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Investigation the surface modification of Polyamide fabrics using Low-Pressure Plasma Technique

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Abstract Plasma technique can be used to improve the surface characteristics of polyamide fabric with elastane through surface modification. In this study, the Polyamide fabrics with elastane treated with low-temperature, low-pressure, radio frequency argon plasma were investigated. After treated with the Plasma, in order to observe the effect of plasma treatment, fabrics were characterized and examined by the Scanning Electron Microscope (SEM). The changes in surface roughness and etching effect was observed. SEM analyses showed that the surface roughness increased due to the etching effect of the plasma treatment, leading to the improvement of the making the fabric conductive via different coating approaches for E-Textile applications.

From the experimental results, it was observed that higher surface roughness can be achieved by the increasing the plasma exposure time. The polyamide fabric with examined at different plasma exposure time 2, 4 and 20 minutes with the argon gas.

The obtained samples are promising for making the fabric conductive via different coating approaches for E-Textile applications.

Keywords — plasma treatment, polyamide, Scanning electron microscope (SEM).

I. INTRODUCTION

The major end use application of textile fibres is its use in apparel fabrics. Now a days, wearing comfort and the functional requirements of clothing have increased for daily wear. Knitted fabrics are widely used in apparel products for their extraordinary properties like elasticity, extension, higher strength, better solvent, flame and heat resistance and hand and wearing comfort for whole the year and seasons.

Polyamide with elastane fabric adjust easily with the body’s natural movements, but the original shape is recovered when it is allowed to relax. A knitted fabric has always elastic properties even without elastane.

Knitted fabrics with elastane can easily recover its original shape due to elastane in the fabrics. Fabrics containing spandex yarn have a wide application value, especially because of their increased extensibility, elasticity, the high degree of recovery, good dimensional stability and simple care [1-3].

Plasma treatments were an extensively used in textile processing technology is a clean and dry process that requires no water or organic solvent during processing. Plasma may be used for the surface modification and it changes the surface properties without affecting the bulk properties of materials, and less energy is consumed compared to conventional treatments [4]. Low-temperature plasma or gas discharge plasma is the subject of this study because most of the textile materials are heat sensitive polymers [5].

Plasma-induced surface modification is an effective way to produce functional textiles. Numerous studies indicated that plasma treatment improves the adhesion characteristics of surfaces. These studies stated that the etching effect of plasma gases caused nano- or micro-roughness, which contributes to the enhancement of adhesion on the surfaces[ 6,7].

The adhesion improvement of polyamide laminated fabric through argon and CO2 plasma treatment was also studied. It was observed that the adhesion properties of polyamide fabrics improved with plasma induced surface roughness compared to the untreated samples [8].

Plasma technology can be used to improve the surface characteristics of polypropylene through surface modification [9].

II. METHODS AND PROCEDURES

The polyamide fabric was cut into small pieces of about 8 cm × 10 cm by the scissors in the dust-free zone in order to get accurate results and the following samples were treated.
1. Untreated fabric
2. Treated fabric with plasma for 2 min by Argon gas
3. Treated fabric with plasma for 4 min by Argon gas
4. Treated fabric with plasma for 20 min by Argon gas

Argon (purity higher than 99.99 %) was used as processing gas with a gas flow rate of 0.3 l/m. Plasma chamber pressure was fixed at 0.3 mbar and 13.56 MHz radiofrequency was utilized during the process. Fabric samples were placed over the tray in the plasma chamber. Then, argon gas was fed in plasma chamber using various plasma treatment conditions (discharge power: 40 W, 60 W and 80 W, and exposure time: 2, 4 and 20 min). The one side of fabric was exposed to plasma.

Before plasma treatment, samples were washed with detergent for about 20 min, rinsed with distilled water, dried at 30°C in an oven for half an hour and were conditioned in desiccators.

Table 1:

| Plasma Discharge Pressure (mbar) | Plasma Gas | Frequency (Radio, Mhz) | Plasma Discharge Power (Watt) | Plasma Exposure Time (min) |
|---------------------------------|------------|------------------------|-----------------------------|---------------------------|
| 0.3 Argon                       | 13.56      | 40                     | 2                           |                           |
| 0.3 Argon                       | 13.56      | 60                     | 4                           | 20                        |
| 0.3 Argon                       | 13.56      | 80                     | 2                           | 4                         | 20                        |

III. RESULTS

The SEM has been extensively used in analysis of the surface characteristics of plasma treated textiles. Qualitative information providing an image of the surface at high magnification is obtained from SEM. Accelerated beam of high-energy electrons generate a variety of signals at the surface. These signals are collected and transferred to the screen in order to obtain high-resolution images. The SEM uses a magnification ranging from 20X to approximately 30,000X. If the material is not electrically conductive, like most of the textiles, material surface has to be coated with conductive elements such as carbon, gold, platinium etc. before the tests. Here for the characterization of the samples, we coated the fabric samples with the gold and platinium coating in order to make the sample conductive before the test.

Plasma induced surface modification of fabrics were analyzed by SEM measurements. The increase in surface roughness after plasma treatment may facilitate the interaction between the adhesive and the coated layers, and thus contribute the mechanical adhesion of the coating.

As can be seen from Figures below that increasing the plasma power and exposure time enhanced roughness of the fabrics. As the plasma treatment time was increased from 4 min to 20 min, the surface roughness increased at a plasma power of 80 W. The highest surface roughness were obtained at a plasma power of 80 W and plasma time of 20 min. The results showed that the plasma treatment time was more effective in improving the adhesion than the plasma power. The results are in agreement with recent studies showing that the degree of plasma modification depended on the plasma exposure time and discharge power [10].
IV. CONCLUSION

This research work mainly focuses to analyze and investigate the surface modification of the polyamide fabric with elastane. Plasma technique are very useful to improve the surface characteristics of polyamide fabric with elastane through surface modification. SEM analyses showed that the surface roughness increased due to the etching effect of the plasma treatment, leading to the improvement of the making the fabric conductive via different coating approaches for E-Textile applications.

Additionally, this study will highlight the reasons of variation in innovation, and suggest solutions to firms to increase their innovation performance, which not only will increase their performance, but national economic performance too.

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VI. FUTURE WORKS

Polyamide fabrics with elastane can be further utilize and by different coating methods make the fabric stretchable. The further study will help to findout the new era of stretchable conductive fabrics in E-Textile industry, because E-Textile has fastest growing industry now a days.

Conductive materials with high flexibility and stretchability have gained much attention in both academia and industry now a days.

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