IMPACT OF SINNER CYCLE WASHING PARAMETERS ON THERMAL CHARACTERISTICS AND APPEARANCE OF PROBAN® - FLAME RETARDANT MATERIAL

Tea KAURIN; Tanja PUŠIĆ; Tihana DEKANIĆ; Sandra FLINČEC GRGAC

University of Zagreb Faculty of Textile Technology

14th International Scientific-Professional Symposium
„Textile Science and Economy“
THE TRANSFER OF INNOVATIONS TO THE ECONOMY
26 January, 2022

Introduction

Proban® is a multiphase treatment of cotton fabrics based on the formation of pre-condensates using a flame retardant (FR) agent based on tetrakis(hydroxymethyl)phosphonium salts (THPx). The assessment of the durability of a product demand the preliminary understanding of how relevant is to extend its lifetime. Changes in surface properties and pore volume are the main causes of the change in material properties. It is therefore important to minimise the risk of agents acting on: (1) protection level, (2) shape and dimensions and (3) additional comfort characteristics.

This research focused on impact of washing conditions on the durability of FR properties and appearance of Proban® cotton fabrics of surface mass 347 g/cm^2, warp and weft density 22/24 threads per cm, was systematically organized through variation in chemistry distribution in the Sinner cycle.

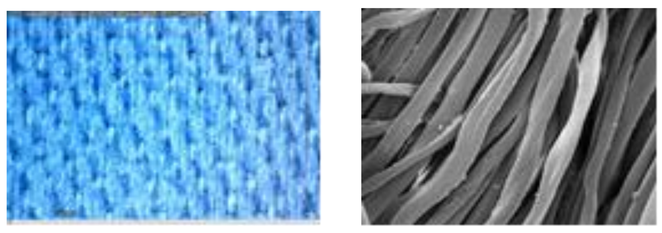

Figure 1: Digital and SEM image of Proban® fabric

Experimental

The fabric (UNW) has been treated during the washing process in Wascator FOM, Electrolux for 10 cycles. The component dosage system was applied in two variations in alkalinity (46_10x and 47_10x), where 46_10x is higher alkaline than 47_10x. The fabrics (49_10x) was washed with standard ECE-1 detergent and water (49_10x).

The results in Table 1 show the differences in the pH of the wash baths affected by the NaOH dose for programs 46 and 47. The composition of the standard ECE-1 detergent is reflected in the alkaline bath of program 49.

The characterization of the fabric properties was performed to check whether the lower alkaline bath has a better potential to preserve the functional properties and appearance of the fabric for a longer life cycle

Table 1: pH of washing baths

	46	47	48	49
pre-wash	8.14	8.14	-	-
1st wash	12.28	10.98	-	9.8
2nd wash	12.28	10.98	-	8.6
3rd wash	11.02	7.37	-	-

The limited oxygen index (LOI), calorimetric parameters (Microscale Combustion Calorimeter, MCC), thermogravimetric analysis with monitoring of gas exhaust during the sample decomposition (TGA-FTIR), surface examination (SEM), spectral characteristics before and after 10 washing cycles were selected for proof of the concept.

Results

LOI values for all samples regardless of the treatment conditions (46, 47, 48 and 49) retain the same value (32 %) as the pristine Proban® sample. So high-retained value classifies all samples as self-extinguishing material.

Results of **MCC analysis** samples before and after washing are specified in Table 2 through heat release capacity (ηc); maximum specific heat release rate (Qmax), specific heat release (hc), specific heat of flammable gases (hc, g), temperature at maximum specified heat release rate (Tmax) and combustion residue.

Table 2: Parameters of MCC analysis

Parameters	UNW	46_10x	47_10x	48_10x	49_10x
ηc (J(g*K)-1)	61.0	65.7	71.7	62.7	69.3
Qmax (Wg-1)	62.5	66.7	72.9	64.0	71.0
hc (kJg-1)	2.0	2.1	2.4	1.9	2.1
hc, gas (kJg-1)	2.0	2.2	3.8	3.1	3.4
Tmax (°C)	314.1	313.0	314.5	311.0	312.8
Residue (%)	40.81	37.40	35.63	39.83	38.78

The resulting values of the released heat capacity (ηc) shown in Table 2 show that the untreated Proban® sample (UNW) has the lowest value as expected. When considering the sample after 10 washing cycles in water (48_10x), it is clear that a slight increase in the heat released capacity (ηc) compared to the pristine sample, correlated with the resulting LOI value. The heat release capacity (ηc) of the samples 46_10x has the lowest value and the lowest specific heat release, hc, gas = 2.2 compared to the other samples. An important parameter for monitoring the thermal stability of the samples is the pyrolysis residue. The largest residue had a sample washed in water (48_10x) 39.83 %. Slightly less residue had the sample washed with a standard detergent containing phosphates (49_10x) 38.78 %, while the smallest residue shows a sample 47_10x at 35.63 %. The highest specific heat value of fuel gases was recorded for this sample, probably due to of combustion of organic sample components.

Comparison of samples (UNW) and 49_10 clearly indicate on a positive effect of the detergent, but due to known problems of phosphate impact on the ecosystem, such applications are limited and doubt. The high amount of residue after TG analysis in sample 49_10 was affected by residual substances derived from detergent components, not used to remove stains. Thermal stability and incombustibility of sample 47_10 is similar to sample 49_10.

According to results of spectral characteristics of blue cotton fabrics are changed through 10 washing cycles and intensity of changes depend on the composition of a washing bath. The decrease in alkalinity (47_10) proved to be the most favourable for preservation of blue colour characteristics.

SEM images of washed samples indicate specific fibrillation that can be caused by characteristics of cotton cellulose and chemical share in the Sinner cycle. The significant change in appearance specified for washed fabric 46_10 can be caused by the stronger swelling ability of cotton cellulose in alkali conditions of this washing bath.

Conclusion

Proof of a medium alkali bath as a washing concept for Proban® cotton fabric is approved through preservation of FR properties examined through LOI, TGA and MCC parameters and appearance - colour and low level of fibrillation. Added value of a process can be considered through environmental and economic benefits compared to other washing processes in this research.

Acknowledgement

This work has been supported by the European Union from the European Regional Development Fund under the project KK.01.2.1.02.0064 Development of multifunctional non-flammable fabric for dual use.