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Petung Bamboo As Microwave Absorber At 8-12 Ghz Frequency

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Abstract

It has been successful in characterizing activated carbon from petung bamboo using the carbonization method as a microwave absorber in the frequency range of 8-12 GHz. The micro-order activated carbon material, which is 23.5 µm, is a semiconductor with an electrical conductivity value of 2.16 x 10-7 S/m. The activated carbon of petung bamboo was carbonized at a temperature of 600 oC and an activated carbon phase was formed at an angle of 2θ 22,93° and 42.98° and the results of the FTIR characterization showed the presence of a C=C bond at wave number 1535.39 cm-1 as confirmation of the formation of activated carbon. The VNA test showed that the optimum reflection loss on the activated carbon sample of petung bamboo with a thickness of 1 mm was -21.2 dB at a frequency of 10.8 GHz

Keywords: *Bamboo Petung; Activated Carbon; Absorbers; Microwave*

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INTRODUCTION

Along with the rapid advancement of radar technology, research to inhibit radar effectiveness has begun to be developed (Li et al. 2018). These studies aim to reduce the amount of reflection (reflection loss) of electromagnetic waves by absorbing the emitted waves, of course using special materials and designs (Qin et al. 2012; Kong et al. 2013; Chen et al. 2017). These materials are defined as Microwave Absorbing Materials (MAMs) (Wang et al. 2020; Liang et al. 2020).

In this study using activated carbon from petung bamboo which is included in natural materials where the material is easy to obtain and abundant availability, low cost of synthesis and easy to renew (Liu et al. 2019).

Petung bamboo is known as a source of activated carbon which has unique characteristics. Carbon material has good thermal and electrical conductivity properties (King et al. 2006), high resistance to prevent corrosion (Wood et al. 2007), chemical stability over a high temperature range (Balandin et al. 2011), generally has a high density. lower than metals and alloys (Min et al. 2018; Baseghi et al. 2015), so it can absorb electromagnetic waves by taking advantage of dielectric loss properties (Liu et al. 2018). Ideally, an absorber material should have properties that are light, thin, high electrical conductivity, low density, good thermal stability and also anti-corrosion (Huang et al. 2016).

RESEARCH METHOD

This study used petung bamboo (Dendrocalamus Asper) which is 3-5 years old and has abundant cellulose and lignin content so that it produces a dominant amount of carbon. The initial process of synthesizing petung bamboo activated carbon is combustion which aims to convert the bamboo material into charcoal. After the bamboo charcoal is formed, the next process is grinding and filtering using a 200 mesh filter which aims to obtain a uniform particle size. Petung bamboo charcoal powder that has been filtered will be carbonized at a temperature of 600 oC for 45 minutes using the Furnace model FB1400 located in the ITS Physics laboratory in Surabaya. The carbonization process at high temperatures can affect high electrical conductivity values and a large surface area so that carbon materials can be used as microwave absorbers (Wu et al. 2008).

RESEARCH RESULTS AND DISCUSSION

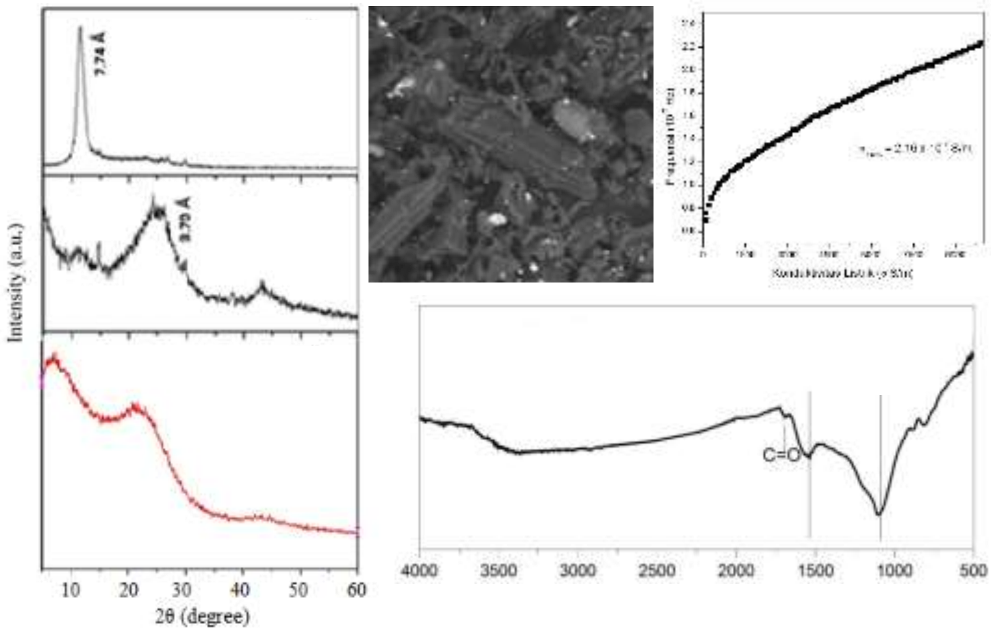

Image 1. (a1) Diffraction pattern of graphene oxide (GO) reference, (a2) Diffraction pattern of reduced graphene oxide (rGO), (a3) Diffraction pattern of activated carbon of petung bamboo, (b) mapping of activated carbon of petung bamboo, (c) average value petung bamboo electrical conductivity and (d) FTIR spectroscopy of petung bamboo activated carbon

Petung bamboo charcoal which has been carbonized at 600 oC and characterized using XRD produces an amorphous structure with two broad peaks, namely at 2θ 22.93o and 42.98o (figure 1.a1,a2,a3) which indicates that at low temperature treatment activated carbon phase with crystal planes (002) at an angle of 22.93o and (100) at an angle of 42.98o. This analysis was carried out by comparing the measured rGO diffraction pattern (XRD) with reference to research conducted by Fu, (2013) which showed that there were two corresponding peaks, namely in the region 2θ = 20o – 30o and 2θ = 40o – 50o.

Characterization of morphology and particle size using Scanning Electro Microscopy (SEM) with a magnification of 200 µm. Based on this test (figure 1b) it is known that the average particle size of petung bamboo activated carbon is 23.5 µm.

The electrical conductivity of petung bamboo activated carbon was characterized using the Two Point Probe method yielding a value of 2.16 x 10-7 S/m (figure 1c). This value indicates that the activated carbon material of petung bamboo is classified as a semiconductor material, which is known to be good for use as a microwave absorbent material because it has the property of converting microwave energy into heat energy (Perez et al. 2022).

The results of the FTIR spectroscopy (figure 1d) show that the activated carbon of petung bamboo has been formed which is characterized by the presence of a C=C bond at wave number 1535.39 cm-1 (Skoog et al. 2007). In addition, there are characteristics of organic materials, namely =CH bonds in the absorption areas of 877.64 cm-1 and 808.20 cm-1. In addition, there is a carbonyl fall (C=O) in the 1681.98 cm-1 area and CO strain bonds in the 1103.32 cm-1 area (Skoog et al. 2007).

Characterization of microwave absorption using a Vector Network analyzer (VNA) in the X-band frequency range (8-12 GHz). Theoretically, the reflection loss of an absorber material can be calculated using the following equation.

$$RL = 20log\left|\frac{Z_{in}-Z_0}{Z_{in}+Z_0}\right| \quad (1)$$

with

$$Z_{in} = Z_0\sqrt{\frac{\mu_r}{\varepsilon_r}}tanh\left(j\frac{2\pi fd}{c}\sqrt{\mu_r\varepsilon_r}\right)$$

here, Zin is the input impedance, Z0 is the characteristic impedance of a vacuum with a value of 120π Ω, f is the microwave frequency, c is the speed of light in a vacuum, d is the thickness of the sample, µr is the permeability of the material and is the permittivity of the material.ε_r

Based on this equation, it can be said that no microwaves are reflected from the surface if the input impedance (Zin) of the material is designed to be the same as the characteristic impedance of a vacuum (Z0), which indicates that all microwaves exposed to the surface of the material will be transmitted into the material. This phenomenon is called impedance matching (Guan et al. 2021).

Experimentally, the value of reflection loss (RL) is presented in Figure 2. Based on the results of VNA characterization at sample thicknesses of 1 mm, 1.5 mm and 2 mm from activated carbon of petung bamboo, it can be identified as follows:

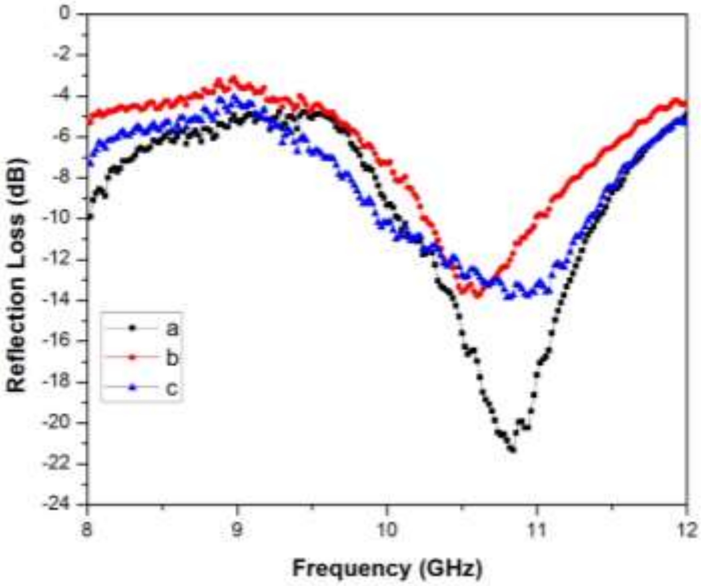

Figure 2. VNA characterization of activated carbon samples with a thickness of (a) 1 mm, (b) 1.5 mm and (c) 2 mm

It is known that the absorption of microwaves in the sample can be seen based on the reflection loss value, the greater the negative reflection loss value indicates the greater the absorption of the material against microwaves (Phang et al., 2008). Based on the results of the VNA characterization in Figure 2, the optimum reflection loss value is found in an activated carbon sample with a thickness of 1 mm which is -21.2 dB at a frequency of 10.8 GHz. Whereas in samples with a thickness of 1.5 mm the reflection loss value is -12.9 dB at a frequency of 10.7 GHz and in samples with a thickness of 2 mm the reflection loss value is -13.5 dB at a frequency of 10.5 GHz.

This value when compared with equation 1 shows a symptom of impedance compatibility at a sample thickness of 1 mm. The sample thickness factor (d) is not a determining factor for the value of reflection loss because it must be adjusted to the intrinsic impedance value of the material and free space impedance so that at a thickness of 1.5 mm and 2 mm optimum reflection loss does not occur. In general, it can be said that the activated carbon of petung bamboo can be used as a microwave absorbent in the 8-12 GHz frequency range.

CONCLUSION

The results of the research that has been done can be concluded that petung bamboo can be synthesized into activated carbon as a microwave absorbent material. Activated carbon material has an average particle size of 23.5 µm. At the micro-order, reflection loss of activated carbon occurs in samples with a thickness of 1 mm, which is equal to -21.2 dB at 10.8 GHz.

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