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AGRICULTURAL WASTE BASED RADAR ABSORBING MATERIAL

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Abstract

The smart and fast advancement in electronic and telecommunication systems increases electromagnetic pollution due to electromagnetic interference (EMI) resulting new technological issues for stealth technology. The production of low cost and green Radar Absorbing Material (RAM) is now challenging technology for the researcher and academicians. The heavy use of ceramic materials for RAM are expensive and causes environmental problem for future technology. This study presents the effect of carbon rich agricultural waste like banana wastes aiming at the radar absorbing material processing. The experiments consider the sample preparation with banana wastes. The prepared samples were evaluated by reflectivity measurements, in the frequency range of 8.2-12.4 GHz and scanning electron microscopy analysis. The reflectivity and absorption characteristics of the synthesized samples shows the circular shape of the material have good absorbing capacity of microwave in X-band. The epoxy blended composite of banana wastes having thickness 0.14mm possesses the maximum reflection loss -5.04dB at10.300GHz.

Keywords: Ultrasonic wave, blended chemicals, banana waste, dielectric loss, microwave absorbing material

Introduction

The increasing demand of electronic devices in every step of our activity makes life risk by embedding an electromagnetic network around us due to electromagnetic interference (EMI). The use of microwave absorbing material to reduce such EMI made from polyurethane and polystyrene plastic based materials, pose harm to the surroundings as well as human beings by releasing toxic gases when operating under high temperatures [1]. In order to increase the absorption properties of the basic material, finely powdered coal is added due to its high porosity and carbon content but over time addition increases the contamination to the environment and reduces the absorber lifetime. Thus searching an alternative to these absorbers made essential for use of agricultural wastes like banana stem fibers/leaves, sugarcane bagasse, rice husk etc. for the same purpose. The presence of high percentage of carbon and oxygen makes it possible for strong microwave absorbing property of the composites fabricated from banana stem wastes. In this work, focus is on microwave absorbing property of banana stem waste. Banana stems and leaves are waste activated carbon and biproducts of banana and are used in horticulture and agricultural applications. Aiming at controlling the problems created by EMI, the electromagnetic wave absorbing technology is an important topic to be considered for fulfilling civil and military purposes. Generally, in the military area the studies involve development of radar absorbing materials for the frequency range of 8.2 to 12.4 GHz. Thus, RAM is used to cover the surface of targets, which can consist of different types of equipment, land vehicles, aircraft and ships. In the radar absorbing material the processing of several parameters have to be taken into account. Among them, weight, thickness, microwave absorption, environmental resistance and mechanical strength are of major importance [2-3]. Developing thin, flexible and light RAM is the main challenge of the studies involving microwave absorbers. Innovations involving manufacturing procedures of RAM with conducting polymers are under study to improve the quality of this type of materials.

Theory for computational parameter

In bio composite industry for synthesis and fabrication of any material as filler it must needs bleaching or surface modification as a starting step. This primary work can be well performed by a suitable blend of chemicals which are better compatible with the treated material. This suitability/compatibility can be well computed by computation of acoustic parameter like compressibility of the solvent. This acoustic parameter can be computed from the experimental experimentally measured ultrasonic velocity data by the following relation: $\beta = \frac{1}{\rho V^2}$

(1)

Where "ρ" is the density of the chemical mixture and "V"is the ultrasonic velocity.

Any material /medium is mainly characterized by its electrical permittivity (ε) and magnetic permeability (μ).During the propagation, EM wave strikes on absorber or interface and undergoes the basic phenomena like reflection ,transmission and absorption.

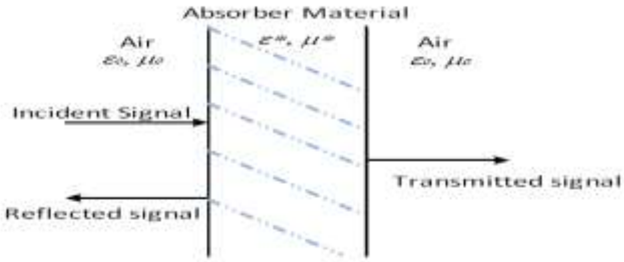

Figure 1. Absorber properties of a material

As the agricultural wastes is carbon rich material and have no metallic composition so the material has only electrical permittivity. Thus for a dielectric material, the complex permittivity is given as

$$\varepsilon^* = \varepsilon^{'} - j\varepsilon^{''} \qquad (2)$$

where $\varepsilon^{'}$ is the dielectric constant represents the real part and corresponds to storage of electromagnetic energy and $\varepsilon^{''}$ is the loss factor or dissipative or loss component represents the imaginary part and correspond to conversion of EM energy to heat. The effectiveness of a material as an absorber is determined by loss tangent which results in attenuation of EM wave is given as

$$\tan\delta = \frac{\varepsilon^{''}}{\varepsilon^{'}} \qquad (3)$$

$$\alpha = \frac{\sqrt{2}\pi f}{C}\left(\sqrt{\left(\mu^{''}\varepsilon^{''} - \mu^{'}\varepsilon^{'}\right) + \sqrt{\left(\left(\mu^{''}\varepsilon^{''} - \mu^{'}\varepsilon^{'}\right)^2 + \left(\mu^{''}\varepsilon^{'} + \mu^{'}\varepsilon^{''}\right)^2\right)}}\right) \qquad (4)$$

Where "f" is the frequency of EM wave on the surface of the medium determined by S parameter properties which includes reflected signal S_{11} and transmitted signal S_{21} from which the absorption rate of the material can be determined as:

$$AR(\omega) = 1 - |S_{11}|^2 - |S_{21}|^2 \qquad (5)$$

Material and methodology

The raw banana fibres are collected from the stems are cut into small pieces of size 10mm.The small pieces are bleached with the ultrasonically determined blend of acetone and ethanol(50-50) for making the fibre becomes hydrophobic and removal of foreign materials. This makes the fibres become more porous for better interlocking between fibre and matrix which provides strong mechanical strength to the composites. After washing, the small fibre pieces are allowed to dry and grinded to make them fine size up to 150µm by test sieve. This micro size particle enhances the complex permittivity and microwave absorption of the epoxy composite. The epoxy resin used as binding agent to bind the dust of banana stem powder without forming new bonding between them. The methyl ethyl ketone peroxide as a hardener agent is used to harden the mixtures to facilitate the fabrication processes. A circular mould of diameter 29 mm and thickness 0.14mm is used to fabricate sample for microwave absorber which is fixed to waveguide adaptor for X band frequency.

Characterisation of banana fiber and its composite

The small pieces of banana fibre treated with blended acetone and ethanol mixture observed by HITACHI SU 3500 Scanning Electron Microscope shown in Fig.2 and Fig.3 which shows that fibre surface are covered protrusions and small voids that may facilitate the epoxy impregnation on to the fibre. The Energy dispersive spectroscopy (EDS) analysis performed at a micro region of the fibre surface as shown in Fig.4 which reveals that the banana stem fiber is mostly rich with carbon nearly it is 48.37% . Surface morphology of the composite as shown in Fig.5 reveals that treatment has improved the property by adhesion between fibre and matrix which turn improved the mechanical strength.

Figure 2. SEM of untreated banana fibres

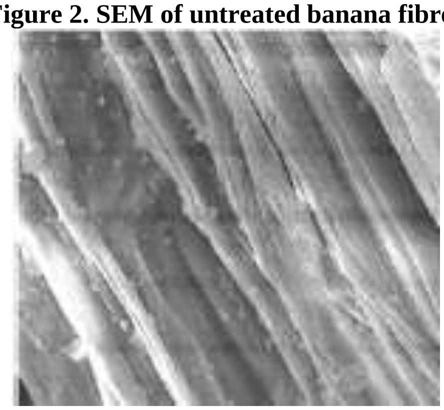

Figure 3. SEM of treated banana fibres

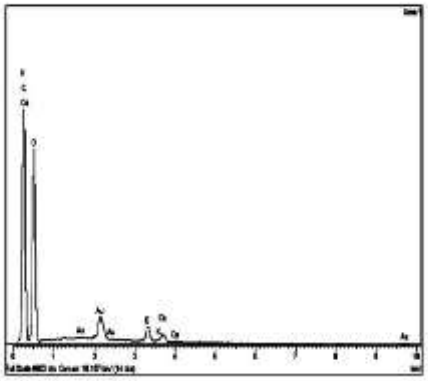

Figure 4. Energy dispersive spectroscopy of banana fibres

Figure 5. SEM image of banana fiber epoxy composite

Microwave measurement: For measurement of dielectric properties the experimental arrangement is shown in Fig.6. In the present study since the material is dielectric in nature *we have kept* $\mu_r^{'} = 1$ *and* $\mu_r^{''} = 0$.The dielectric properties of the banana fibre composite is measured over the frequency range of 8.2GHz to 12.4GHz (X band) using commercial dielectric probe by means of Network Analyzer with Agilent technologies 85070 software. The microwave absorption study was performed with the following experimental arrangement for free space set up as shown in Fig.7.

Figure 6.a. Experimental set up b. Schematic for free space measurement set up

The experimental measurement for free space set up consists of a pair of focusing horn lens transmitting and receiving antenna which are mounted on a large aluminum table (1.83 m X 1.83 m) as shown in Fig.7.The spot focusing horn lens antenna consists of two equal plano-convex dielectric lens mounted back to back in a conical horn antenna. The ratio of focal distance to diameter of the horn lens (F/D) is unity and D is approximately 30.5 cm, the corresponding 3- dB beam width is 1λ and depth of focus is 10 λ, where λ is the wavelength of measurement frequency. A special designed sample holder is placed at the common focal plane for holding the samples and is mounted on a micrometer-driven carriage. The sample was placed at the focal plane of antennas; measurement of the reflection loss of fabricated absorber with respect to the aluminium metal was carried after calibrating the transmission loss (TRL) calibration of the setup.

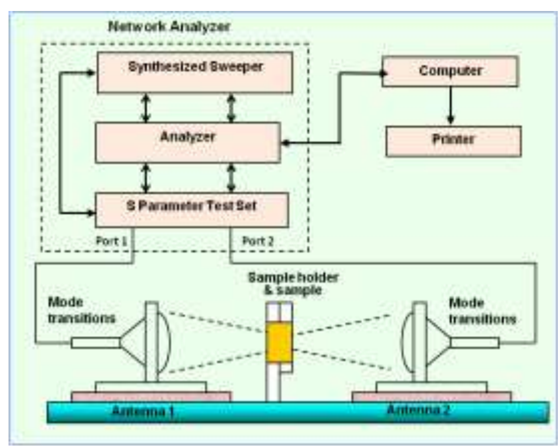

Figure 7. Schematic for free space measurement set up

Result and Discussion

The frequency dependence of both ϵ′, ϵ’’ and tanδ of composite at room temperature (RT) are shown in Figure 8-10 respectively. The ϵ′ values of composite are found to be nonlinear with increase in frequency. The decrease in ϵ′ values with increase in frequency can be explained on the basis of decrease in polarization. Polarization of a material is the sum of dipolar, electronics, ionic and interfacial polarizations [4]. At low frequencies, all the polarizations can respond easily to the time varying electric field, but as the frequency increases the contribution of different polarizations filter out. Thus the net polarization of the material decreases. As a result of which the ϵ′ values of banana samples decreases [4]. Figure 9 and 10 shows RT variation of ϵ″ and tanδ loss of banana fibre with frequency. The increase of both ϵ″ and tanδ with increase in frequency attains a maximum and then decreases at higher frequency. The variation of frequency shows one relaxation process. The decrease in their values at low frequency is due to migration of ions. The variation of ϵ″ and tanδ at higher frequency can be attributed to vibration of ions only [4-5]. The absorption coefficient increase with increase frequency which may be due to random migration of carbon particles from one point to other which causes loss of energy within the material as shown in Figure 11. The S11 parameters shows -5.4dB reflection loss at 10.300 GHz which corresponds to 80%power attenuation of EM wave and S21 parameters shows transmission loss of -2.54dB at 10.300 frequency indicating that material has good absorbing property as shown in Figure 12 respectively.

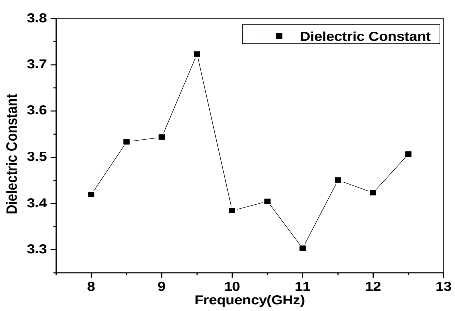

Figure 8. Room temperature frequency dependence of ε' of composite

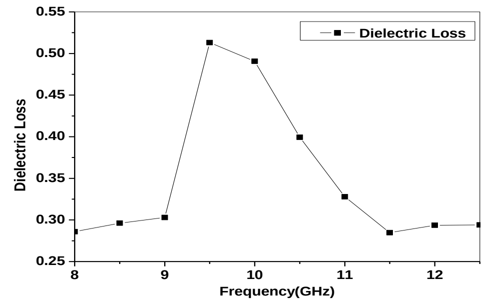

Figure 9. Room temperature frequency dependence of ε'' of composite

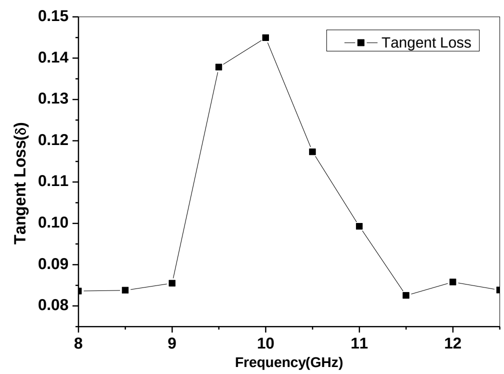

Figure 10. Room temperature frequency dependence of $\tan\delta$ of composite

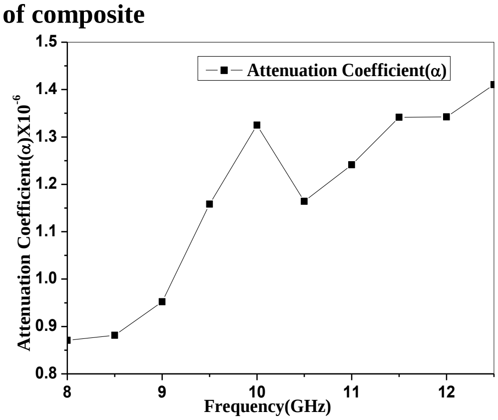

Figure 11. Variation of absorption coefficient of banana fibre composite

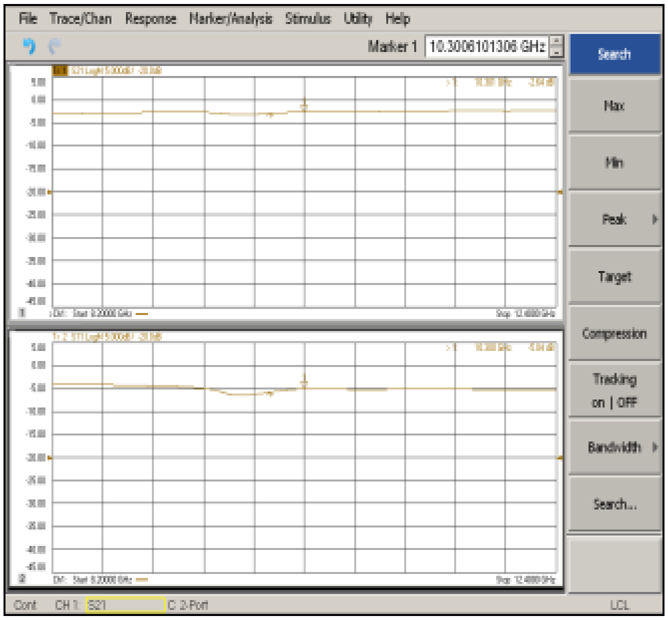

Figure 12. Variation of absorption coefficient banana fibre composite

Conclusion

The decrease in dielectric constant, dielectric loss and angle tangent (tanδ) are well agreed with that of microwave absorption property. The variation of S_{11} parameter and absorption coefficient shows that the composite attenuates 80% power at 10.300GHz. Thus the banana dust composite has good microwave absorbing property and find its application for synthesis of Radar absorbing material (RAM) and stealth material for application in defense like surface of targets, which can consist of different types of equipment, land vehicles, aircraft and ships.

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References

[1] B. Smythe,, S. Casserly and D. Arakaki, "Organic-based microwave frequency absorbers using corn stover," USA Antennas and Propagation Society, International Syposium Proceedings, pp. 920– 921, 2011.

[2] J. H. Oh, K. S. Oh, C. G. Kim and C. S. Hong, "Design radar absorbing structures using glass/epoxy composite containing carbon black in the X frequency ranges", Composites Part B: Engineering, Vol. 35(1), pp. 49-56, 2004.

[3] Y. M. M. Antar and H. W. Liu, "Effect of radar absorbing materials on RCS of partially coated targets", Microwave and Optical Technology Letters, Vol. 17(5), pp. 281-284, 1998.

[4] N. Shukla, V. Kumar and D. K. Dwivedi, J. Non-Oxide Glasses, Vol. 8(2), 47-57, 2016.

[5] S. Fares, Natural Science, Vol. 3(12), pp. 1034-1039, 2011.

Biographies

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