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BROAD BAND ELECTROMAGNETIC INTERFERENCE (EMI) SHIELDING PROPERTIES OF POLYANILINE/ POLYVINYL ALCOHOL / MnO_2/ FLY ASH FREE STANDING FILMS

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ABSTRACT

Microwave absorbing material (MAM) is a kind of functional material that can absorb electromagnetic wave effectively and convert electromagnetic energy into heat or make electromagnetic wave disappear by interference. These types of materials are gaining much attention in the field of civil and military applications. The present work is the report of our effort in studying the EMI-Shielding properties of conducting polyaniline (PANI) and their composites. The wet dark green precipitate and varied weight percentage (wt %) of cenosphere particles were transferred directly to the 5% polyvinyl alcohol (PVA) solution. The resulting mixture was stirred continuously for 1 hour for homogeneous distribution of the particles. The mixture was poured on to the glass plate and allowed to dry at room temperature to get freestanding PANI/FA/MnO_2/PVA polymer matrix. The electromagnetic wave absorption, reflection and EMI Shielding Effectiveness (EMI SE) of the composites has been measured at X-band (8-12 GHz) micro wave frequencies. The experimental results indicate that the absorption dominated EMI SE of the composites is influenced by the fly ash weight percentage. The study suggests the prospects of the composites as effective shielding materials for a broad range of micro wave frequency.

Indexing terms/Keywords

PANI / FA; MnO_2; EMI-SE;

Academic Discipline And Sub-Disciplines

Electromagnetic interference shielding effectiveness application, Microwave Shielding effectiveness

SUBJECT CLASSIFICATION

Applied chemistry ,polymer composites, material Science

TYPE (METHOD/APPROACH)

Prepared conducting free standing film composites by using insitu polymerization technique in presence of oxidizing agent , Experimental determination of EMI SE with the help vector network analyzer.

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1. INTRODUCTION

In the present era of high-speed transmission and great volume of information depends on large microwave spectrum, in the GHz band and is increasingly using various wireless communication tools to achieve the high speed transmission. Also the electromagnetic wave of quasi-microwave band of 1–3GHz is used in a mobile phone (1.5, 2.0 GHz), Personal handy Phone system (1.9 GHz) and a wireless LAN (2.45 GHZ). These advancements in the microwave wireless technology has led to many advanced applications, simultaneously they become the major source of electromagnetic interference. The electromagnetic interference (EMI) of the electromagnetic wave causes the breakdown of machinery, medical instruments, computer and so on and is becoming a serious problem day by day. So much attention has also been paid to find a suitable material for electromagnetic wave absorption as a countermeasure to the EMI problem. Electromagnetic compatibility (EMC) is considered to cope with the EMI. For example, a conventional electromagnetic absorber has been designed on the basis that wave impedance is constant and the electromagnetic wave is plain in the far EM field. However in the near EM field, the wave impedance changes. Thereby, it is difficult to design impedance matching type absorber and cope with noise. Therefore, a passive electromagnetic absorber / EMI shielder is a suitable option than an active noise suppressor [1-3]. The EMI shielders are the composite materials which include dielectric or magnetic materials or both combined in a matrix to effectively shield the EM interference.

Conducting polymers have a variety of applications in the Industrial, Scientific and Medical (ISM) fields. Applications like anticorrosion, static coating electromagnetic shielding etc come under first generation. Second generation of electric polymers have applications such as transistors, LEDs, solar cells batteries etc. Controlled conductivity, high temperature resistance, low cost and ease of bulk preparation make these materials attractive in the engineering and scientific world. Polypyrrole (Ppy) and polyaniline (Pani) are especially promising for commercial applications because of their good environmental stability, facile synthesis, and higher conductivity than many other conducting polymers [4-6]. Polyaniline has received much attention because of its unique reversible proton doping, high electrical conductivity, ease of preparation and low cost. The demand of high quality materials for electromagnetic compatibility is alarmingly increasing. These considerations led us to study the synthesis, characterization and the EMI-Shielding Effectiveness (EMI-SE) of polyaniline conducting films of varied wt% of cenosphere content in the different polymer matrix of PANI/PVA/FA.

1. Experimental Details

1.1. Synthesis of PANI/FA/MnO_2 composites

The PANI/FA/MnO_2 composites were synthesized according to the literature [7]. Aniline (AR) was purified by distillation before use and ammonium peroxydisulfate [$(NH_4)_2S_2O_8$], HCl were used as received. A purified fine and fresh (FA) was collected from a local source. The compositions of FA are: silica, alumina, iron oxide lime magnesia and alkalis and different metallic and non-metallic elements [7]. A 0.1 mol of aniline was dissolved in 1000 mL of 2 M HCl to form polyaniline (PANI). Varied wt% amount of FA and MnO_2 powder (10, 20, 30, 40 and 50%) was added to the PANI solution with vigorous stirring. A 0.1 mol $(NH_4)_2S_2O_8$ aqueous solution was added slowly with continuous stirring, which acts as the oxidant. The reaction mixture was agitated continuously for another 8 hrs keeping the solution in an ice bath. The precipitate formed was collected by filtration and washed with distilled water and acetone until the filtrate became colorless and free from aniline and SO_4^{2-}. The filtrate was dried at room temperature. The prepared PANI/PVA/FA/MnO_2 composites contain 10%, 20%, 30%, 40%, and 50% by weight of FA/MnO_2 in PANI.

1.2. Preparation of Free-standing Films

Polyethylene petri dishes were precleaned with deionized water and dried at room temperature. Free-standing films (40 – 60 μm) were prepared by casting the conducting blend solution (PANI/PVA and PANI-Fly ash / MnO_2 PVA) onto the polyethylene petri dishes using a solution casting method. The films were thoroughly dried on a flat surface at room temperature for a period of 1 − 2 days and kept in silica gel filled desiccators before the measurement. For preparation of PVA films, the fully dissolved 5% PVA aqueous solution was cooled from 80^{o} C to room temperature, and then cast into films using the same procedures as for the blends. The preparation steps for freestanding films are shown in Figure 1.

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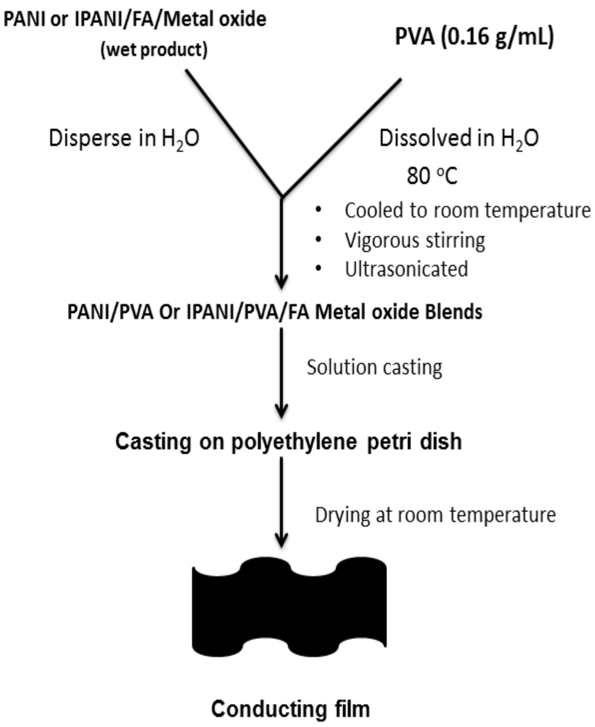

Figure 1. Preparation of PANI/PVA and PANI/PVA/MnO_2/FA blends into conducting films

1.3. Measurement of EMISE

The EMI-SE of the composite films was measured by the transmission line technique in the 8 to 12 GHz frequency range [8]. The waveguide flange sized composite films were loaded in the rectangular wave guide coupled vector network analyzer. This set up was used to measure the transmission coefficient (S_{12}/S_{21}) and reflection coefficients (S_{11} / S_{22}). The EMI SE can be expressed as [9-12],

$$EMI\ SE = 10 \log_{10} (P_I / P_T)\ dB \qquad (1)$$

where P_I and P_T are the power (W) of the incident wave and transmitted wave respectively.

The transmittance (T), reflectance (R) and absorbance (A) can be expressed in terms of the S-parameters as,

$$T = |S_{12}|^2\ (=|S21|^2) \qquad (2)$$

$$R = |S_{11}|^2\ (=|S_{22}|^2) \qquad (3)$$

$$\text{and } A = 1-R-T \qquad (4)$$

Here, 1-R represents the relative intensity of the electromagnetic waves incident effectively inside the materials after reflection

2. Results and discussion

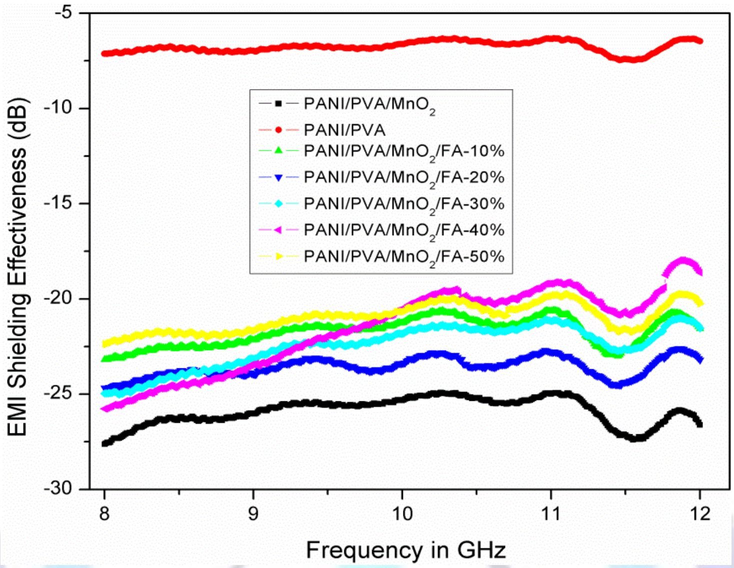

Figure 2: EMI-Shielding Effectiveness of PANI/PVA/Mno$_2$/FA free standing filmc composites

Figure.2. shows the EMI-SE versus frequency for different wt % polyaniline/PVA/MnO$_2$ – fly ash composites in the entire X-Band. We can observe here that polyaniline/PVA/MnO$_2$ is showing an excellent EMI-SE than higher wt % of Polyaniline/PVA/MnO$_2$ – fly ash **c**omposites. Except for few range of frequencies, EMI-SE of composites is independent of frequency. The EMI-SE as high as -27.5 dB (considered as an effective standard value of EMI SE) have been observed here. Here as frequency increases the EMI-SE fluctuates with in a stable value. It is also reported that EMI-SE of a composite depends not only on conductivity, but also on permittivity of the composite. Thus the composition of the sample, nature of the dispersed phase, its particle size and shape etc are important factors and can affect the EM radiation absorption and EMI-SE. This effect is less for higher wt % Polyaniline/PVA/MnO$_2$ – fly ash composites. This may be due to the higher concentration of fly ash cenosphere particles, whose properties are frequency dependent, especially its permittivity. In lower wt % composites this dependency is not so observable, due to the smaller concentration of MnO$_2$ and fly ash particles. Altogether the composites show very effective shielding in the entire X-band. The shielding effectiveness of the in situ composites were better than the solid-solid composites, as the in situ polymerization confirms the homogenous distribution of the dispersed phase MnO$_2$ and fly ash cenosphere particles.

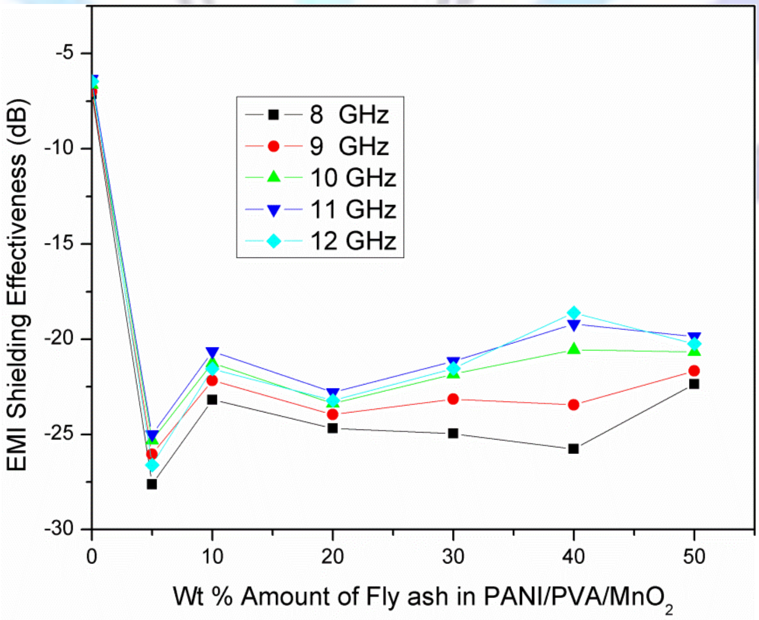

Figure 3: EMI-Shielding Effectiveness of wt% of cenospheres in PANI/PVA/MnO$_2$ free standing film composites.

Figure .3. Shows the variation of Shielding effectiveness values as a function of wt% fly ash in polyaniline/PVA/MnO_2 at five fixed frequencies viz., at 8, 9, 10, 11 and 12 GHz. Through graph it has been observed that the values of EMI shielding effectiveness of these composites increases till the 0 wt % of fly ash in polyaniline/PVA/MnO_2 free standing film and for excess wt% of fly ash in polyaniline/PVA/MnO_2 the values shielding effectiveness decreases due to the presence of fly ash in form of cenosphere which scatters the radiation.

The degradation in the shielding properties of the composites with the high cenospheres concentration could be explained by the in homogeneity of the composite to form a good continuous network in the PVA matrix. The effectiveness of the dispersed phase in disordered systems of polyaniline composites is active at moderate concentrations of the dispersed phase. Upon increase of concentration of the dispersed phase, the polymer chain clusters get strained causing the deterioration of the properties of the composites. Here the composites have shown absorption dominant shielding properties by the heat loss under the action between magnetic and electric dipole present in the PANI/PVA/FA/MnO_2 composite and the electromagnetic field. The selection of a material for shielding and electromagnetic compatibility applications is based on its EMI SE value. A shielding effectiveness of 10 dB indicates that 90% of the electro magnetic energy is absorbed or reflected by the material. The higher the EMI-SE values in decibels, the lower the energy passing through the sample. In general for strategic applications complete EMI SE (100 %) is not required and low detecting ability is more advantages for aircraft and ships detecting by radar [13].

3.1 CONCLUSIONS:

The conducting polymer composites have been synthesized by in situ polymerization technique by the incorporation of cenospheres in PVA dispersed polymer matrix. The electromagnetic shielding effectiveness of the synthesized free standing conducting PANI/PVA/MnO_2/FA films was measured using the Vector Network Analyzer. The results of the measurements show that the concentration (wt %) of cenosphere (fly ash particles) have major role in enhancing the EMI-SE of the composite films. Our study leads us to conclude that PANI/PVA/ MnO_2 /FA polyblend matrix possesses better EMI-SE properties.

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