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AGRICULTURAL WASTE BASED-COCO PEAT MICROWAVE ABSORBER

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ABSTRACT

This paper presents the performance of coco peat microwave absorber in terms of dielectric properties and reflection loss. Coco peat microwave absorber was fabricated using raw coco peat, polyester resin and MEKP hardener. The dielectric properties and reflection loss of coco peat microwave absorber is measured using Agilent E8362B P-series Network Analyzer. Dielectric properties of coco peat microwave absorber were determined by open-ended method via coaxial probe while the reflection loss of coco peat microwave were determined by waveguide method via WR-90 waveguide adapters over X band frequency (8 GHz- 12.4 GHz). Coco peat microwave absorber achieved desirable reflection loss below -30dB which indicates that more than 90 % of microwave absorbing efficiency. It is potentially useful as a substitute material for microwave absorber.

KEYWORDS: *Agricultural Waste, Coco peat, Microwave Absorber*

I. INTRODUCTION

Coconut by-products such as coconut husk are one of the readily-available agricultural wastes from coconut production. In Malaysia, it was estimated that 5,280 kg of coconut waste were become available per hectare per year [1]. At present, coconut wastes are used in horticultural and agricultural applications [2]. To make better use of this cheap and abundant agricultural waste, the coconut wastes is used as microwave absorber materials.

The coconut husk contains about 30% by weight of coir fibres and 70% coir dust. At present, Coir fibre is used for making traditional coir products such as mats, rugs and carpets. The coir dust or coco peat is mainly used in horticultural and agricultural applications [2]. The coco peat contains lignin, cellulose and hemi-cellulose. Lignin is the most stable component out of these three. In coco peat, the lignin component acts as an intrinsic bonding agent in the production of binderless composite [3].The presence of lignin helps the coco peat to remain stable and retain its longer durability properties [4]. These properties of coco peat are potentially useful as a microwave absorber that is to be implemented in telecommunication industry application. The content of carbon in coco peat is 38-50%[5].

Microwave Absorber is the material that attenuates the energy in an electromagnetic wave. Microwave Absorber is used in a wide range of telecommunication industry applications to eliminate stray or unwanted radiation that could interfere with a system's operation [6]. Microwave Absorber 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 [7].

Several researchers have stated that carbon has an important role in microwave absorption [8], [9], [10], [11]. Carbon is a very good absorbent of microwaves as it is easily heated by microwave energy. Carbon is suitable for transforming the microwave energy to thermal energy because carbon is impeded as they pass through the carbon [12], [13]. When microwave pass through the carbon based absorber, an electric field is produced at the surfaces of the absorbers. When this occurs, the electrical energy is transformed into thermal energy and is dissipated [14]. Recently, researchers have focused to identify the agricultural wastes (organic materials) as a new, microwave energy absorbing material. The agricultural wastes include oil palm shell, rice husk, coconut shell and others. The results obtained from recent research projects show the agricultural wastes are potentially useful as microwave absorber [7] – [14].

Salleh et al [9], presents a study of single layer radar absorbing material by using coconut shell-based activated carbon with the mixture of Flaxane-80. The performance of the coconut shell-based activated carbon microwave absorbers offer great alternative for RF application. This is because the relative permittivity of the absorber was found to be the highest at a value of 12 while the minimum reflection at 9.6 GHz with -22 dB reflection loss. The coconut shell based microwave absorber also has the highest loss tangent of 0.4. Nornikman et al. [10], Malek et al. [11], [12] and Iqbal et al. [13],[14] used rice husks from paddy as the material in the microwave absorber for anechoic chamber. The rice husks microwave absorbers were designed to operate in the frequency range of 1 GHz to 20GHz. The rice husks microwave absorbers are fabricated in term of pure rice husks (PRH) microwave absorber and rice husks-rubber tire dust (RHRTD) composite microwave absorber. From their research, the reflection loss results obtained from RHRTD microwave absorber is better compared to PRH microwave absorber at the frequency range of 7 Ghz -13Ghz. The reflection loss obtained for the RHRTD microwave absorber is - 34.96 dB while for the PRH microwave absorber, the reflection loss is - 20.18 GHz. Lee et al. [14] proposed the composite of rice husks and carbon nanotubes (RHCNT) as microwave absorber. Both rice husks and carbon nanotubes (CNTs) have high percentage of carbon. The RHCNT microwave absorber with 5% of carbon nanotubes had the average absorption of 88.9%, while PRH microwave absorber had the average absorption of 45.2% over the frequency range of 12 to 18 GHz (Ku band).

This paper is organized as follow. Section 2 presents the coco peat microwave absorber fabrication process. The performance of coco peat microwave absorber is presented in Section 3.

II. COCO PEAT MICROWAVE ABSORBER FABRICATION PROCESS

Phase 1: Preparing the mixture for coco peat with polyester resin and MEKP hardener

Firstly, the coco peat with polyester resin and MEKP hardener composite will be prepared. The readily-available coco peat structure is rough and big. In order to ease the fabrication process, the coco peat will be grinded to more fine size (≤ micron size particle) by using planetary ball mill.. This is because the complex permittivity and microwave absorption of the epoxy composites have increased with the reduction of particle [16]. The microwave absorbing particles should be smaller than the skin depth for suppressing the eddy current phenomenon [17], [18], [19].

The polyester resin is used as the bonding agent to bind the coco peat and CBSiC physically without forming any new bonding. The methyl ethyl ketone peroxide (MEKP) as a hardener agent is used to harden the mixtures and to facilitate fabrication process. The weight ratio of polyester resin to MEKP is set to 5:1 of the total weight of the coco peat used for fabrication. Figure 1 shows the coco peat and the composite of coco peat with polyester resin and MEKP.

(a) (b) (c)

Figure 1. (a) Coco peat (b) Polyester resin (c) MEKP hardener

Phase 2: Fabrication process

Rectangular mould [15] is used to fabricate the coco peat into planar microwave absorber. Figure 2 shows the rectangular mould that will be used to fabricate the microwave absorber. This rectangular mould is custom made at the inside dimension of 22.86 mm in length and 10.16 mm in width. The thickness of coco peat microwave absorber is 1 mm. This is to fix the WR-90 waveguide adapter for X-band frequency (8.2 GHz to 12.4 GHz).

Figure 2. Rectangular Mould

III. RESULT AND DISCUSSION

3.1 Dielectric Properties Measurement

The dielectric properties, which are dielectric constant (ε') and dielectric loss factor (ε") of material, are the important parameters that must be concern when modeling a microwave absorber. The relationship of dielectric constant (ε') and dielectric loss factor (ε") is defined as complex permittivity, shown in equation (1) [20].

$$\varepsilon = \varepsilon' - j\varepsilon'' \quad (1)$$

The dielectric constant (ε') represents the real part while dielectric loss factor (ε") represents imaginary part. The real part of complex permittivity determines the strength of material to store electromagnetic energy. The imaginary part determines the ability of the material to convert the electromagnetic energy to heat that will be dissipated. The dielectric loss factor (ε") is also a measure of the attenuation of the electric field caused by the materials. The loss tangent, tan δ of the dielectric materials is shown in equation (2).

$$tan\delta = \frac{\varepsilon''}{\varepsilon'} \quad (2)$$

The greater the loss tangent of a material, the greater the attenuation as the electromagnetic energy travels through the material. The dielectric properties determine the strength of reflected/transmitted microwave signals from a sample material [21]. The dielectric properties of the coco peat microwave absorber is measured over the frequency range of 8.2 GHz to 12.4 GHz (X band) using a commercial dielectric probe by means of Network Analyzer [22]. Agilent E8362B P-series Network Analyzer (PNA) and the dielectric probe with Agilent Technologies 85070 software is used to performed dielectric properties measurement.

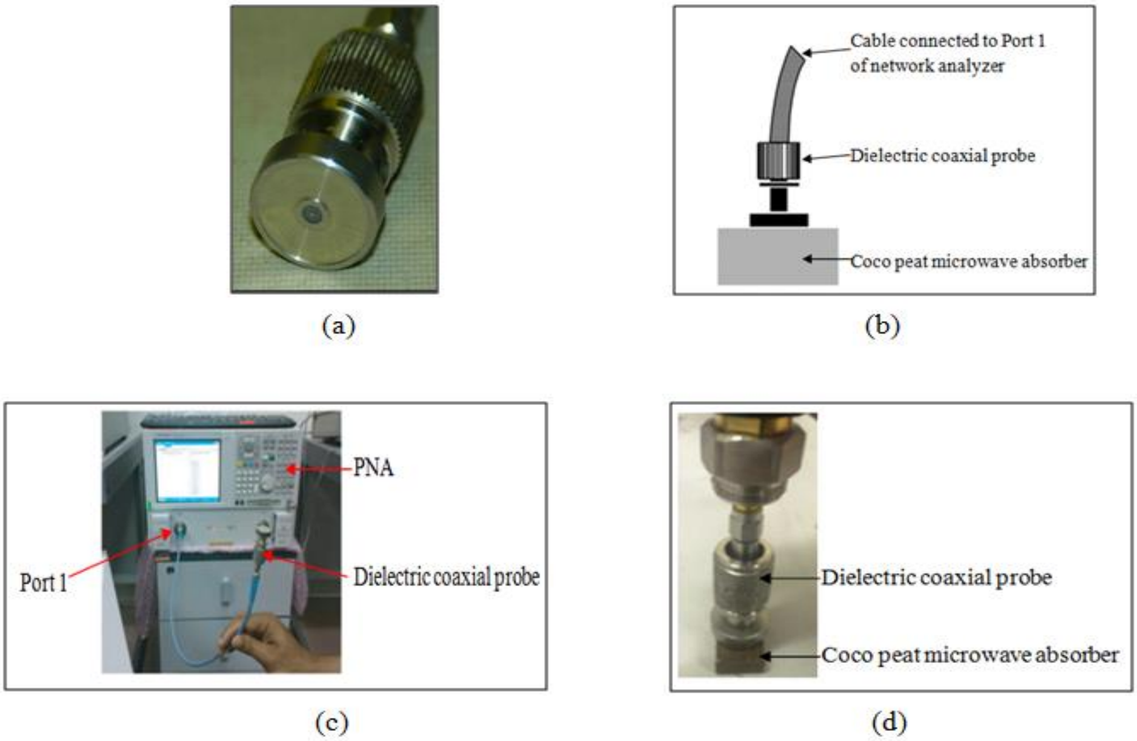


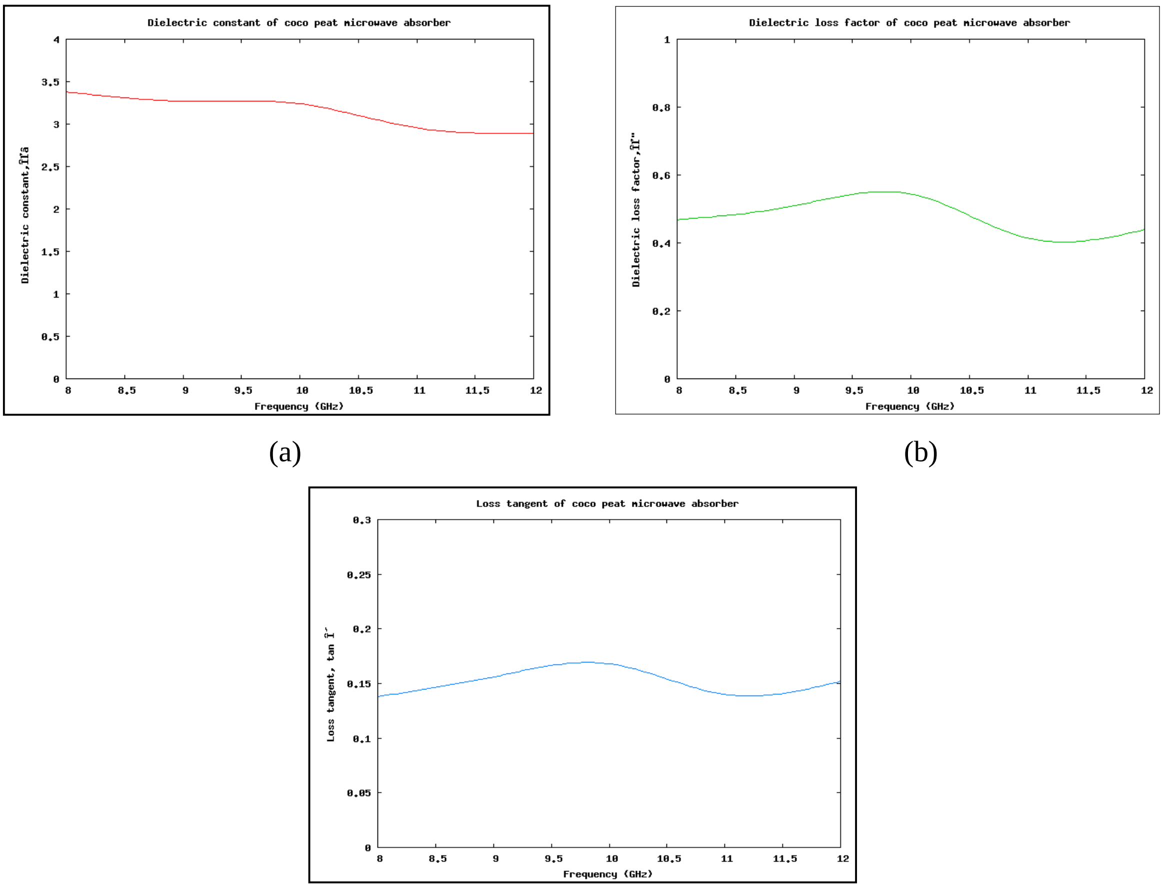
Figure 3. (a) Dielectric probe coaxial probe (b) Sketch of dielectric coaxial probe position and material under test (c) Connection of dielectric coaxial probe connection to port 1 of PNA (d) Figure 3 (d) Actual dielectric properties measurement.

Figure 3 (a) shows the dielectric probe that is used to measure the dielectric properties of the coco peat microwave absorber. Figure 3 (b) presents the sketch of dielectric coaxial probe position and material under test (coco peat microwave absorber) during dielectric properties measurements. Figure 3 (c) presents the dielectric coaxial probe connection to port 1 of PNA. Figure 3 (d) presents the actual dielectric properties measurement. The result of dielectric properties of coco peat microwave absorber over five frequencies is presented in Table 1.

Table 1. Dielectric properties (dielectric constant, ε') for coco peat microwave absorber

Frequency (GHz)	Dielectric Properties		
	Dielectric Constant, ε'	Dielectric loss factor, ε"	Loss Tangent, tan δ
8	3.381	0.468	0.138
9	3.270	0.509	0.156
10	3.239	0.544	0.168
11	2.955	0.414	0.140
12	2.892	0.439	0.152

Figure 4 (a), 4 (b) and 4 (c) present the dielectric properties that are measured from coco peat microwave absorber. The dielectric constant and dielectric loss factor vary when the frequency increased from 8 GHz to 12 GHz. It can be observed that the highest dielectric constant, ε' was 3.381 at 8 GHz, while the highest dielectric loss factor, ε" was 0.544 at 10 GHz.



(a) (b)

(c)

Figure 4. (a) Dielectric constant (b) Dielectric loss factor and (c) loss tangent of coco peat microwave absorber

3.2 Reflection Loss, S11, Measurement

The acceptable performance of microwave absorber of the reflection loss, S11, results better than -10 dB. A desirable performance is to achieve reflection loss of better than -30 dB, which indicates that the efficiency of the absorbing performance is 90% [9][13]. PNA was used to measure the reflection loss via WR-90 waveguide adapters over X-band frequencies. Two low-loss coaxial cable were used connect WR-90 waveguide adapters as the source port (Port 1) and receiver source (Port 2). The measurement setup using waveguide method is presented in Figure 5 [15].

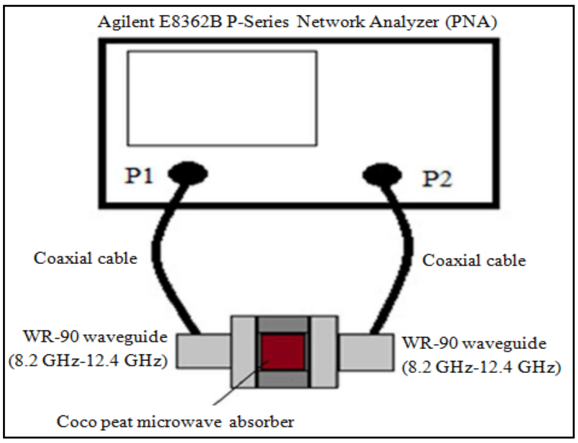


Figure 5. Measurement setup using WR-90 waveguide adapters

The result of the measured reflection loss, S11, is presented in Table 2.

Table 2. Reflection loss of coco peat microwave absorber

Frequency (GHz)	Reflection Loss (-dB)
8	-37.165
9	-38.758
10	-38.914
11	-37.589
12	-38.580

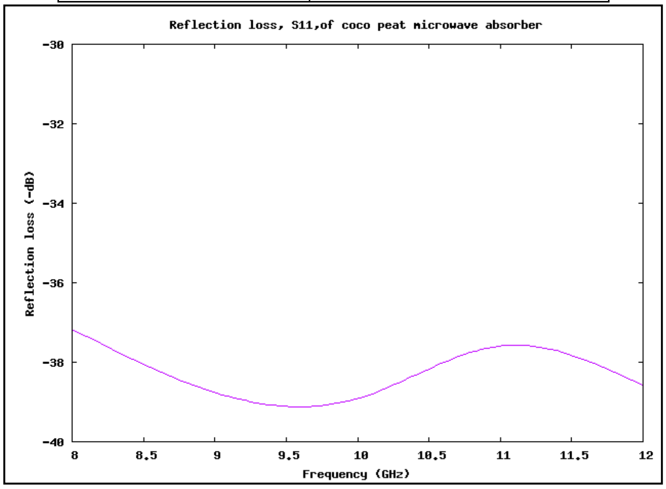


Figure 6. The reflection loss of coco peat microwave absorber over frequency range 8 GHz- 12GHz.

Figure 6 presents the reflection loss of coco peat microwave absorber. The maximum reflection loss of -38.914 dB occurred at 10 GHz, while the minimum reflection loss of -37.165 dB is seen at frequency 8 GHz. The reflection loss of coco pet microwave absorber over X band shows than the electromagnetic absorption energy is desirable, which is better than -30 dB, varying form -37.165 dB, -37.589 dB, -38.580 dB, -38.758 dB and -38.914 dB.

IV. CONCLUSIONS

Coco peat with polyester resin and MEKP hardener composite was investigated to determine its dielectric properties and reflection loss as a microwave absorber. The open-ended method is used to measure the dielectric properties of coco peat microwave absorber. The reflection loss of coco peat microwave absorber is measure by using the WR-90 waveguide adaptors in conjunction with network analyzer. The results of this work show that the agricultural waste, i.e coco peat is potential useful as a substitute material for microwave absorber as its show desirable reflection loss that is better than -30 dB. Moreover, pollution causes by agricultural waste is minimises by utilising the agricultural waste as a useful material for microwave absorber.

V. FUTURE WORK

In future, composite or mixture with other materials that posses high content of carbon can be added to improve the absorption ability of the agricultural based microwave absorber. Carbon materials are, in general, a good microwave absorber. The examples of material of high content of carbon are carbon black, carbon nanotubes, silicon carbide.

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