

INFLUENCE OF SILANIZATION ON COPPER COATED NONWOVEN FABRIC AND THEIR ELECTRICAL CONDUCTIVITY

Aravin Prince Periyasamy*, Kai Yang, Xiaoman Xiong, Mohanapriya Venkatraman, Jiri Militky, Rajesh Mishra, Dana Kremenakova

Department of Material Engineering, Technical University of Liberec, Studentska 2, 46117, Liberec, Czech Republic, e-mail: aravinprince@gmail.com

ABSTRACT

A stabilized electromagnetic shielded (EMI) fabric was produced with a copper coating. For this, the Milife (nonwoven) was used, since it is a promising material for surface metallization which is composed of the dense net of monofilaments bonded by solid spots. For stabilization of copper deposition on the milife fabric, we treat with three different silanes. The surface morphology of the fabrics was studied and it confirms the enhanced stabilization. In this paper we describe only the electrical properties of nonwoven fabrics, the obtained results show that the copper coated fabrics were more stable and the lowest surface resistivity in the range of 3000-3400 Ω . It confirms that it belongs to shielding material and can be classified into conductive composites, but all these results are depending on the type of silane used for Silanization.

Key words: copper coated, non-woven, silanization, electrical conductivity, surface resistivity.

INTRODUCTION

Textiles are omnipresent, the interaction with textiles is made continuously with some form such as garments, bed linen, towels, furniture upholstery and technical textiles. In order to integrate the smart applications such as electronic and electromagnetic shielding functionalities is to expand the ways using textiles and to interact with it. Metal coated textiles are classified as smart textiles due to their functionality [1-3], lightness, flexibility and with required mechanical properties that are adequate to replace the conventional metal materials. In general, the copper is metal and poor affinity on the textile materials, which results in the poor stability of the functional properties. Therefore, it is necessary to stabilize the copper particles in the textile materials, which is the promising interest for this work to develop the stabilized copper coated fabric for various functional applications such as electrical conductivity and electromagnetic shielding. Therefore, we found the novel method to stabilize the copper particles by simple sol-gel coating. In this paper, we discuss the influence of sol-gel coating on the electrical conductivity of copper coated fabric.

2. EXPERIMENTAL SECTION

100% polyester filament cross-laminated (Milife) have been used for this work. The basic characteristics of milife fabric provided by the producer (Dr. Vecernik s.r.o.) have been given in Table 1.

Table 1. Basic geometrical characteristics of MIWC and MIC samples

Type	Areal mass ($\text{g}\cdot\text{m}^{-2}$)	Thickness ^{a)} (mm)	Density porosity (%)
TY 0505FE (MIWC)	11.4	0.040 <0.006; 0.074> ^{b)}	79
TY 0505FE (MIC)	16.6	0.063 <0.016; 0.110> ^{b)}	81

^{a)}(Thickness for measured under pretension 200 Pa; ^{b)} 95% mean value confidence interval).

2.1 Sol-gel synthesis and coating

During the sol-gel coating, there are three types of silanes are used, Triethoxy(octyl)silane (OTES), Triethoxy(phenyl)silane (PhTES) and Tetraethylorthosilicate (TEOS). Sols prepared by the mixing of silanes with catalyst and solvent. Further, add the deionized water slowly on this mixture to enhance the hydrolysis and condensation reactions which takes place for 24 hours under stirring conditions. After the preparation of sol, both MIC and MIWC has been coated (i.e. dip coated) with standard conditions, then it is dried at atmosphere and cured at 110°C for 10 minutes. Before measurement, the coated fabric was left in atmospheric condition for 24-48 h to ensure complete stabilization of the silica matrices.

2.2 Characterization of sol-gel coated fabrics

The surface characteristics of both MIC and MIWC has been analyzed by use of scanning electron microscopy (TS5130 Vega-Tescan) with the acceleration voltage of 20 kV. Surface resistance (see Equation (1)) of the MIC and MIWC has been measured according to standard ASTM D257-07. Samples were placed in the air-conditioned room 24 h prior to testing. The room temperature was 21°C and the relative humidity was 45 %. Volume resistance is measured by applying a voltage potential across opposite sides of the sample and measuring the resultant current through sample, Specific volume resistivity ρ_v [Ω cm] was calculated from the Equation (2).

$$\rho_s = R_s \left(\frac{\pi D_0}{g} \right) \quad (1)$$

where ρ_s -surface resistivity (Ω), R_s -surface resistance (Ω), D_0 equals to $(D_2-D_1)/2$, D_0 is the outer diameter of the center electrode (mm), D_1 is the inner diameter of the outer ring electrode (mm) and g -distance between D_1 and D_2 (mm).

$$\rho_v = R_v \left(\frac{S}{h} \right) \quad (2)$$

where ρ_v -specific volume resistivity (Ω cm), R_v - volume resistance (Ω), h -thickness of fabric (cm), S -surface area of electrodes (cm^2).

3. RESULTS AND DISCUSSION

Scanning electron microscopy (SEM) was utilized to analyze the surface properties of both MIC and MIWC fabrics and the results are described in Fig. 1. From this result, it is evident that the sols were covered the copper particle on the surface of every fiber which resulting in the stabilized copper coating (Fig. 1c). Also, the images prove that the uniformity of Si sols and their distribution.

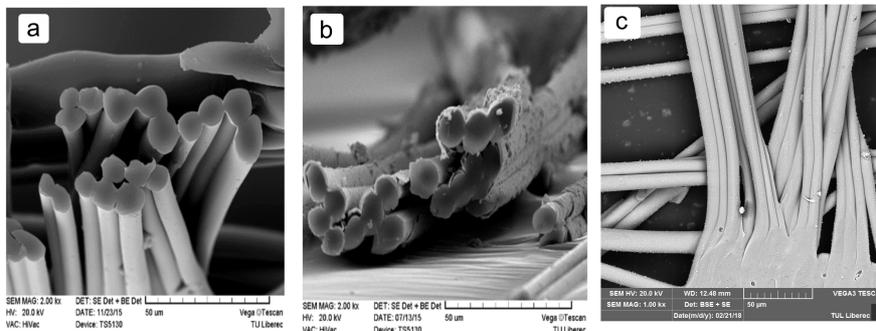


Figure 1. (a) Cross section views of MIWC, (b) MIC (before sol-gel coating), (c) MIC after PhTES coating.

Figure 2 shows the results of the electrical conductivity of MIWC and MIC analyzed. Copper coated fabric with most stable and low surface resistivity including the control and sol-gel coated samples shown clear evident from Figure.2a. Further, it discloses that it fits shielding material and can be categorized into conductive composites. Alternatively, the range of 10^9 to $10^{15} \Omega$ is shown by the MIWC samples, used as static dissipative composites. It reveals that there is no significant difference in the electrical conductivity of the sol-gel and control samples. Henceforth, this gives a conclusion of copper acts as an important role in reducing surface resistivity. The surface resistivity fluctuation ranges of 10^3 to $10^6 \Omega$ for MIC samples. Interpretation may take place when the PhTES silane experiences some damage to the continuity of the surface conductivity. A significant effect is made on surface resistivity by the effect of PhTES treatment for MIWC samples. Side effect on surface resistivity of samples coated with copper is activated by the TEOS treatment.

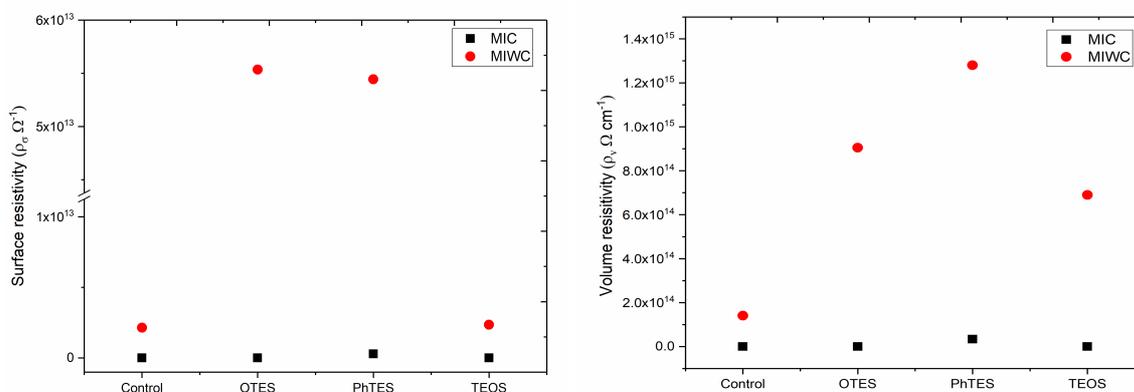


Figure 2. (a) Surface resistivity of MIC and MIWC samples, (b) Volume resistance of MIC and MIWC fabrics.

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