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Electromagnetic shielding of Conductive Cotton Fabric Developed by In situ polymerization of Aniline

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Abstract- The present paper reports studies in-situ polymerization of aniline on cotton fabric to develop conductive properties for electromagnetic shielding properties. Cotton fabric having plain weave has been treated with ammonium persulphate (APS) as oxidant, Hydrochloric acid as a dopant and aniline monomer to produce in situ polyaniline (PANI). This polymerization of polyaniline(PANI) cotton(C) substrates carried out in water circulating bath for maintaining desired polymerization temperature. The synthesizing parameters which govern the properties of the resulting conductive fabrics such as monomer concentration, oxidant concentration, monomer and oxidant molar ratio, polymerization time, polymerization temperature have been studied. The polyaniline coated cotton fabrics (PANI +C) are also characterized for their electrical, morphology and physical properties. The conductivity of the fabric was in the range 10^{-5} to 10^{-3} S/cm. The electromagnetic interference (EMI) shielding parameters absorption (SE_A), transmission (SE_T) & refection (SE_R) evaluated for composites in frequency range 2.5 -3.5GHz.

Keywords: Electromagnetic shielding, conductive fabrics, polyaniline, polymeric composition, composite.

INTRODUCTION

Electromagnetic shielding is the term for defining the process of limiting the penetration of electromagnetic fields in to the space, by blocking them with a barrier made of conductive material. Electronic engineering facing great challenge of operation of devices at higher frequencies shielding is a very popular method of protecting electronic and electrical equipment and human beings against radiated electromagnetic energy. Electrically conductive textiles make it possible to produce interactive textiles for electromagnetic shielding. They can be used for communication, entertainment, healthcare, safety, homeland security, computation, thermal purposes, protective clothing, and wearable electronics & fashions [1]. Textiles are extremely versatile in products as well as processes. They are playing more and important role in realizing strength, high surface to mass ratio lightweight, flexibility, resistance to chemicals, durability against deformation, harsh environmental conditions, and formability to desired product[2,] .

In recent years, electrically conducting polymers and polymer based conductive composites have gained popularity for electromagnetic shielding applications because they have distinct advantages over the conventional metals such as light weight, corrosion resistance and flexibility, lower cost, etc. In conductive polymers, polyaniline (PANI) have attracted special interest because of their high conductivity, their ease and high flexibility in preparation, their stability in doped state, processing abilities and good mechanical properties. Objective of this Study is to improve the electromagnetic shielding properties of polyaniline(PANI) deposited cotton fabric. Aniline was polymerised using ammonium persulphate (APS) as initiator and using hydrochloric acid (HCl) as dopant used to achieve conductivity. The polymerization temperature of 5°C and polymerization duration of 4h is found to be optimum for the synthesis.
[3]

MATERIALS AND METHODS

Materials

Commercially desized, scoured and bleached 100% cotton fabric having weight of 120 g/m2, and plain weave was used as textile substrate. AR grade chemicals such as aniline (Spectrochem, India) as monomer and ammonium per Ammonium Persulphate, $(NH_4)_2S_2O_8$ (SDFCL, India) as oxidant were used to develop in situ polyaniline and Hydrochloric acid Conc. HCl (SDFCL, India) as a dopant. The monomer to oxidant molar ratio was used 1:0.75, with the 0.2 M of concentrations of aniline and Ammonium Persulphate with 1 M HCL.

Methods

2.2.1In situ polymerization of aniline

Aniline monomer was dissolved in 50 ml of 1 M HCl and solution of APS was prepared in 50 ml distilled water. The concentration of aniline was used as 0.2 M where as APS concentrations were used in monomer proportionate of 0.75 with aniline concentration. Thereafter, the polymerization is initiated by the drop wise addition of aqueous solution of APS in to the acidic aniline and solution for 4 hours at 5°C. After the completion of treatment fabric samples were removed, washed thoroughly with distilled water and air dried. [4]

2.2.2 SEM Imaging

Scanning electron microscopy-imaging was carried out using a EVO 50 microscope for surface characterization of polyaniline deposited cotton fabric.

2.2.3 Measurement of surface Resistance

The resistance of polyaniline cotton fabric samples was measured by Digital multimeter Mic 6000Z. From these resistance values, the resistivity and conductivity of the polyaniline-cotton composites was calculated. The conductivity of the resulted composites was expressed in S/cm. The conductivity was computed according to following equation.

$$\rho = \frac{R.t.b}{l}$$

$$\sigma = \frac{1}{\rho}$$

Where, ρ and σ is the resistivity and conductivity of polyaniline cotton composites. R, t, b and l be the resistance reading, thickness, width and length of polyaniline cotton composite fabrics.

2.2.4 Test methods

The surface morphologies of PAn coated cotton fabrics were examined using Scanning Electron Microscope (EVO 50). The sheilding paramters absorption (SE_A), transmission (SE_T) & refection (SE_R) of the samples were determine by using HPE8363B model (Vector Network Analyzer) incoaxial mode within the range of freguency 2 – 3.5 GHz.

RESULTS AND DISCUSSIONS

Morphological Studies

The SEM images of untreated cotton fabric and PAn in situ treated sample with 0.2 M aniline and 1:0.75 ratio of monomer and oxidant are as shown in fig No. 1 under 5,000 x magnifications. SEM Image (1b) shows a clear surface and deposition of polyaniline on the cotton fibers. The polymerization of polaniline on cotton fabrics takes place through diffusion of polymer inside the fiber bulk as well as the deposition on the fiber surface and the interstices in the fabric.

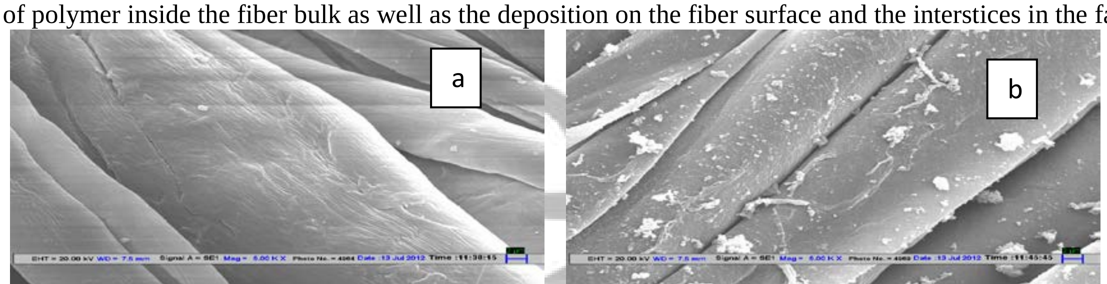

Fig 1: SEM micrographs 5000x magnification of (a) untreated cotton (b) Polyaniline deposited cotton fabric

Electromagnetic Shielding

EMI shielding is the practice of attenuation of electromagnetic radiations by using conductive materials. EMI shielding is based on three processes, (i) reflection (SE_R), (ii) absorption (SE_A) and (iii) transmission (SE_T) at the interface [5]. Mathematically, EMI shielding process expressed as Eq. (1),

$$SE_{Total} = 10 \log \{Pi/Po\} = SE_{A} + SE_R + SE_M \quad (1)$$

Where, P_i is power incident and P_o is power transmitted. The term SE_M is dropped for $SE_{Total} \geq 10$ dB. The individual contribution for SE_R, SE_A and SE_T is given by (Eq. (2), (3) and (4)),

$$SE_R = \left[\frac{1}{1-|S_{11}|^2}\right] \quad (2)$$

$$SE_A = \left[\frac{1-|S_{11}|^2}{|S_{21}|^2}\right] \quad (3)$$

$$SE_T = SE_R + SE_A = 10\log\left[\frac{1}{|S_{21}|^2}\right] \quad (4)$$

Where, S_{11} and S_{21} are the surface reflection coefficients and transmission coefficient of the samples [6].

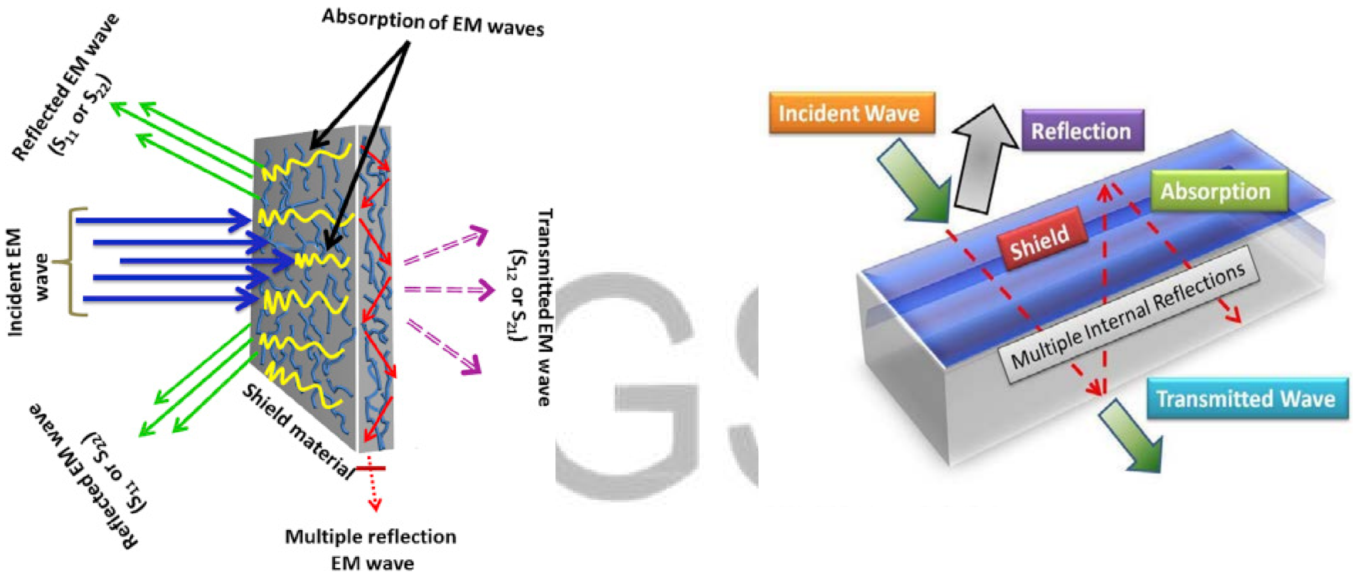

Figure 2. Schematic of EMI shielding process.

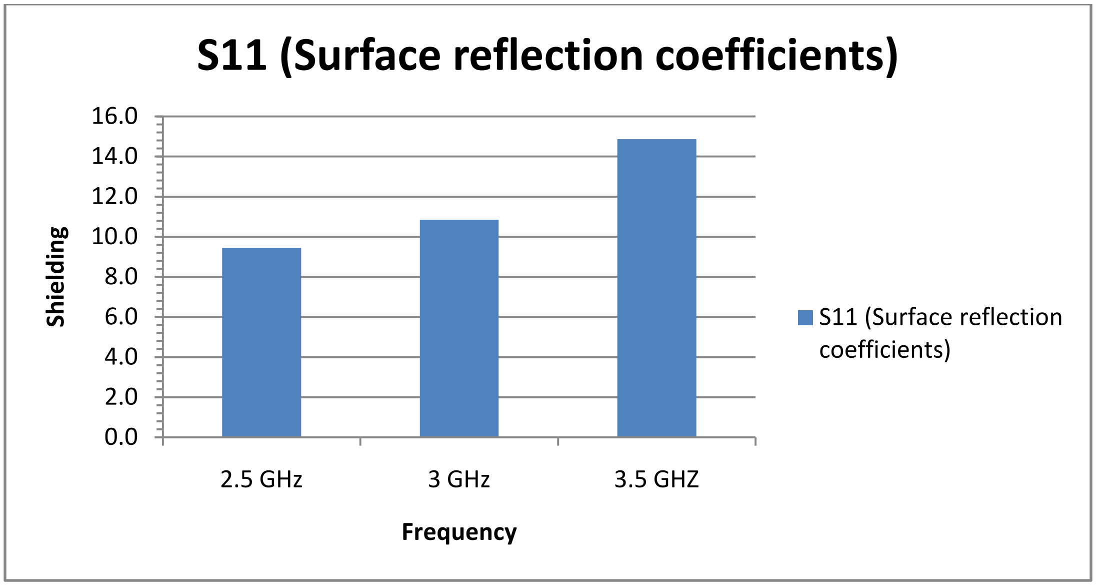

Fig 3 (a). Surface reflection coefficients (S_{11})

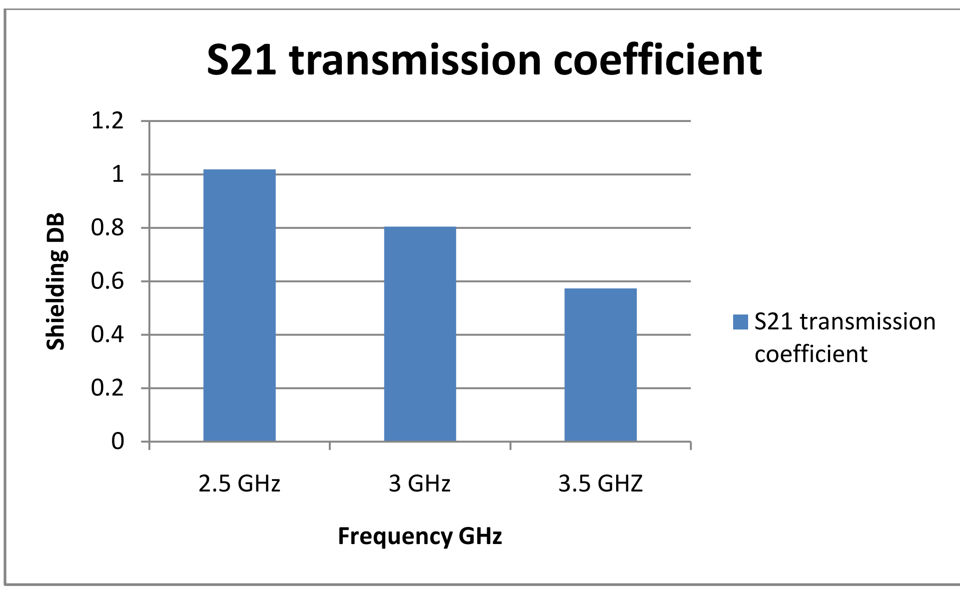

Fig. 3.(b) Transmission coefficient (S_{21})

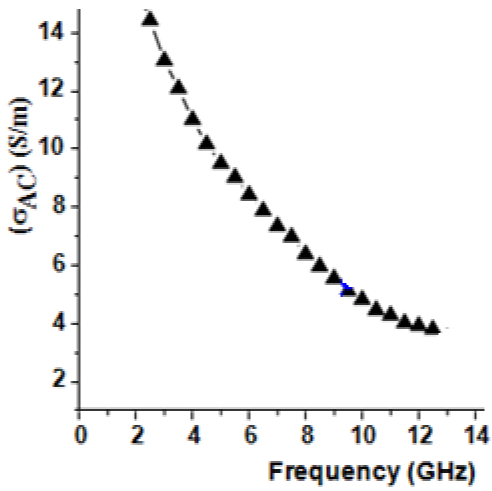

Figure 4. Variation of AC conductivity and skin depth with frequency for polyaniline.

Conclusions

In conclusion, we successfully analyzed the EMI shielding properties of PANi-composites. In EMI shielding, the magnitude of reflection coefficient S_{11} is more than transmission coefficient S_{21}, which makes PANi composite enable for coating application protect electronic devices in space from energetic radiation.

Similarly, good SE_A of PANi composite indicates ability to trap microwave radiation leakage in domestic microwave oven. The performance of PANi composite, attributed to various factors such as larger contact surface area due to PANi, good AC conductivity and smaller skin depth. The surface conductivity was decreased from 0.26 to 0.13 S/cm with increasing time because cause of this is oxidative degradation of the conductive polymer which causes loss of conjugation of the polymer.

1. Devendek, Ramasamy S.R., A Review of EMI Shielding and Suppression Materials, Proceedings of the lnternutionul Conference on Electromugrletic interfererice and Coitiputibility ’97 459-466 (1997)

2. Jan-Chan Huang, EMI Shielding Plastics: A Review, Advances in Polymer Technology, Vol. 14, No. 2, 137-150 (1995)

3. X. Cheng, Y. Li, X.Tao, Y. Tsang, M. Leung, P. Xue, X.Cheng, & C. Yuen, “Polypyrrole coated fabric strain sensor with high sensitivity and good stability”, Proceedings of the 1st IEEE international conference on nano/micro Engineered and molecular systems, JAN 18-21, (2006), Zhuhai, China.

4. A. Macasaquit, & C. Binag, “Preparation of conductive polyester textile by in situ polymerization of pyrrole”, Philippine journal of science, 139 (2), 189-196 Dec 2010.

5. F. Wu, Z. Xu, Y. Wang, M. Wang, Electromagnetic interference shielding properties of solid-state polymerization conducting polymer, RSC Adv., 4, 38797–38803 (2014).

6. P. Saini, V. Choudhary, P.B. Singh, B.R. Mathur, K.S. Dhawan, Polyaniline-MWCNT nanocomposites for microwave absorption and EMI shielding, Mater. Chem. Phys., 113, 919–926 (2009)