Sublimation transfer printing of linen and polyester/linen fabrics

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Received 5 January 1999; revised received 20 May 1999; accepted July 1999

An attempt has been made to chemically modify the linen and polyester/linen fabrics via benzylation. Linen fabric is more susceptible to the benzylation reaction than its blend with polyester. The maximum degree of substitution obtained in the case of blend is 0.26 as compared to 0.85 in case of 100% linen when benzylation is conducted for 4 h. Partial benzylation of linen and polyester/linen fabrics increases their transfer printability. Partially benzylated printed fabrics have high colour strength and their overall fastness properties are good to very good.

Keywords: Linen fabric, Polyester/linen fabric, Sublimation transfer printing

1 Introduction

The sublimation transfer printing process involves the transfer of disperse dye from the paper to fabric and it is particularly popular for printing of 100% polyester. This process is not suitable for fabrics made from cellulosic fibres because of the lack of affinity of cellulosic fabrics for disperse dyes. Various pretreatments are recommended for modification of cellulosic fabrics to make them suitable for sublimation transfer printing with disperse dyes. Some of the important modifications recommended are cyanoethylation1, acetylation2, benzylation3, pretreatment with resin or cross-linking agent4, and use of high boiling point swelling agent5.

The present work was carried out with the following two objectives:
—To render the linen fabrics and the cellulosic component in the polyester/linen fabric amenable to heat transfer printing by chemical modification of these substrates through benzylation.
—Using the coloured films, prepared from a paste containing disperse dye and mixture of CMC/PVA as a thickener, as a substitute for the normal commercial transfer paper.

2 Materials and Methods

2.1 Materials

2.1.1 Fabrics

Mill scoured and bleached linen fabric of 194 g/m² (supplied by El-Sharkia Company) was treated with a solution of 6 g/litre soap and 1 g/litre Na₂CO₃ at 90-100 °C for 1 h, thoroughly washed and air dried at room temperature.

Mill scoured and bleached polyester/linen fabric (65/35) of 255 g/m² (supplied by El-Sharkia Company) was treated with a solution of 0.5 g/litre soap and 1 g/litre Na₂CO₃ at 60-70 °C for 1 h, thoroughly washed and air dried at room temperature.

2.1.2 Chemicals

Benzy chloride, sodium hydroxide and sodium carbonate, all of laboratory grade, were used.

Hostatherm Blue HBL Liquid, commercial sodium carboxymethyl cellulose (Tylose C600) and polyvinyl alcohol (Vinarol STH), supplied by Höechst, were used.

2.2 Methods

2.2.1 Fabric Treatment

The benzylated linen and polyester/linen fabrics having different degrees of substitution were immersed in a mixture of 70 ml sodium hydroxide (17%) and 350 ml benzy chloride using material-to-liquor ratio of 1:8 for 0.5-6 h at 100 °C, washed in running water and air dried6.

2.2.2 Preparation of Coloured Films

The film was prepared from a paste according to the following recipe:
Dye & 30 g 
Carboxy methyl cellulose (CMC) & 25 g 
Polyvinyl alcohol (PVA) & 100 g 
Distilled water & 845 g 
1000 g 

2.2.3 Transfer Printing

The samples of the modified and unmodified linen and polyester/linen fabrics were transfer printed using the coloured CMC/PVA film as substitute for the printed paper. The heat source was a $40 \times 25$ cm flat bed press. Printing time was varied from 15s to 60s and the temperatures used were 180 °C and 200 °C. The samples were allowed to cool at room temperature before the film was withdrawn.

2.2.4 Determination of Degree of Substitution

The degree of substitution (D.S.) of benzylated cellulose sample and the cellulosic portion of the blend was determined by measuring the percent of carbon in the fabric.

The D.S. of benzylated cellulose and cellulose polyester was calculated as follows:

$$D.S. = \frac{84 \cdot K \cdot S - 194C}{90C - 84}$$

where C = carbon atom.

2.2.5 Colour Assessment

The colour strength ($K/S$) of the printed samples was determined by reflection measurements using an automatic filter spectrophotometer.

2.2.6 Fastness Properties

Fastness to washing, rubbing and perspiration was assessed according to the standard methods.

3 Results and Discussion

The results obtained by partial benzylation of linen and polyester/linen fabrics through treatment with benzyl chloride and sodium hydroxide for different intervals of time are shown in Fig. 1. It is observed that under the same conditions of treatment, the linen is much more susceptible to benzylation than its blend with polyester. In case of the blend, the cellulosic component which amounts to 35% of blend is liable to the benzylation reaction, while the polyester component is not affected by the benzylation treatment. Therefore, a maximum D.S. value of 0.26 is obtained in case of the blend as compared to 0.85 in case of 100% linen fabric when the benzylation reaction is conducted for 4 h.

The degree of benzylation reaches its maximum value in 4 h when the reaction is carried out at 100 °C. Increasing the reaction time over that limit (i.e. from 4 h to 6 h) results in rapid hydrolysis of the benzyl content, and D.S. values of 0.02 and 0.66 are obtained for the blend and linen fabrics respectively (Fig. 1).

It was found that the linen fabric treated for 6 h under the same conditions was completely destroyed and could not be transfer printed, while the polyester/linen fabric treated under the same conditions was not destroyed as the polyester constituent, which amounts to 65% of the fabric, was not affected and it preserved the shape of the fabric which could be transfer printed. This means that the reaction time should not exceed 4 h under the selected conditions of reaction, especially in the case of 100% linen fabric.

3.1 Transfer Printing

3.1.1 Linen

The effect of changing the transfer printing time on the colour strength of benzylated linen fabrics having
different degrees of substitution and transfer printed at 180 °C and 200 °C is shown in Figs 2 and 3.

Generally speaking, at any chosen temperature as the time of transfer is increased, the colour strength of the printed modified linen fabric increases and this increment depends largely on the degree of modification.

The effect of transfer temperature on printing is very obvious. For example, the colour strength obtained when printing the benzylated linen fabric having a D.S. of 0.85 for 60 s is 13.3 and 15.14 at the transfer temperatures of 180 °C and 200 °C respectively, indicating the important role of transfer temperature.

The above results imply that increasing the benzyl content of the linen fabrics render them more susceptible to transfer printing. In other words, benzylaion increases the thermoplasticity of the fabrics which is favourable for transfer printing. Also, the magnitude of improvement is highly dependant upon the degree of modification and the conditions of transfer, i.e. time and temperature. It may be concluded from above that at any selected transfer temperature, increase in the transfer time up to 30 s increases the colour strength of the printed benzylated linen fabric markedly. Over that time limit, a slower rate of increase is observed.

3.1.2 Polyester/Linen

It is observed that a similar pattern of results is obtained in case of transfer printing the benzylated polyester/linen blend when compared to that obtained on printing benzylated linen fabric. The colour strength of the printed untreated polyester/linen

![Fig.2](image1.png)

![Fig.3](image2.png)

![Fig.4](image3.png)
fabrics is much higher than that of the corresponding untreated linen fabric under any selected conditions of time and temperature of transfer. This is because of the presence of the polyester component which is highly receptive of the disperse dye vapours. The effect of transfer printing time on the colour strength of the printed benzylated polyester/linen fabrics (having different benzyl contents) transfer printed at 180 °C and 200 °C is shown in Figs 4 and 5. It is observed that the colour strength of the printed modified fabrics increases markedly on increasing the transfer time up to about 30 s, irrespective of the degree of modification. As the time of transfer increases over that range, a slower rate of increase in the colour strength is noticed for all transfer temperatures and remarkably at 200 °C. Therefore, it is not recommended to increase transfer time over 30 s at temperature of 200 °C, since it does not improve the colour yield to a reasonable extent.

3.2 Fastness Properties
Table 1 shows the colour strength and fastness properties of some selected partially benzylated linen and polyester/linen fabrics transfer printed at 180 °C for 30 s. It is observed that besides the poor colour strength of the prints on the untreated linen fabrics, they acquire poor wash fastness. The fastness to perspiration and rubbing ranges from moderate to good. For partially benzylated linen fabrics, the overall fastness properties range from good to very good.

For the blend fabric, the overall fastness properties are very good. A slight improvement, especially in the

Table I—Colour strength and fastness properties of transfer printed partially benzylated linen and polyester/linen fabrics

<table>
<thead>
<tr>
<th>Benzyl content (D.S.)</th>
<th>Colour strength (K/S)</th>
<th>Wash fastness at 45°C</th>
<th>Prespiration fastness</th>
<th>Rubbing fastness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before wash</td>
<td>After wash</td>
<td>Before wash</td>
<td>After wash</td>
</tr>
<tr>
<td>Linen fabrics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nil</td>
<td>0.78</td>
<td>0.50</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0.71</td>
<td>2.77</td>
<td>1.11</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>0.75</td>
<td>3.41</td>
<td>3.33</td>
<td>4-5</td>
<td>4</td>
</tr>
<tr>
<td>0.85</td>
<td>9.02</td>
<td>8.83</td>
<td>4-5</td>
<td>4</td>
</tr>
<tr>
<td>0.66°</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Linen/polyester fabrics</th>
<th>Colour strength (K/S)</th>
<th>Wash fastness at 45°C</th>
<th>Prespiration fastness</th>
<th>Rubbing fastness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>6.18</td>
<td>5.29</td>
<td>3</td>
<td>2-3</td>
</tr>
<tr>
<td>0.01</td>
<td>6.39</td>
<td>5.68</td>
<td>4</td>
<td>2-3</td>
</tr>
<tr>
<td>0.20</td>
<td>7.80</td>
<td>7.23</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>0.26°</td>
<td>8.85</td>
<td>8.29</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>0.02°</td>
<td>8.29</td>
<td>5.14</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

*aSample completely destroyed.*

*bThe cellulosic portion of the fabric was destroyed.*
wash fastness, is observed due to the modification treatment.

References