COMPARISON STUDY ON CLEANABILITY OF PET FABRIC WITH O$_2$- AND NH$_3$- PLASMA MODIFICATION BEFORE AND AFTER APPLYING SOIL RELEASE POLYMER (SRP)

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ABSTRACT


A complete different phenomenon is found after two different plasma i.e. O₂- and NH₃- treatment in case of soiling as well as cleaning behaviour. Longer irradiation durations and Soil Release Polymer (SRP) play a significant role to improve cleanability. Difference between soiling behaviour and cleanability of PET fabrics before and after impregnation were revealed and discussed. The results obtained correlate with cleanability of polyester fabric of different exposure times to low pressure RF O₂- and NH₃-plasma, before and after deposition of Soil Release Polymer (SRP).

Key words: polyester fabric, plasma, soil release polymer (SRP), cleanability

INTRODUCTION

Polyester fabric is one of the most popular fabrics in the world. It has many desirable properties, including relatively high tenacity, low creep, good resistance to strain and deformation, high glass transition temperature (Tₛ), and good resistance to acids and oxidizing agents. These physical, mechanical, and chemical attributes make polyester excellent candidates not only for apparel and textile products but also for industrial and composite applications.

Plasma modification chemically change the surface behaviour and Soil release polymer (SRP) is responsible for cleanability.

Here, in this study observed different plasma (NH₃, O₂) with different time and SRP are also induced to characterise the comparison cleanability to establish correlation with each other.

MATERIALS

A polyester test fabric was used as substrate for this study. The fabric was supplied by Wfk-Testgewebe GmbH, Krefeld, Germany. The material was used as it received without any pretreatment. Different parameter of the test fabric is given in Table 1.

Table 1. Specifications of polyester fabric

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fineness (warp)</td>
<td>295 dtex</td>
</tr>
<tr>
<td>Fineness (weft)</td>
<td>295 dtex</td>
</tr>
<tr>
<td>Yarn density (warp)</td>
<td>270 +/- 5 yarn / dm</td>
</tr>
<tr>
<td>Yarn density (weft)</td>
<td>270 +/- 5 yarn / dm</td>
</tr>
<tr>
<td>Width</td>
<td>80 cm</td>
</tr>
<tr>
<td>Fabric weight</td>
<td>170 g/m²</td>
</tr>
<tr>
<td>Weave</td>
<td>1 / 1 plain</td>
</tr>
</tbody>
</table>

METHODS

Plasma modification of PET fabric

The plasma treatment was done in a computer controlled customized MicroSys apparatus by Roth & Rau, Germany. The cylindrical vacuum chamber, made of stainless steel, has a diameter of 350 mm and a height of 350 mm. The base pressure obtained with a turbomolecular pump is <10⁻⁷ mbar. A ‘Micropole’ mass spectrometer by Ferran, the United States, is used to monitor the residual gas. On the top of the chamber a 2.46 GHz electron cyclotron resonance (ECR) plasma source RR 160 by Roth & Rau with a diameter of 160 mm and a maximum power of 800 W is mounted. The process gas is introduced into the active volume of the plasma source via a gas flow control system. When the plasma source is on, the pressure is measured by a capacitive vacuum gauge. The sample were introduced by a load-lock-system and placed on a grounded aluminium holder near the centre of the chamber. The distance between the sample and the excitation volume of the plasma source is about 200 mm. For the plasma treatment the following parameters were applied respectively: i) process gas NH₃ (99.999%, Messer Griesheim, Germany), flow 15 standard cubic centimeters per minute, pressure 3.6 10⁻³ mbar, effective microwave power 600 W and ii) process gas O₂ (99.95%, Messer Griesheim, Germany), flow 15 standard cubic centimeters per minute, pressure 3.6 10⁻³ mbar, effective microwave power 100 W.
Soiling and cleanability

The aim was to find, whether there is difference in soiling degree and cleanability between polyester fabrics. Cleanability of stained textiles was evaluated by the SAD (soiling additional density) analysis (Badruel 2007).

Testing pieces of each fabric with 1 cm x 1 cm size were immersed into a SRP (soil release polymer) solution for 15 minutes. The SRP chosen for the investigation was Marloquest SL produced by Sasol Germany (Marl). A 1 g/l aqueous solution of the SRP was prepared with deionised reagent-grade water followed by drying overnight at 24°C in the open air.

In this thesis, a combination of two kinds of stain material—paraffin oil and acetylene black—was used in the weight ratio of 97.98:2.02, respectively, according to (Jacobasch 1978; Kratzsch 1964). A 2 µl drop containing oil/black oil was applied to differently treated testing surfaces of each type of fabric—impregnated with SRP and untreated reference. For each fabric, 10 testing pieces were prepared by staining with the soil mixture followed by drying at 24°C in the open air overnight.

An aqueous mixture of anionic surfactant Marlon A350 (1 g/l) and non-ionic Marlowet 4538 (1 g/l), both from Sasol Germany (Marl), was used as a washing detergent. The samples were washed in the detergent at room temperature 15 minutes and rinsed 5 min with deionised water. Then they were dried overnight at room temperature.

Colour measurements on stained and washed fabrics were carried out with a usual scanner. Soiling additional density (SAD) was obtained from images with different grey intensities using the equation (Rees 1954)

\[
SAD = \log \frac{R_{\text{reference}}}{R_{\text{stained or washed}}}
\]

Where, \( R \) is a reflection ability factor calculated from digitised images using Origin 7.5, data analysis and graphic software. Every picture scanned is represented by a two-dimensional image as a finite set of digital values (picture elements). Picture elements are the smallest individual element in an image, holding quantised values that represent the brightness of a given colour at any specific point. Colour images were automatically converted into greyscale images by Origin 7.5. \( R \) was calculated as a sum of all quantised values on grey scale for each image. \( R_{\text{stained}} \) is the reflection ability factor for a surface after staining before washing. \( R_{\text{washed}} \) is the reflection ability factor for a surface after staining and washing.

Surface cleanability (or ‘percentage cleanability’) is defined according (Flath and Muller, 1967) as

\[
\Gamma = \frac{SAD_{\text{stained}} - SAD_{\text{washed}}}{SAD_{\text{stained}}} \cdot 100\%
\]

In order to compare the cleanability of different substrates, relative cleanability \( \Delta\Gamma \) was considered:

\[
\Delta\Gamma = \Gamma_{\text{after washing (treated with SRP) \& after washing (untreated)}}
\]

RESULTS AND DISCUSSION

Here PET fabrics were modified with NH\(_3\)- and O\(_2\)-plasma using different treatment durations. Fabric samples of 1 cm x 1 cm size were submitted to soil release analysis. Two µL oil drops of paraffin oil and acetylene black mixtures were used as soil material. An aqueous mixture of anionic surfactant Marlon A350 (1g/L) and non-ionic Marlowet 4538 (1g/L), both from Sasol Germany (Marl), were used as washing detergent. With the help of the equations presented in experimental part, cleanability percentage \( (\Delta\Gamma\%)\) and difference of cleanability \( (\Delta\Gamma)\) were obtained.

Cleanability in case of NH\(_3\) plasma

After gradually increasing the plasma treatment time, it is significantly seen that the cleanability percentage \( (\Gamma\%)\) is gradually increased in case of SRP and without SRP and the difference of cleanability \( (\Delta\Gamma\%)\) is also increased gradually, shown in Table 2 and Table 3 correspondingly Fig. 1 and Fig. 2.

<table>
<thead>
<tr>
<th>Cleanability ((\Gamma%))</th>
<th>Cleanability difference ((\Delta\Gamma%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRP Without SRP</td>
<td>Cleanability difference</td>
</tr>
<tr>
<td>22.51</td>
<td>14.55</td>
</tr>
</tbody>
</table>

Table 2. Cleanability of origin fabric

<table>
<thead>
<tr>
<th>Treated time</th>
<th>Cleanability ((\Gamma%))</th>
<th>Cleanability difference ((\Delta\Gamma%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRP Without SRP</td>
<td>Cleanability difference</td>
<td>Cleanability difference</td>
</tr>
<tr>
<td>2 min</td>
<td>3.92</td>
<td>3.32</td>
</tr>
<tr>
<td>5 min</td>
<td>6.10</td>
<td>4.94</td>
</tr>
<tr>
<td>10 min</td>
<td>12.86</td>
<td>10.26</td>
</tr>
</tbody>
</table>

Table 3. Cleanability of NH\(_3\) plasma modified fabric
Comparison study on cleanability of pet fabric with O$_2$- and NH$_3$- plasma modification before and after applying Soil Release Polymer (SRP)

**Comparison study**

According to Figs. 1 and 3, NH$_3$- and O$_2$-plasma treatments respectively cause an important decrease of fabric cleanability. However, by longer irradiation durations, cleanability increases linearly in both cases.
Figures 2 and 4 show that the effect of SRP-impregnation on cleanability \( \Delta \Gamma \) is proportional to the measured cleanability on non-impregnated textile surfaces.

**CONCLUSION**

The main objective of the present study was to verify if plasma treatment of PET fabrics can improve the effect of the posterior impregnation with SRP in order to increase cleanability. Results show that plasma irradiation time really improves the effect of SRP-impregnation on soil release. However, cleanability values obtained show that the effect is not better than the observed by untreated fabrics before and after impregnation with SRP.

**REFERENCES**


