# A Comparative Study of Care Processes Effect on the Abrasion Resistance of some Virgin and Recycled Polyester Fabrics

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**Abstract:**
Polyethylene terephthalate (PET), which commonly referred to as 'polyester' in the textile industry, is considered one of the most important thermoplastic polyesters. It is widely used for various applications such as bottles, fibers, moldings, and sheets because of its excellent tensile and impact strength, clarity, process-ability, chemical resistance, and thermal stability. PET bottle wastes are separated from other wastes and then some processes are applied to obtain PET flakes. Recycled polyester fibers are produced by melt spinning method from these recycled PET flakes. In this research, usability of recycled PET fibers in textile industry was studied. A comparative investigation of fabric abrasion resistance property were done to fabrics produced from virgin and recycled polyester before and after care processes.

**Keywords:**
***Polyester Recycling***
***Care Processes***
***Textile Properties***
***Fabric Abrasion***

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## 1. Introduction

Most of fibrous waste is composed of natural and synthetic polymeric materials such as cotton, polyester, nylon, and polypropylene. The primary source of raw material for synthetic polymers is petroleum. Even for renewable natural polymers such as cotton, the production requires energy and chemicals that are based on non-renewable resources.

Although the global petroleum reserve may last at least more several hundred years ahead at the rate of current consumption, petroleum and other natural resources are non-renewable in practical terms. It is our responsibility to conserve resources for the benefit of future generations [1].

Increasing recovery of post consuming textile and apparel waste can create economic opportunity, and reduce environmental contamination impact. As part of paving the way for the recapture and recycling of textiles, policy makers must create an environment that allows for the easy disposal and free-flow of all recyclable materials, including textiles [2].

**Polyester Recycling**

PET is an ideal material for recycling. It can be reprocessed multiple times and the source material is available in large quantities, mostly as a 'mono-material'. The main focus today is on PET bottles which are collected in dedicated collection systems or separated from other waste streams [3].

PET goods such as fibers and bottles have become a major part of human life, and their production and consumption have increased continuously. PET, unlike natural polymers, is a non-degradable polymer in the natural environment, leading to environmental pollution when it is discarded after use. Procedures to enable biological degradation of PET are both complicated and expensive and become an important social issue because of PET's increasing consumption and non-biodegradability.

PET waste management with up-cycling concept has utilization of PET results in waste management difficulties. Landfill of PET is undesirable because of space limitations and ground pollution. Incineration is also non-preferred option, because of the inevitable emission of toxic gases that are generated from the decomposition of PET molecular chains [4].

PET bottles are collected at communities and then baled and brought to a processing facility, where they are sorted by type (PET, HDPE, LDPE, etc.) and color. The PET bottles are then stripped of their labels and caps and washed multiple times to remove any adhesives and other possible contaminants next, the bottles are crushed and chopped into flakes.

The small flakes are fed into an extruder, filtered, and spun through spinnerets to produce recycled PET fibers. The fiber is crimped, cut, drawn, and stretched into required lengths for baling. Baled fiber can be processed into fabric for a variety of textile products [5].

It is obvious that virgin polyester will present better fabric performance properties than the recycled, so our concern in this research is to find out how much is this difference regarding the low price of the recycled material.

**Textile Properties**

Textile materials deteriorate, during their useful life, by being subjected to the effects of many degradative mechanisms. Sunlight, weathering, laundering or dry-cleaning treatments, abrasion, perspiration, and other such unavoidable sources of fiber damage all exert their toll on physical or chemical properties to cause changes that can limit useful fabric life.

Physical changes may occur in the dimensions, tensile, tearing, or bursting strength, stiffness or elasticity, abrasion-resistance, and color of a cloth. In addition it involving the permeability to air, water, moisture vapor, and gas, or the resistance to heat, flame, and electrical current can occur. All of these changes are potentially important in determining whether a fabric can continue to lead a useful life.

Properties of textile products include all its physical, mechanical and surface appearance and the advantages and disadvantages, that will influence its use and determine its suitability for a given purposes. Fabrics are exposed to different forms of deformations as a result of stress during use, which may change or affect its appearance and properties.A fabric may be affected by one or more than one type of stress.

**Fabric Abrasion**

Abrasion resistance is one of the most important mechanical properties that affect fabric appearance during and after use. When a fabric surface is subjected to abrasion by another surface, friction is existed. With continuous rubbing the result is a gradual removal of fibers from the yarn surface which may lead to fabric wear. It is important for fabrics to resist abrasion in some uses to keep a durable fabric and to avoid deterioration.

Abrasion resistance is dependent on several factors such as the fiber type and properties, yarn structure, fabric construction and type and amount of finishing material present. Abrasion can be found in three types: flat or plane, edge and flex.

In flat abrasion, a flat part of the material is abraded, edge abrasion occurs at folds and flex abrasion rubbing is accompanied by flexing and bending.

The selection of suitable yarn and fabric structure can therefore provide high abrasion resistance [6].

**Care of Fabrics**

The maintenance of a textile product after purchase is of prime interest to the consumer. There are number of processes are applied to textile products during continuing use, such as soil removal, laundering, dry cleaning, ironing and storing. Care also depends on dyes, fabrication, Finish, product construction, other materials present in the product, type of soil, extent of soiling.

Laundering is the most common means of cleaning textiles. Laundering depends on the kind, amount and temperature of water, soaps, laundry aids and detergents. The hardness of water, turbidity, color, dissolved salts and metals may also affect laundering. Whenever and however domestic washing is done, wither it is on a river bank, in a sink, bowl or bucket, or in an automatic washing machine, the principles of the process are the same.

Fabrics are saturated with water and agitated or beaten in the presence of products which are designed to aid wetting, and the breakdown and removal of soils. Water is used as the solvent in washing because it is cheap, readily available, nontoxic, and requires no special equipment. Water's ability to dissolve a wide variety of substances makes it an effective cleaning agent for a large percentage of soils. Most substances are more soluble in water than in any other solvent After squeezing out dirty water, rinsing in clean water (usually several times) and finally squeezing out as much water as possible, the fabrics are dried. Usually at least some of the dry fabrics are finished by pressing or ironing.

Ironing is a treatment used to provide more elegance to clothing. Using pressure and steam at precise temperature, the crumpled zones are removed from the fabrics. This treatment provides a better arrangement of yarns on fabric and improvement of its quality. Ironing or pressing are processes carried out on a textile fabric or garment to eliminate undesirable wrinkles and to restore its shape and appearance by applying mechanical pressure with heat, either in dry state or in the presence of steam.

In industry, there are three general pressing operations, via under pressing of garment during making up, molding to give a three dimensional shape and top-pressing to finish the fully assembled item. The ironing temperature depends to a large extent on the type of fiber, its thermal properties and on the construction of fabric or garment. The safe ironing temperature of a fabric is determined by the softening and/or decomposition temperature of the fiber and must be significantly below this temperature.

Although the repeating of care processes has a positive side in keeping the textile product in a good appearance and good conditions, it has sometimes a negative side, results from using washing detergents as a chemical agent, and also from the application of beating and agitation during washing, which has a negative effect on fabric performance properties.

## 2. Experimental

**Fabric Production**

Four different fabric structures were employed, they are:

- Plain 1/1.
- Canvas 2/2.
- Twill 3/1 (Stripes – Squares).
- Satin 5 (Stripes – Squares).

All fabrics were manufactured with the same number of warp threads which was 36 ends per cm, and the same number of picks which was 17 picks per cm.

Two different types of polyester yarns were used, (virgin and recycled) to produce two fabric groups, the first group was with virgin polyester yarns for warp threads and virgin polyester yarns for wefts. For the second group warp threads were of virgin polyester yarns, while wefts were of recycled polyester.

**Yarn Specifications:**

300/1 Denier (17.7 Ne) was used for warp yarns (virgin polyester yarns).

20/1 Ne was used for weft yarns (virgin and recycled polyester yarns).

**Table (1): Weft yarn specifications**

| Yarn | Twist Factor | Elongation % | Tensile Strength K.gm |
|---|---|---|---|
| virgin polyester | 4 | 12.7 | 25.2 |
| recycled polyester | 4.1 | 16.5 | 19 |

**Care Processes:** (Washing, drying, and Ironing):

Washing cycles were performed by using a home washing machine, with 100ml of liquid laundry detergent (Tide) for each washing process.

The washing machine was with the following specifications:

Capacity: 6 kg.

Speed: 700 rpm.

Program Period: 55 minutes.

Water Temperature: 30°C.

Samples were dried by hanging in open air.

Ironing was done by using home iron at a temperature of 148°C (polyester ironing temperature).

**Fabric Testing:**

Fabric abrasion resistance test was carried out by a Martindale Abrasion and Pilling Tester (with 4 Heads), Model: MD-04.

This apparatus is designed to give a controlled amount of abrasion between fabric surfaces at known pressures in continuously changing directions. The circular fabric specimen under test is abraded against a standard fabric surface. Resistance to abrasion is estimated by the amount of loss in mass of the specimen.

The test was carried out according to the standard method ISO 12947-2(1998) [7].

## 3. Results and Discussion:

Test results as the percentage of the weight loss was calculated and graphs were plotted for all specimens of the two fabric groups.

Table (2) and figures from (1) to (6) represent the relationships between repeated care processes and fabric abrasion resistance of produced fabrics.

**Table (2): the effect of repeated care processes on fabric abrasion resistance**

| Fabric structure | Polyester type | Before care processes | After 5 care process cycles | After 10 care process cycles | After 15 care process cycles |
|---|---|---|---|---|---|
| | | **(Weight loss %)** | | | |
| **Plain 1/1** | **Virgin** | 0.80 | 0.38 | 0.32 | 0.13 |
| | **Recycled** | 1.07 | 0.45 | 0.38 | 0.23 |
| **Canvas 2/2** | **Virgin** | 1.40 | 1.14 | 0.88 | 0.79 |
| | **Recycled** | 1.66 | 1.35 | 0.96 | 0.86 |
| **Twill 3/1 Stripes** | **Virgin** | 1.69 | 1.25 | 1.12 | 0.38 |
| | **Recycled** | 1.96 | 1.39 | 1.25 | 0.78 |
| **Twill 3/1 squares** | **Virgin** | 1.20 | 0.48 | 0.37 | 0.30 |
| | **Recycled** | 1.48 | 0.55 | 0.42 | 0.35 |
| **Satin 5 Stripes** | **Virgin** | 2.02 | 1.39 | 1.24 | 1.17 |

| | | | | | |
|---|---|---|---|---|---|
| | **Recycled** | 2.29 | 1.60 | 1.31 | 1.30 |
| **Satin 5 squares** | **Virgin** | 1.90 | 1.70 | 1.44 | 1.06 |
| | **Recycled** | 2.20 | 1.80 | 1.70 | 1.14 |

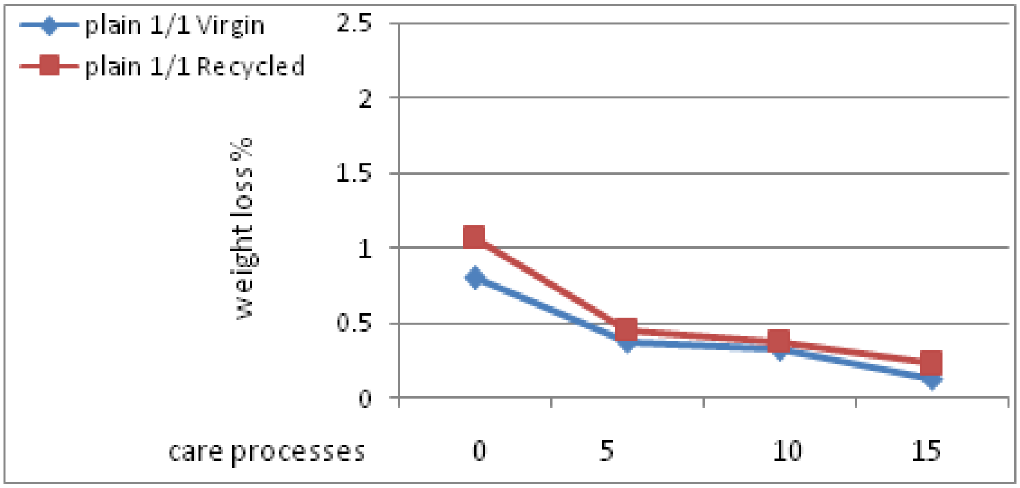


**Figure (1): the relationship between repeated care processes and fabric abrasion resistance for plain weave 1/1**

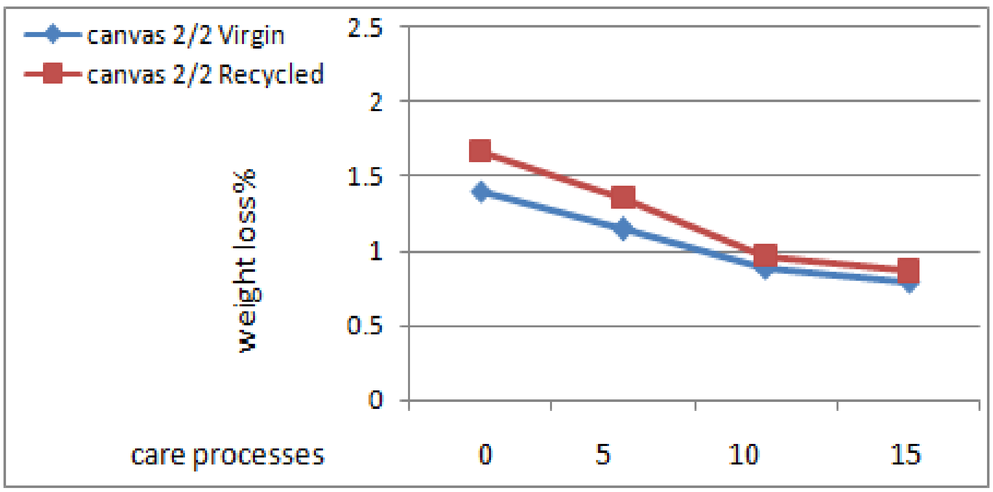


**Figure (2): the relationship between repeated care processes and fabric abrasion resistance for canvas 2/2**

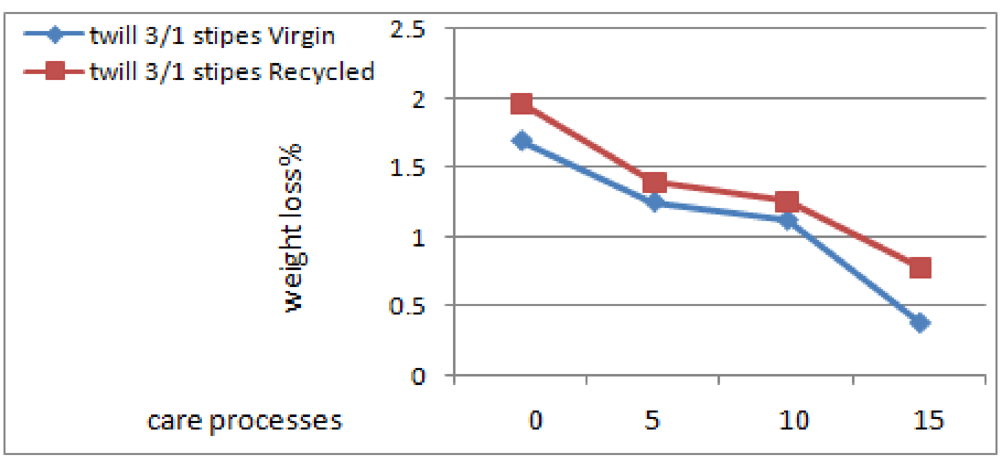


**Figure (3): the relationship between repeated care processes and fabric abrasion resistance for twill 3/1 stripes**

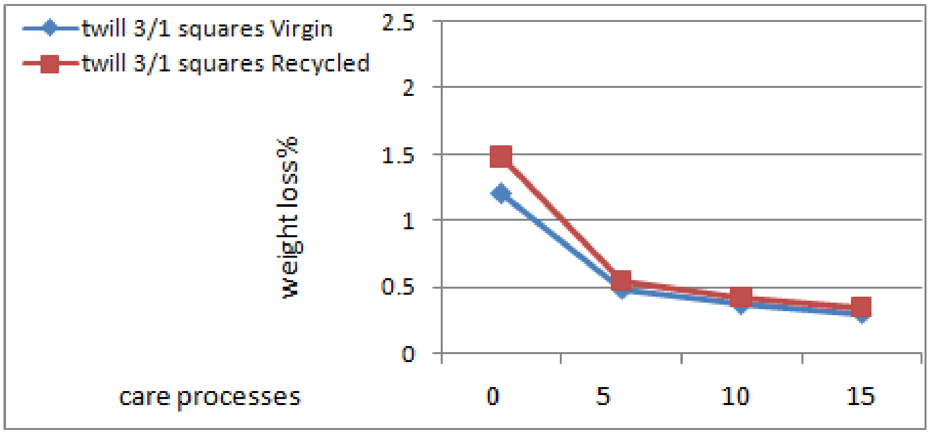


**Figure (4): the relationship between repeated care processes and fabric abrasion resistance for twill 3/1 squares**

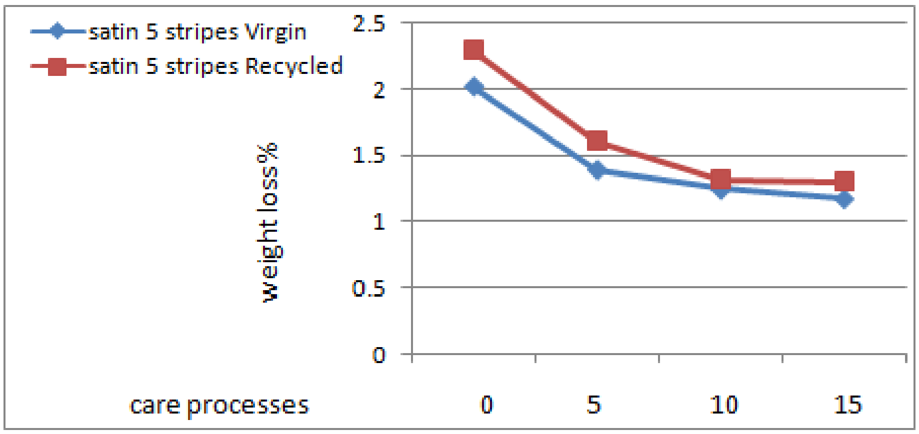


**Figure (5): the relationship between repeated care processes and fabric abrasion resistance for satin 5 stripes**

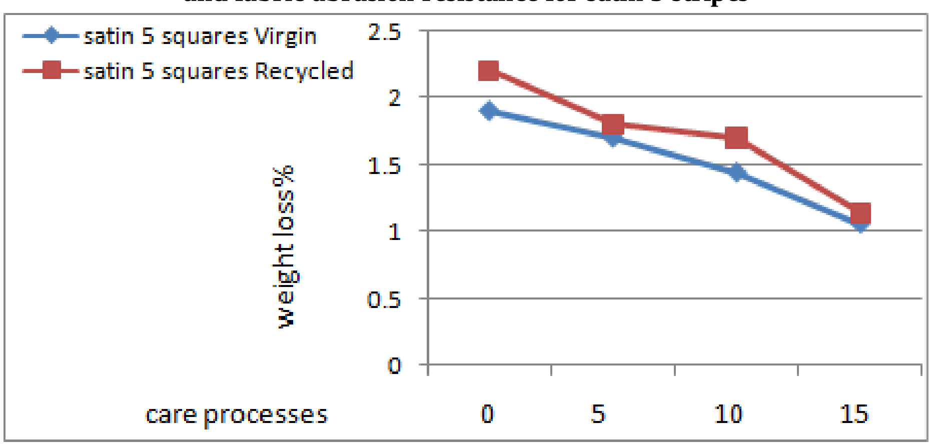


**Figure (6): the relationship between repeated care processes and fabric abrasion resistance for satin 5 squares**

From Table (2) and the above figures it is clear that the applied care processes affect fabric abrasion, as with more cycles there is a decrease in weight loss, this means that with more cycles there is an increase in fabric abrasion resistance. This is probably a result of loosening much of short fibers from the fabric surface during the early stage of cycling, and also may be a result of fabric shrinkage with more cycles which results in more compact structure, which become more resistant to abrasion action.

It also can be seen that generally fabrics with virgin polyester yarns represent a bit slight more resistance to abrasion than fabrics with recycled polyester wefts, but indeed the difference is not significant, this indicates that recycled polyester yarns could be used as an alternative to the virgin polyester yarns, benefiting from the low price of the recycled material.

## Conclusion:

The effect of care processes on abrasion resistance of both groups was almost similar, this leads to the approaching of using recycled polyester from used bottles as textile yarns and an alternative to the virgin polyester yarns.

Recycled polyester fibers could be blended with another raw material (virgin polyester or cotton) without noticeable changes in fabrics quality.

Recycled polyester fibers have lower price by 35%off, compared to virgin polyester so it is recommended to use the recycled polyester in some textile products benefiting from the low cost advantage and being ecologically friendly.

## References

**[1] Youjiang Wang**, "Recycling in textiles" Woodhead Publishing Limited, England, 2006.

**[2] Autumn S. Newell**, "Textile Waste Resource Recovery" M.Art, Thesis, Faculty of the Graduate School, Cornell University, August 2015.

**[3] John Scheirs,** "Modern Polyesters: Chemistry and Technology of Polyesters and Copolyesters", John Wiley & Sons Ltd, England, 2003.

**[4] Sang Ho Park, and Seong Hun Kim,** "Poly (ethylene terephthalate) recycling for high value added textiles", Fashion and Textiles journal, 2014.

[5] **Raj SHAH,** "Turning PET to Textiles" International fiber journal, February 2013.

[6] **Rose Sinclair,** "Textiles and Fashion" Woodhead Publishing Limited, United Kingdom, 2015.

[7] **ISO** 12947 – 2(1998), "standard test method for Fabric Abrasion Resistance".