The Performances of Sugarcane Bagasse (SCB) — Rubber Tire Dust Composite as Microwave Absorber in X-Band Frequency

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Abstract— In this work, the performances which are the reflection loss and absorption for composite of sugarcane bagasse (SCB) and rubber tire dust as microwave absorber were investigated in the range frequency of 8.2–12.4 GHz (X-Band). Sugarcane bagasse (SCB) is one of the major agricultural wastes. This residue agricultural waste material has potential to be used as an alternative material for microwave absorber in Radio Frequency (RF) anechoic chamber. Rubber tire dust is one of the residues from tire wear. This paper shows the method about how the sample which is the composite of sugarcane bagasse with rubber tire dust was fabricated and the measurement to get the reflection loss (S_{11}) and transmission coefficient (S_{21}). The thickness of the sample is 5 mm. The methodologies included in this work are defining the dielectric properties and measurement of the samples using transmission line technique (waveguide). The dielectric constant, ε' from the transmission line measurement of the composite of sugarcane bagasse-rubber tire dust is 3.35. The S_{11} results showed that the SCB-rubber tire dust composite absorber was found to be better which means lower than -10 dB. The results proved that SCB-rubber tire dust was a good alternative to be used as microwave absorber. The goal of this investigation is to have the better electromagnetic reflection (S_{11}) which is less that -10 dB with the usage of the new agricultural waste such as sugarcane bagasse (SCB) and rubber tire dust. These can help save the nature and environmental friendly.

1. INTRODUCTION

Sugarcane bagasse, SCB is the byproduct from the production and processing of sugar cane (*Saccarhumofficinarum*) to produce sugar. In the SEM-EDS results for determination of carbon and silica content in sugarcane bagasse, it showed that sugarcane bagasse contained 9.78% of silica and 90.22% of carbon [1]. Carbon is one of the elements in a microwave absorber to absorb the unwanted microwave signal [2]. A radio frequency anechoic chamber is a shielded room whose walls have been covered with a material that can scatter and absorb the incident energy that can simulate free space. Recent innovations such as the used of ferrite tiles have greatly enhanced the performance of anechoic chamber [3]. So, this work which is the composite of sugarcane bagasse with rubber tire dust is one of the innovation to improve the performance of microwave absorber. Absorbers are the main components in anechoic chamber. They were functioning in eliminating the reflected signals [4]. Rubber tire dust is tire wear that are commonly composed of natural and/orsynthetic rubbers, carbon black, and extender oils, respectively, accounting for 40–60%, $\sim 30\%$, and 10–20% by mass [5].

2. METHODOLOGY

The methodology included in this work are fabricating the sample which is the composite of sugarcane bagasse with rubber tire dust, defining the dielectric properties consist of dielectric constant and loss factor and measurement of the samples using transmission line technique (waveguide technique). Before fabricating the samples, the sugarcane bagasses needed to be processed first. Then, the sugarcane bagasse will be mixed with rubber tire dust and turn them into composite form using mould. For two-port reflection/transmission measurement, the sample is placed between two waveguides. In this work, the dielectric properties have been determined using Agilent 85071E Software. The measured reflection and transmission coefficients, S_{11} and S_{21} of samples were obtained from this transmission line technique measurement [6].

3. RESULT AND DISCUSSION

The electric permittivity and magnetic permeability are important factor in characterizing the microwave absorbers. The permittivity is a measure of the material's effect on the electric field in the electromagnetic wave. The quantity ε' is sometimes called the dielectric constant which is something of a misnomer when applied to absorbers as ε' can vary significantly with frequency. The quantity ε'' is a measure of the attenuation of the electric field cause by the material. So, the dielectric constant of materials such as sugarcane bagasse and rubber tire dust needed to be defined first. In this work, the transmission line technique has been used. In order to measure the reflection coefficient (S_{11}) and transmission coefficient (S_{21}), a section and part of the waveguide was filled in with the material sample [7–11]. Adequate sample thickness must be used in order to obtain an accurate measurement result.

3.1. Dielectric Constant and Loss Factor

Table 1 below shows the dielectric constant and loss factor of the two materials which are sugarcane bagasse and rubber tire dust in the range frequency of 8.2 to 12.4 GHz.

Table 1: Dielectric constant of sugarcane bagasse and rubber tire dust.

Material	Dielectric Constant, ε'	Loss Factor ε''
	8.2–12.4 GHz	
Sugarcane Bagasse (SCB)	2.66	0.29
Rubber Tire Dust	4.12	0.18

The overall dielectric constant for the rubber tire-dust sample for the entire X-Band frequency spectrum (8.2–12.4 GHz) was in the range of 3.4 to 4.2 which was greater than the range for the sugarcane bagasse material which is in the range of 2.6 to 2.9. This was due to the presence of the high dielectric constant material, that is, rubber, which is the major component in the tire dust. The higher value of the dielectric constant of the tire dust indicated that the signal was propagated at a slow speed due to the large refractive index of the medium [12]. Based on the result, the composite of sugarcane bagasse has high loss factor than other composite. In consideration of microwave absorption, the dissipation of energy in material is related to the imaginary part (ε'') [13].

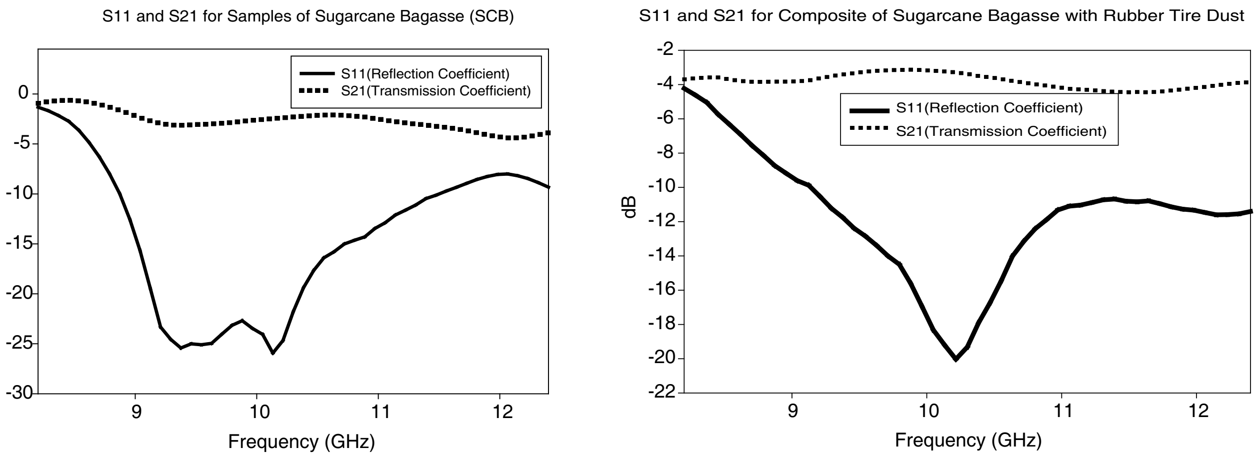
3.2. Measurement of the Samples Using Transmission Line Technique

Figures 1(a) & (b) below showed the S_{11} and S_{21} for pure sugarcane bagasse and composite of SCB and RTD in range frequency of 8.2–12.4 GHz. Table 2 showed the average reflection loss and percentage of the microwave signal absorption.

In this work, the average reflection loss of sugarcane bagasse sample is 14.06 and the absorption is about 41.51%. Then, the next sample is fabricated in composite of sugarcane bagasse and rubber tire dust. The composition of sugarcane bagasse-rubber tire dust is 50 : 50 respectively. The average reflection loss for composite of SCB and RTD is 11.73. From the result, it shows

Table 2: Average reflection loss and absorption of sugarcane bagasse and composite of sugarcane bagasse with rubber tire dust.

Frequencies (GHz)	Pure Sugarcane Bagasse (SCB)		Composite of sugarcane bagasse with rubber tire dust	
	Average Reflection Loss (dB)	Absorption (%)	Average Reflection Loss (dB)	Absorption (%)
8.2–10.0	−15.00	34.47	−9.97	45.6
10.0–12.4	−13.35	46.04	−13.07	55.23
8.2–12.4	−14.06	41.51	−11.73	51.62



(a) (b)

Figure 1: S_{11} and S_{21} for samples of sugarcane bagasse and composite of sugarcane bagasse with rubber tire dust.

that when sugarcane bagasse was added with rubber tire dust, it enhances the performance of the absorber which is 51.62% of absorption compare to pure sugarcane bagasse which is 41.51%. So, rubber tire dust can be a potential material to be added to sugarcane bagasse in fabricating the pyramidal microwave absorber.

4. CONCLUSION

Based on the reflection loss performance from the measurement using the transmission line technique, the sugarcane bagasse-rubber tire dust has the potential to be used as the alternative material in fabricating the microwave absorber. The main objectives of this research are to design, develop, fabricate and measure an efficient, environmental friendly and low cost pyramidal microwave absorber using agricultural waste such as sugarcane bagasse and rubber tire dust. By using the sugarcane bagasse, they can reduce the landfill waste and reduce the cost of production of the microwave absorber compared to use the existing expensive material such as polyurethane and polystyrene. The fabricated microwave absorber can operate successfully in the microwave range frequency 8.2 to 12.4 GHz.

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