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AN INVESTIGATION ON SURFACE RESISTIVITY OF POLYPROPYLENE FABRICS MODIFIED WITH IONIC LIQUIDS

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Yasemin SEKI[1]*, Aylin Altinisik TAGAC[2]

[1]Department of Textile Engineering, Dokuz Eylul University, Tınaztepe Campus, İzmir, Turkey, e-mail:yasemin.seki@deu.edu.tr

[2]Department of Chemistry, Dokuz Eylul University, Tınaztepe Campus, İzmir, Turkey, e-mail:aylin.altinisik@deu.edu.tr

Corresponding author: Yasemin Seki, E-mail: yasemin.seki@deu.edu.tr

Abstract: *In this study, polypropylene fabric was modified with two types of ionic liquids such as 1- ethyl-2,3-dimethylimidazolium ethyl sulfate (EIL) (2, 6, 10 %w/v in ethanol) and methyl-trin-butylammonium methyl sulfate (10, 15, 20 %w/v in ethanol)at different concentrations. Before modification, the fabrics were pre-treated with chromic acid to activate the surface. The effect of the modifications was investigated by thermogravimetric analysis, surface resistivity measurements and scanning electron microscopy. The pre- treatment changed surface resistivity from 10^{10} to 10^{13} ohm/sq. The modifications with the ionic liquids decreased surface resistivity of the PP fabrics short and long-term periods in the range of 106 - 108 ohm/sq. Increasing the concentration of the ionic liquids can be considered as an efficient way to reduce the surface resistivity of PP. Thermal stability of the PP altered after modification. It was observed that a coating layer formed on surface of the fabric and in the gaps of the yarns of PP with modification. This environmentally- friendly method can be used as an alternative way for improving conductivity of PP fabrics generally characterized by their high surface resistivity.*

Key words: *Polypropylene, ionic liquid, electrical conductivity, textile*

1. INTRODUCTION

Polypropylene is recognized as the most widely used petroleum based fiber in textile industry [1]. Based on its ease of processability, low density, chemical inertness, relatively specific strength and low cost, polypropylene is utilized for manufacturing high consumption materials for different applications in industry. However, because of non-polar and highly hydrophobic nature of polypropylene high surface resistivity occurs which may resist their use of potential in some applications. Many attempts were performed to overcome this drawback. Different types of micron and/or nano sized additives such as graphene [2], silver [3], carbon nano-tube [4] were incorporated in polypropylene for this purpose. Surface treatments were also applied to enhance conductivity of polypropylene [5,6]. According to our best knowledge, there are very limited studies investigating the improvement of electrical conductivity of the polypropylene fabric even the other textile fabrics with ionic liquids [7-9]. For this purpose, polypropylene (PP) fabrics were modified with two types of ionic liquids, 1-ethyl-2,3-dimethylimidazolium ethyl sulfate (EIL) (2, 6, 10 %w/v in ethanol) and methyl-trin-butylammonium methyl sulfate (10, 15, 20 %w/v in ethanol) at different concentrations.

2. EXPERIMENTAL

Polypropylene woven fabrics (F) were treated with two types of ionic liquids such as 1-ethyl-2,3-dimethylimidazolium ethyl sulfate (EIL) and methyl-tri-n-butylammonium methyl sulfate (BIL) which were purchased from Sigma-Aldrich Corp. For pre-treatment of the PP fabrics, $K_2Cr_2O_7$ and H_2SO_4 were utilized and supplied from Merck Corp.

In case of the pre-treatment process, PP fabrics were dipped in chromic acid solution which consisted of $K_2Cr_2O_7$, H_2SO_4, and H_2O (7: 150: 12 wt %) for 5 min at 35°C and then rinsed with distilled water several times and finally dried. for the modifications, For the ionic liquid treatments, EIL was dissolved in ethanol in 2, 6, and 10 w/v% concentrations and BIL was dissolved in ethanol in 10, 15, 20 wt%/v concentrations by continuously stirring via magnetic stirrer until totally dissolved. the fabrics were modified with these solutions for 5 min at ambient temperature and after removing the excessive solution from the fabric samples, PP fabrics were dried at room temperature. The efficiency of the modifications was assessed by surface resistivity measurements, thermal gravimetric analysis (TGA) and scanning electron microscopy (SEM).

Surface resistivity tests of the unmodified and modified PP fabrics were performed in accordance with ASTM D 257–9 using 6517B/E Keithley Electrometer/High Resistance Meter.

Thermal stability of PP fibers was determined by thermogravimetric analysis (TGA). TGA was carried out by Perkin Elmer STA 8000 TG/DTA by heating from room temperature to 700 °C by a heating rate of 10 °C/min under N_2 atmosphere to avoid oxidation effects.

Surface morphology of the unmodified and modified PP fabrics are investigated by JEOL-JJM 6060 model scanning electron microscopy (SEM) operated at 5 kV. The surfaces of the fabrics were coated with Au-Pd by sputter coating prior to scanning to avoid electron beam charging effects during examination

3. RESULTS AND DISCUSSION

TGA analysis

Figure 1 shows TGA graphs of the unmodified and modified PP fabrics. Thermal degradation of the F was determined by thermogravimetric analysis. The first degradation is due to the dehydration of polypropylene. The pre-treatment increased moisture content of polypropylene from 0.69% to 0.93%. This may be possibly due to the introduction of oxygen based groups after chromic acid treatment. Both of the ionic liquid modifications decreased this value.

The pre-treatment increased maximum degradation temperature of the fabric (from 449°C to 458°C). The pre-treatment performed in this study is a type of etching process can be regarded as an oxidative scission of the polymer backbone, producing soluble low molecular weight fractions.

After ionic liquid modifications, the polypropylene fabrics presented two maximum degradation temperatures. EIL modified samples presented resembling maximum degradation temperatures with MF. This may be due to the application of low concentrations of EIL. In case of BIL modified fabrics, maximum degradation temperatures decreased with increasing concentrations. This may be due to that the ionic liquids having ammonium counterpart, the thermal stability was found to be lower in comparison with the other ionic liquids.

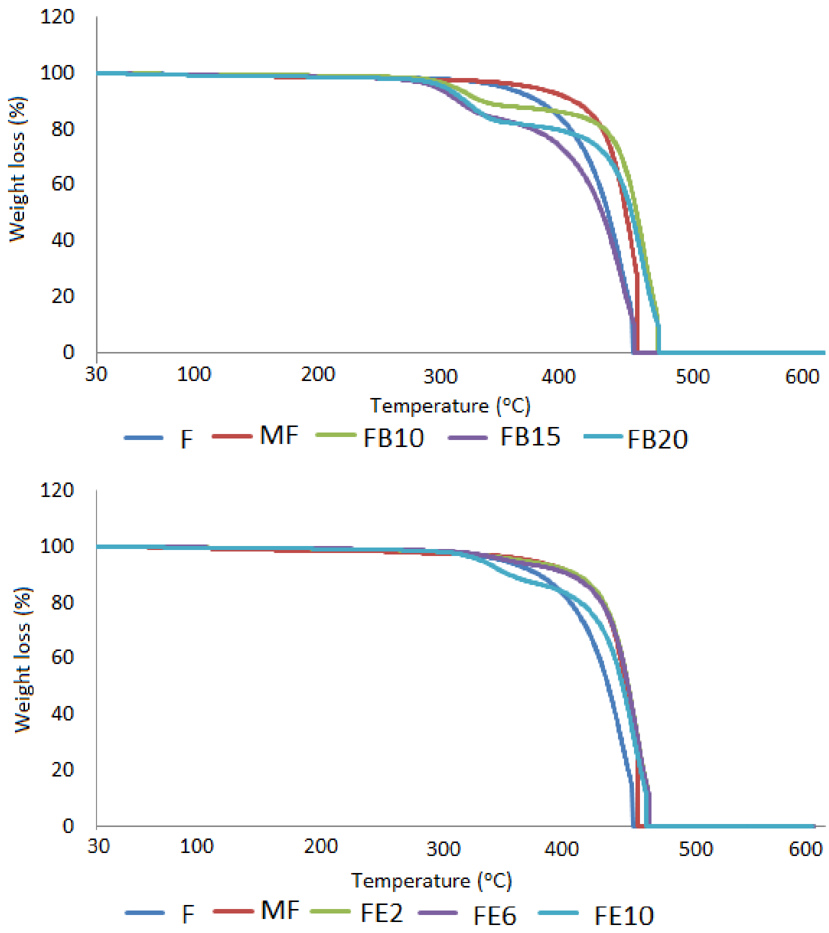
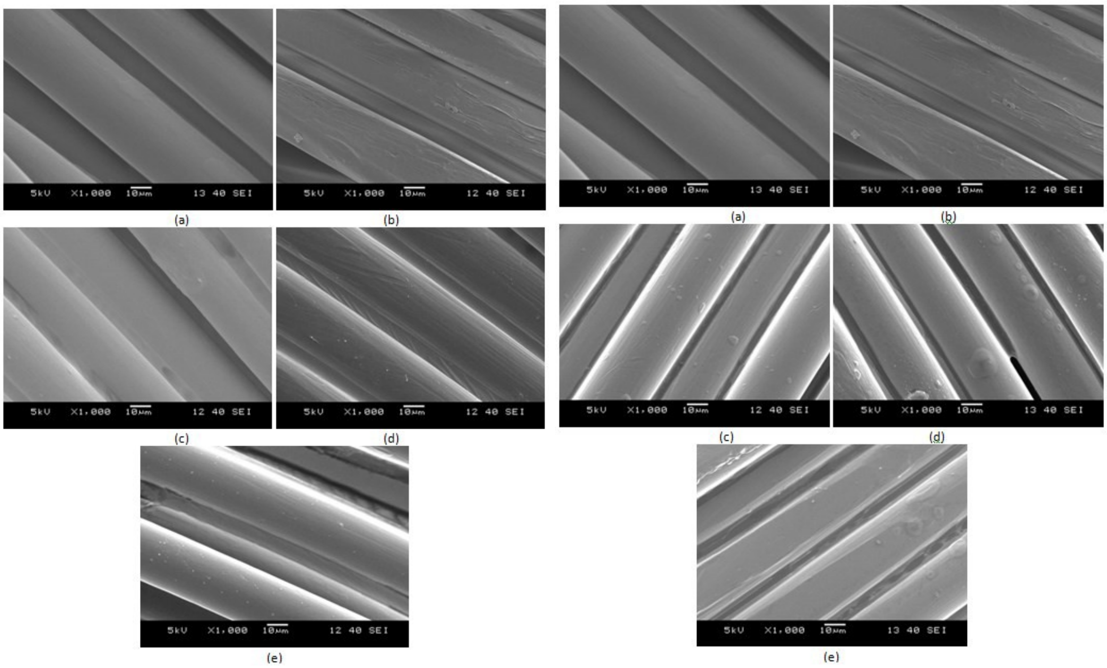


Fig.1. *TGA graphs of the unmodified and modified PP fabrics*

The efficiency of the ionic liquid treatments was determined by surface resistivity measurements. The surface resistivity of the polypropylene increased from 10^{10} to 10^{13} ohm/sq. EIL application decreased the data to 10^{9}, 10^{7} and 10^{6} ohm/sq for FE2, FE6 and FE6, respectively. In case of BIL application, FB10 and FB15 presented 10^{7} and 10^{6} ohm/sq resistivity data, respectively. For FB20 coded fabric, the resistivity data is non-available because it became too low (lower than 10^{3} ohm/sq) for the Keithley Electrometer/High Resistance Meter to measure. Therefore, it may be possible to reveal that FB20 sample can be classified as conductive having resistivity data in the range of 10^{1}-10^{6} ohm/sq [11]. The surface resistivity of the polypropylene fabrics were tested for two weeks intervals during two months. It is noticed that ionic liquid modified fabrics still exhibit lower surface resistivity values in comparison with the unmodified PP. This is due to the high electrical conductivity performance of the ionic liquids [12,13]. The modified fabrics can still exhibit static dissipative property having surface resistivity between 10^{6}-10^{12} ohm/sq because of their air stability [11,14].

SEM observations

Figure 2 presents SEM images of the F fabrics at x1000 magnification. SEM micrographs show that polypropylene fibers have smooth surface structure. However, it is observable that polypropylene fibers were possibly damaged by pre-treatment. The chromic acid modification increases surface roughness by exposing the underlying fibrillar structure [10]. After ionic liquid modifications, there becomes a coating layer observable both on the surface and in the gaps of the yarns.



A B

Fig.2. *SEM images of the PP fabrics under x1000 magnification*
A: a, b, c, d, e: F, MF, FB10, FB15,FB20
B: a, b, c, d, e: F, MF, FE2, FE6, FE10

4. CONCLUSION

In this study, polypropylene fabrics were treated with chromic acid and post-modified with BIL and EIL ionic liquids in order to decrease surface resistivity. Chromic acid enhanced thermal stability of PP but damaged the surface of the fiber optically. The main output of this research is both of the ionic liquids decreased surface resistivity of the PP for short and long-time intervals. Moreover, the increasing concentration was noticed to affect positively electrical conductivity. In some cases, the data was measured to be lower than 10^6 ohm/sq. this work may suggest an alternative finishing treatment for fabrics for improvement of conductivity performance.

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