Coatings with Reduced Flammability for Linen Fabrics

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Abstract. The aim of this research is the investigation of burning characteristics and abrasion resistance of the Latvian local raw and bleached linen fabrics and the same fabrics with continuous anti flammable coating, containing commercial printing paste Printperfect EX-TS, pigment Bezaprint GELB (both of the producer CHT BEZEMA) and antimony trioxide (Sb₂O₃) as the flame-retardant additive. For the coating of the linen fabrics the flat screen method was used. After the coating 5 washing cycles were applied to the half of the fabrics. The burning test of the raw and the bleached linen fabrics and those coated with commercial printing paste and antimony trioxide, as well as the washed fabrics was accomplished. The results of the test show, that the raw and the bleached linen fabrics burn completely. The flame extinction was observed for coated fabrics and coated washed fabrics. The abrasion resistance of coated fabrics depends on thickness of coating.

1. Introduction

Flame protection has become mandatory for personal protective equipment in many branches of industry. Flame protection in combination with the high abrasion–resistance of materials is perspective technology [1]. It is noticeable, that hazards may occur by fires as the combined effect of smoke and toxic gases. Standards and codes of human safety based on recognized general requirements of fire protection are obligatory for lot of textile materials used in building, transport, construction, home and protection garments [2]. All fabrics will burn with some being more combustible than others. The burning rates can be reduced with flame retardants (FR), applied through treatment [3] with chemicals, such as inorganic salts, mix of ammonium polyphosphates, halogen donators, expandable graphite (intumescent) etc. The choice of every individual FR and kind of treatment depends on requirements for produced material. The antimony compounds can be safely used for the textile treatment without causing a risk to human health and the environment [4].

The aim of this research is the investigation of burning characteristics of the Latvian local linen (raw and bleached) fabrics without and with continuous coating, containing commercial printing paste Printperfect EX-TS, pigment Bezaprint GELB and antimony trioxide (Sb₂O₃) as the flame-retardant additive. The manual flat screen method for coating of fabrics was used. The fabrics burning characteristics were tested with the vertical and the horizontal flame applying method, before and after 5 washing cycles. The abrasion resistance was determined on Taber Rotary Platform abrader.

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2. Materials and Methods

2.1. Material.
The Latvian local [Company Larelini Ltd.] plain weave 100% raw and bleached linen fabrics were used for experiment. Before the coating the fabrics were pre-washed in distilled water solution (liquor ratio M 30) of washing agent Felosan NOF (2 g/l) [CHT R Beitlich GMBH] at 100\(^\circ\)C for 60 min with following rinse in cold / warm water. The raw linen fabric – sample designation R0 fabric surface density 178 g/m\(^2\), thickness 0.24 mm (Fig. 1A); the bleached linen fabric – sample designation B0 fabric surface density 190 g/m\(^2\), thickness 0.23 mm (Fig.1B).

![Figure 1. A- raw linen fabric (R0), B- bleached linen fabric (B0)](image)

2.2. Coating.
Coating composition on base of poliacrylate dispersion swelling printing paste Printperfect EX-TS [commercial producer CHT BEZEMA] with flame retardant additive Sb\(_2\)O\(_3\) (proportion 9:1) and pigment Bezaprint Gelb 5G (2 mass % of paste) was mixed manually. The flat screen method for coating of the raw linen (sample designation R/C) and the bleached linen (sample designation B/C) fabrics were used. Drying of coated samples at 100\(^\circ\)C for 7±1 min and the thermal treating at 150\(^\circ\)C for 5±1 min was applied.

2.3. Microscopy
The linen fabric surface investigation with the image of optical microscopy [Microscope Leica Microsystems, GmbH, magnification 50] was carried out.

2.4. Whiteness level
Whiteness level of the linen fabric surface was determined with Rhopoint Novo-Shade Duo 45°/0 reflectometer [Rhopoint Instrumentation Ltd, UK]. Preparing and testing of samples according to user manual [5] was performed.

2.5. Washing of coated fabrics
For the half of coated raw linen (sample designation R/C/W) and coated bleached linen (sample designation B/C/W) fabrics 5 washing cycles in distilled water solution (M 30) of sodium carbonate (3 g/l) and washing agent Felosan NOF (5 g/l) at 40\(^\circ\)C for 15 min with following rinse in cold / warm water, according the ISO 105-C10:2006 was used.

2.6. Testing of abrasive resistance
The abrasion resistance of untreated and coated samples (Ø10.2mm) on Taber Rotary Platform abrader, according LVS EN ISO 5470-1:2001 was determined.
2.7. **Burning tests**

The fabric samples (8 for vertical and 6 for horizontal test) were used according LVS EN ISO 15025:2003. The burning tests were realized in Latvian Centre of Certification (LATSERT).

3. **Results and Discussion**

The continuous coating on the right side of fabrics was made with manual flat screen method. The Fig.1 and table 1 show the difference of used base fabrics. The raw fabric low whiteness (32, 23 %) testifies, that fabric refining only with prewashing is not completely. It causes the difference of coating thickness (35%) made with identical technology on raw and bleached textiles.

| Designation of sample | R0  | B0  | R/C | B/C |
|-----------------------|-----|-----|-----|-----|
| Thickness of sample, mm | 0.24 | 0.23 | 0.69 | 0.45 |
| Whiteness of sample, %  | 32.23 | 78.72 | -   | -   |
| Abrasion resistance of sample, cycles | 25  | 24  | 1080 | 660 |

![Figure 2](image1.png)

**Figure 2.** Coated raw linen samples (R/C); right side (A) left side (B).

![Figure 3](image2.png)

**Figure 3.** Coated bleached linen samples (R/B); right side (A) left side (B).

The partial coating composition passing through from the right side to the left side of the fabric is observed (Fig. 2B, 3B). There is practically no difference of abrasion resistance for uncoated (25 cycles for R0 sample and 24 cycles for B0 sample) base fabrics. The abrasion resistance of coated materials increases significantly – 43 times for R/C and 28 times for B/C samples. The coating...
thickness influence on abrasion resistance is observed (Table 1) – the growth of sample thickness for
35 % (R/C in comparison with B/C) causes increase of abrasion resistance for 39 %.

The main task of investigation is decrease of burning characteristics of coated materials on base of
linen fabrics. The results of burning tests are presented in Table 2.

| Designation of sample | R0 | B0 | R/C | B/C | R/C/W | B/C/W |
|-----------------------|----|----|-----|-----|-------|-------|
| Flame spreading time till top of the sample, s |
| **Horizontal test** | 27-30 (right side) | 20-21s (right side), 23-24s (left side) | 23-24 (right side), 24-25 (left side) | Don’t reaches (right side) 25-26 (left side) |
| 8-9 | 10-11 |
| **Vertical test** | 10-13 (both sides) | 10-11 (both sides) | 8-9 (right side), 9-10 (left side) | 9-11 (both sides) |
| 8-9 | 8-9 |

| After burning time, s |
|-----------------------|---------------------|---------------------|---------------------|---------------------|
| **Horizontal test** | Burns completely 50-60 (right side), 120-130 (left side) | Burns completely 100-115 (right side), 90-95 (left side) | Burns completely 10-12 (right side), 65-70 (left side) | Burns completely 19-22 (right side), 93-95 (left side) |
| **Vertical test** | Burns completely 40-45 (right side), 65-70 (left side) | Burns completely 60-80 (right side), 62-68 (left side) | Burns completely 80-85 (right side), 70-71 (left side) | Burns completely 67-69 (right side), 66-70 (left side) |

| After glowing time, s |
|-----------------------|---------------------|---------------------|---------------------|---------------------|
| **Horizontal test** | 150-177 (right side), 175-190 (left side) | 160-164 (right side), 150-161 (left side) | 175-180 (right side), 177-180 (left side) | 157-160 (right side), 154-163 (left side) |
| **Vertical test** | 182-186 (right side), 170-175 (left side) | 160-164 (right side), 150-161 (left side) | 175-180 (right side), 177-180 (left side) | 157-160 (right side), 154-163 (left side) |

| Formation of debris |
|---------------------|---------------------|---------------------|---------------------|---------------------|
| **Horizontal test** | Yes | Yes | No (right side) | Yes (left side) | Yes (right side); yes (left side) |
| **Vertical test** | Yes | Yes | Yes | Yes | Yes |

The characteristic of burning was tested with the horizontal and the vertical method (Table 2). The
obtained results differ with used method – in all cases the higher results are obtained with horizontal
test method.
The raw and the bleached linen fabrics before coating burn completely with the both used methods for 40-70 s. The use of flame resistant coating increases the materials resistance to burning. As expected the right side of samples with uninterrupted coating (Fig. 2, Fig. 3) is more resistant to flame as the left side. In horizontal test the extinction of flame is observed. The lower after burning and after glowing time is obtained for samples with bleached linen fabric base despite the lower coating thickness of samples in comparison with coated samples on base of the raw linen. Formation of thermal degradation product – debris is observed with both testing methods practically in all cases (exception – the horizontal test for the right side of bleached linen coated and coated washed samples). The influence of washing of coated textiles is not significant.

4. Summary

- The raw and the bleached linen fabrics used as the base of coating burn completely,
- The horizontal and the vertical burning test results differ. In the horizontal test the extinction of flame is observed,
- The right side of samples with uninterrupted coating is more resistant to flame as the left side,
- The base fabric selection influences the coating thickness, burning characteristics and abrasion resistance of obtained materials,
- The influence of 5 washing cycles on flame resistance of coated textiles is not significant,
- The investigated coating technology increases the abrasion resistance of examined textile fabrics 28 – 43 times.

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