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Characterization of Rubber Bark (Hevea Brasiliensis) as s Raw Material and Fly Ash as a Catalyst for the Production of Biofuel

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Abstract: The research conducted on the utilization of rubber wood bark biomass for biofuel production employs the pyrolysis process. Rubber wood bark, a by-product of rubber plantation waste, has the potential to be converted into energy. However, its utilization has not been optimal, often leading to accumulation issues due to its inability to be fully utilized. Therefore, this study aims to utilize rubber wood bark to produce biofuel. Fly ash catalyst is employed to expedite the biofuel production process. The testing methods used to analysis the characteristics of rubber wood bark include proximate analysis and calorific value analysis. Proximate analysis of rubber wood bark yielded the following values: moisture content of 6.39%, ash content of 4.61%, volatile matter of 71.41%, and fixed carbon of 17.59%. The calorific value of rubber wood bark was determined to be 4200.00 calories per gram. Meanwhile, the characteristics of coal fly ash used as a catalyst were analyzed using X-Ray Fluorescence (XRF) or X-ray diffraction. The analysis revealed the presence of silicon dioxide (SiO_2) at 49.21%, aluminum oxide (Al_2O_3) at 16.22%, iron (III) oxide (Fe_2O_3) at 5.49%, calcium oxide (CaO) at 7.37%, magnesium oxide (MgO) at 1.72%, and potassium oxide (K_2O) at 0.50%. The analysis of rubber wood bark and coal fly ash indicates that rubber wood bark can be used as a raw material for biofuel production, while coal fly ash can serve as a catalyst.

Keywords: biofuel, characterization, fly ash, rubber bark

1. Introduction

Due to petroleum remaining the primary energy source in Indonesia, its consumption continues to raise despite the nation's dwindling energy reserves. Therefore, it is imperative to begin using renewable energy sources such as wind, solar, hydro, biomass, and others to replace petroleum. Indonesia has the potential to utilize biomass as a sustainable energy source. The term "biomass" describes non-fossil organic compounds found in living organisms such as plants, animals, and even microorganisms. Forestry, agriculture, aquaculture, livestock farming, and various types of industrial and domestic waste all serve as potential sources of biomass [1]. Biomass derived from sources such as wood, straw, sugarcane bagasse, oil palm residues, coconut shells, palm kernel shells, bamboo, and rubber waste offers substantial prospects [2].

Rubber wood is an abundant local resource in several regions, particularly in agrarian countries and rural areas. Utilizing this material as a feedstock for biofuel production offers significant potential in efforts to diversify sustainable energy sources and can serve as an efficient and environmentally friendly alternative energy source [3]. The process of tapping rubber wood can generate rubber wood waste. According to the Central Statistics Agency, based on data from the Ministry of Agriculture (Directorate General of Plantation), rubber production throughout 2022 reached 3,135.3 tons (Central Statistics Agency, 2023) [4]. Rubber wood, as a biomass resource, demonstrates substantial potential as a feedstock for biofuel production [5].

Rubber production by companies inevitably generates economically worthless waste that no longer serves any functional or profitable purpose. The waste primarily consists of rubber shavings from washing and rubber sedimentation processes. Solid waste originates from the bark and leaves mixed during rubber tapping. In addition to unintentionally mixed wastes, there are also intentionally added solid wastes like soil or sand by rubber farmers to increase weight [6]. Although companies have designated disposal sites for these shavings, accumulation issues arise because the waste is not fully utilized. Local employees' efforts to use shavings as landfill material have not reduced waste volumes. The company has attempted to use this waste as fuel; however tests revealed that the resulting flame is too small for direct combustion. Consequently, effective management is crucial to transform this waste into more useful products [7].

Direct combustion generates heat, gasification creates gases such as CH4 (methane); CO (carbon monoxide); and H (hydrogen), and liquefaction produces liquid fuel. These methods are among the various ways to convert biomass into energy sources [8]. Pyrolysis is a method to convert biomass into usable energy by utilizing waste from rubber wood bark. The technique of pyrolysis, biomass properties, and reaction parameters determine the relative amounts of the three by-products: charcoal, gas, and oil [9]. Pyrolysis techniques outperform other standard methods in terms of the yields they produce [10]. Heat transfer remains a challenge in this process. Specifically, there is insufficient heat transfer from the solid/biomass surface to gases, which reduces efficiency and increases energy consumption. It is easier to convert biomass breakdown into needed products with the aid of catalysts, enabling somewhat greater heat transmission [11]. The catalyst to be used in this study is fly ash. The performance of fly ash can be observed in previous research, such as that by Dewi (2021). Research has shown that fly ash is effective as the yield of biofuel increases with more fly ash used as a catalyst. Compounds like sodium carbonate, alumina, and silica increase proportionately with the amount of fly ash used. The conversion of pyrolyzed oil material into biofuel improves as the catalyst amount increases [12].

In this study, the characterization of rubber wood bark raw material begins with initial pretreatment, starting with drying the raw material and then reducing its size. The method used to characterize the rubber wood bark raw material includes proximate analysis, which aims to know the moisture, volatile matter, content ash content, and fixed carbon content of the material.

Next, calorific value analysis is conducted on the rubber wood bark raw material using a Calorimeter Bomb apparatus. This device is used to measure the heat released during the complete combustion (with excess oxygen) of different substances, including compounds and fuels. Several samples are positioned inside a tube filled with oxygen and immersed in a medium that absorbs heat called a calorimeter. The sample will burn; an electrically heated wire inside the tube ignites. This process allows researchers to accurately determine the energy content of the rubber wood bark raw material, essential for evaluating its potential as a feedstock to produce biofuel.

The characterization of the catalyst to be used in biofuel production is conducted through XRF (X-ray Fluorescence) testing. XRF or X-Ray Fluorescence is an analytical method employed to quickly ascertain the elemental composition of a material or sample. The principle used in determining elements or elements based on X-ray interactions with materials or samples.

Characterization of rubber wood bark and coal fly ash can determine the characteristics of rubber wood bark that can be used as raw materials and coal fly ash that can be utilized as a catalyst to produce biofuel.

2. Material Dan Method

21. Raw Material Preparation

The materials used are rubber tree bark sourced from rubber plantations in Tanjung Batu, Ogan Ilir, South Sumatra. The fly ash used as a catalyst was obtained from PT. Pupuk Sriwidjaja, Palembang. In this study, raw material preparation was carried out. First, the rubber tree bark was prepared and then its characteristics were analyzed through proximate analysis and calorific value assessment.

Figure 1. *Rubber Tree Bark Sample*

Second, prepare the catalyst; in this case the catalyst used is subjected to a characteristic analysis with the aim of seeing the components contained in the fly ash using the X-Ray Fluorescence (XRF) method.

Figure 2. *Coal Fly Ash Catalyst*

2.2 Characteristics Analysis of Raw Material

The rubber tree bark was first subjected to proximate analysis, which includes the analysis of ash, moisture, fixed carbon, and volatile matter content. Next, the calorific value of the raw material was analyzed. The fly ash catalyst intended for use in the pyrolysis process was then tested with X-Ray Fluorescence (XRF) to identify the compounds contained within the fly ash.

3. Result and Discussions

3.1 This Proximate Analysis

Proximate analysis serves as an indicator to assess the efficiency of biomass conversion into energy by measuring its content of volatile matter, moisture, ash and fixed carbon using the gravimetric method. The calorific value analysis of the raw material was performed using a Parr 6200 bomb calorimeter. The results of the proximate analysis for the rubber tree bark used in this study are presented in Figure 3.

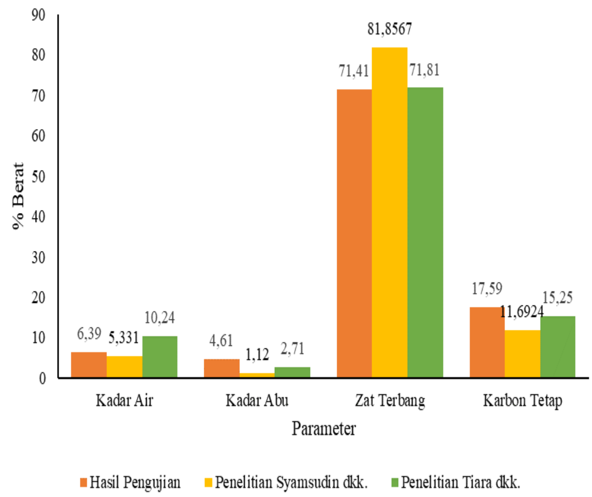

Figure 3. **Comparison of Proximate Analysis of Rubber Tree Bark with Previous Studies**

Figure 3 shows that the moisture content of the rubber bark used in this study is 6.39 %. The drying process of the rubber bark did not proceed as planned due to unfavorable weather conditions and an oven that was too cold, resulting in slightly high moisture content. High moisture content can impede the pyrolysis process because of the water content in the raw material, which can subsequently lower the calorific value of the fuel [13]. The ash content in the rubber tree bark is 4.61 %. The ash content is a negative factor for fuel quality because it can increase operating costs; the higher the ash content, the more challenging the combustion process becomes, the more difficult the combustion process becomes [14].

For volatile matter content, the test results shown in Figure 3 indicate that the volatile matter in rubber tree bark is 71.41%. This percentage is slightly lower than in previous studies, which reported 81.85% and 71.81 %, indicating potential difficulties in combustion. A relatively high volatile matter content suggests that the material is easily liquefied, thereby potentially maximizing the pyrolysis yield. The fixed carbon content of the rubber tree bark is 17.59 %. This percentage is slightly higher than the literature range but still within normal limits. The material's ability to release chemical energy increases with the ratio of volatile carbon to fixed carbon [15]. Compared to biomass rich in fixed carbon, biomass rich in volatile matter shows greater conversion. Biochar can be more effectively produced from biomass with a high fixed carbon content, while bio-oil can be more effectively extracted from biomass with a high proportion of volatile matter [16].

1.1. Calorific Value

The calorific value of the rubber tree bark sample was measured using the bomb calorimeter. Elevated calorific values are associated with higher carbon (C) content, indicating the availability of carbon to form new bonds with hydrogen (H) through liquefaction or other thermochemical conversions. The elevated calorific value of the rubber tree bark suggests that it is a comparatively promising biomass for generating biofuel. The research results of the calorific value analysis of the rubber tree bark raw material are shown in Table 1 below.

Table 1. *Calorific Value Analysis of Raw Material*

Sample	Calorific Value (cal/gr)	Comparative Literature	
		Syamsudin dkk (2022)	Tiara dkk. (2023)
Rubber wood bark	4200	4190,63 kal/gr	4526,98 kal/gr

From the table 1 indicates that the calorific value of the rubber tree bark sample is 4200,00 cal/gram. This value is only slightly different from previous studies. The relatively low calorific value may also be attributed to the high moisture content observed in the proximate analysis, which was around 6.39 %. Elevated moisture content can obstruct the pyrolysis process because the moisture in the raw material can interfere with it and can subsequently reduce the calorific value of the fuel [17]. A comparative graph of the calorific value results with reference literature can be viewed in Figure 4.

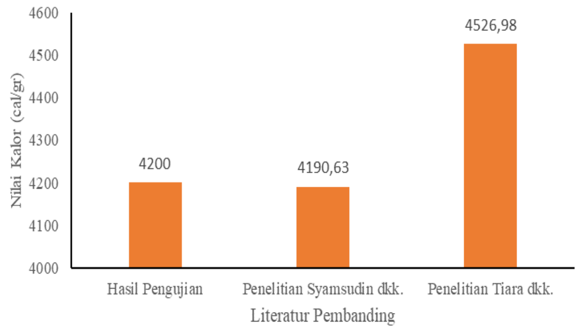

Figure 4. Comparison of the Calorific Value Analysis of Rubber Bark with Previous Studies

1.2. Characterization of Coal Fly Ash Catalyst

In this study, the elements present in the fly ash were analyzed using the XRF method. The research results of the XRF analysis of the coal fly ash are shown in Table 2 below.

Table 2. *Characterization Analysis of Fly Ash*

Composition	Research Results
Silicon Dioxide (SiO_2)	49,21
Aluminium Oxide (Al_2O_3)	16,22
Iron (III) Oxide (Fe_2O_3)	5,49
Calcium Oxide (CaO)	7,37
Magnesium Oxide (MgO)	1,72
Calium Oxide (K_2O)	0,50

The data above results from tests using the X-Ray Fluorescence (XRF) method, which is the primary technique for identifying catalyst components. Fly ash contains chemical elements such as aluminum oxide (Al_2O_3), silicon dioxide (SiO_2), calcium oxide (CaO), iron (III) oxide (Fe_2O_3) and other additional elements. The XRF analysis shows that the silica dioxide (SiO_2) content is relatively high at 49.21%. Based on its composition, the fly ash falls into class F (SiO_2 + Al_2O_3 + Fe_2O_3), which is categorized within the bituminous coal group. Fly ash is rich in silica, calcium, aluminum, and iron. This makes it a suitable candidate for use as a catalyst in this study, as a higher silica dioxide (SiO_2) content is considered better for catalytic applications [18].

4. Conclusion

Based on the research performed, the characteristics of rubber tree bark have shown potential as a fuel source, while the coal fly ash catalyst also demonstrates potential for use as a catalyst. Rubber tree bark is a valuable raw material to produce biofuel due to its comparatively high volatile matter content. The moisture content of 6.39% in the sample, it must be reduced, and this moisture level can be decreased by selecting a more efficient drying method. If not reduced, it can obstruct performance during the process of pyrolysis.

The analysis of calorific value from rubber tree bark indicates a value of 4200.00 cal/gram. This relatively low calorific value may also be attributed to the high moisture content observed in the proximate analysis. Biomass with an elevated calorific value can generate more energy-dense product of pyrolysis, for example biochar to be used fuel briquettes.

The characterization analysis of coal fly ash reveals the presence of silicon dioxide (SiO_2) at a concentration of 49.21%, alumina (Al_2O_3) at 16.22%, iron (III) oxide (Fe_2O_3) at 5.49%, calcium oxide (CaO) at 7.37%, magnesium oxide (MgO) at 1.72%, and potassium oxide (K_2O) at 0.50%. The highest concentration found in the fly ash is silicon dioxide (SiO_2) at 49.21%. To achieve optimal results, it is recommended that the rubber wood bark undergo pretreatment before being utilized as fuel. This pretreatment process aims to improve the quality of the resulting biofuel.

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