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ELECTROMAGNETIC INTERFERENCE SHIELDING EFFECTIVENESS OF POLYANILINE-Ta_2O_5 COMPOSITES

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Abstract: Conducting polymer composites are required in many engineering applications, especially, for the design of microwave absorbers and microwave shielding to ensure electromagnetic compatibility and electromagnetic immunity. In this paper, we report the synthesis of conducting polymer i.e. polyaniline (PANI) and its composites. Polyaniline is prepared by oxidation of aniline and the polyaniline composites were prepared by in situ polymerization method with dispersion of Ta_2O_5. For the microwave measurements these samples were made in rectangular pellet of thickness 0.3mm using Pye-Unicam dye. The permittivity, return loss and electromagnetic interference shielding effectiveness (EMI-SE) of PANI composites in the frequency range 8-12 GH_z is discussed in this paper and the maximum EMI-SE is observed in 10 wt% Ta_2O_5 in PANI

Key words: Composites, Electromagnetic, Permitivity, Shielding, Ta_2O_5.

1. Introduction

Since the discovery of intrinsically conducting polymers there has been a growing recognition of its importance for technological and scientific applications. Conducting polymers with metal oxide materials shows the electrical properties and hence more applications in electronic field. Polyaniline (PANI) is one of the widely used conducting polymer owing to its tunable electrical conductivity, excellent electro magnetic properties and environmental stability. Many researchers and companies have focused on Conducting Polymer composites where a modification in multiple properties of the conduction polymer is achieved to match with potential applications [1-5]. A number of different metal and metal oxide particles have so far been encapsulated into the shell of conducting polymers giving rise to a host of composites with exciting physical and chemical properties [6]. Also the PANI is an excellent candidate for radar absorbing materials (RAM) [7]. Tantalum Pentoxide (Ta_2O_5) is a high dielectric constant material [8, 9]. Ta_2O_5 is one of the most excellent dielectric materials for environmental compatibility [10]. Due to their excellent electromagnetic shielding properties of both PANI and Ta_2O_5 has inspired us to take up this work. In this paper we report the synthesis of PANI- Ta_2O_5 composite and their permittivity, return loss & EMI-SE is studied.

2. Experimental

2.1.Methods and Materials

Chemicals used in the preparation PANI and PANI composites are Ammonium persulphate $(NH4)_2S_2O_8$, Hydrochloric acid (HCl), aniline and Tantalum pentoxide (Ta_2O_5) are of AR grade. Double distilled water was used in the synthetic process Chemical oxidation of aniline was carried out for Polyaniline and Tantalum pentoxide composite materials.

2.2. **Synthesis of Polyaniline-Ta_2O_5 Composites**

Aniline, Ta_2O_5, ammonium persulphate (APS), and hydrochloric acid (HCI) obtained form S.D. Fine Chem. Ltd., Mumbai, India were used as received. Aniline was double distilled before using for the polymerization. Aniline was dissolved in 1m HCl to form aniline hydrochloride. Ta_2O_5 was added to PANI solution with vigorous stirring to keep the Tantalum Pentoxide (Ta_2O_5) suspended in the solution. To this reaction mixture, 0.1M of ammonium persulphate $[(NH_4)_2S_2O_8]$, which acts as the oxidant, was added slowly with continuous stirring for 4-6 hours at 0-5O^{0}C. The precipitated powder recovered was vacuum-filtered and washed with deionizer water. Finally, the resultant precipitate was dried in an oven for 24 hours to achieve a constant weight. In the similar manner pure PANI is prepared without adding Ta_2O_5. PANI-Ta_2O_5 composites were prepared in weight percent ratio in which the concentration of Tantalum Pentoxide (10, 30 and 50wt %) was varied [11].The microwave absorption of the PANI-Ta_2O_5 composites were analyzed using S-Parameters i.e. rectangular waveguides were used. The samples were fitted into the cross section of the waveguide sample holder without any air gap. The scattering parameters for this assembly were measured using the (HPES 6719) vector network analyser (VNA).

3. Results and Discussions

Figure 1 (a) and 1(b) shows the variation of real (ε') and imaginary (ε'') part of the permittivity at X-band frequency (8 to 12 GHz) respectively. The ε' spectra of all the sample shows multiband significant variation in the whole frequency range used in the present work. However the ε' values have decreased with the increase of frequency, and also observed that different compositions shows different dielectric constant values but 50wt% Ta_2O_5 in Polyaniline shows maximum dielectric constant and also observed that ε' value increases with the increase of Ta_2O_5 in Polyaniline, this may be due to the interfacial polarization. The ε'' spectra shows the multiband significant variation in the whole frequency range used in the present work. However the ε'' values have increased with the increase of frequency, different compositions shows different dielectric loss values but 10wt% of Ta_2O_5 in Polyaniline shows maximum dielectric loss. This may be due to lag in polarization vis a vis the applied field. Figure 2 shows the variation of return loss spectra at X-band frequency for the composites samples 10 wt% to 50 wt% of Ta_2O_5 in polyaniline in the frequency range 8 to 12 GHz. These composite shows increase in return loss value in multiple band form as frequency increases and observed that the 10wt% of Ta_2O_5 in PANI shows maximum return loss and also observed that the return loss increases with the decrease of Ta_2O_5 in PANI this may be due to resonance. In case PANI-Ta_2O_5 composites the return loss varies from 7dB to 22dB.

Figure 3 shows the variation of EMI-SE at X-band frequency (8 to 12 GHz). The EMI-SE spectra of all the sample shows multiple bands spectra with significant variation in the whole frequency range used in the present work. However the EMI-SE values is increased with the decrease of Ta_2O_5 wt% in PANI, and also observed that different compositions shows different EMI-SE but varies from 75 to 98 but maximum EMI-SE is observed in 10 wt% Ta_2O_5 in PANI, This may be due to the orientation of domains remained perpendicular to the direction of wave propagation.

The microwave absorption measurements are made using the formulas

Return loss RL (in decibel, dB) is obtained by RL = 20 log [(Z_{in} - Z_o) (Z_{in} + Z_o) equation and electromagnetic interfacing shielding effectiveness is obtained by

$$\text{EMI-SE } (\%) = [(P_I - P_T)/P_I] \text{ x100 equation [12]}$$

Where, P_1 is the incident power on the samples and P_T is the transmitted power from the samples.

Conclusions

In this paper microwave absorption properties (Return loss) and EMI-SE (in %) of PANI-Ta_2O_5 composites in the X-band frequency range have been presented. Our results clearly demonstrate that conducting PANI composite with Ta_2O_5 show better return loss and shielding properties (Maximum EMI-SE is observed in 10 wt% Ta_2O_5 in PANI). These composites may be used for electromagnetic compatibility (EMC) applications.

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Figures:

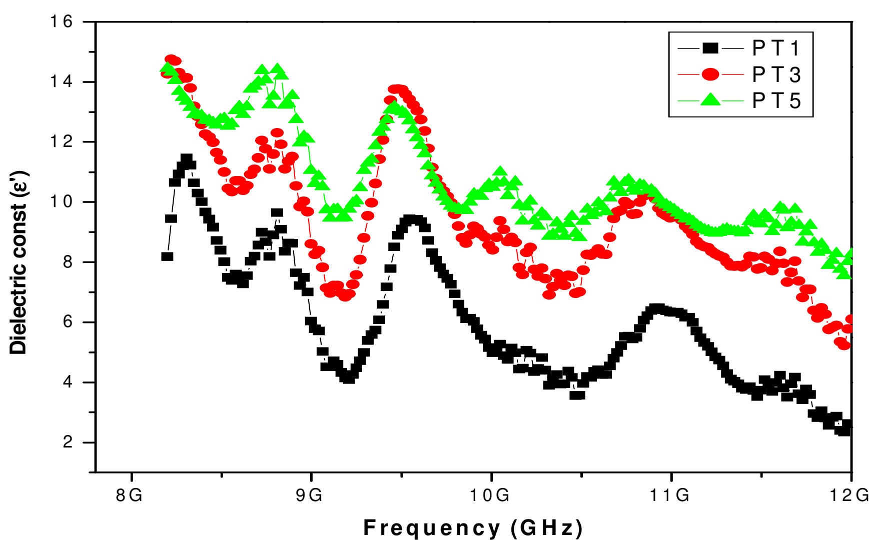

Figure 1 (a): Variation of Dielectric const (ε') Vs frequency (PANI-Ta_2O_5)

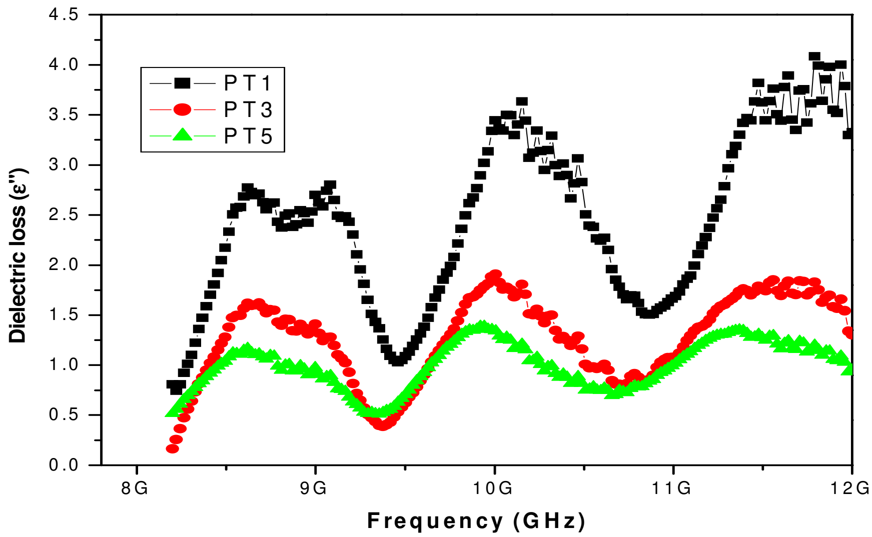

Figure 1(b): Variation of dielectric loss (ε'') Vs Frequency (PANI-Ta_2O_5)

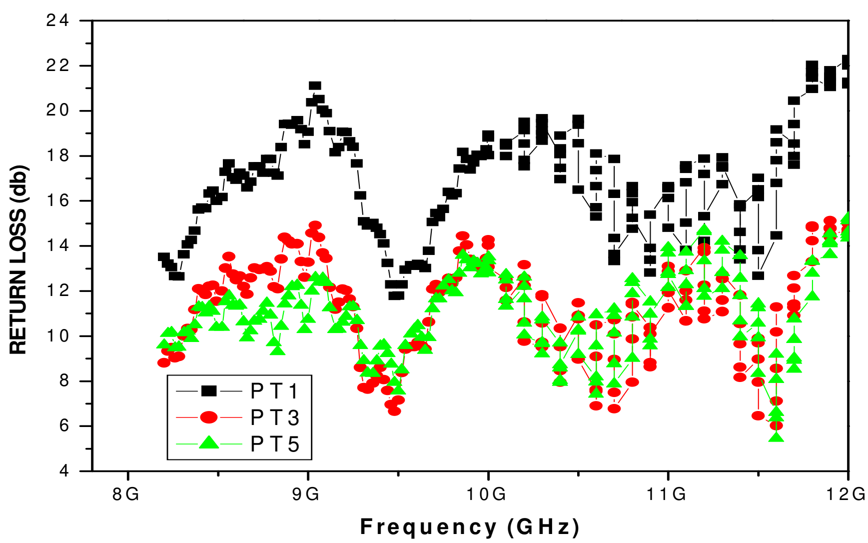

Figure 2: Variation of return loss Vs frequency (PANI-Ta_2O_5)

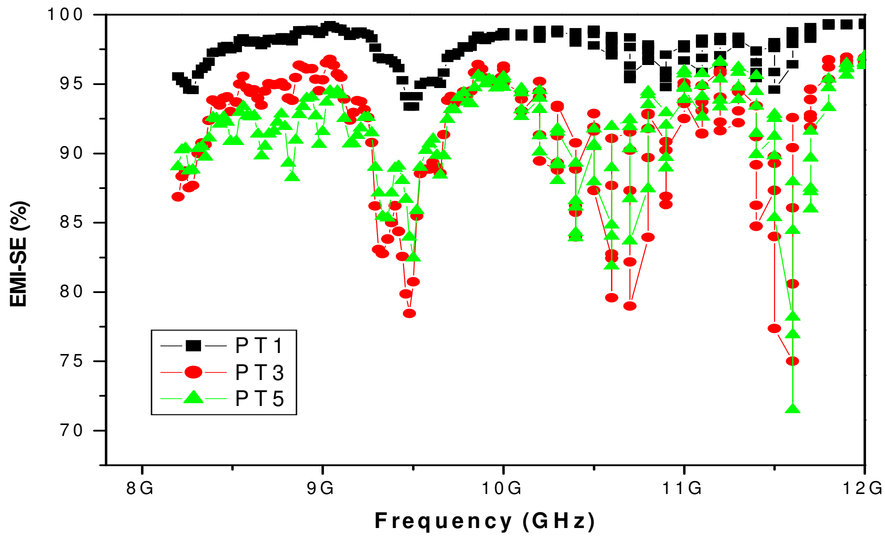

Figure 3: Variation of EMI-SE Vs frequencies (PANI-Ta_2O_5)

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