prepare the tools and materials. The following equipment was used to make activated carbon: oven, digital scales, furnace, mortar and pestle, 120 mesh sieve, beaker, measuring flask, measuring cup, filter paper, funnel, condenser, porcelain chair, porcelain cup, aluminum foil, pH meter. Coconut pulp was the primary source of the study's materials, 0.5M HCl (activator substance), distilled water. The tools used for sample characterization are oven, analytical balance, furnace, X-Ray Diffraction type X'Pert PRO.

The process of making activated carbon was done through the stage of dehydration by baking coconut pulp at 105ºC for 2 hours. The dried coconut pulp was weighed as much as 100g, then carried out the carbonization stage using a furnace with temperature variations of 250ºC, 300ºC, 350ºC, 400ºC and 450ºC for 15 minutes [25]. After carbonization was complete, the resulting carbon was weighed to determine the carbon yield value. Coconut pulp that has been carbonized perfectly will continue for the activation process.

The carbonized coconut pulp was then pulverized with a mortar and pestle and sieved through a 120 mesh sieve. The sifted carbon was weighed to 10 grams and then activated with 100 mL of 0.5M HCl for 24 hours in a beaker covered with aluminum foil. Filtered activated carbon was rinsed with distilled water until its pH was the same as that of the aquadest. Figure 1 below shows the process of converting coconut pulp into activated carbon.

(a) (b) (c)

Fig. 1. Manufacturing process of coconut pulp activated carbon (a) dehydration, (b) carbonization, (c) activation

Based on Figure 1, we can see the changes in coconut pulp after the dehydration, carbonization and activation processes. This result then becomes coconut pulp activated carbon. The quality of the water content, ash content, bound carbon content, and XRD characterisation are tested next.

Characterization of coconut pulp carbon from the carbonization process was carried out by calculating the yield value (%). This test was carried out by weighing 100g of dried coconut pulp and then carbonized with a predetermined temperature, after the carbonization process was complete, the resulting product was weighed using a balance sheet. The carbon yield value of coconut pulp was obtained from the following equation [26].

$$Yield(\%) = \frac{a}{b} \times 100\% \quad (1)$$

Equation (1) is the yield value equation, where "b" is the starting weight of coconut pulp (g) and "a" is the end weight of carbon (g).

One gram of activated carbon was weighed, placed into a costed porcelain cup, and baked at 105°C for an hour to determine the amount of water present. The sample was finished and cold weighed using an analytical balance before being placed into the desiccator for 30 minutes. The following equation can be used to calculate the water content [27].

$$Water\ content(\%) = \frac{(a-b)}{a} \times 100\% \quad (2)$$

Equation (2) is the equation for the value of water content, “a” is the starting weight of carbon activated (g), and “b” is the weight of dried activated carbon (g).

Ash content testing was done by weighing 1g of activated carbon and then putting it into a porcelain cup that has been stabilized. Activated carbon was then inserted into the furnace for 1 hour with a temperature of 700°C. After finishing, the sample was chilled in a desiccator before being weighed. Ash content can be obtained through the following equation [28].

$$Ash\ content(\%) = \frac{b}{a} \times 100\% \quad (3)$$

Equation (3) is the equation for the value of ash content, “a” is the starting weight of activated carbon (g), and “b” is the mass of ash (g).

Testing for vapor content involves weighing 1g of activated carbon, then placed in a stable porcelain cup. The cup was then placed in the furnace for 6 minutes at the carbonization temperature plus 10° C. Following completion, the sample was chilled in a desiccator before being weighed. The following equation can be used to determine the vapor content value [15].

$$Vapor\ content(\%) = \frac{(a-b)}{a} \times 100\% \tag{4}$$

Equation (4) is the equation for the value of vapor content, “a” the starting weight of activated carbon (g), and “b” is the weight of heated activated carbon (g).

The bound carbon content was examined as the final aspect of activated carbon quality testing. When testing vapor content and ash content, bound carbon content can be determined by subtracting the portion that was lost during heating. The following equation can be used to calculate the amount of bound carbon [15].

$$Bound\ carbon\ content(\%) = 100\% - (A + B) \tag{5}$$

Equation (5) is the equation for bound carbon content, “A” is the amount of ash (%), and “B” is the amount of vapor (%).

In the characterization of activated carbon using XRD, the samples used are in powder form. Samples that are characterized are samples with carbonization at 300ºC, 350ºC, and 400ºC.

III. RESULTS AND DISCUSSION

Carbonization is a process to convert coconut pulp (organic material) into carbon by heating, so that the complex compounds that make up the coconut pulp are decomposed into charcoal with a high carbon element contentThe carbonization of coconut pulp at temperatures of 250°C, 300°C, 350°C, 400°C, and 450°C is depicted in Figure 2.

(a) (b) (c) (d) (e)

Fig. 2. Results of coconut pulp carbonization at temperature
(a) 250ºC, (b) 300ºC, (c) 350ºC, (d) 400ºC, (e) 450 ºC

From Figure 2, we can see that coconut pulp carbon at temperature 250ºC (Figure 2a) has a brown color (not perfectly charred), at a temperature of 300ºC, 350ºC, 400ºC produces carbon with a black color, while at a temperature of 450ºC the carbon produced is slightly grayish because more ash is produced than carbon. Figure 3 below shows the relationship between the carbonization temperature of coconut pulp at 250ºC, 300ºC, 350ºC, 400ºC and 450ºC with the resulting yield value.

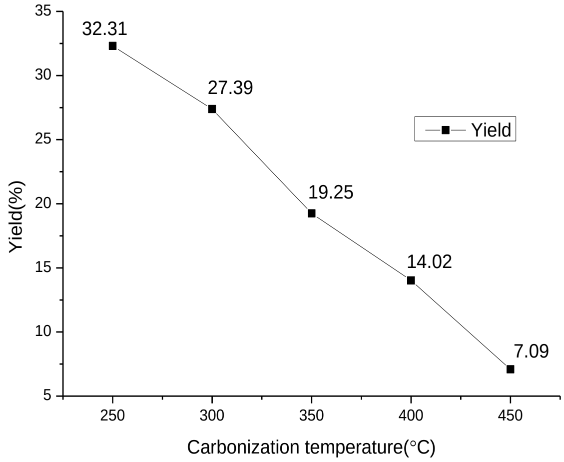


Fig. 3. Relationship between carbonization temperature and yield value of coconut pulp carbon

Based on Figure 3, It is evident that the yield value decreases as the carbonization temperature is raised. There is an inversely proportional relationship between carbonization temperature and yield value in the manufacture of carbon from coconut pulp. The process of turning organic materials into carbon or charcoal is known as carbonization. The amount of carbon created will depend on the temperature during carbonization (yield). When a temperature 250°C, the highest yield value is 32.31%, but at this temperature the coconut pulp has not become the whole carbon so that the carbon results cannot be continued to the activation process. At 300°C the resulting yield is 27.39%, at 350°C the resulting yield is 19.25%, while at 400°C a yield value of 14.02% is obtained, and at 450°C the lowest yield value is 7.09%, carbon at 450°C is the least amount of carbon because at this temperature some of the samples have become ash, so the carbon at 450°C cannot be continued for the activation process. The findings of this study are in line with that of [24], where at 400°C the yield value is obtained in the range of 13.05-15.28% and it was noted in this study that when the carbonization temperature increased (500-600°C), the yield results were getting smaller.

From the results obtained, it is evident that the final carbon product is lower the higher the carbonization temperature. The decrease in yield value is because when the carbonization temperature increases, more carbon turns into ash, CO_2 and H_2 due to the reaction with oxygen in the furnace, so the amount of carbon produced decreases [29], and can also be caused by coconut pulp having little lignin content [21][24]. Carbonization temperature affects carbon products because high carbonization temperatures cause less carbon to be produced but liquid and gas products will increase because many substances undergo decomposition and evaporation. In making activated carbon, it is expected to produce a greater yield value. Therefore, the best carbon was obtained from carbonization with a temperature of 300°C.

From the results obtained, carbon with carbonization temperature of 250°C and 450°C cannot be used for the activation process, Therefore, the carbon required to make activated carbon is carbonized at temperatures of 300°C, 350°C, and 400°C. The purpose of this study is to establish the optimum coconut pulp carbonization temperature for producing activated carbon. The purpose of this study is to identify the ideal coconut pulp carbonization temperature for producing activated carbon. SNI 06-3730-1995 is the foundation for the regulation of the quality of activated carbon [30]. Table 1 below displays the results of tests conducted on coconut pulp activated carbon's water, ash, vapor, and bound carbon contents.

Table 1. Coconut pulp activated carbon test results

Testing	**Requirements SNI 06-3730-1995**	**Carbonization temperature**			**Description**
		300°C	**350°C**	**400°C**	
Water content (%)	max. 15	2,01	2,68	6,53	Qualify SNI 06-3730-1995
Ash content (%)	max. 10	0,65	0,62	0,61	Qualify SNI 06-3730-1995
Vapor content (%)	max. 25	10,47	15,86	21,62	Qualify SNI 06-3730-1995
Bound carbon content (%)	min. 65	88,88	83,52	77,77	Qualify SNI 06-3730-1995

From Table 1 above, as can be seen, all activated carbon with different carbonization temperatures has complied with SNI 06-3730-1995. However, additional analysis is done about the water content, ash content, vapor content, and bound carbon content of coconut pulp activated carbon created in order to obtain the ideal temperature in the process of making it.

The first test on activated carbon is the water content test. The amount of water in activated carbon is referred to as its water content. Figure 4 below shows the relationship between the carbonization temperature of coconut pulp with the value of water content resulting from the manufacture of coconut pulp activated carbon.

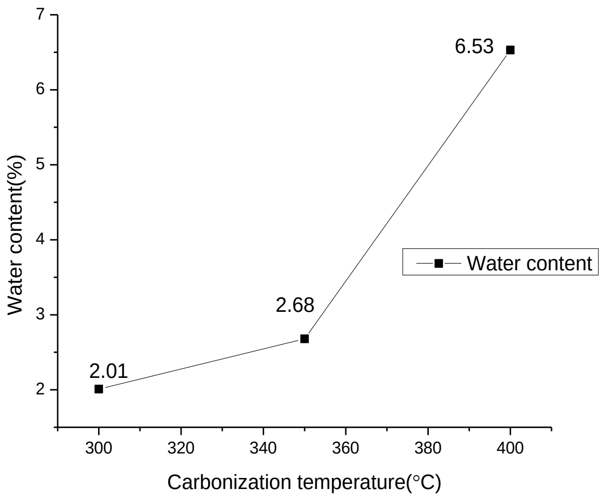


Fig. 4. Relationship between carbonization temperature and water content in coconut pulp activated carbon

Based on Figure 4, When coconut pulp is carbonized at temperatures of 300°, 350°, and 400°, the amount of water that results increases along with the increase in carbonization temperature. At 300°C carbonization temperature, the moisture content was 2.01%; at 350°C, the moisture content was 2.68%; and at 400°C, the moisture content was 6.53%. At 300°C carbonization temperature, the moisture content is at the lowest value, while at 400°C, the moisture content is at the highest value. Therefore, there is a directly proportional relationship between carbonization temperature and the water content value of activated carbon made from coconut pulp. Increasing water content can be influenced by the remaining distilled water during incomplete washing and drying. This is based on research by [31] The hygroscopic characteristics of activated carbon, the amount of airborne water vapor, and the length of the drying process all have an impact on how much water content is present in the material. A low water content in an activated charcoal means that there aren't many water molecules left to cover the pores. An excessive amount of water in activated charcoal has the potential to lower its quality and make it easier for other molecules to access the carbon's pores. All carbonization temperatures employed in the production of coconut pulp activated carbon were confirmed to comply with SNI 06-3730-1995 norms. The best activated carbon, in terms of water content, has a carbonization temperature of 300°C. The lower the water content value, the better the quality of the activated carbon.

Figure 5 below demonstrates the connection between the coconut pulp's carbonization temperature and the value of the produced ash content.

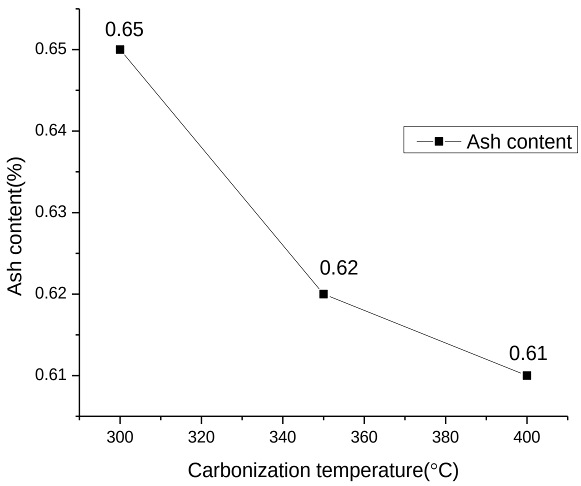


Fig. 5. Relationship between carbonization temperature and ash concentration of activated carbon from coconut pulp

Based on Figure 5, it was discovered that the amount of ash in the activated carbon made from coconut pulp reduced as the carbonization temperature was raised. Ash is the residue that remains when carbon-containing substances have burned during the process of ignition. Ash can be minerals such as silica, oxides, aluminum, iron oxides, magnesium, and calcium [29]. In this study, the lowest amount of ash was found at a carbonization temperature of 400°C, where it was 0.61%, and the highest amount was found at a carbonization temperature of 300°C, where it was 0.65%. At 350°C, ash content was found to be 0.62%. According to the results, all activated carbons satisfy SNI 06-3730-1995 standards. However, when the ash content of activated carbon decreases, the quality of the material increases. This is because many substances are removed during the carbonization process as the carbonization temperature rises, so the activated carbon produced in this study has an ash content that decreases with increasing carbonization temperature. This means that in this ash content test, activated carbon at higher temperatures will have lower ash content.

The graph above demonstrates that the ash content decreases with increasing carbonization temperature. This is consistent with the research of [32] more and more substances are removed or destroyed when a decrease in ash content is caused at an increase in carbonization temperature. High ash content in activated carbon can prevent the pores of the carbon from opening up, thus reducing the surface area of the material [33]. Therefore, the optimal activated carbon in terms of ash concentration has a carbonization temperature of 400°C.

The concentration of unvaporized substances in coconut pulp activated carbon is the next characteristic. The link between the coconut pulp's carbonization temperature and the value of the resulting vapor content is depicted in Figure 6 below.

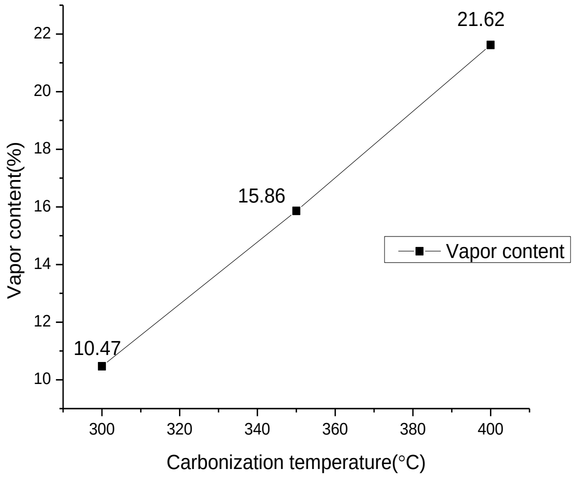


Fig. 6. Relationship between carbonization temperature and vapor content of coconut pulp activated carbon

Based on Figure 6 above, as the carbonization temperature is raised, it is clear that the value of the vapor content of the activated carbon made from coconut pulp rises as well. At a carbonization temperature of 300°C, the vapor content is 10.47%, at a temperature of 350°C, the vapor content is obtained; at a temperature of 400°C, the vapor content is acquired; and at a temperature of 450°C, the vapor content is obtained. At a carbonization temperature of 300°C, the vapor content value is lowest, and at a temperature of 400°C, it is highest. As a result, the value of the activated carbon content in coconut pulp and the carbonization temperature are directly proportional. Testing for the presence of chemicals that have not evaporated during the carbonization process is known as vapor content. All activated carbon already meets SNI 06-3730-1995. Research results by [29] We also found that the vapor content increased with the addition of carbonization temperature. This can be caused by the interaction between carbon and air, so that the resulting vapor content will increase. The results of the increasing steam content are in line with the results of the water content which also increases along with the increase in carbonization temperature. A high water content in activated carbon suggests that there are many compounds there that have not yet evaporated, leading to a high vapor content value. SNI 06-3730-1995 requirements of the vapor content of activated carbon is a maximum of 25%, The quality of activated carbon improves with decreasing vapor content values, hence the best activated carbon in terms of vapor content has a carbonization temperature of 300°C.

The quantity of pure carbon that is bound in activated carbon is known as bound carbon content. Ash and vapor levels in activated carbon have an impact on bound carbon content. The value of the bound carbon content of the activated carbon will be low if the ash content and vapor content are both high. A considerable amount of bound carbon will be present in an activated carbon if its ash and vapor contents are both low. The relationship between the carbonization temperature of coconut pulp and the value of the produced bound carbon content is depicted in Figure 7 below.

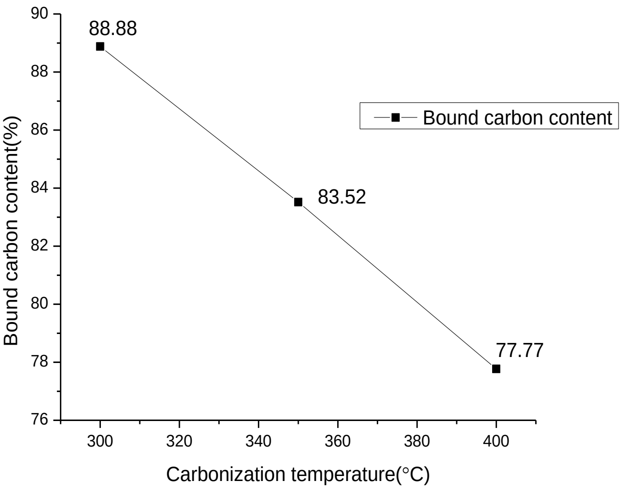
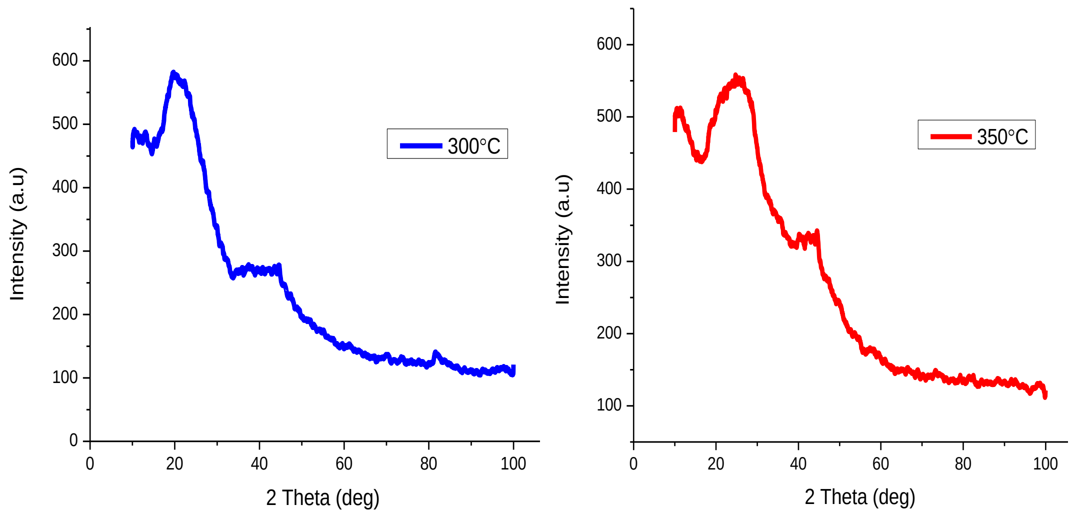
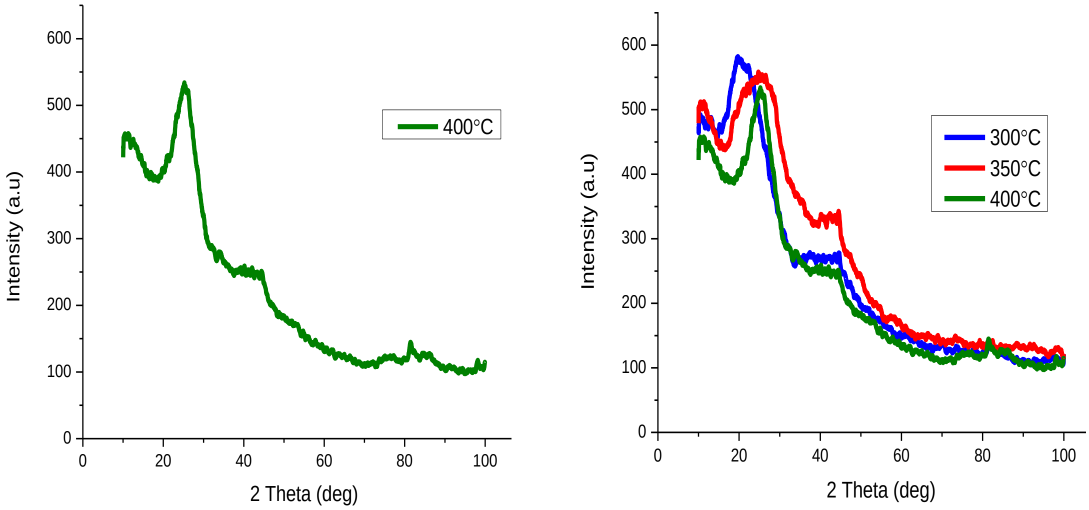


Fig. 7. Relationship between carbonization temperature and the value of bound carbon content in coconut pulp activated carbon

Based on Figure 7, As can be seen, as the carbonization temperature is raised, the value of the bound carbon content of the activated carbon made from coconut pulp drops. The bound carbon percentage is 88.88% at carbonization temperatures of 300°C, 350°C, and 400°C, respectively. At 350°C, the bound carbon content is 83.52%, and at 400°C, it is 77.77%. At a carbonization temperature of 300°C, the bound carbon content was at its lowest value, while at a temperature of 400°C, it was at its highest. As a result, there is an inverse relationship between the carbonization temperature and the value of the bound carbon content of activated carbon made from coconut pulp. Bound carbon content can be defined as the amount of pure carbon bound in charcoal [34]. Other researchers say that bound carbon content is the fraction of carbon contained in charcoal which can be in the form of solids or carbon remaining after determining ash content and vapor content [35]. Bound carbon content with variations in carbonization temperature meets SNI 06-3730-1995. According to studies by [29], it can be seen that as the carbonization temperature rises, the amount of bonded carbon gained decreases. This outcome is possible because raising the carbonization temperature will harm the walls of the carbon pore, so the amount of carbon formed will be less [23] as well as being affected by the ash and vapor contents of the activated carbon itself. According to SNI 06-3730-1995, activated carbon must have a bound carbon content of at least 65%. The higher the value of the bound carbon content, the higher the quality of the activated carbon, so the best activated carbon has a carbonization temperature of 300°C.

XRD characterization of activated carbon was carried out using HighScore Plus Software with Reference code 96-100-0066. Carbon is a material that has a hexagonal crystal system. Figure 8 below is the XRD pattern of the coconut pulp activated carbon produced.





(c) (d)

Fig. 8. XRD pattern of coconut pulp activated carbon with carbonization temperature
(a) 300°C, (b) 350°C, (c) 400°C, (d) carbonization temperature combination

Based on Figure 8, in each variation of carbonization temperature, the angle 2Θ is used in the range of 10° to 100°. The diffratogram pattern formed on activated carbon with variations in carbonization temperature is relatively the same, this can be seen from the small diffraction intensity and does not have a specific peak, which indicates that the activated carbon is amorphous [36]. On activated carbon with a 300 °C carbonization temperature (figure a) shows two diffraction peaks appearing at 2Θ =~20° and ~44.718°. At 350°C (figure b), the XRD diffractogram pattern shows two diffraction peaks appearing at 2Θ = ~24.207° and ~43.908°. While at 400°C (figure c), the XRD diffractogram pattern shows two diffraction peaks appearing at 2Θ = ~25.556° and ~42.559°, these two angles are characteristic of graphite on a flat plane (plannar, L) [37]. XRD results show that all activated carbons have a broadened diffraction peak at an angle of 2Θ= ~20° to ~30°, indicating that the activated carbons have an amorphous structure with a heterogeneous surface [38]. In Figure 8 (d), the initial peak of activated carbon has the highest intensity when the carbonization temperature is 300°C. In the first peak of XRD of activated carbon, there is a peak shift (300°C, 350°C, 400°C) towards a larger 2Θ angle (300°C temperature has the lowest 2Θ angle), this shows that activated carbon has the pores of activated carbon are larger at 300°C than at 350°C and 400°C, due to the shift of diffraction peaks towards smaller angles [39]. In the second peak, activated carbon at 350°C has the highest intensity, but there is a peak shift (300°C, 350°C, 400°C) to a smaller 2Θ angle. Meanwhile, the XRD intensity value can be influenced by the degree of crystallinity of the material. The higher the intensity of a material, the more crystalline the material is, so the material has a more organized and tidy atomic arrangement [40].

IV. CONCLUSION

The preparation of coconut pulp activated carbon was carried out at a variation of carbonization temperatures of 250°C, 300°C, 350°C, 400°C, and 450°C. The results showed that with increasing carbonization temperature, the value of carbon yield, ash content and carbon content obtained decreased, the value of water content and steam content increased. Good activated carbon has a large redeman value and bound carbon content, as well as a small water content, ash content, and vapor content. From the test results, it can be seen that all activated carbon with carbonization temperature variations have met SNI 06-3730-1995, but for the optimum temperature in the manufacture of coconut pulp activated carbon obtained at 300°C, with a yield value of 27.39%, moisture content of 2.01%, ash content of 0.65%, vapor content of 10.47%, bound carbon content of 88.88%, and has a diffraction peak that appears at angles 2Θ = ~20° and ~ 44.718°. From the research that has been done, coconut pulp activated carbon with a carbonization temperature of 300 ° C can be used in making composites for thermoelectric materials.

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