Study of Single Layer Radar Absorber Material (RAM) Based on Coconut Shell Activated Carbon

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Abstract— A study of single layer Radar Absorber Material (RAM) based on coconut shell activated carbon is presented in this work. Coconut shell is resulting waste of coconut milk industry that has high carbon content. This study aims to determine the maximum absorption of coconut shell activated carbon as well as the activation effect on coconut shell carbon. The carbon was prepared using carbonization and activated using KOH and HCl. These process aims to open the pores of carbon, so the absorbance of the active carbon is increased. The Scanning Electron Microscopy (SEM) and Vector Network Analysis (VNA) are operated in active carbon characterization. The electromagnetic properties of these RAMs were analyzed using the waveguide technique in the frequency range of 4 to 8 GHz (C-Band). The VNA result showed maximum absorption of −19.5 dB at thickness of 6 mm with 1M HCl activator. The SEM images show the activated carbon has more pore than non-activated carbon. The single-layer RAMs exhibited behavior of satisfy absorbers in the frequency range studied. The result shows the reflectivity response of the carbon is satisfied as RAM in the investigating frequency.

1. INTRODUCTION

Most of Coconut shells are only considered as industrial waste of coconut processing as well as environmental problem. But actually the charcoal of coconut shell can be utilize as starting material to produce a product that has a high economic value, for example as an activated carbon or activated charcoal [1]. Activated carbon is processed and prepared in to obtain high porosity and very large surface area that benefit adsorption [2]. Coconut shells have hard characteristic due to high silicate (SiO_2) content, high bound carbon content, and low mineral ash content. Coconut shell carbons have several advantages like high density, high purity [3]. The content makes the coconut shell is excellent to be processed as activated carbon [1].The activated carbon based on coconut shell have many micro-pores, large surface area and high adsorption power especially for radar wave absorption or as RAM (Radar Absorber Materials).

Radar Absorber Material (RAM) is the material that attenuates the energy in an electromagnetic wave [4]. RAM can be used externally to reduce the reflection from or transmission to particular objects and can also be used internally to reduce oscillations caused by cavity resonance. They can also be used to recreate a free space environment by eliminating reflections in an anechoic chamber [5]. The principle of Stealth technology based on the absorption of radar by a material has become a modern military innovation recently, in order to improve the military technology and anticipate the disruption of border area security. Stealth technology has been known to be a combination of approaches in which the electromagnetic wave absorption was achieved by either shaping the target, using radar absorbing materials (RAM) and further enhancement of the absorption by applying coatings or paints [1].

The absorption ability of activated carbon is determined by the particle surface area. Activated carbon is a microcrystalline, non-graphite form of carbon that has been processed to develop internal porosity [7], characterized by a very large specific surface area. This research conducted to determine the effect of thickness of activated carbon based on coconut shell, concentration activator and activation substance toward the ability of absorption on radar. Natural raw materials used coconut shell activated carbon as dielectric material. The Activated carbon characterized using VNA for RAM wave absorption test. The Scanning Electron Microscopy to analyze Micro-structural and morphology of materials.

2. METHOD

2.1. Synthesis of Activated Carbon Based on Coconut Shell

The starting material used in the research is coconut shell. The coconut shell cleared from other materials soil and gravel. Carbonization of the coconut shell is carried out by an imperfect *Pyrolysis* process of a carbonaceous material. The carbonization result mashed using a blender and sieved using 100 mesh. The Activation process is conducted using HCl and KOH with variation of concentration 1 M to 5 M. Amount of 20 grams of materials dissolved in activator (KOH and HCL) based on the variation of concentration with constant stirring for 1 hour. The activation result is precipitated for 48 hours. It is then neutralized by adding the KOH solution wisely to the solution with HCl until pH 6-7 reached, whereas in the KOH solution it is neutralized by adding HCL solution wisely until pH 6-7 reached. After neutralization, the material is washed with aquades and then filtered using filter paper until the impurity water is separated from the activated material. The ingredients were then dried in an oven at 110 ° for 2 hours and the activated carbon obtained.

2.2. Characterization

Vector Network Analysis (VNA) is performed to measure the absorptive performance of the activated carbon. The Measurement was carried out with variations in thickness of 2 mm, 4 mm, 6 mm, 8 mm, and 10 mm. SEM characterization was performed to obtain microstructures and morphology of the non-activated and activated carbon to examine many pores that occur due to activation. The process of SEM characterization is done with 3000x enlargement.

3. RESULT AND DISCUSSION

The Absorption of radar in materials of thickness of 2 mm, 4 mm, 6 mm, 8 mm, and 10 mm were identified using a Vector Network Analyzer in the 4–8 GHz frequency range. The effect of material thickness on the absorption of wave generated at each concentration variation (M) can be seen from the maximum reflection coefficient (RL) in dB. The result of characterization using VNA with KOH activator is shown in Figure 1.

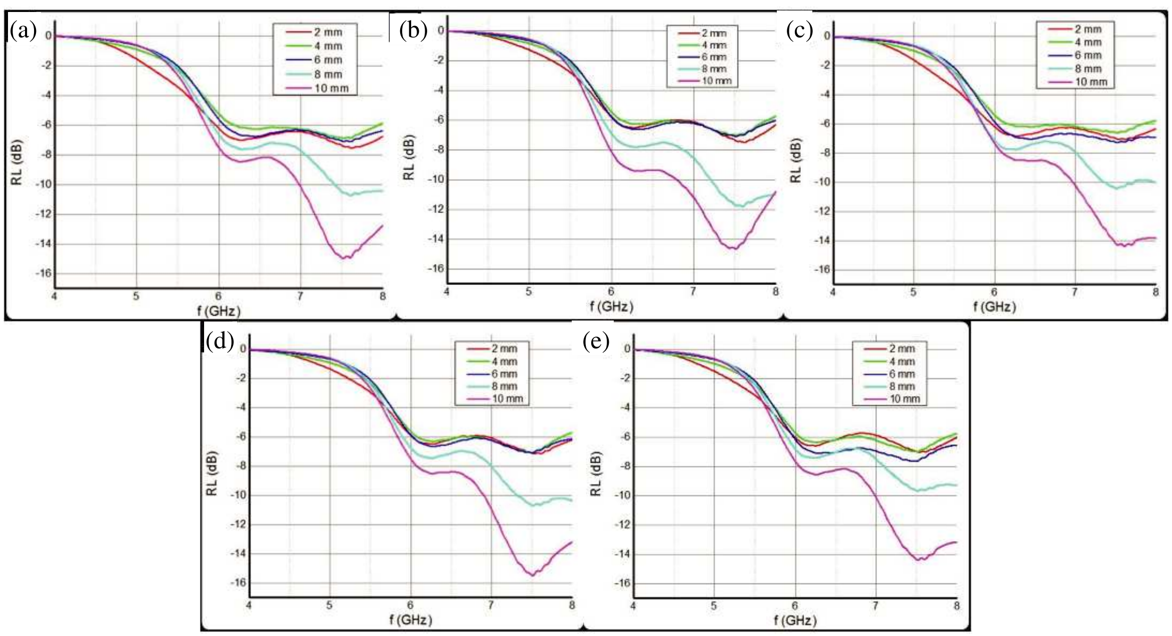


Figure 1: Relation of RL value to frequency graph with KOH activator for variation of material thickness and concentration of activator (a) KOH 1M, (b) KOH 2M, (c) KOH 3M, (d) KOH 4M and (e) KOH 5M.

The largest absorption of radar wave occurs at the concentration of KOH 4 M with a thickness of 10 mm that can be seen on Figure 1. The maximum RL value obtained is −16.1 dB at 7.6 GHz (see Table 1). The data on Table 1 also explained that the material with a thickness of 10 mm has the largest reflection loss value. The thickness of 10 mm of the material has a large volume so that more particles that interact with radar waves that cause absorption increased. The result of characterization using VNA with HCL activator substances is shown in Figure 2.

The result of VNA characterization on coconut shell activated carbon with HCl activator can be seen in Figure 2. The maximum radar wave absorption capacity is −19.5 dB at 6 GHz frequency. The maximum Absorption radar occurs at the HCl 1 M with a thickness of 6 mm. However, in substances with HCl activator substances showed a decrease in absorption rate along with increasing thickness at some point. The absorption mechanism in the dielectric material of activated carbon is caused by the presence of free radicals that play a role in the process of conducting current. When microwaves introduced to materials coated with dielectric such as activated carbon that

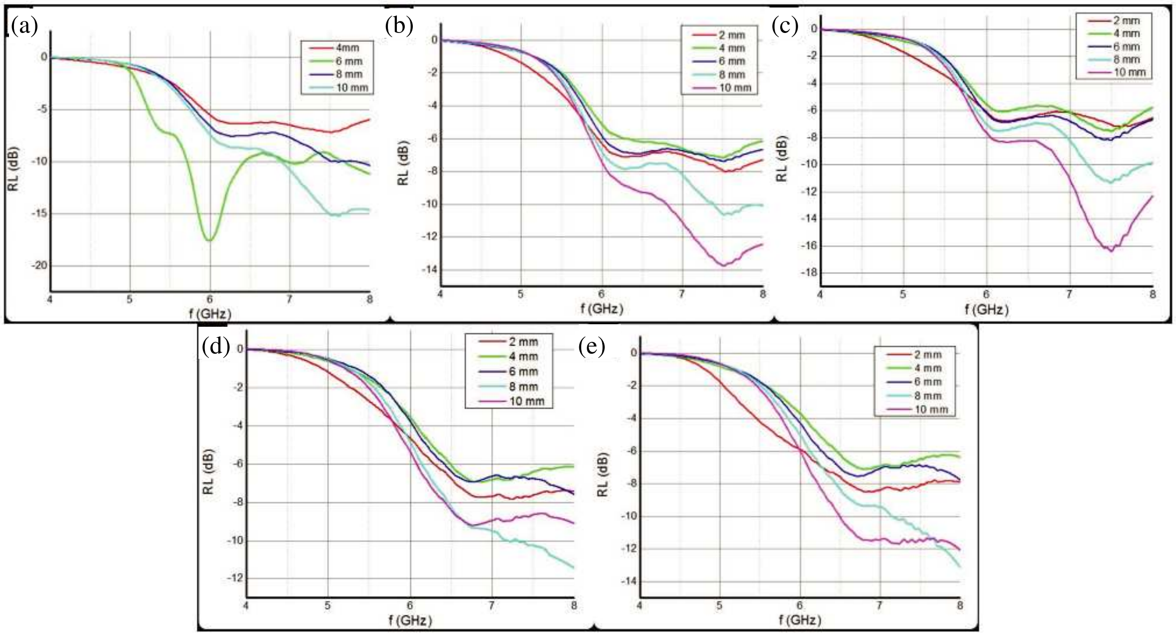
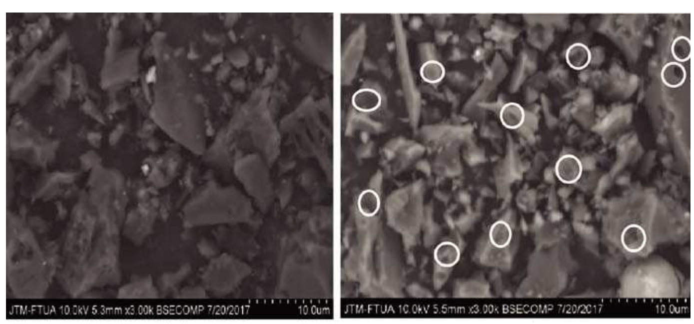


Figure 2: Relation of RL value to frequency graph with KOH activator for variation of material thickness and concentration of activator (a) HCL 1 M, (b) HCL 2 M, (c) HCL 3 M, (d) HCL 4 M dan (e) HCL 5 M.

have free radicals, the electric field of EM waves will cause the Coulomb force. The charge will move with certain acceleration and produces an electric current from the movement of the charge. The existence of the magnetic field of both materials will be mutually destructive with the magnetic field of the coming microwaves where the amplitude values are the same but have different phase difference, so the microwaves are not re-received by the radar receiver. Samples with HCl activation have an RL value greater than KOH.

In order To analyze the morphology of either activated or non-activated carbon, SEM (Scanning Electron Microscopy) introduced on both materials. The results of observation of non-activated carbon and activated carbon can be seen in Figure 3.



(a) (b)

Figure 3: SEM image of coconut shell carbon (a) before activation (b) after activation.

Morphological observations on the surface of activated carbon indicate that the activated carbon particle has more pore than the non-activated material. The number of pores present on the surface of the carbon causes the amount of surface area or specific surface area that contribute to microwave absorption. This activation process causes the liberation of gases such as CO and CO2 which will diffused on surface of activated carbon and then erode the surface so that pore embed [5].

4. CONCLUSION

Test VNA characterization showed a maximum absorber value of -19.5 dB at a thickness of 6 mm with a HCl activator of 1 M. the XRD graphs showed that activated carbon diffraction patterns existed at an angle of $2\theta =$ to $2\theta =$ and SEM results show that the activated carbon has more pores than Non-activated carbon. From the results of research shows that coconut shell activated carbon can be used as material of RAM.

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