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The effect of recycled fiber content on performance/quality properties of swimwear fabrics

Abstract

Due to the decrease in natural resources all over the world and the increase in global CO_2 emissions, which make the biggest contribution to global warming and climate change, the use of recycled materials has gained great importance in the textile industry, as in other application areas.

Reducing the use of new raw materials and producing products from old raw materials not only minimizes environmental impacts such as lower CO_2 emissions during the landfilling, reduced consumption of natural resources, reduced waste disposal, but also reduces costs and provides a longer product life. This study investigates the effect of recycled polyester fiber on the performance/quality properties of swimwear fabrics. Swimwear fabric samples were produced from 100% recycled polyester, 50% recycled polyester/50% polyamide, 100% polyester and 100% polyamide, and tested in terms of bursting strength, seam strength, abrasion resistance, air permeability and color fastness properties.

Keywords: swimwear, synthetic fibers, recycled fibers, recycled polyester

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Introduction

The textile industry is one of the main sources of greenhouse gas emissions, creating a carbon footprint at every stage of a textile product's life cycle. Recycling of textile waste and diversifying the content of recycled raw materials is one of the promising way to reduce the carbon footprint. The use of recycled materials has gained great importance in the textile industry as well as in other application areas due to the decrease in natural resources all over the world. The use of recycled fiber reduces the demand for virgin fibers, conserves natural resources, reduces waste, and carbon dioxide emission, promoting a circular economy.[1,2]

Synthetic textile waste takes a long time to decompose in nature, and the accumulation of waste posses a great dangerous to the ecosystem due to the generation of greenhouse gases, contributing to carbon emissions and environmental pollution. By 2050, textile production is expected to consume 300 million tonnes of fossil fuels and contribute 26% of carbon emissions.[2,3] Reducing use of new raw materials and turning these wastes into new products offer many benefits such as lower carbon dioxide emission during the landfilling, reduced natural resources consumption, reduced waste disposal, and longer product life.[4–11]

The two most common forms of recycled synthetics are recycled polyester and recycled polyamide. Polyamide, the first synthetic polymer introduced to the market, is commonly used in a wide range of applications from apparels, ropes, carpets, to technical textile applications. Polyamide fibers have excellent tensile strength, good elastic recovery, excellent abrasion resistance, and excellent resistance to most chemicals. Polyester fibers are hydrophobic and have a low moisture regain value of 0.4%. Polyester fibers are water repellent and quick drying due to its hydrophobicity. They have excellent tensile strength, resistance to stretching, excellent abrasion resistance and resistance to chemicals. They are easy care and wrinkle resistant.[12–14] Recycled polyester can be made from pre-consumer waste, such as waste from spinning of yarn or cutting of garments, or from post-consumer waste, such as plastic PET (polyethylene terephthalate) bottles, industrial fishing nets, or used garments. Recycled nylon can made from pre-consumer spinning or fabric waste or post-consumer industrial fishing nets. It was reported that recycled polyester reduces emissions by 32% and uses 59% less energy compared to virgin polyester. Recycled nylon reduces emissions by 26% and chemically regenerated nylon uses 60% less energy compared to virgin nylon.[4,5,14]

Since the recycling process requires a breaking down process, the quality of the recycled fiber varies depending on the fiber and the recycling process used. Replacing virgin fiber with recycled fiber may adversely affect the mechanical properties, performance/quality properties of the final product. In order to achieve the required material properties and performance, recycled fibers can be blended with virgin fibers.[5,6,14–16] Nowadays, some brands, such as Econyl, Repreve, Amni Soul Eco®, Batoko have focused on promoting the use of recycled synthetic fibers in swimwear design to reduce the environmental impact of synthetics.[16,17] In this study, the effect of recycled fiber content on the performance/quality properties of swimwear fabrics was investigated, with the aim of contributing to the circular economy. The performance/quality properties of swimwear fabrics produced from recycled fiber and recycled fiber/virgin fiber combination (100% recycled polyester and 50% recycled polyester/50% polyamide) were compared with those produced from virgin fiber (100%polyester and 100% polyamide). The fabric samples were tested in terms of bursting strength, abrasion resistance, seam strength, air permeability and color fastness properties.

Materials and methods

Materials

In this study, four different swimwear fabric samples were produced from virgin and recycled fiber compositions as presented in Table 1. All fabric samples have a warp knitted jersey structure with a unit weight of 180 gr/m^2.

Table 1 Technical properties of the fabrics used in this study

Sample codes	Fiber	Blend Ratio %	Yarn Count	Thickness (mm)	Fabric Construction	Fabric unit weight (g/m²)
100PA	Polyamide	100	44dtex/12F	0.6	Warp knitting /Jersey	180
100PES	Polyester	100	44dtex/12F	0.6	Warp knitting /Jersey	180
100rPES	Recycled Polyester	100	44dtex/12F	0.6	Warp knitting /Jersey	180
50rPES/50PA	Recycled Polyester/Polyamide	50/50	44dtex/12F	0.6	Warp knitting /Jersey	180

Performance tests

Bursting strength: Bursting strength of the samples were tested in accordance with the standard of TS 393 EN ISO 13938-1:2002.

Seam strength: Seam strength of the swimwear fabric samples was determined in accordance with ISO 13935-2:2014.

Abrasion resistance: Abrasion resistance of the swimwear fabric samples was tested under a known pressure fixed at 9 kPa, in accordance with the ISO standard EN ISO 12947-2:2016.

Air permeability test: Air permeability was measured according to ISO 9237:1995; the test pressure was 100 Pa on an area of 20 cm^2. Test was repeated 10 times and their average was calculated to obtain the mean air permeability of each sample.

Color fastness tests: Color fastness to washing, water, perspiration, rubbing and artificial day light were carried out according to the standard of ISO 105-C06:2010 (A2S), ISO 105-E01:2013, ISO 105-E04:2013, ISO 105-X12:2016, and ISO 105-B02:2014, respectively. Washing fastness was conducted using ECE Detergent-B phosphate and sodium perborate with 10 steel balls in Gyrowash device.

Color fastness to sea water and chlorinated water (swimming-pool water) were performed according to the standard of ISO 105-E02:2013 and ISO 105-E03:2010, respectively. Color fastness to chlorinated water was tested at 50 mg/L active chlorine concentration.

Results and discussion

The bursting strength of the fabric samples is shown in Figure 1. While 50rPES/50PA, 100rPES and 100PA fabric samples have almost similar bursting strength in the range of 151 kPa-156 kPa, the 100PES sample has the highest bursting strength of 166 kPa. Recycled polyester has lower bursting strength compared to virgin polyester, which could due to the its lower crystalline structure. The decrese in crystallinity may be explained by the process of remelting and reorganization of the polymer in the recycling process.[15]

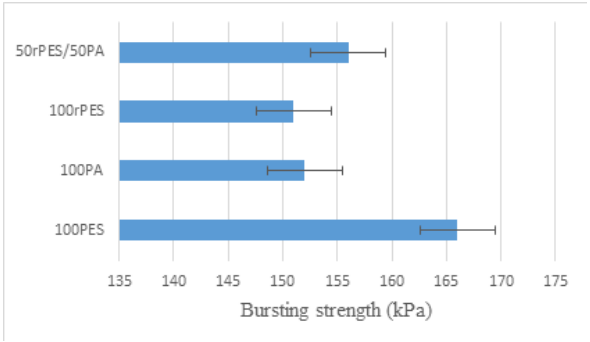

Figure 1 Bursting strength of swimwear fabric samples.

Seam strength and abrasion resistance

The seam strength of the samples is shown in Figure 2. Figure 2 shows that 50rPES/50PA, and 100PA have similar seam strength in both warp and weft directions, in the range of 30-32 kg. While the seam strength of the swimwear fabric produced from 100% recycled polyester (100rPES) in the weft direction decreases to 23 kg, the warp strength is similar to the fabrics produced with virgin fiber.

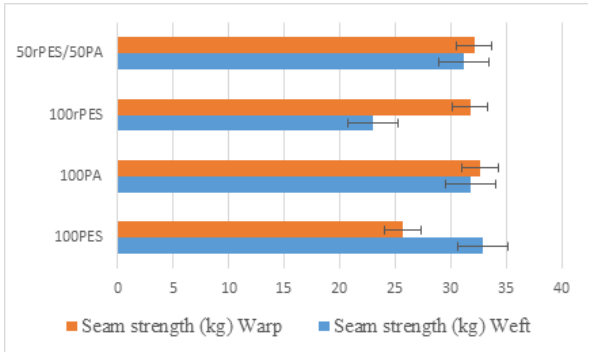

Figure 2 Seam strength of swimwear fabric samples.

The abrasion resistance of textile materials is an important feature that determines the lifespan of fabrics.[16] The abrasion resistance of the fabric samples was evaluated by the mass loss difference between the masses before and after abrasion cycles. It is observed that all swimwear fabric samples withstand 15,000 rubbing cycles without any damage.

Air permeability

Air permeability, the measure of air flow passed through a given area of a fabric, is related to porous structure of the fabric and greatly affects the thermal comfort properties of fabrics.[17]

As can be seen in Figure 3, fabric samples containing recycled fibers (50rPES/50PA and 100rPES) have higher air permeability than virgin ones, indicating that they are more breathable and therefore more comfortable to wear. Air permeability value increased with blending with recycled polyester. This may be because recycled fibers are more porous and have a looser structure, allowing air to pass through more easily.

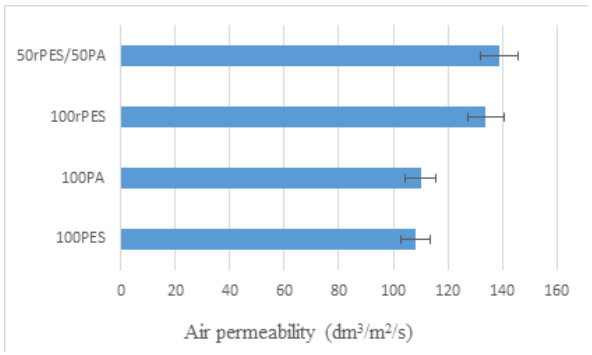

Figure 3 Air permeability of swimwear fabric samples.

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Color fastness results

Color fastness test results of each swimwear fabric samples (100PA, 100PES,100rPES, and 50rPES/50PA) are indicated in Tables 2–6. 100PA fabric sample has a poor color fastness to chlorinated water, with a gray scale rating of 1/2. The 50rPES-50PA sample also has a poor color fastness to chlorinated water, with a gray scale value of 2. The light fastness of the 50PES/50PA sample was found to be fairly good (3/4). Apart from these samples, all samples have good color fastness properties against washing, water, sea water, chlorinated water, acidic and alkaline perspiration, and rubbing with gray scale ratings of 4/5 and 4.

Table 2 Color fastness test results for swimwear fabric made of 100% PES

	Color change	Color staining					
Color fastness to		**Acetate**	**Cotton**	**Nylon**	**Polyester**	**Acrylic**	**Wool**
Washing	4/5	4	4/5	4	4/5	4/5	4/5
Water	4/5	4	4/5	4	4/5	4/5	4/5
Sea water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Chlorinated water	4	-	-	-	-	-	-
Acidic perspiration	4/5	4	4/5	4	4/5	4/5	4/5
Alkaline perspiration	4/5	4	4/5	4	4/5	4/5	4/5
Rubbing	Dry- 4/5	-	-	-	-	-	-
	Wet- 4/5						
Artificial light	3/4	-	-	-	-	-	-

Table 3 Color fastness test results for swimwear fabric made of 100PA

	Color change	Color staining					
Color fastness to		**Acetate**	**Cotton**	**Nylon**	**Polyester**	**Acrylic**	**Wool**
Washing	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Sea water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Chlorinated water	1/2	-	-	-	-	-	-
Acidic perspiration	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Alkaline perspiration	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Rubbing	Dry- 4/5	-	-	-	-	-	-
	Wet- 4/5						
Artificial light	4	-	-	-	-	-	-

Table 4 Color fastness test results for swimwear fabric made of 50PES/50PA

	Color change	Color staining					
Color fastness to		**Acetate**	**Cotton**	**Nylon**	**Polyester**	**Acrylic**	**Wool**
Washing	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Sea water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Chlorinated water	4	-	-	-	-	-	-
Acidic perspiration	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Alkaline perspiration	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Rubbing	Dry- 4/5	-	-	-	-	-	-
	Wet- 4/5						
Artificial light	3/4	-	-	-	-	-	-

Table 5 Color fastness test results for swimwear fabric made of 100rPES

	Color change	Color staining					
Color fastness to		**Acetate**	**Cotton**	**Nylon**	**Polyester**	**Acrylic**	**Wool**
Washing	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Sea water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Chlorinated water	4/5	-	-	-	-	-	-
Acidic perspiration	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Alkaline perspiration	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Rubbing	Dry- 4/5	-	-	-	-	-	-
	Wet- 4/5						
Artificial light	4	-	-	-	-	-	-

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Table 6 Color fastness test results for swimwear fabric made of 50rPES-50PA

	Color change	Color staining					
Color fastness to		**Acetate**	**Cotton**	**Nylon**	**Polyester**	**Acrylic**	**Wool**
Washing	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Sea water	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Chlorinated water	2	-	-	-	-	-	-
Acidic perspiration	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Alkaline perspiration	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Rubbing	Dry- 4/5	-	-	-	-	-	-
	Wet- 4/5						
Artificial light	4	-	-	-	-	-	-

Conclusion

This study investigates the performance properties swimwear fabric samples made of virgin fiber/recycled fber combinations in terms of bursting strength, abrasion resistance, seam strength, air permeability and color fastness properties. It is expected that the results obtained from this study will promote the use of recycled fiber or recycled fiber combination in swimwear fabric through circular economy approaches.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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