Advanced Research in Electrical and Electronic Engineering
p-ISSN: 2349-5804; e-ISSN: 2349-5812 Volume 2, Issue 12 July-September (2015) pp. 64-67

http://www.krishisanskriti.org/Publication.html

Activated Carbon from Used Tea Leaves for Development of Thin Sheet Composite Absorbers in X-band

Soma Chakraborty[1], Nidhi S. Bhattacharyya[2] and Satyajib Bhattacharyya[3]

[1,3]Dept. of ECE Tezpur University Assam-784028, India
[2]Dept. of Physics Tezpur University Assam-784028, India
E-mail: [1]somach@tezu.ernet.in, [2]nidhisbhatta@gmail.com, [3]satyajib@gmail.com

Abstract—*In the present work, activated carbon is prepared from used tea leaves and introduced as inclusions in Linear Low Density Polyethylene (LLDPE) matrix to develop composites. The activated carbon is used as filler in different weight percentages obtain 5 wt %, 7 wt % and 10 wt % composites. The composite is characterized for its microwave properties in X-band. 10 wt % composite shows maximum reflection loss. A thickness optimization of the sample carried out shows -10 dB bandwidth of ~ 1GHz for 5 mm thickness.*

1. INTRODUCTION

For reliable and efficient use of communication links, it is important to efficiently manage Electro-Magnetic Interference (EMI) to minimize system susceptibility to other sources or itself being a source for service disruption in other systems. Increase in EMI due to the rapid growth of recent complex electronic equipments and systems have lead to the need for designing Microwave Absorbing Materials (MAMs) which can sufficiently reduce these interferences. The electrical/ magnetic properties of the EM wave absorbing layers as well as the geometry are customized to achieve absorption at broadband frequencies. The design of these structures depends on material properties such as complex permittivity, complex permeability and conductivity [1].

Due to light weight, low cost, wetherability and design flexibility composite materials find use in the field of electromagnetic shielding materials [2]- [8].

Selection of the host matrix is done based on the properties such as its flexibility, lighter weight, binding energy, resistance to chemicals, solvents, etc., availability and cost effectiveness.

Carbonaceous materials are reported to demonstrate good microwave absorbing properties rendering them effective materials in the development of microwave absorbing materials (MAMs) [9]. These materials are characterized by good electrical and thermal conductivity, low density as well as excellent corrosion resistance. The filler material used here is activated carbon (AC) made from used tea leaves like other agricultural wastes used [10]-[12]. Choice of the filler material depends on the properties: Highly lossy, high permittivity, low cost, availability and environmentally compatible. Due to its low cost, high carbon content and high surface-area-to-volume ratio and due to its small particle size and low ash content AC is a potential material for producing carbon-based microwave absorber [13].

In the present work, dielectric- polymer composites are fabricated using used tea grains. Polymer composites were developed using tea leaves as the fillers in LLDPE matrix. The micro-structural and the EM wave absorbing properties of the materials are investigated.

2. EXPERIMENTAL

2.1 Sample preparation

Preparation of Activated carbon from waste tea leaves

The used tea leaves are collected and washed several times to remove the surface impurities. It is initially sun dried for 5 days. 20 gms of tea waste is powdered. The powder is treated with 32 ml of sulphuric acid and nitric acid in a ratio of 3:1 to digest the tea waste for 12 hours at 30˚C. The digested sample is washed for 8 to 10 times using distilled water to remove any traces of acid and checked pH determination of the carbonized sample was done. The sample is kept inside the hot-air oven at 55˚C for 5 hours to remove moisture. The dried leaves are heated up to 400˚C in the muffle furnace for 20 minutes. The sample is then crushed to powder. XRD of the powdered sample is conducted to see formation of activated carbon.

2.2 Composite Preparation

LLDPE is used as the polymer matrix. LLDPE has a melting point of 130˚C. The composite is prepared in situ by mixing mechanically desired weight % of the filler material into LLDPE powder. The mixture is put into a mould and heated upto 130℃ at constant pressure of 1torr for 12 minutes. Fig. 1 shows schematic of composite preparation.

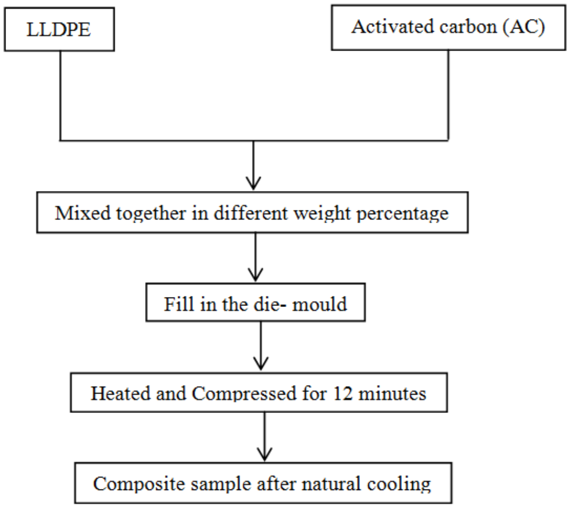

Fig. 1: Block diagram of composite preparation.

The weight % is mathematically determined as follows:

If total weight of the composite is Z grams and X and Y are the weights of host and filler, respectively, i.e., Z=X+Y. To fabricate N weight % of the composite, amount of filler present in the composite is given by

$$Weight\ \% = \left(\frac{X}{X+Y}\right) \times 100$$

Using the above relation, 5, 7, 10 weight % of activated carbon/LLDPE composite is prepared. The prepared pellets are shown in given in Fig. 2.

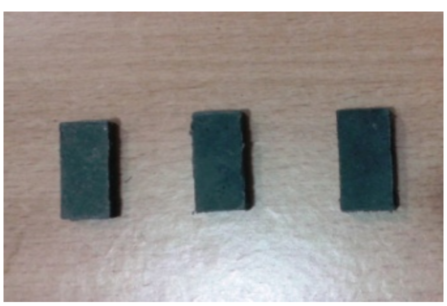

Fig. 2: Prepared composites for X- band characterization.

2.3 Characterization

Microstructual characterizations

The structural analysis of the fillers are done using X-ray diffractometer (Rigaku Miniflex 200) with monochromatic CuKα radiation (λ=1.54178Å) over a 2θ angle from 10˚ to 70˚.

Fig. 3 shows the X-ray diffraction pattern.

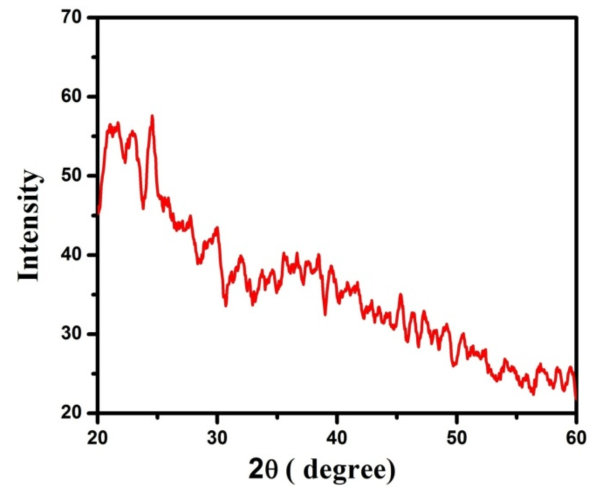

Fig. 3: Filtered XRD pattern of activated carbon.

Table I shows the interplanar spacing. The specific peaks at 24.56˚ and 45.33˚ show the formation of activated carbon [14]. The value of lattice parameters and inter planar spacing (d) is calculated using Bragg's Law

$$2s\ sin\theta = n\lambda \qquad (1)$$

$$s = \frac{n\lambda}{2\ sin\theta} \qquad (2)$$

where θ is the Bragg's angle, n is the no. of lattice plane, λ wavelength of X-ray

Table 1: XRD profile planar spacing of the crystal lattice.

2 θ of the Intense peak *(in ˚)*	**Inter planar spacing** *(s in nm)*
24.56	0.362
45.33	0.199

From the most prominent peaks, the average crystallite size (D) is found to be between 11.648 nm to 20.25 nm which is calculated using Debye-Scherrer's equation

$$D = \frac{k\lambda}{\beta\ cos\theta} \qquad (3)$$

where D is the crystallite size, k is a constant known as Scherrer's constant, β is full width at half maximum (FWHM) of the particular peak.

Table 2: XRD profile and crystalline size (D) of the synthesized material.

2 θ of the Intense peak *(in ˚)*	**FWHM (β) of Intense peak** *(in ˚)*	**FWHM (β) of Intense peak** *(in radian)*	**Size of the particle** *(D in nm)*
24.52	0.6900	0.01204	11.648
45.27	0.4202	7.33×10^{-3}	20.25

Microwave Characterizations

Permittivity ($\varepsilon=\varepsilon'+j\varepsilon''$) of composite is measured using Thru-Reflect-Line (TRL) method. Pellets of dimensions 10.16 mm x 22.86 mm x 4mm, of different weight % of composite is placed in Agilent WR-90 X11644A. The measurements are carried out using Agilent E8362C Vector Network Analyzer, in the frequency range 8-12 GHz, The permittivity is determined using Nicolson-Ross technique.

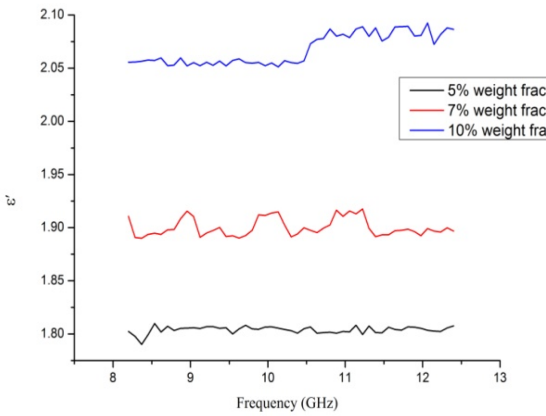

Fig. 4: Dielectric constant (ε') of the prepared composites.

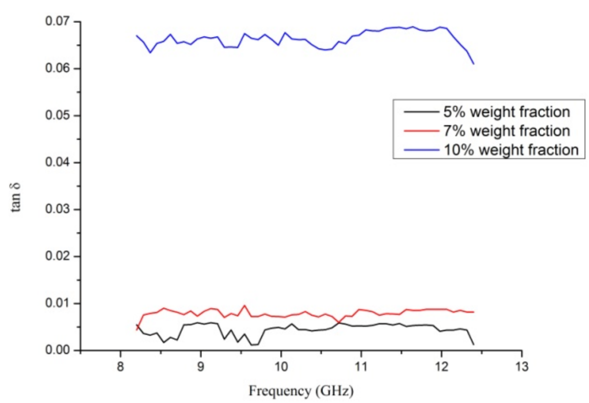

Fig. 5: Loss tangents (*tan δ*) of the prepared composites.

Fig. 4 and Fig. 5 show spectra of real part of permittivity (ε') and the loss tangent (*tan* $\delta=\varepsilon''/\varepsilon'$) for different weight percentage composites, respectively. ε' of 10 wt% activated carbon/ LLDPE composite is found to be ~2 and tan delta of ~0.07 over the X-band.

3. ABSORPTION STUDIES

Sample with 10wt% activated carbon/LLDPE composite has higher real part of permittivity and loss tangent of ~0.07, and the values of ε' and ε'' are used to determine reflection loss (RL) and hence the absorption. To determine RL, single layer conductor backed configuration is considered. The schematic diagram of a single layer metal- backed absorber is shown in Fig. 6. When an electromagnetic wave strikes the surface of a metal- backed microwave absorber at normal incidence, the reflection loss is a function of frequency, thickness, dielectric permittivity and magnetic permeability of the absorbing material.

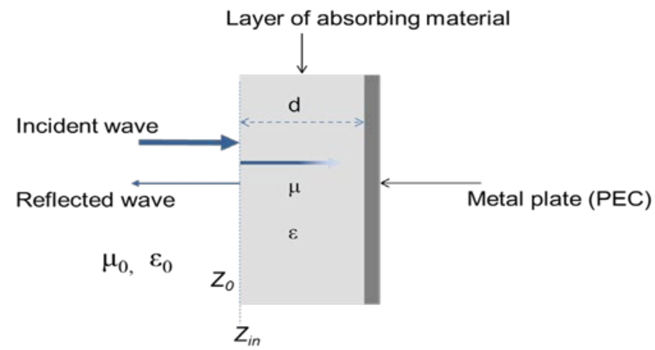

Fig. 6: Schematic of a single layer metal- backed absorber.

The reflection loss of the metal-backed single layer absorber from TLM is determined from,

$$RL = 20 \log|(Z_{in} - Z_0)/(Z_{in} + Z_0)| \qquad (4)$$

where $Z_0 = (\mu_0/\varepsilon_0)^{1/2}$ is the free- space impedance, and the input impedance at the air- absorber interface is given as

$$Z_{in} = Z_0(\mu/\varepsilon)^{1/2} \tanh\left[j2\pi f d(\mu/\varepsilon)^{1/2}/c\right] \qquad (5)$$

for dielectric sample $\mu=1$ hence equation (5) can be rewritten as

$$Z_{in} = Z_0(1/\varepsilon)^{1/2} \tanh\left[j2\pi f d(1/\varepsilon)^{1/2}/c\right] \qquad (6)$$

f is the frequency, c is the velocity of light and d is the thickness of the absorbing material.

A thickness optimization is carried out for the absorber sample from 2 mm to 10 mm. Fig. 8 shows the RL for different values of *d*. *d* = 5 mm thickness showed maximum reflection loss and a -10dB bandwidth (i.e. 90% absorption).

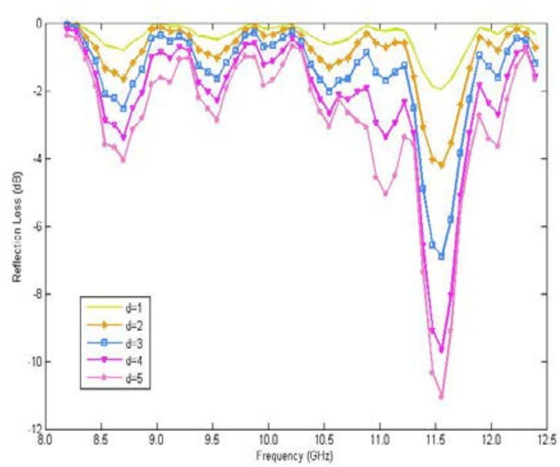

Fig. 7: Reflection Loss (RL) of the conductor bacled single layer 10 wt% composite for different thickness (*d*) values

The flow chart of the program is given in Fig. 8.

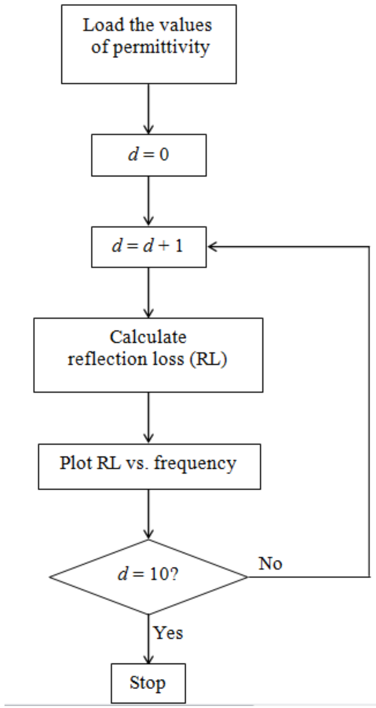

Fig. 8: Schematic of algorithim of the program.

4. CONCLUSIONS

10 wt% activated carbon/LLDPE composites shows a a -10 dB bandwidth (i.e. 90% absorption) of ~ 1GHz in X-band. The optimized thickness of the sample giving maximum reflection loss is found to be 5 mm. The absorber is less expensive as the activated carbon is developed from the used tea leaves. The present studies suggests that AC/LLDPE composites are promising material for making efficient absorbers in X-band.

REFERENCES

[1] Chung, D. D. L., “Materials for electromagnetic interference shielding,” *Journal of Materials Engineering and Performance*, 9, 3, Jan. 2000, pp. 350-354.

[2] Yew, B. S., and Wee, F. H., “Agricultural waste based-coco peat microwave absorber,” *International Journal of Engineering Sciences & Emerging Technologies*,7, Oct. 2014, pp. 547-554.

[3] Iqbal, M. N., Malek,F., Ronald, S. H., Shafiq, M., Juni, K. M., and Chat, R., “A study of the EMC performance of a gradded-impedance, microwave, rice- husk absorber”, *Progress In Electromagnetics Research.*, 131, Sept. 2012, pp. 19-44.

[4] Cheng, E. M., Malek, F., Ahmed, M., You, K. Y., Lee, K. Y. and Nornikman, H., “The use of dielectric mixture equations to analyze the dielectric properties of a mixture of a rubber tire dust and rice husks in a microwave absorber," *Progress In Electromagnetics Research*, 129, Mar. 2012, pp. 559-578.

[5] Farhany, Z. S., Malek, F., Nornikman, H., Affendi, N. A. M., Mohammed, L., Saudin, N., and Ali, A. A., “Potential of dried banana leaves for pyramidal microwave absorber design”, in *IEEE Symposium on Wireless Technology and Applications (ISWTA)*, 2012, pp. 60.

[6] Salleh, M. K. M., Yahya, M., Awang, Z., Muhamad, W. N. W., Mozi, A. M., and Yaacob, N., “Experimental verification of multi-Layer coconut shell-derived microwave absorbers”, in *IEEE International RF and Microwave Conference (RFM)*, 2011, pp. 115.

[7] Zahid, L., Malek, F., Nornikman, H., Afendi, N. A. M., Ali, A., Hussin, N., Ahmad, B. H., and Aziz,M. Z. A. A., “Development of pyramidal microwave absorber using sugar cane bagasse (SCB)”, *Progress In Electromagnetics Research*, 137, Mar. 2013, pp. 687-702.

[8] Gogoi, J. P., Sarmah, S., Sarmah, D., and Bhattacharyya, N. S., “$Ni_{0.5}Zn_{0.5}Fe_2O_4$/ bamboo charcoal/titania LDPE composites as viable microwave absorbing materials”, in *Applied Electromagnetics Conference (AEMC)*, 2009, pp. 1-4.

[9] Chung, D. D. L., “Electromagnetic interference shielding effectiveness of carbon materials,” *Carbon*, 39, 2001, pp.279-285.

[10] Rengaraj, S., Arabindoo, B., and Murugesan, V., “Preparation and characterisation of activated carbon from agricultural wastes”, *Indian Journal of Chemical Technology*, 6, Jan. 1999, pp. 1-4.

[11] Yagmur, E., Ozmak, M., and Aktas, Z., “A novel method for production of activated carbon from waste tea by chemical activation with microwave energy”, *Fuel*, 87, May 2008, pp. 3278-3285.

[12] Khalil, H. P. S. A., Jawaid, M., Firoozian, P., Rashid, U., Islam, A., and Akil, H. M., “Activated Carbon from Various Agricultural Wastes by Chemical Activation with KOH: Preparation and Characterization, *Journal of Biobased Materials and Bioenergy*, 7, 2013, pp. 1-7.

[13] Khan, S. D., Arora, M., Puri, C., Wahab, M. A., and Saini, P., “Permittivity and electromagnetic interference shielding investigations of activated charcoal loaded acrylic coating compositions”, *Journal of Polymers*, May 2014.

[14] Khan, S. D., Arora, M., Puri, C., Wahab, M. A., and Saini, P., “Synthesis and characterization of acrylic resin/activated carbon composites,” *Indian Journal of Pure and Applied Physics*, 52, 2014, pp. 251-254.