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Microwave Absorption Efficiency of CNBs synthesized from Brassica Nigra Oil

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ABSTRACT

Spherical carbon nano beads (CNBs) were synthesized by pyrolysis of brassica nigra oil at 850°C in hydrogen atmosphere in presence of transition metal powder as a catalyst. Micro-Raman spectrum exposes the graphitic nature of material. Scanning electron microscopy (SEM) and Transmission electron microscopy (TEM) illustrate that CNBs are interconnected with outer shell of thickness around 100 nm. A microwave reflection measurement explores an ability of CNBs as an absorber with absorption up to 89% corresponds to reflection coefficient about ~ -22dB for maximum band width of 0.8GHz in Ku-band.

Keywords : Carbon nano-beads, Pyrolysis, Natural oïl vapour deposition, Microwave absorption

I. INTRODUCTION

Carbon materials have attracted increasing attentions due to their significant electrical and mechanical properties. With rapid developments of information technology and extensive applications of electrical and electronic devices cause increasing electromagnetic wave radiation which is drawing considerable attention as a potential kind of environmental pollution. As one of the ways to overcome these problems is a carbon-based material which play an important role due to their light weight, large surface area, good conductivity and thermal and chemical stability. Usually precursors for getting carbon nano materials are various types of hydrocarbons derived from fossil fuels like methane etc. [1-3], which can be catalytically decomposed into carbon atoms in a chemical vapour deposition unit. But these sources are about to deplete in near future. Therefore there is a need to look for precursors which can be cultivated as and when required like plants material, oil seeds etc. [4-7]. Dubey and Kshirsagar et al [8] tried to synthesize carbon nanomaterial from coconut shell, a natural precursor. Where Sharon et al [9] studied the microwave properties of nanomaterial obtained from camphor. Later on, the attempts were made to utilize carbon nanomaterials for giga hertz frequency applications [10-15]. In this paper we have reported the synthesis of CNBs from natural brassica nigra oil and its properties in Ku-band of microwave frequency region.

II. EXPERIMENTAL

2.1. Materials

Natural brassica nigra oil is pale yellow to brownish yellow liquid, also known as mustard oil. It was used as a precursor, which is derived by hydro-distillation of small round dark brown seeds of mustard plant.

2.2 Sample Preparation

Vapour deposition of linseeds oil was used to synthesize CNBs using a CVD system. This method is discussed in details elsewhere [10]. Ceramic material sheet of 1 × 3 cm^2 was used as a substrate for film deposition. A quartz tube of length one meter and 45 mm in diameter was inserted in the vaporizing furnaces. Substrate was kept in the quartz tube at the central hot zone of furnace, temperature of which was maintained at 850°C. Precursor was kept near hot zone whose temperature was maintained around 300°C. The flow rate of hydrogen was maintained in such a way that 5ml of linseeds oil could be transferred to the reaction zone in about 1hr. In the beginning, the entire assembly was flushed with hydrogen for 15 minutes to ensure removal of oxygen from the system. After completion of the reaction, thick films of CNBs deposited on ceramic sheet was taken out at room temperature. Film was characterized before use to study its properties in the range of Ku-band of microwave frequency region.

2.3 Characterizations

Scanning electron microscopy (SEM) with Hitachi S-4300 was used to study the surface morphology of film. Transmission electron microscopy (TEM) image of the film was taken with Field effect TEM, JEOL- 2100F. Micro-Raman spectra using green laser with 532nm excitation was also used to characterize the film. Vander Pauw method was used to measure the sheet resistance of the film. Microwave conductivity, absorption and shielding effectiveness was studied using microwave test bench in 13-18 GHz range.

III. RESULTS AND DISCUSSION

Figure 1 shows the CNBs with diameter of around 550 nm along with some micro size beads of dimension ~2.5μm. These beads are merging with each other and formed a string along with free beads.

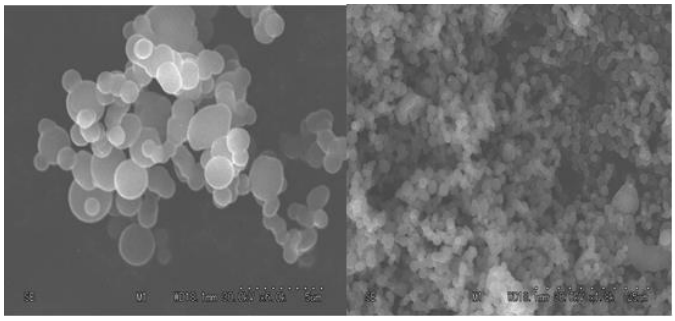

Figure 1. SEM images of CNBs synthesized using brassica nigra oil

TEM shows (figure 2) , the carbon beads are interconnected with each other through outer wall. Here, the inner diameter of beads was observed in the range of 0.45 nm with the thickness of wall about ~ 100nm.

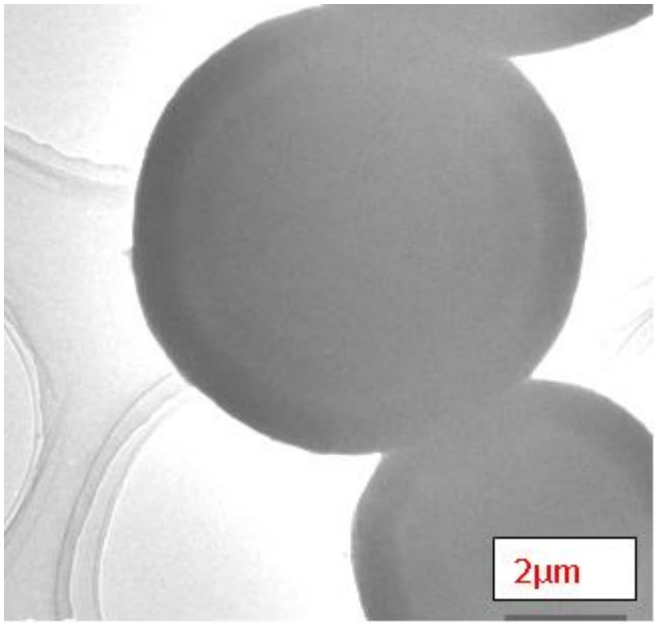

Figure 2. TEM image of CNBs synthesized using brassica nigra oil.

In micro-Raman analysis of samples two broad peaks were observed for the carbon beads, the peak centred at 1588 cm^{-1} was corresponds to standard graphitic G-peak commonly occurring at 1580cm^{-1} .The other peak centred at 1345cm^{-1}, was observed comparatively broad and could be corresponding to disordered carbon D-peak normally observed at 1300-1350cm^{-1}. The ratio of

G to D band intensities indicates the relative amount of highly ordered graphite carbon as compared to amorphous carbon. IG to ID band ratio much greater than unity indicates as abundance of highly ordered graphite and a low amount of undesired carbon content. From the micro-Raman spectra, intensity ratio of graphitic (IG) and disordered graphitic peak (ID) i.e. I_D/I_G for brassica nigra oil based carbon nano beads was found to be 0.89.

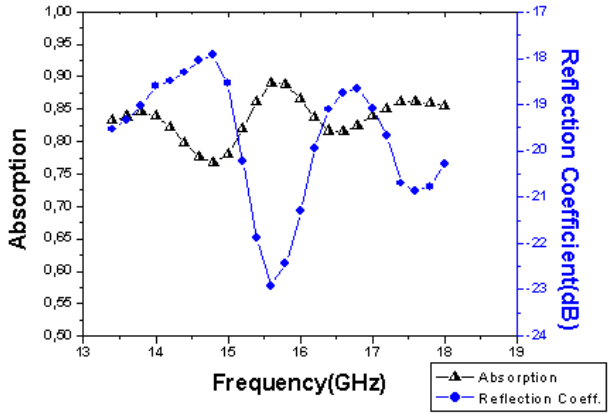

Figure 3. Set of curves showing the relation between reflection coefficient and absorption Vs. Frequency for CNBs films

Figure3, Shows the relation between of reflection coefficient and absorption with respect to frequency. From the curve (figure3),it is seen that, the film of CNBs gives a low reflection of microwave energy on overall frequency range. The reflection coefficient for the film was observed from -20dB to - 22dB in the frequency range 15.2 -16GHz and17.4-18 GHz. For the remaining frequencies RC varies in the range of -17dB to -19dB.As a result the absorption curve explores the efficiency of CNBs as potential microwave absorber in Ku-band with absorption band width of 0.8GHz and 0.6GHz.Overall absorption for the CNBs films was observed in the range of 0.76-0.89 .

An ability to block the passage of microwaves by CNBs was confirmed from EMI shielding effectiveness (SE) study of films in Ku-band. Here, effectiveness of shielding microwave was calculated using equation (1)

$$SE = -20\log T \quad (1)$$

Where, T is an electromagnetic radiation transmittance.

From the study of shielding effectiveness against frequency , it is observed that CNBs has potential to block the passage of microwaves through the system with EMI SE between -29dB to -40dB on overall Ku-band of microwaves frequency region.

IV. CONCLUSION

Natural Brassica nigra oil was used as a source of carbon nano-beads using simple natural oil vapour deposition method. Microwave absorption study of the as prepared CNBs films material exposed its capability as an absorber in Ku-band of electromagnetic waves with absorption band width of 0.8GHz and 0.6GHz in the frequency range 15.2 -16 GHz and 17.4-18 GHz .Ku-band absorption between 76-89% was observed on overall frequency range indicates its efficiency as an absorber material for various applications.

V. ACKNOWLEDGMENTS

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