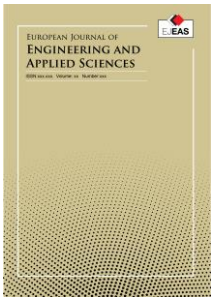
European Journal of Engineering and Applied Sciences

ISSN: 2651-3412 (Print) & 2667-8454 (Online)
Journal homepage: http://dergipark.gov.tr/EJEAS
Published by Çorlu Faculty of Engineering, Tekirdağ Namık Kemal University

European J. Eng. App. Sci. 5(1), 57-60, 2022



Research Article

Could Dyeing Process Be Eliminated for PES/CO Fabrics Through Recycling?

Rıza Atav[1, a, *], Selma Soysal[2, b] Fatma Yıldız [2, c]

[1] Tekstil Mühendisliği, Çorlu Mühendislik Fakültesi, Tekirdağ Namık Kemal Üniversitesi, Tekirdağ, Turkey, 59860
[2] Gülle Tekstil A.Ş., Tekirdağ, Turkey, 59870
[a] ratav@nku.edu.tr, [b] selma.soysal@gulletekstil.com.tr, [c] fatma.tok@gulletekstil.com.tr

Received: 28.04.2022 Accepted: 27.07.2022 DOI: 10.55581/ejeas.1110619

Abstract: As it is known, finishing processes of polyester/cotton blended fabrics require a double dyeing process. Therefore, the consumption of water, energy and chemicals and the waste it generates are quite high. Within the scope of this study, it is aimed to compare the yarn and fabric performance properties of a PES/CO blended fabric of a certain color, produced by using virgin fiber or recycled fiber in its CO component. In the light of the studies, it can be said that during the production of PES/CO blend fabric, recycle cotton can be used as well as virgin fiber, and although there won't be problem in terms of color and fastness, the fabric produced cannot meet the standards provided by the fabric produced from 100% virgin fiber in terms of general appearance and physical-technological properties. Beyond that, the color gamut will also be limited. However, in the case of using recycled fiber, it is thought that significant environmental benefits will be achieved, both because a waste is recycled and a fabric that requires too many processing steps such as a PES/CO blend can be produced without dyeing. It is also worth noting that fabrics produced using recycle fibers have a unique visual effect. The worn-out look can be particularly interesting in some product lines.

Keywords: *Polyester/cotton, dyeing, recycle, virgin fiber, visual effect*

PES/CO Kumaşlarda Geri Dönüşüm Yoluyla Boyama İşlemi Ortadan Kaldırılabilir mi?

Öz: Bilindiği gibi polyester/pamuk karışımlı kumaşların terbiye işlemleri çift boyama işlemi gerektirir. Bu nedenle su, enerji ve kimyasalların tüketimi ve açığa çıkan atıklar oldukça fazladır. Bu çalışma kapsamında, pamuk bileşeninde virjin elyaf veya geri dönüştürülmüş elyaf kullanılarak üretilen belirli bir renkteki PES/CO karışımlı bir kumaşın iplik ve kumaş performans özelliklerinin karşılaştırılması amaçlanmaktadır. Yapılan çalışmalar ışığında PES/CO karışımlı kumaş üretiminde virjin elyafın yanı sıra geri dönüşüm pamuğunun da kullanılabileceği, renk ve haslık açısından herhangi bir sorun olmamasına rağmen geri dönüşüm elyaftan üretilen kumaşın genel görünüm ve fiziksel-teknolojik özellikler açısından %100 virjin elyaftan üretilen kumaşın sağladığı standartları karşılayamayacağı söylenebilir. Bunun ötesinde, renk gamı da sınırlı olacaktır. Bununla birlikte, geri dönüştürülmüş elyaf kullanılması durumunda hem bir atığın geri dönüştürülmesi hem de PES/CO karışımı gibi çok fazla işlem adımı gerektiren bir kumaşın boyama yapılmadan üretilebilmesi nedeniyle önemli çevresel faydaların elde edileceği düşünülmektedir. Geri dönüşüm lifleri kullanılarak üretilen kumaşların kendine özgü bir görsel etkiye sahip olduğunu da belirtmekte fayda vardır. Bazı ürün gruplarında yıpranmış görünüm özellikle ilgi çekici olabilir.

Anahtar kelimeler: *Boyama, Geri dönüşüm, Görsel efekt, Polyester/pamuk, Virjin elyaf.*

1. Introduction

Blends refers to the population possibilities that can be formed by many fiber polymers that differ in their physical or chemical properties [1]. Blends may be needed for a variety of reasons. Blends have become a key word to meet the increasing demands of consumers in order to optimize the clothing comfort and at the same time to bring innovative

* Corresponding author
E-mail adresi: ratav@nku.edu.tr (R. Atav)

trends to the fashion industry. Blends of ester fibres with cotton or viscose are produced in greater quantity. Factors contributing to this situation have been the relative ease of processing, effective clearing and versatility of application, leading to a wide range of dyed and finished effects. Polyester/cellulosic yarns are used in sewing threads and slub effects for apparel [2].

Sustainability is one of the most up-to-date terms in the world, which consists of three aspects: environment, economy and society. With the emergence, acceptance and obsolescence of fast fashion, textile waste is rising to unprecedented levels at extraordinary speeds. On the other hand, textile wastes can be raw materials for the development of high value-added products with an appropriate recycling methodology. Textile waste management systems are currently going through a crucial phase aimed at producing value-added products with various recycling concepts and methods [3].

Inoue and Yamamoto (2004) investigated the performance and durability of woven fabrics containing recycled polyester fiber in their study. First, forty-eight commercially available fabrics containing polyester fibers made from PET bottles were collected and their mechanical, surface and thermal/moisture/air transport properties were measured with the KES-F system to clarify performance. In addition, the performances of the fabrics were tested after repeated washings. It was determined that the bending stiffness and shear strength values tended to increase with the increase in the recycled polyester fiber ratio [4].

Kurtoglu et al. (2013) investigated the usability of recycled clothing produced by evaluating fabric residues in their study. Ne 28 50% recycled cotton - 50% polyester yarns were produced from fabric scraps of a clothing company and compared with Ne 28 50% cotton - 50% polyester yarns. Single jersey fabrics were knitted with these yarns and garments were sewn with these fabrics under the same production conditions. The physical properties of yarns, fabrics and clothing were compared with products made from virgin fibers. Test results showed no significant difference between recycled and virgin clothing grades. As a result of this study, it was stated that recycled clothes obtained from fabric residues can be used in the garment manufacturing industry [5].

Telli and Özdil (2015) investigated the usability of recycled PET fibers in the apparel industry in their study. The burst strength, abrasion resistance, air permeability, surface friction, circular bending stiffness and dimensional stability properties of knitted fabrics made from recycled PET and blends of PET and cotton fiber were compared. It has been determined that while producing the fabric, recycled PET fibers can be blended in certain amounts instead of PET without sacrificing fabric performance [6].

Yuksekkaya et al. (2016) compared some properties of yarns and fabrics produced from virgin and recycled polyester and cotton fibers. Virgin cotton, recycled cotton, virgin polyester, recycled polyester fiber and blends of these fibers were used to produce OE (rotor) yarns. Single jersey fabrics were knitted from these yarns. The physical properties of yarns and fabrics such as strength, evenness, yarn evenness, bursting strength, pilling and kinetic friction coefficient were measured and compared statistically. Although, in general, the properties of yarns and fabrics produced from virgin fibers are better than those produced from recycled fibers, it was emphasized in this study that it is possible to produce textiles of optimum quality [7].

In the light of this information, it can be said that there are a limited number of studies in the literature on the use of both cotton and polyester and the mixture of these two fibers in the production of recycled fabrics and the comparison of the performance properties of the recycled fabric with the virgin fabric. However, in none of these studies, the environmental and economic benefits of using recycled fiber in the production of colored fabrics have not been examined, since dyeing is not required if the equivalent of the colored recycled fabrics produced from virgin fiber are produced. Therefore, it can be said that this study will make an original contribution to the literature.

As it is known, finishing processes of polyester/cotton blended fabrics require a double dyeing process. Therefore, the consumption of water, energy and chemicals and the waste it generates are quite high. Within the scope of this study, it is aimed to compare the yarn and fabric performance properties of a PES/CO blended fabric of a certain color, produced by using virgin fiber or recycled fiber in its CO component. Beyond the comparison of product performance characteristics between producing a fabric from virgin fiber and recycled fiber, it is also aimed to reveal the environmental effects of this production route.

2. Material and Methods

While producing 70/30 PES/CO blend fabric, 70 cotton part was produced by using 42% Recycle / 28% virgin cotton. Flament PES was used as the core yarn in the middle. Colored fabric production was carried out using colored fibers directly. Beyond that, fabric was produced using 70% virgin undyed cotton and 30% undyed PES filament, and then dyed in fabric form by two-bath method. Then, Martindale pilling (TS EN ISO 12945-2 (ISO 2021), bursting strength (ISO 13938-2 (ISO 2019)), fastness (washing ISO-105 C06 (ISO 2010), dry and wet rubbing (ISO 105-X12 (ISO 2016)), water (ISO 105-E01 (ISO 2013), alkaline and acidic perspiration (ISO 105-E04 (ISO 2013)), saliva fastness (GB/T 1886-2009)) tests were performed on all fabric samples. Furthermore, Datacolor 850 spectrophotometer (D 65/10°) was used to determine the reflectance (R%) values of samples. Then color yield (K/S) values were calculated by using the Kubelka-Munk equation;

$$\boldsymbol{K/S} = \boldsymbol{(1-R)^2/2R} \quad (1)$$

R: Reflection value at maximum absorption wavelength
K: Absorption coefficient
S: Scattering coefficient

3. Results and Discussion

USTER test values of the produced yarns are given in Table 1.

Table 1 USTER test values of the yarns

Fiber Content	22/1 70% Virgin Cotton / 30% Virgin Polyester Flament	22/1 28% Virgin Cotton / %42 Recycled Cotton / 30% Virgin Polyester Flament
Weight (g/m^2)	175	161
Um %	8.86	28.2
Thin Place (-50%)	0	4853
Thick Place (+50%)	14.2	5763
Neps (-200)	11.3	7607
Neps (+280)	3.8	3882
Hairness (H)	5.09	9.92
Tenacity (cN/tex)	17.3	9.7
Elasticity	6.61	192.7
Yarn Count (Ne)	21.5	21.9
Yarn Cv (Ne)	0.63	1.8
Twist T/m	706	890
Twist % Cv	2.82	4.25
Paraffin Mean [µ]	0.1	0.28
Humidity	7	6

When Table 1 is examined, the values such as thin place-thick place, hairiness and neps are quite good for 70/30 PES/CO blend yarn produced using virgin cotton, but these values deteriorate if recycle cotton is used. In addition, although the yarn twists were higher, the tenacity values were worse in the yarns containing recycle fiber. Looking at the yarn counts, it can be said that they have similar values.

The photos of fabrics produced are given in Figure 1. Color yield values of fabrics produced from virgin and recycle fiber were 16,24 and 21,79, respectively.

Figure 1. *Photos of fabric sample produced by using virgin and recycled fiber*

Washing, water, dry and wet rubbing, alkaline and acidic perspiration and saliva fastness test results (staining) of samples are given in Table 2-4. Color change values for each fastness tests were found to be 4/5 for both fabric types.

Table 2 Washing and water fastness test values of fabrics produced from recycled and virgin cotton fibers

	Washing Fastness						Water Fastness					
	WO	PAC	PES	PA	CO	CA	WO	PAC	PES	PA	CO	CA
70% Virgin Cotton / 30% Virgin Polyester Flament	4/5	4/5	4/5	3	4	4	4/5	4/5	4/5	4/5	4/5	4/5
28% Virgin Cotton / %42 Recycled Cotton / 30% Virgin Polyester Flament	4/5	4/5	4/5	3	4	4	4/5	4/5	4/5	4/5	4/5	4/5

Table 3 Alkali and acidic perspiration fastness test values of fabrics produced from recycled and virgin cotton fibers

	Acidic Perspiration Fastness						Alkaline Perspiration Fastness					
	WO	PAC	PES	PA	CO	CA	WO	PAC	PES	PA	CO	CA
70% Virgin Cotton / 30% Virgin Polyester Flament	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5
28% Virgin Cotton / %42 Recycled Cotton / 30% Virgin Polyester Flament	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5

Table 4 Saliva and rubbing fastness test values of fabrics produced from recycled and virgin cotton fibers

	Saliva Fastness						Rubbing Fastness	
	WO	PAC	PES	PA	CO	CA	Dry	Wet
70% Virgin Cotton / 30% Virgin Polyester Flament	4/5	4/5	4/5	4/5	4/5	4/5	4/5	3
28% Virgin Cotton / %42 Recycled Cotton / 30% Virgin Polyester Flament	4/5	4/5	4/5	4/5	4/5	4/5	4	3

When the tables are examined, it can be said that all the fastness values of the fabric containing only virgin cotton and the fabrics containing recycled cotton are at very good levels and there is no significant difference between them.

Fabric samples were also tested for bursting strength and results are given in Table 5.

Table 5 Bursting strength values of fabrics produced from recycled and virgin cotton fibers

	Bursting Strength		
	KPA	mm	Sec.
70% Virgin Cotton / 30% Virgin Polyester Flament	180.26	29.86	15
28% Virgin Cotton / %42 Recycled Cotton / 30% Virgin Polyester Flament	158.4	32	22.2

However, the bursting strength of the fabrics were lower in those using recycled fiber. In addition, fabric handles were also compared with the subjective method, and it can be said that the handle is well balanced with the finishing processes and a performance similar, but not equal, to the fabric produced from virgin fiber can be achieved.

Cost analyzes of the fabrics (70% Cotton / 30% Polyester) produced were also made and the results are given in Table 6.

Table 6 Cost comparison of fabrics produced from recycled and virgin cotton fiber

	Cost change in case of recycled cotton usage instead of virgin cotton
Cotton (Virgin/Recycled) ($/kg)	-%15
Polyester ($/kg)	0
Yarn ($/kg)	+%25
Knitting ($/kg)	+%10
Dyeing/Washing ($/kg)	-%70
Finishing ($/kg)	0
Total ($/kg)	-%10

When Table 6 is examined, the first thing that draws attention is that the production costs of fabrics containing recycled fiber are similar (even lower) to the case of using 100% virgin fiber. Although there seems to be something wrong at first glance, the reason for this is that the PES fiber to be used with it must be supplied in colored form in order for the dyed cotton fiber from the recycling to be used in the production of recycle fabric. The high price of colored PES fiber leads to the high price of fabrics using recycled cotton. However, if undyed recycled cotton fiber is used directly, the cost of fabric will significantly be reduced since it will be possible to use undyed PES filament together with it.

4. Conclusion

In the light of the studies, it can be said that during the production of PES/CO blend fabric, recycle cotton can be used as well as virgin fiber, and although there won't be problem in terms of color and fastness, the fabric produced cannot meet the standards provided by the fabric produced from 100% virgin fiber in terms of general appearance and physical-technological properties. Beyond that, the color gamut will also be limited. However, in the case of using recycled fiber, it is thought that significant environmental benefits will be achieved, both because a waste is recycled and a fabric that requires too many processing steps such as a PES/CO blend can be produced without dyeing. Because the fabric produced from PES/CO blended virgin fiber needs to consume 10 baths such as pretreatment, PES dyeing, reducing washing, rinsing, cotton dyeing, 4-5 washing steps. The use of recycle fiber will provide a serious advantage by eliminating all these steps. It is also worth noting that fabrics produced using recycle fibers have a unique visual effect. The worn-out look can be particularly interesting in some product lines.

In future studies, it will be useful to work on determining the ideal blend ratio that will allow production without negatively affecting the general yarn and fabric properties by reducing the amount of recycle cotton used in the yarn production stage.

Author Contribution

Data curation - Rıza ATAV (RA), Selma Soysal (SS), Fatma Yıldız (FY); Formal analysis - RA, SS, FY; investigation - RA, SS, FY; Experimental Performance - SS; Data Collection - RA, SS; Processing - RA, SS; Literature review - RA, SS; Writing - RA, SS; Review and editing - RA, SS.

Declaration of Competing Interest

The authors declared no conflicts of interest with respect to the research, authorship, and/or publication of this article.

Kaynaklar

[1] Aniş, P., & Eren, H.A. (2003). Poliester/Pamuk Karışımlarının Boyanması: Uygulamalar ve Yeni Yaklaşımlar. *Uludağ Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi*, 8(1): 131-139.

[2] Shore, J. (1998). Blends Dyeing. *Society of Dyers & Colourists,* 169.

[3] Vadicherla, T., & Saravanan, D. (2014). Textiles and Apparel Development Using Recycled and Reclaimed Fibers, Book Chapter in "Roadmap to Sustainable Textiles and Clothing", 139-160.

[4] Inoue, M., & Yamamoto, S. (2004). Performance and Durability of Woven Fabrics Including Recycled Polyester Fibers, *Journal of Textile Engineering*, 50.

[5] Kurtoğlu Necef, Ö., Seventekin, N., & Pamuk, M. (2013). A Study on Recycling the Fabric Scraps in Apparel Manufacturing Industry, *Journal of Textile & Apparel,* 23(3), 286-289.

[6] Telli, A., Özdil, N. (2015). Effect of Recycled PET Fibers on the Performance Properties of Knitted Fabrics, *Journal of Engineered Fibers and Fabrics,* 10(2), 47-60.

[7] Yuksekkaya, M. E., Celep, G., Dogan, G., Tercan, M., Urhan, B. (2016). A Comparative Study of Physical Properties of Yarns and Fabrics Produced from Virgin and Recycled Fibers, *Journal of Engineered Fibers and Fabrics,* 11(2), 68