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CARBON COMPOSITION, SURFACE POROSITIES AND DIELECTRIC PROPERTIES OF COCONUT SHELL POWDER AND COCONUT SHELL ACTIVATED CARBON COMPOSITES

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ABSTRACT

This paper investigates the potential of coconut shell powder (CSP) and coconut shell activated carbon (CSAC) with epoxy resin matrix composites to be used as absorbing materials over frequency of 1-8 GHz. Carbonaceous materials are preferable to be used as electromagnetic absorbent due to its excellent thermal conductivity. The CHNS Elemental Analysis is performed to evaluate the carbon composition (%) of the raw CSP and CSAC. From CHNS analysis, it was found that the carbon % of CSP and CSAC is 48.37% and 83.94% respectively. The surface porosities of CSP and CSAC were examined using scanning electron microscope (SEM) at an accelerating voltage of 15 kV. The porosity of CSP and CSAC is in the range of 2µm and 1µm respectively. The dielectric properties (complex permittivity) of the composites were determined by using high temperature dielectric probe in conjunction with Network Analyser. The dielectric constant for CSP and CSAC is 3.769 and 7.240 respectively while the dielectric loss factor for CSP and CSAC is 0.289 and 0.859 respectively.

Keywords: dielectric properties, carbon composition, surface porosity.

INTRODUCTION

In recent years, researchers have focused to identify a new electromagnetic interference (EMI) absorbing material from cheap and renewable material such as oil palm shell, rice husk, coconut shell, corncobs, durian shell (Chandra TC *et al*., 2009), soybean oil cake, bamboo, cotton stalks (Chengwen Song *et al*., 2014). (Daud *et al*., 2004), (Salleh M. K. M. *et al.,* 2011), (K. Sivakumar *et al*., 2010), (Ami Cobb *et al*., 2012), (Tay T *et al*., 2009). In this work, focus on using the CSP and CSAC as the carbonaceous material. The purpose is to diversify the coconut waste as EMI absorbing material. At present, coconut wastes are mostly used in horticultural and agricultural applications (Cresswell, G., 2011).

Carbon materials are good absorbent of electromagnetic energy as it is easily heated. This is because carbon is the main element to absorb unwanted electromagnetic signals (A. A. Yusof, 2004), (A. A. Yusof *et al*., 2005), (Z. Liyana *et al*., 2013), (J.A. Menendez *et al*., 2010). Organic carbonaceous materials are potentially useful as electromagnetic absorbing material. Moreover, electromagnetic absorbing material should possess large surface area for larger thermal conduction losses. Therefore, materials with minimum surface porosity (micrometer range) are desirable to enhance the surface area of the absorbing material.

The carbon composition of the CSP and CSAC is determined by using ultimate analysis through CHNS Elemental Analysis. The CHNS elemental analysers provide a means for rapid determination of carbon, hydrogen, nitrogen and sulphur in organic matrices (Prem Lata Meena *et al*., 2014), (Achaw *et al*., 2008).

Dielectric materials are characterised by their dielectric properties. A good electromagnetic absorbing material absorbs the unwanted electromagnetic waves and converts this wave as heat. Dielectric properties or complex permittivity determine the ability of the material to absorb energy. The dielectric properties (ε) can be represented by complex permittivity as shown in Equation 1: (P. Saini and M. Arora, 2012), (S. Li *et al*., 2012), (D. Micheli *et al*., 2011).

$$\varepsilon = \varepsilon' - j\varepsilon'' \tag{1}$$

ε = Dielectric properties,
ε' = Dielectric constant,
ε'' = Dielectric loss factor

The real part of the complex permittivity is called dielectric constant (ε') whereas the imaginary part of the complex permittivity is called the dielectric loss factor (ε"). The dielectric constant defines the ability of a material to store the microwave energy while the dielectric loss factor defines the ability of a material to convert and dissipate the stored microwave energy to heat (Wee FwenHoon *et al*., 2012). Moreover in this paper aims to investigates the potential of coconut shell powder (CSP) and coconut shell activated carbon (CSAC) with epoxy

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resin matrix composites to be used as absorbing materials over frequency of 1-8 GHz.

EXPERIMENTAL

Material preparations

The raw materials were coconut shell powder (CSP) and coconut shell activated carbon (CSAC). The coconut shell was taken from Gong Badak, Terengganu, Malaysia and cleaned, dried, sanded into very fine powder form. Readily market available CSAC with mesh -200 particle size is used.

Material characterisation

The powder samples of both CSP and CSAC were used characterised. The carbon composition is determined through CHNS Elemental Analysis by using CHNS Analyser Elemental Germany vario MICRO cube. Meanrable, the particle sizes were examined by TM3000 scanning electron microscope (SEM) operated in high magnification. For SEM measurements, the samples were prepared by coated with a thin layer of platinum (Chandra TC *et al*., 2009), (Achaw and Afrane, 2008), (Andrew P. Gregory and Robert N. Clarke, 2006), (Kyla *et al,* 2013), (Manocha L. M *et al.*, 2010), (Achaw, 2012).

Composite preparation

The raw material and epoxy resin matrix composites are prepared in weight ratio of 50:50 and mix using IKA RW20 Digital Stire. Sample 1 was prepared by mixing CSP and epoxy resin and stir for 1hour. Sample 2 was prepared in similar manner but using CSAC. The mixture was poured in 30mm x 30mm x 5 mm rectangular planner moulds. Fabrication of sample 1was done through the steps represented in Table-1.

Table-1. Fabrication of composite sample.

Step 1		Collection of agricultural wastes and grind into fine powder form
Step 2		Mixing of agricultural wastes with resin and hardener.
Step 3		The composites were stirred by using IKA RW20 Digital Stirer for 1hour
Step 4		The composite were filled and fabricate using mould.

Dielectric properties measurement

One of the most convenient and frequently used technique to measure the dielectric properties of a materials at high frequencies is by using open-ended coaxial-line method (Andrew P. Gregory and Robert N. Clarke, 2006), (Jilani. M. T *et al.*, 2012). The high temperature dielectric probe is performed by contacting the probe into the samples. The high temperature probe measurement procedure, which is done by contacting the probe to a flat surface of a sampleis as shown in Figure-1. The fields at the probe end "fringe" into the material and change as they come into contact with the MUT.

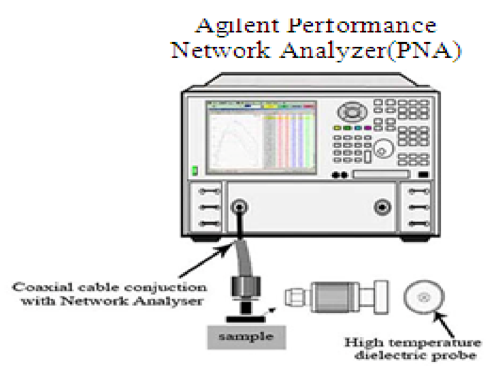

Figure-1. Measurement techniques for CSP and CSAC: high temperature dielectric probe technique.

RESULT AND DISCUSSIONS

Carbon composition

The CHNS Elemental Analysis find utility in determining the percentages of carbon, hydrogen, nitrogen and sulphur (Michael Thompson, 2008), (Sumedha Chakma *et al*., 2014). The result of elemental analysis of CSP and CSAC are presented in Table-2.

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Table-2. The CHNS elemental analysis of CSP and CSAC.

Description	Carbon %	Hydrogen %	Nitrogen %	Sulfur %	Oxygen (by diff.)
CSP	48.370	6.313	1.620	0.306	43.390
CSAC	83.940	1.263	0.860	0.175	13.760

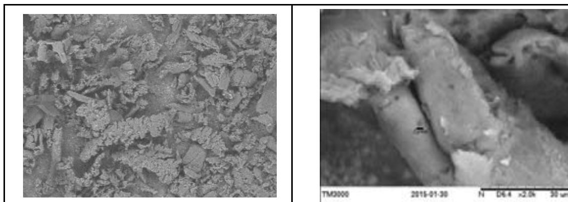
As presented in Table-2, the carbon% of CSP and CSAC is 48.37% and 83.94% respectively. The CSP has lower carbon content compare to CSAC. Thecomposition of carbon in the CSPand CSAC as presented from the elemental analysis indicates a good precursor material for porous carbon (Cazetta *et al*., 2011).

The previous study from Jessica Hung (2012) show the result of activated carbon is 97% pure. Besides that, based on Table-2, the CSAC have higher carbon content compared to CSP. This may be due to the fact in order to produce activated carbon from coconut shells; the overall process utilizes the pyrolysis of coconut shells into char, followed by steam activation in a fluidized bed reactor (FBR). According to Yuen *et al*., (2009) there are two processes to produce activated carbon from carbonaceous materials, i.e. chemical and physical activation processes. Physical activation procedure involves a two-step process, i.e. carbonisation, followed by activation using steam, oxygen or carbon dioxide as an activating agent (MN MohdIqbaldin *et al.* 2013).

Surface morphology

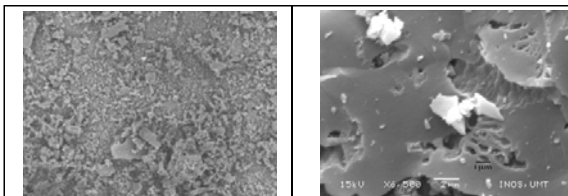
Morphology and pore structure characteristic of coconut shell powder and coconut shell activated carbon were analyzed by SEM method (Scanning Electron Microscope). Micrographs in Figure-2 and Figure-3 reveal the micrograph of CSP and CSAC.

The SEM micrographs in Figures 2(a) and 3(a) present the surface area of CSP and CSAC. The results show that CSAC has pore structures falling in the range of mesopores. The surface features observed from these micrographs are significantly different. From SEM micrographs in Figures 2(b) and 3(b), presence of mesopores are detected in CSP and CSAC, where it is in the range of 2µm and 1µm respectively. Li *et al*., (2008) reported activated carbon (CSAC) having porous structure and high surface area where the pore structure is importance for absorbing material (MN MohdIqbaldin *et al*., 2013). The results showed that CSAC is a high surface area material (J.E. Atwater and Jr. R.R. Wheeler, 2004) compared to CSP.



(a) (b)

Figure-2. (a) SEM micrograph of surface morphology of CSP; (b) SEM micrograph of porosity of CSP.



(a) (b)

Figure-3. (a) SEM micrograph of surface morphology of CSAC; (b) SEM micrograph of porosity of CSAC.

Dielectric properties

The results of dielectric properties of CSPand CSAC over frequency of 1-8 GHz are presented in Table-3.

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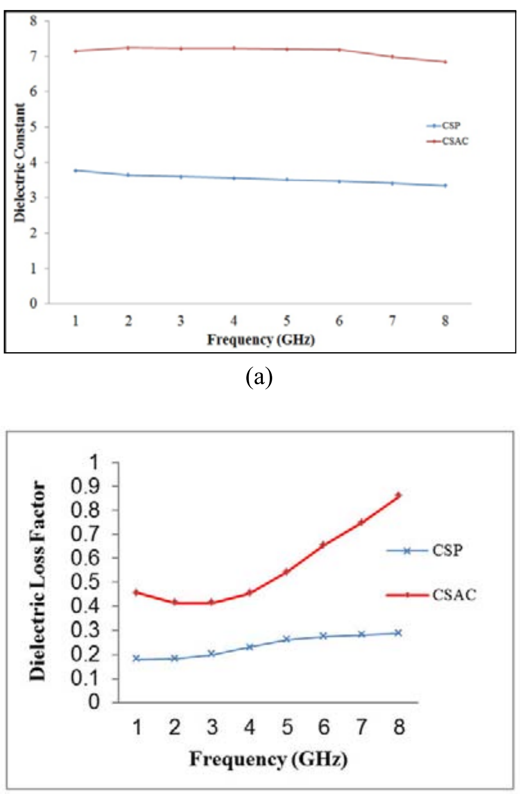
Table-3. Dielectric properties for CSP and CSAC.

Frequency (GHz)	Sample composite	Dielectric properties		
		Dielectric constant, ε'	Dielectric loss factor, ε''	Loss Tangen, tan δ
1	CSP	3.769	0.180	0.048
	CSAC	7.145	0.455	0.066
2	CSP	3.641	0.181	0.050
	CSAC	7.240	0.412	0.057
3	CSP	3.598	0.199	0.056
	CSAC	7.223	0.412	0.057
4	CSP	3.558	0.230	0.065
	CSAC	7.236	0.455	0.063
5	CSP	3.511	0.263	0.075
	CSAC	7.201	0.542	0.075
6	CSP	3.462	0.273	0.079
	CSAC	7.189	0.656	0.091
7	CSP	3.403	0.282	0.083
	CSAC	6.985	0.751	0.122
8	CSP	3.341	0.289	0.087
	CSAC	6.748	0.859	0.127



(a)

(b)

Figure-4. Complex permittivity (a) Real part; (b) Imaginary part.

Figures 4 (a) and (b) show the dielectric properties that are measured from CSP and CSAC composites. The dielectric constant and dielectric loss factor vary when the frequency increase from 1GHz to 8GHz. The dielectric constant, ε' of CSP is in range of 3.341-3.769 respectively, while CSAC is in range of 6.748-7.240respectively. The dielectric loss factor, ε'' of CSP is in the range of 0.180 - 0.29 respectively, while CSAC is in the range of 0.412 - 0.859 respectively. It can be observed that the dielectric properties of the CSAC composite are higher compared to the CSP composite. This is due to high carbon composition in the CSAC compared to the raw CSP. The higher value of the dielectric constant of the CSAC indicated that the signal was propagated at a slow speed due to large refractive index of the medium. This shows that the wavelength of the transmitted wave inside the CSAC composite decreases more rapidly than that of CSP composite material.

CONCLUSIONS

From this experiment, the potential of CSP and CSAC composites as EMI absorbing material in term of carbon composition, surface morphology and dielectric properties have been investigated. Both CSP and CSAC composites show desirable potential to be used as EMI absorbing material, in term of carbon as dominant element, mesopores porosity and thermal conductivity. From the result, CSAC composite possess better carbon composition, surface morphology and dielectric properties compared to CSP composite. It can be conclude that the coconut shell activated carbons offers greater potential as absorbing material rather than CSP.

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