

ANALYSIS OF ACTIVATED CARBON (PETUNG BAMBOO)/LATEX COMPOSITE AS X-BAND WAVE-ABSORBING MATERIAL

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ABSTRACT

In maintaining the sovereignty of a country, especially in border regions was needed defense tools that had the latest technology, such as stealth technology. Stealth technology was applied to military ships or aircraft so that they could not be detected by Radio Detection and Ranging. Stealth technology in this research was realized by coating the ship's or aircraft's body using RAM (Radar Absorbing Material). RAM could be composed of dielectric materials, such as activated carbon. The activated carbon was synthesized from Dendrocalamus asper. This research aimed to analyze the proper of composition the composite and thickness of the RAM for the X-band wave range. The methods were carbonization, activation by KOH and HCl solutions, and characterization. The characterizations were by XRD, FTIR, and SEM to identify the active carbon phase, and VNA to determine the value of reflection loss. The variations in this research were composite composition (7:3, 9:1) and thickness (1mm, 3mm). It was obtained a composite of activated a composite of activated carbon of Petung bamboo and latex of rubber tree, which is indicated by the formation of two broad peaks in the diffraction pattern, the presence of band groups C=C, C-C, C-H, C-O, O-H, and morphology with a porous structure. In addition, the highest reflection loss is obtained for the 9:1 composite and thickness of 3 mm, which reached -17.25 dB at a frequency of 9.32 GHz.

Keywords: Activated carbon; latex, petung bamboo, reflection loss.

INTRODUCTION

In a country, sovereignty is the most important aspect that must be maintained (Adnyana, 2022). So it is necessary to have a state defense tool that has advanced technology to monitor and maintain state sovereignty, especially in border areas that are prone to conflict and other threats (Azmi, et al, 2011). In 1935, Robert Alexander W.W. invented Radar (Radio Detection and Ranging), a technology that could detect objects at long distances, and had been applied to various areas of national defense. But nowadays another technology has developed, namely stealth technology (Hoesada, 2007). Stealth technology can be created in two ways, namely designing the surface of a ship/aircraft with a certain shape and dimension that can redirect radio waves, and coating a ship or aircraft with Radar Absorbing Material (RAM) (Pattanaik, B. and Chauhan, A., 2021).

RAM is a material that can absorb radar waves so that it can reduce microwaves being reflected (Saville, P., 2005). This absorption occurs due to the interaction between microwaves and absorbent materials, thus generating heat which is the dissipation of energy. Absorbent materials can be classified into two, namely dielectric materials

and magnetic materials (Gaylor, K., 1989). Previously, research on the development of anti-radar materials with inorganic materials has been widely developed, such as polycrystalline iron and carbonyl iron (Ghasemi, et al, 2008). But currently, researchers are also starting to develop anti-radar materials with organic materials, such as carbon derived from bamboo charcoal (Mistar, et al, 2020).

Mistar E.M. (2020) in his research stated that carbon produced from the synthesis of bamboo charcoal has an activated carbon phase. Activated carbon is a type of carbon that has a high surface area, pore volume, and porosity. As well as having good absorption capacity and thermal stability, etc. And due to these unique and superior properties, activated carbon has been widely developed and produced in the 20th century this year (Mistar, et al, 2020). Activated carbon synthesis can be done through an activation process using activators in the form of KOH and HCl (Yohandri, et al, 2017).

Most carbon materials such as activated carbon, graphite, and graphene have the same characteristics, namely having dielectric properties, so they can absorb microwaves and generate heat due to their interaction with electric fields (Shkal, et

al, 2017). Activated carbon is a material that has dielectric properties. Carbon materials have been widely developed into composite materials with magnetic materials, such as Fe₃O₄ to maximize their ability to absorb microwaves (Zhang, K., et al, 2018). The ability of this absorbent material is represented by reflection loss (RL) values and expressed in dB units and negative (-) values (Durmus, Z., et al, 2015). Based on Yohandri's research (2017), as one of the carbon materials, activated carbon has a fairly high ability to absorb microwaves, reaching -19.5 dB at a frequency of 6 GHz.

Based on the RL value produced from various types of bamboo in Mashuri's research (2020), the results were obtained that the type of bamboo that has the most potential as an anti-radar material is Petung bamboo (*Dendrocalamus asper*) (Mashuri, et al, 2020). In addition, optimizing the capabilities of anti-radar materials is generally done by combining several materials into composite materials (Zhang, K., et al, 2018). Latex is a material that can glue object to the medium, has high strength and durability, and contains 92-94% hydrocarbons (Triwiyoso and Siswantoro, 1995). Therefore, carbon of Petung bamboo Charcoal will be used combined with rubber tree latex as an anti-radar composite material.

METHOD

The organic materials used to make anti-radar composites in this research were petung bamboo (*Dendrocalamus Asper*) and rubber tree latex (*Hevea Braziliensis*). The synthesis method in this research is divided into four steps, namely:

2.1 Preparation of Bamboo Charcoal Powder

This step begins with drying the petung bamboo that has been cut thinly, drying it under the hot sun. Furthermore, the bamboo is burned into charcoal, then smoothed using mortar, and sifted using 200 mesh to obtain a homogeneous particle size, so that fine carbon powder is obtained.

2.2 Activation of Carbon Bamboo Charcoal

This step begins with a carbonization process at a temperature of 600 °C and a holding time of 1 hour using a furnace. Furthermore, the activation process is carried out using KOH 3M solution. The purpose of this process is to reduce hydrogen bonds that bind to oxygen and other impurity atoms. After that, the mixing process is carried out mechanically using a stir. And to neutralize, a 3M HCL solution is added, until a pH of 6-7 is obtained (Yohandri, et al, 2017). Furthermore, the sample is rinsed with

aquades, then filtered, and heated at a temperature of 110°C, until activated carbon powder is obtained.

2.3 Synthesis of Bamboo Charcoal/Latex Composites

This step is carried out by mixing the dried bamboo charcoal powder with the latex of the rubber tree. This mixing is done with variations in the composition of activated carbon of bamboo charcoal: the latex of the rubber tree is (7:3) and (9:1). This mixing is done for 30 minutes until it becomes homogeneous using a stirrer. After that, the process of forming a composite film of activated carbon and latex with a variation in thickness of 1 mm and 3 mm is carried out, then dried.

2.4 Characterization

This step is divided into two, namely: 1) Activated carbon characterization test, which consists of XRD (X-Ray Diffraction) to determine the type of activated carbon phase, FTIR (*Fourier Transform Infrared*) to analyze the constituent functional groups of activated carbon, and SEM (*Scanning Electron Microscopy*) to analyze the morphology of activated carbon/latex composites. 2) Reflection loss test, which uses a VNA (Vector Network Analyzer) to find out how much the composite has to absorb microwaves. Where the microwave frequency tested was at the X-Band wave interval, which is 8.20 – 12.4 GHz (Mitraryana, 2015).

RESULTS AND DISCUSSION

3.1 Analysis of X-ray Diffraction

XRD characterization was performed on activated carbon powder samples from Petung bamboo charcoal. The resulting diffraction pattern consists of diffraction peaks with the main characteristics, namely position (2θ), intensity (peak height), and half peak width (FWHM). Where these characteristics are those used to identify the phase of a sample (Cullity, B.D. and S.R. Stock, 2014). In this research, XRD characterization was carried out in a small angular range, namely $2\theta = 10^\circ - 70^\circ$. Thus, a diffraction pattern is obtained as shown in Figure 1.

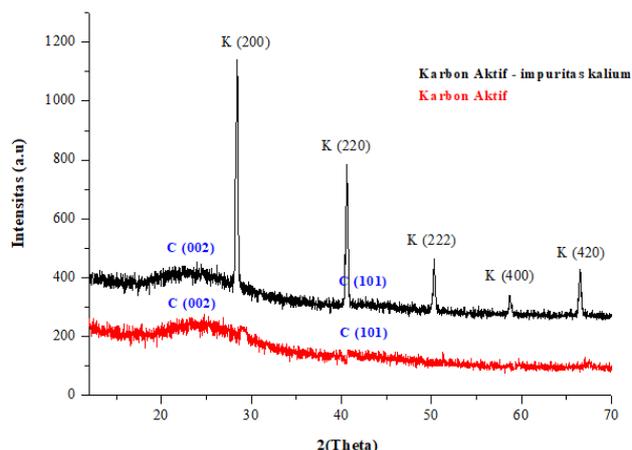


Figure 1. Diffraction Pattern of Petung Bamboo Charcoal Carbon Powder

In Figure 1 two diffraction patterns from two different samples are presented, namely activated carbon-containing impurity (black) and pure activated carbon (red). In the first diffraction pattern, sharp peaks are visible with different intensities at a value of $2\theta = 28.2^\circ, 40.5^\circ, 50.12^\circ, 58.5^\circ,$ and 66.7° indicating fields (200), (220), (222), (400), and (420). Where based on the method of matching with diffraction patterns from Ismail's research (2022), it has been confirmed that these peaks indicate the crystalline phase of the potassium chloride (KCl) compound, as shown in Figure 2(b) (Agarwal, M., et al, 2017). This compound contains potassium elements, so the presence of this compound as an impurity in this research is normal because the activator used in the activation process is a KOH solution. Therefore, to remove the potassium content and neutralize the sample, the addition of an HCl solution is carried out (Yohandri, et al, 2017). And also carried out the process of washing activated carbon using aquades, so that a diffraction pattern is obtained as shown in Figure 2.

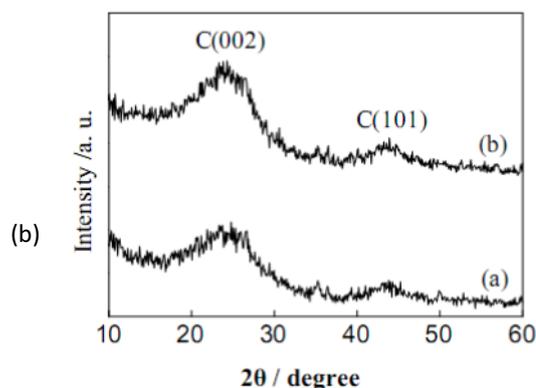
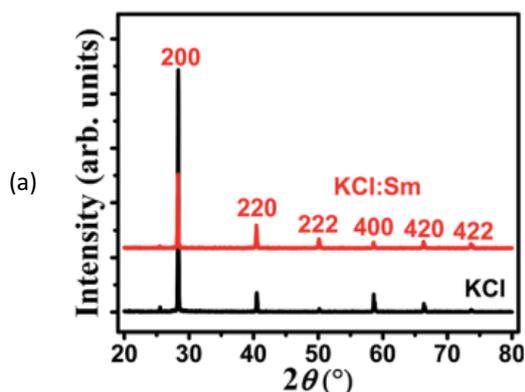


Figure 2. Diffraction Patterns (a) Activated Carbon (Liu, X.Y., et al, 2010), (b) Potassium Chloride (Agarwal, M., et al, 2017)

The second diffraction pattern in Figure 2 shows that the sharp peaks (potassium) have decreased after the neutralization and flushing process. So there are only two wide peaks, namely at the position of $2\theta \approx 24^\circ$ with a fairly high intensity and $2\theta \approx 42.5^\circ$ with a lower intensity. This wide peak indicates that activated carbon powder particles are small in size and short-term, so the structure formed is not crystalline but amorphous (Cullity, B.D. and S.R. Stock, 2014). Based on the diffraction pattern (Figure 1) and phase identification by matching method to the research of Liu, X.Y. (2010), it can be stated that the two wide peaks in the field (002) and (101) of the results of this research correspond to the diffraction pattern formed in Figure 2.2(a).

As described in the previous discussion, materials with an amorphous carbon phase are materials that have regularity of short-range C-C bonds. Where the regularity of such a bond is what distinguishes amorphous carbon from other crystalline carbon allotropes (Cullity, B.D. and S.R. Stock, 2014).

3.2 Analysis of Fourier Transform Infrared

FTIR characterization was performed on powder samples to identify the functional groups contained in the activated carbon of petung bamboo charcoal. Where the functional group of the FTIR result is a spectrum represented by the peak of the absorption area at a certain wave number, as shown in Figure 3.

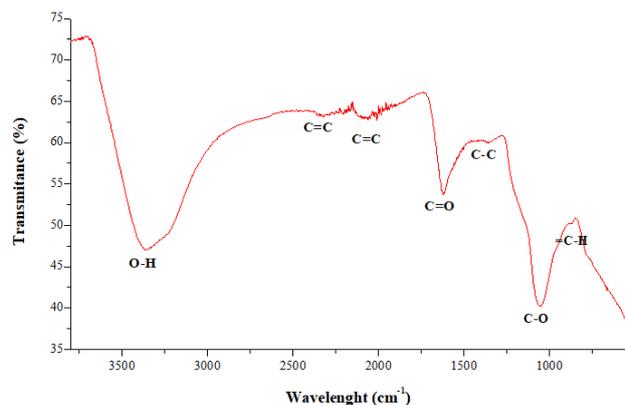


Figure 3. FTIR Spectrum Carbon Powder Petung Bamboo Charcoal

Figure 3 shows that in this research a wide peak was formed in the absorption area around wave number 3361 cm^{-1} . This value indicates the presence of a bond from the O-H group due to the vibration of the water molecule (Mojoudi, N., et al, 2019). Peaks at 2321 cm^{-1} and 2110 cm^{-1} indicate the presence of conjugated weak bonds of the C=C group (Mecozzi, M., et al, 2012). A peak at 1622 cm^{-1} indicates the presence of a C=O strain bond of the carboxylic acid group (Mojoudi, N., et al, 2019). In Mashuri's research (2020), of the three types of bamboo tested, only petung bamboo has a single carbon bond C-C. Where the bond was also formed in this research, which is indicated by the presence of a peak at 1452 cm^{-1} . The single C-C bond is an alkane group in a type of aromatic compound (Mashuri, et al, 2020).

Figure 3 also formed a peak at 1060 cm^{-1} , which represents the presence of a weak bond from the C-O group (Mojoudi, N., et al, 2019). And the peak at wave number 875 cm^{-1} indicates the presence of a bond =C-H which is out of plane bending (Mojoudi, N., et al, 2019). This =C-H bond shows that the carbon in petung bamboo charcoal has a covalent (single) bond with a hydrogen atom (H) and a double bond with another impurity atom (Mashuri, et al, 2020).

3.3 Analysis of Scanning Electron Microscopy

SEM characterization was performed on samples of activated carbon composite powder of petung bamboo charcoal and rubber tree latex with a magnification of 2500x. The samples tested were two based on variations in their composition, so Figure 4 was obtained.

Mistar E.M. (2020) states that carbon from bamboo charcoal not only contains carbon atoms, but also various other atoms such as hydrogen, nitrogen, oxygen, halogens, phosphorus, sulfur, and

so on. Where carbon atoms and other atoms will be bound to each other at the edges of the activated carbon film which is determined by the level of acidity and basicity in the surface formation of activated carbon. Figure 4 shows that the morphological structure on the composite surface of bamboo charcoal and latex is hollow/porous with a rough and irregular surface. The presence of extensive cavities and pores on the surface of activated carbon is influenced because the synthesis step is carried out through a heating process so that carbon atoms bound to hydrogen atoms (hydrocarbon compounds) are released (Mentari, V.A., et al, 2018). In addition, the hollow structure of activated carbon is also affected by the activation process. This is evidenced by the results of Yohandri's research (2017), where the number of pores in activated carbon is more than in carbon without activation. The use of KOH activators causes the release of gases, such as carbon monoxide and carbon dioxide which are diffused on the surface of activated carbon, then erode so that a hollow/porous structure is formed (Yohandri, et al, 2017).

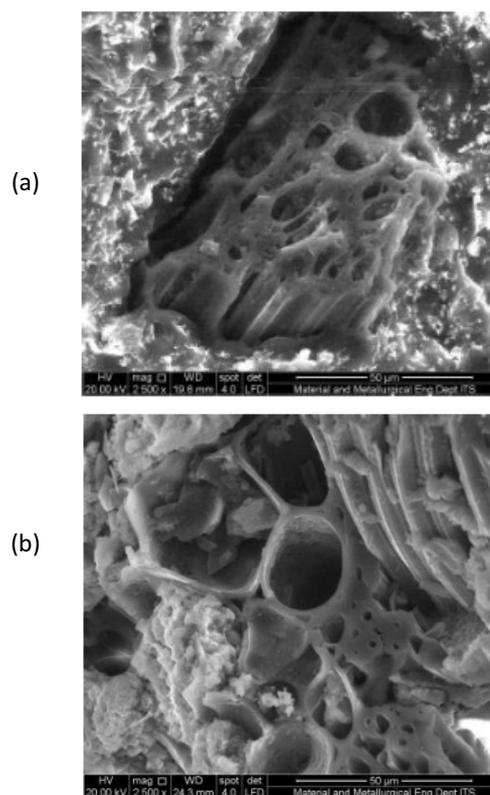


Figure 4. Morphology of bamboo/latex activated carbon composites in composition (a) 7 : 3 and (b) 9: 1

With the same magnification, the morphological structure formed on the composite surface is almost the same (hollow/porous) for each variation of the composition. But there is a slight difference, namely in the pore area. Where in figure 4(b) it can be seen that the pore area is larger than in figure 4(a). This can be influenced by the concentration of latex, where in figure 4(a) the latex used is greater, resulting in agglomeration (clumping) on the surface of activated carbon. Yohandri (2017) states that the number of pores/cavities present on the surface of carbon causes the specific surface area of activated carbon (Yohandri, et al, 2017). So it can be said that from the SEM test results, the specific surface area of activated carbon and latex composites in the 9:1 composition is greater when compared to the 7:3 composition.

3.4 Analysis of Vector Network Analyzer

Microwave absorption analysis of activated carbon composites of bamboo charcoal and rubber tree latex was performed by measuring Reflection Loss (RL). RL is negative, and the amount of absorption of material against microwaves will be greater as the negative price of RL gets bigger (Durmus, Z., et al, 2015). This test was carried out by firing microwaves with an X-Band wave range, which is 8.20 – 12.4 GHz (Mitrayana, 2015) on composite samples with a thickness of 1 and 3 mm (Figure 5)

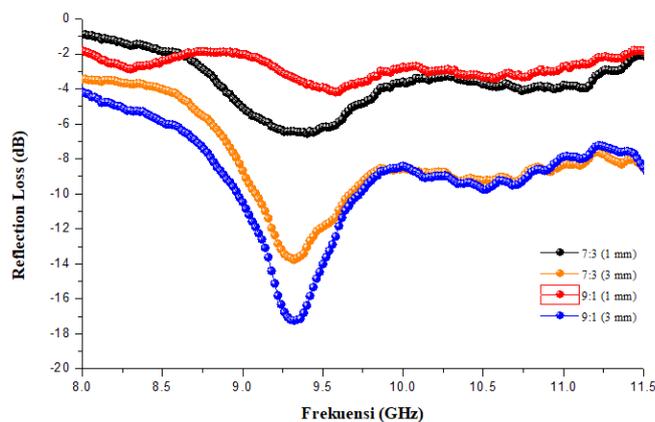


Figure 5. Reflection Loss of bamboo/latex activated carbon composite with a film thickness of 1 mm and 3 mm

Figure 5 shows that the largest RL value is shared by activated carbon and latex composites at a thickness of 3 mm for a composition of 9:1, i.e. with a value of -17.25 dB at a frequency of 9.32 GHz. This value is relatively smaller than the results of Yohandri's (2017) research, which stigmatizes

activated carbon from coconut shell charcoal, which is -19.5 dB (Yohandri, et al, 2017). This is caused by several factors, such as film thickness during the testing process, where in Yohandri's research (2017), the RL value was obtained at a film thickness of 6 mm (Yohandri, et al, 2017), while in this research it was 3 mm. However, even so, the magnitude of the RL value can not only be determined from the thickness of the film but there are several other factors, including the relative permittivity and relative permeability of each absorbent material used (Mashuri, et al, 2020).

In addition to thickness, the difference in the concentration of the activator used also causes a difference in RL values. Where in this research, the activator was in the form of KOH and HCl 3M solutions, while in Yohandri's research (2017) was KOH and HCl 1M solutions (Yohandri, et al, 2017). The purpose of using activators on carbon is to reduce the bond of carbon atoms with atoms of impurity so that pores or cavities are formed which are the main characteristics of activated carbon. Where the more pores, the greater the specific surface area of activated carbon. And this is what affects the ability of activated carbon in microwave absorption (Yohandri, et al, 2017). This aspect can also be seen from the RL value in different composite compositions, where the RL value in the 9:1 composition is greater than the 7:3 composition, for both 1 mm and 3 mm thickness. This RL value indicates a correlation with the morphological structure of the SEM assay relating to the specific surface area of activated carbon.

Activated carbon is a dielectric material (Shkal, et al, 2017), so the microwave absorption mechanism in activated carbon is polarization caused by the interaction of the electric field of the incoming wave with the electric dipole (activated carbon). The existence of this electric dipole is due to the difference in electronegativity, thus forming a covalent bond (Kurniawan, A.F., et al, 2019). In addition, based on the FTIR results, this composite has C=C and C-C group bonds. Where these two bonds include the main bond of activated carbon. In addition, the presence of impurities represented by O-H, C=O, C-O, and =C-H bonds also contributes to the formation of electric dipoles in activated carbon (Kurniawan, A.F., et al, 2019). Where these electric dipoles move according to the direction of the electric field from the outside, then there is alternating motion, so that the atoms rub against each other, and produce energy which is then absorbed by activated carbon in the form of thermal energy (Kurniawan, A.F., et al, 2019).

CONCLUSIONS

Based on data analysis, it can be stated that the activated carbon phase of the composite synthesis of bamboo charcoal and rubber tree latex has been formed, which is indicated by the results of the XRD, FTIR, and SEM tests. As well as the greatest reflection loss is owned by activated carbon/latex composites at a composite composition of 9: 2 with a thickness of 3 mm, whose value reaches -17.25 dB at a frequency of 9.32 GHz. Thus it can be stated that the activated carbon composite of petung bamboo charcoal and rubber tree latex has the potential to be anti-radar material. And for further research, it is necessary to conduct a cross-section SEM test to determine the thickness and evenness of the composite film before the VNA test is carried out. As well as tests of relative permeability and relative permittivity to analyze reflection loss values based on the main properties of amorphous carbon as a dielectric material.

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