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Materials' Properties of Lightweight Spiral Hybrid CNT/Epoxy Composites Enhanced Reflection Loss

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ABSTRACT

Recently, various electronic devices have been developed to meet the requirements of higher frequency technology applications. This widely used application without realizing has created more electromagnetic interference pollution that is harmful to human health and other equipment. Therefore, more research interest focuses on fabricating the electromagnetic (EM) wave absorbing materials that can absorb the EM wave interference. In this regard, this research highlights the use of Iron Oxide and Cobalt Oxide as catalyst to synthesize hybrid CNT by using Thermal Vapor Deposition Tube (TVDT) method. The spiral hybrid CNT/epoxy composites were prepared at thickness of 1mm, 2mm and 3mm. The phase formation, microstructural, particle size and structural analysis of the hybrid CNT were analyzed by using X-ray diffractometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM) and RAMAN spectrometer respectively. The microwave characterization of the hybrid CNT/epoxy composite samples was analyzed by using Vector Network Analyzer (VNA) at GHz frequency range. The phase analysis confirmed the existence of Carbon and iron carbide in the sample. The microstructural of CNT formation are mostly in spiral and straight like structure. On the other hand, the structural analysis shows the sample are more towards defective structure with higher and broader D-band peak. This could enhance the EM wave absorption performance. The minimum reflection loss (RL) peak was ~-23dB (t=3mm) obtained for all hybrid CNT composite samples. The differences of minimum reflection loss peak at different weight percentages are most likely shown by the shift of frequency range. Thus, this lightweight spiral hybrid CNT/epoxy composites results in better EM wave performance at different thin thickness used for different applications.

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1. Introduction

Rapid growth of the use of electronic devices that work at microwave frequency range have increased in the electromagnetic (EM) interference and non-ionizing radiation that are harmful to human health and other electronic equipment. In this regard, it attracts more public attention and researcher interest in conducting research focusing on the EM wave absorbing materials that could absorb and reduce the unwanted EM wave signal. Developing an effective EM wave absorption material requires strong absorption ability and wide bandwidth as reported by Lu *et al.,* [1]. Moreover, the absorber materials should have lower material density, thinner absorption coating and have stability at high temperatures with material compatibility as also being reported by several authors [2-4]. The way EM wave absorbing material works is that it absorbs EM wave energy, gradually transforms it into heat or other types of energy, and then dissipates that energy through attenuation and loss as reported by Lu *et al.,* [1]. The increase in the transmission route and transfer from one medium to another medium contributes to higher efficiency of the EM wave absorber.

Binary combinations such as Nickel (Ni), Iron (Fe) and Cobalt (Co) are often utilized and act as active catalysts that exhibit greater activity than the individual elements. Carbon nanotubes (CNTs) growth from an active catalyst are well-known due to their unique chemical, physical and mechanical properties that makes it suitable for certain modifications for lightweight, wide and strong absorption bandwidth and act as a potential EM wave absorber. The dielectric and resistance loss of EM waves in CNTs is converted into thermal energy dissipation because of surface polarization and dielectric relaxation in the conductive network generated by CNTs. This implies the features of absorption type of EM wave absorbing materials of CNTs. In comparison to other carbon-based EM wave absorbing materials, CNTs have greater EM wave absorption capability because of their flexibility, lighter, thinner and larger specific surface area as reported by Konrath *et al.,* [5]. Other research conducted by Hashim *et al.,* [6] also reported on the highest mechanical strength enhancement was given by the MWCNT-Al5Si where the MWCNT was homogeneously distributed into the matrix and MWCNT helps in reducing the crack propagation.

Therefore, this research highlights the modification of CNTs, with special emphasis on their EM wave absorbing ability. In this study, Magnetite (Fe_3O_4) and Cobalt Ferrite ($CoFe_2O_4$) were mixed and used as catalyst to synthesize spiral hybrid multiwalled carbon nanotubes (MWCNTs) by using thermal vapor deposition tube (TVDT). The prepared sample was then further incorporated into an epoxy resin as matrix. The materials and microwave characteristics were studied to analyze the synthesized MWCNTs from mixed ferrite as catalyst.

2. Methodology

2.1 Synthesized of Spiral Hybrid MWCNTs by Using TVDT

Nanometer particle size of Fe_3O_4 and $CoFe_2O_4$ were prepared by crushing the powder using high energy ball milling (HEBM) as shown in Figure 1(a). The nanometer powder was further sintered at 900^0C and 1100^0C respectively to obtain the full phase. The sintered powder was then used as catalyst to grow CNTs. Different weight percentages of Fe_3O_4 and $CoFe_2O_4$ were mixed and used as catalyst to grow CNTs. The weight percentages of Fe_3O_4 (F) mixed with $CoFe_2O_4$ (C) varies from 20%, 50% and 80%. The sintered powder was mixed and labelled as follows S1 (20wt% F + 80wt%C), S2 (50wt% F + 50wt%C) and S3 (80wt% F + 20wt%C). On the other hand, as for 100% F and 100% C, it was denoted as SF and SC respectively. In the preparation of MWCNTs, 0.1 g catalyst was first placed in the ceramic boat and was placed in the middle of the furnace by using the thermal vapour