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Development Radar Absorber Material using Rice Husk Carbon for Anechoic Chamber Application

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Abstract. The developments of radar technology in Indonesia are very strategic due to the vast territory and had a high-level cloud cover more than 55% of the time. The objective of this research is to develop radar technology facility in Indonesia using local natural resources. The target of this research is to present a low cost and satisfy quality of anechoic chambers. Anechoic chamber is a space designed to avoid reflection of EM waves from outside or from within the room. The reflection coefficient of the EM wave is influenced by the medium imposed by the EM wave. In laboratory experimental research has been done the development of material radar absorber using rice husk. The rice husk is activated using HCl and KOH by stirring using a magnetic stirrer for 1 Hours. The results of rice husk activation were measured using a Vector Network Analyzer by varying the thickness of the ingredients and the concentration of the activation agent. The VNA measurement is obtained reflection coefficient of -12dB and -6.22dB for 1M HCL and KOH at thickness 10mm, respectively.

1. Introduction

Indonesia is in a region spanning the disaster. Based on data and information National Disaster Management Agency of Indonesia from early 2017 to 11 April 2017, there are 884 cases of disaster. Among them are floods, landslides, tidal waves/abrasion, earthquakes, forest and land fires, transportation accidents, and tornadoes. To minimize the impact of the disaster, it is necessary to see the rotation of the disaster that occurred. Accurate observations and data sets, such as mapping from affected areas, are urgent to be met. Reliable technology in mapping the region is one of the remote sensing [1].

Remote sensing is science and art in obtaining information about an object, area, symptoms through analysis of data obtained by means without direct contact with objects, areas, and observed phenomena [2]. Radar is a sensor of remote sensing. Radar is one application of the electromagnetic spectrum (microwave) with a frequency range of 0-300 GHz or wavelength 1m to 1mm. Radar (radio detection and ranging) is an electromagnetic wave system for detecting and determining the location of objects with long distances that work by emitting electromagnetic waves and processing the reflected signal to know the character of the object. Several technologies for radar have been developed in previous studies [3]-[7]. Almost in all the development of remote sensing technology requires a very expensive facility one of them is anechoic chambers. Anechoic chambers are spaces



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designed to absorb electromagnetic wave reflections to reduce reflection and external noise in measuring the characteristics of an antenna or radar component. Anechoic chamber provides precise measurement and controlled electromagnetic environment, and prevents EM interference from inside and outside the room [8].

In general, the anechoic chamber is built using an electromagnetic wave absorber. However, the availability of current electromagnetic wave absorber materials still has some disadvantages such as expensive, high density and low absorptive [9]. Therefore it is necessary to develop electromagnetic wave absorbers with low cost, low density and high level of absorptency based on local resources. Through physical and chemical processing, carbon materials have the potential to be used as EM absorbers. Carbon material is a good electromagnetic energy absorber.

Carbon as radar absorber material can be generated from local resources such as rice husks. This material content of silica (SiO₂) in rice husk ash is 94 - 96% [10]-[12]. Rice is the main product of agriculture in agrarian countries, including Indonesia. Rice husk is an abundant by-product of rice milling, and has been used only as a fuel for burning stone. Unsafe rice husk handling will lead to environmental pollution. 20% of the weight of rice is rice husk, and varies from 13 to 29% of the chaff composition is the husk ash which is always produced each time the husk is burned [12].

The technology of electromagnetic wave absorbing materials is an important topic for military purposes and is also a potential product in the field of business. In particular, the development of material radar absorbers (RAM), electromagnetic wave absorbers in the radar frequency region, at the working frequency of GHz, has been actively studied for a long time. The basic design theories of RAM, such as Salisbury screen theory, Jaumann's absorber theory, etc. were published from the early 1950s onwards [13]. To reduce the radar cross section of the target RAM can be used to cover its surface. Decreased radar cross section (RCS) can be achieved when the RAM is sure to cover all material that allows cross section [13].

In an effort to minimize the reflection from the surface of the medium by considering the physical equations that represent the reflection process. There are three conditions that affect minimum reflectivity, namely: reflection coefficient, impedance, and wave attenuation. For the reflection coefficients can be solved by the following equation:

$$r = \frac{\eta_M - \eta_0}{\eta_M + \eta_0} = \frac{Z_M - Z_0}{Z_M + Z_0}$$

Here, r is the reflection coefficient, η_0 = wave scattering in air, η_M = wave scattering on the medium. The equation can also be converted into an intrinsic impedance ($Z = 1 / \eta$).

The reflection coefficient will be zero if $\eta_M = \eta_0$. In other words, the material on the screen has the same impedance as the waveform medium [14]. The intrinsic impedance in the free space can be calculated by the following equation:

$$Z_0 = \frac{E}{H} = \sqrt{\frac{\mu_0}{\epsilon_0}} \approx 377 \text{ ohms}$$

Where: E and H are electric and magnetic fields. μ_0 and ϵ_0 are permeability and permittivity respectively. Material with impedance of 377 ohm will not reflect microwaves if wave is applied to the material.

The mechanism of electromagnetic wave absorption in the material is generally influenced by two factors: thickness and material type. The thickness factor occurs in all the materials and the thicker the absorbing material is also greater. While the absorption of electromagnetic radiation on the magnetic material in addition to the thickness factor also occurs another interaction of electromagnetic waves from the outside will rotate the magnetic dipole so that the material impedance occurs. The interaction can also occur when the frequency of the electromagnetic wave corresponds to the frequency generated so that the magnetic material will absorb electromagnetic waves only at specific frequencies.

2. Method

2.1. Synthesis of activated carbon based on rice husk

The starting material used in the research is rice husk. The rice husk cleared from other materials soil and gravel. Carbonization of the rice husk is carried out by an imperfect Pyrolysis process of a carbonaceous material. The carbonization result mashed using a blender and sieved using 100 meshes. 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 °C 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 4 mm, 6 mm, 8 mm, and 10 mm.

3. Result and discussion

The Absorption of radar in materials of concentration HCl and KOH of 1M, 2M, 3M, 4M and 5M were identified using a Vector Network Analyzer in the 4-8 GHz frequency range. The effect of concentrate activation on the absorption of wave generated at each thickness variation can be seen from the maximum reflection coefficient (RL) in dB. The result of characterization using VNA with HCL activator is shown in Figure 1-3.

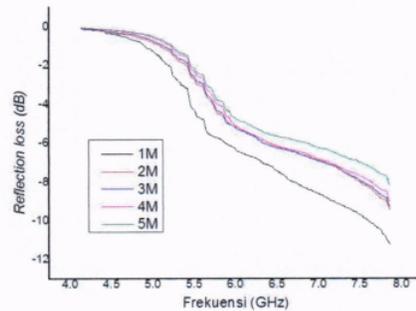


Figure 1. Reflection coefficient plotted as a function of frequency for variation of HCL activator concentration at thickness 6mm.

The RL value and the minimum reflection coefficient of rice husks were -11.2 db, 0.275. These results were obtained from VNA measurements with activation agents using HCL with variation of concentrations of 1-5M and at thickness 6mm. RL and minimum reflection coefficient are obtained when using HCL 1M activation agent.

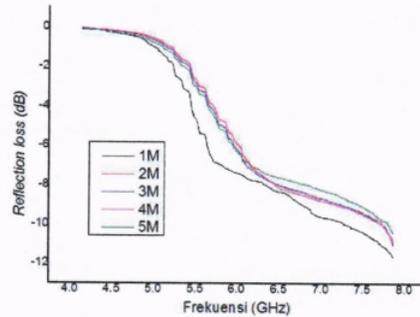


Figure 2. Reflection coefficient plotted as a function of frequency for variation of HCL activator concentration at thickness 8mm.

Figure 2 shows the activation of rice husk using HCL substance with variation of concentration 1-5M at 8mm thickness. The minimum reflection coefficient is obtained at 1M HCL concentration, which the reflection coefficient of -11.60 db.

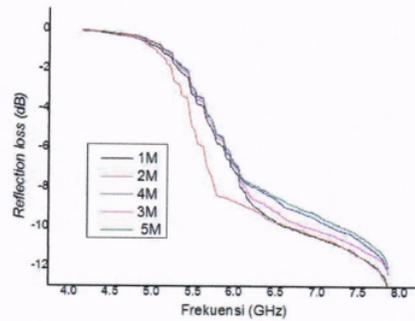


Figure 3. Reflection coefficient plotted as a function of frequency for variation of HCL activator concentration at thickness 10 mm.

The largest absorption of radar wave occurs at the concentration of HCL 1 M with a thickness of 10 mm that can be seen on Figure 3. The measured results of reflection loss and reflection coefficient for 1M HCL activation agent are obtained -12db and 0,251, respectively. The data 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.

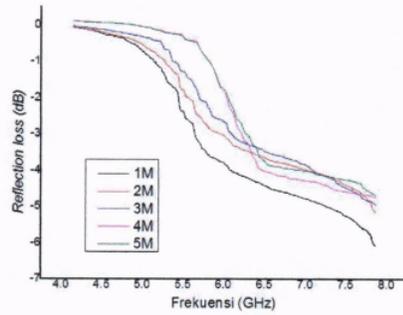


Figure 4. Reflection coefficient plotted as a function of frequency for variation of KOH activator concentration at thickness 6mm.

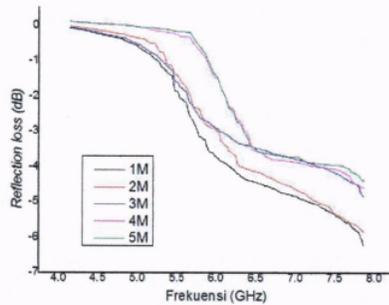


Figure 5. Reflection coefficient plotted as a function of frequency for variation of KOH activator concentration at thickness 8mm.

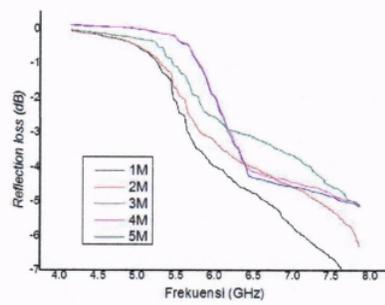


Figure 6. Reflection coefficient plotted as a function of frequency for variation of KOH activator concentration at thickness 10mm.

The largest absorption of radar wave occurs at the concentration of KOH 1 M with a thickness of 10 mm. Result of VNA measurement is obtained reflection loss and reflection coefficient -6.22 db and 0.488 respectively for KOH 1M activation agent. The data 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.

4. Conclusion

Test VNA characterization showed a maximum absorber value of -12.90 dB at a thickness of 10 mm with a HCl activator of 1 M. On the other hand, for KOH activator, the maximum absorber is obtained for 1M concentration at 10 mm thickness. Based on this works, the HCL activator and 10 mm thickness of the material is satisfy for the radar absorber material.

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