Application of silicon based nano emulsion on single jersey knitted fabrics to improve their Comfort

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Abstract- Nano-emulsions are one type of finishing chemical used in the textile industry to modify textile morphology, either physically or chemically. In this research study 10 different Single jersey knitted fabrics(treated and untreated) having different raw materials, with same linear density of 20 tex, 0.29mm stitch length and 150 GSM are used. Air permeability, Overall moisture management capability (OMMC) and Fabric touch Tester (FTT) values were measured for all given samples. After application of silicone base nano emulsion Overall air permeability values decreases, OMMC values improved and no significant effect was found on FTT values, however this trend was different for different raw materials as well.

Index Terms- Nano-emulsions 150 GSM, Air permeability Overall moisture management capability (OMMC),Fabric touch Tester (FTT),

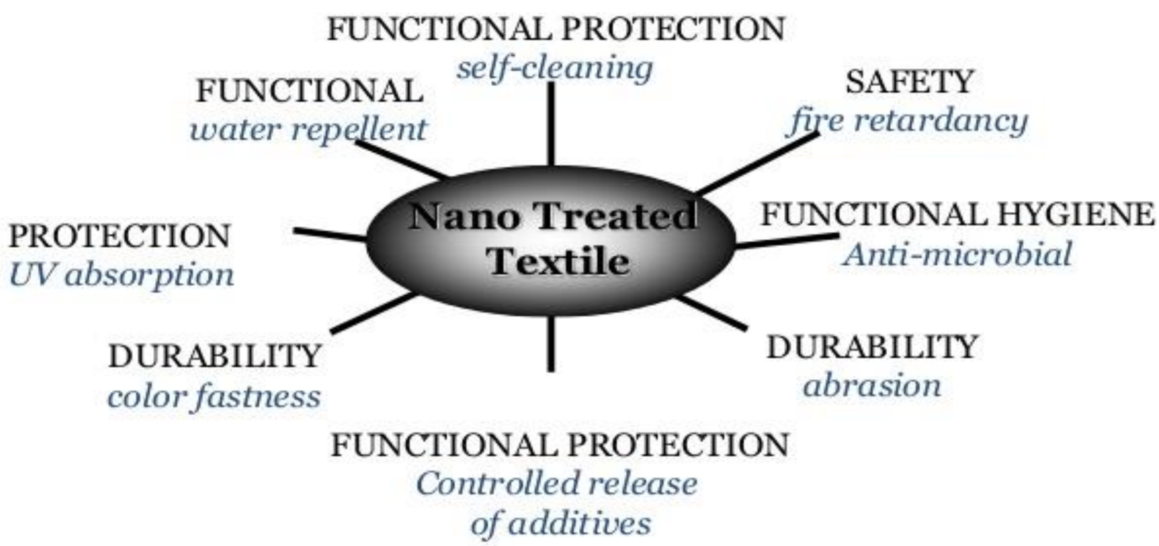
I. Introduction

Nano- materials and Nano technology is used tremendously in almost all fields of science and technology. In textile sector it has many uses and applications for achieving different functional aspects of clothing. Textile-based Nano products are available in different forms including Nano-composites, Nano-fibers, Nano softeners and finishes, Nano emulsion etc. which are being used in conventional textile as well as functional and intelligent textiles. Nano technology is considered as the best approach to enhance the performance of functional textiles.

The phenomenon of Nano technology is based on the fact that, very less size up to 100 nm 'leads to a tremendous increase in surface area and high exposure of surface atoms resulting unexceptional physical properties. [1] The properties of Nano crystalline materials highly depends upon the grain size, shape, distribution of Nano particles on the material, duration of application, temperatures as well as surface conditions. By changing in the above factors, performance properties of given material can be varied. [2, 3] Nano technology has vast area of applications including electronics, bio-medical, advance materials, environmental protection and textiles as well

While discussing about the textiles, the research is mainly focused on generating the Nano structures during manufacturing and finishing process for achieving different properties like water repellency, oil and dust repellency, flame ret ardency, improve comfort level, high moisture management and improve dye ability properties of textiles. [4] Starting from nano fibers to Nano structure formation and Nano embedded garments the Nano technology is widely used in smart and intelligent textiles. [5] Nano technology plays a vital role in the field of textile fashion and industry. They have a lot of applications in scent-embedded textiles, stay-clean textiles, textiles with displays and textiles that can change color to bulletproof lightweight textiles.

Textile Applications of Nano Technology...



Due to Nano-technology, textile finishing has become more even and precise. Nano finishing or application of Nano particles at the finishing stage is classified into two main categories i.e. by use of Nano particles in conventional finishing stage and the 2nd one is to use a finishing composition that can develop Nano structures on the surface of the fabric. Most of the Nano-finishes are in the form of Nano-emulsions or Nano sols. Oil and water repellent Nano finishes, super hydrophobic Nano finishes, Photo catalytic self-cleaning Nano finishes, Hydrophilic Nano finishes, Antibacterial Nano finishes, UV protective Nano finishes and Antistatic Nano finishes are some major types of Nano finishes for different applications.

Emulsion with mean droplet diameter ranges from 50 to 1000 nm is known as Nano-emulsion. Usually the droplet size in Nano-emulsion is 50-500nm which much smaller than conventional emulsions. The study of basic and applied aspects of Nano-emulsions is receiving increasing attention in recent years. As compared to conventional emulsions, Nano-emulsion has high level of technological applications due to its small droplet size, high kinetic stability and optical transparency. These Nano-emulsions can be obtained by self-emulsifying method, phase inversion composition method or by the phase inversion temperature method. Due to limitations in stability these emulsions are prepared just before their use. [6]

RUCO-NANOFIN ISN: a cationic, Nano polymeric siloxane compound is used as a Nano emulsion in my research study, which is applied on different single jersey knitted fabric having different combination of raw materials as well. Polysiloxanes compound has many applications in the field of drug delivery systems, personal care products, and packaging materials. [7, 8, 9] This is because the Polysiloxanes compound has good thermal stability, good air permeability and biocompatibility, very good PH stability as well as a distinct soft handle. [10, 11]

Polysiloxanes compounds can be prepared by ring opening polymerization (ROP) of cyclosiloxanes using acidic or basic catalysts. A wide range of cationic, anionic or non ionic surfactants can be used to develop emulsion polymerization of siloxanes. In this research study cationic surfactants are used. [12] Nano technology is also important for improving the clothing comfort; it may improve the fabric touch and handle, overall moisture management capability (OMMC) and the air permeability value of the fabric. To check the effect of Nano technology on fabric touch, air permeability and overall moisture management capability is the part of my study. All above properties have great impact on fabric comfort level. It is agreed that, transfer of heat, air and moisture from the cloth is very important feature of clothing. Therefore, the fabrics worn very next to the skin must have better moisture management properties. [13]

Air permeability is defined as the volume of air in milliliters which is passed in one second through100mm2 of the fabric at a pressure difference of 10mm head of water. The air permeability of a fabric is a measure of how well it allows the passage of air through it. (Tokarska, M., 2008), studied about the air permeability and said that it is often used to evaluate and compare the “breathability” of different knitted fabrics (coated and uncoated) for end use such as raincoats, tents, and uniform shirting’s, apparels, clothing and garments. Also, it helps in evaluating the performance of parachutes sails, vacuum cleaners, air bags, sail cloth, and industrial filter fabrics. [14]

(Bedek, G. et al., 2011) also studied about the water vapor permeability of different knitted fabrics, produced from cotton, polyester, polyamide and determined water vapor permeability rate, drying time, water vapor resistance and moisture management properties of the fabrics. They concluded that, polyamide is a fiber where water transmission is easy and fast and which has highest moisture management property. [15]
(Patnaik, A. et al., 2006) studied about the moisture transport and said that, the transportation of liquid moisture through fabric or within the fabric is a complex phenomenon, but it is very important for textile dyeing and finishing process as well as for fabric comfort.[16]

(Zhou, L. et al., 2007) Studied about the moisture management property and determined that wool/ cotton blended fabrics have overall better moisture management properties then all other types of fabrics where they have also examined that the liquid transport properties of pure wool, wool/polyester and wool/cotton-blended knitted fabrics, which have different weave types.[17]

The subjective sensation felt by the skin, when the textile fabric is touched with the figure tips and gently compressed is known as fabric hand. Silicon finishes are widely recognized as the best materials for increasing the softness of the fabrics, enhancing their aesthetic feel and imparting excellent hand. [18], while discussing about the nano technology and its impact on the fabric softness, nano emulsion softeners cove the fibers, reduce the fiber friction and increase the mobility results in better softness.

During conventional textile processing techniques, such as finishing, coating and dyeing, nano particles enhances the product performance physically and mechanically. New coating techniques like sol-gel, layer-by-layer, plasma polymerization etc. can develop multi-functionality, intelligence, excellent durability and weather resistance to fabrics. The present paper mainly focus on the development of silicon based nano-emulsion on different single jersey knitted fabrics having different raw materials including polyester 100%, Cotton 100%, PC 52/48, PV 80/20 and CVC 60/40. This nano development will be helpful to enhance the comfort level in different fabrics.

II. MATERIALS AND METHODS:

The single jersey knitted fabrics used for the study were produced on circular knitting machine from yarn having linear density of 20 tex, while five different materials were used. The knitting parameters were kept constant for all the samples, i.e. stitched length was 0.29 mm and the fabrics areal density was 150 grams per square meter. Five samples were treated and other five were untreated with silicon based nano emulsion treatment, resulting in ten different samples (Table 1).

Sr. #	Sample ID	Material	Treatment
1	S1	PES	No
2	S2	PES	Yes
3	S3	PV 80/20	No
4	S4	PV 80/20	Yes
5	S5	COTTON	No
6	S6	COTTON	Yes
7	S7	CVC 60/40	No
8	S8	CVC 60/40	Yes
9	S9	PC 52/48	No
10	S10	PC 52/48	Yes

Details about silicon based nano-emulsion: preparation and application (Table 1)

The silicon based nano emulsion used in this research study is RUCO-NANOFIN ISN, which is the Nano polymeric siloxane cationic compound. It has high absorptive power; very good pH stability as well as a distinct soft handle excels this softener, especially suitable for micro fibres. Moreover it is a clear emulsion with approx. 1 gm/cm3 specific gravity at 20 ℃, having PH approx. 6 – 8. Easily dilute able in cold water having good soft handle, distinct wash performance with good PH stability and shear resistance.
The application of silicon based nano emulsion on the given fabric samples is consist of padding process, wash and wear and exhaust process, detail is given below.

Padding Process Detail:

Chemicals	Concentration	PH	Liquor Pick UP (%)	Dry (℃)
RUCO-NANOFIN ISN	20-80 g/l	**5.0 – 5.5**	40 -80	130 – 170
RUCO-ACID ASC	0.5 g/l			
acetic acid 60 %	0.5 ml/l			

Wash and wear 100 % CO Detail:

Chemicals	Concentration	Liquor Pick UP (%)	Dry/ Cure
Ruco Nano Link com	40 - 80 g/l	60 -80	40 – 60 s 170 ℃
Ruco Nano Fin INS	20 - 50 g/l		
Ruco Nano Lub Pix	0 - 30 g/l		
magnesium chloride	8 - 16 g/l		
RUCO-CAT DKM	1 - 2 g/l		
RUCO-ACID ASC	0.5 - 1 g/l		
acetic acid 60 %	1 ml/l		

Exhaust Method:

RUCO-NANOFIN ISN	2 – 5 % on weight of fabric
PH	5 – 5.5 %
Temperature	30 – 40 ℃
Time	20 min

Characterization:

The comfort properties of the developed samples were investigated in terms of air permeability and overall moisture management capability. The air permeability was tested on air permeability tester M021A according to the ISO 9237, while OMMC was measured using MMT tester according to standard test method AATCC 195. In addition, fabric touch tester M293 (FTT) was used to investigate the fabric compression, bending and thermal properties.

Fabric touch tester (FTT) includes four modules (compression, thermal, bending and surface), which are activated simultaneously to record the dynamic responses from the samples. The samples are cut in L Shape with 200 mm arms as shown in Figure 1, and placed on the lower plate with the extension arms on the adjacent platforms. The center square of sample is dragged downwards leading to horizontal movements of two arm-parts. Compression and thermal modules measure center part while bending and surfaces modules evaluate the arms-parts. There are two mirror-duplicated designs for bending and surface modules, so that both directions of samples could be measured in only a single testing.

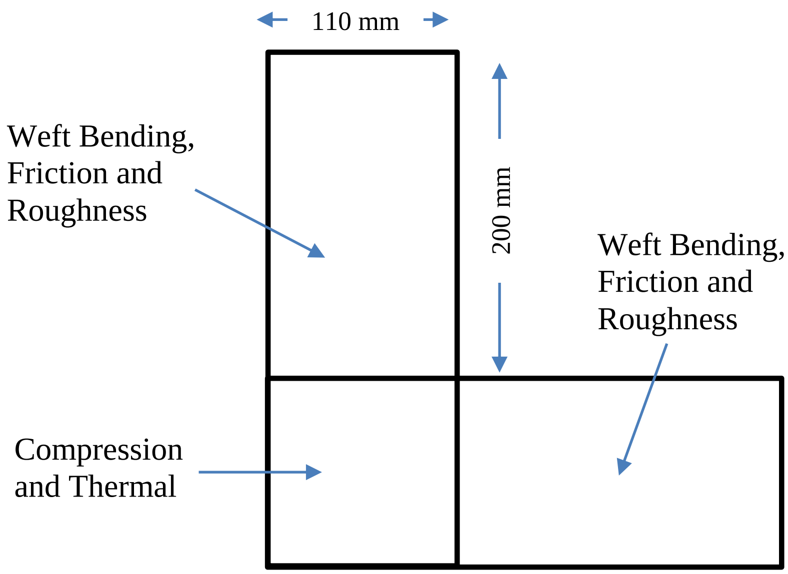


Figure 1. Sample dimensions for FTT

III. Results and Discussion

Air permeability

The fabric air permeability results are given in Figure 1. From the results it is obvious that the application of silicon based nano emulsion to the fabrics has caused a decrease in the air permeability of the fabrics. There are two factors responsible for this phenomenon. Firstly, there may be relaxation shrinkage in the fabric after the application of emulsion, causing the yarns to come close and hinder the flow of air.

Secondly, during the application of nano emulsion, small particles have deposited on the yarn structure and interstices, reducing the fabric air gap spacing (pore size). The fabric pore size has a direct relation with the air permeability of the fabric. Therefore, reduction in pore size has caused a decrease in the air permeability of the fabric. The air permeability is higher for the fabrics produced with polyester yarn, while it is lower for the spun yarns. This is due to the more uniform cross section of the yarn, which provides less hindrance to the flow of air. The spun yarns have a low uniformity and hairiness, which cause resistance to the flow of air and leading to low air permeability.

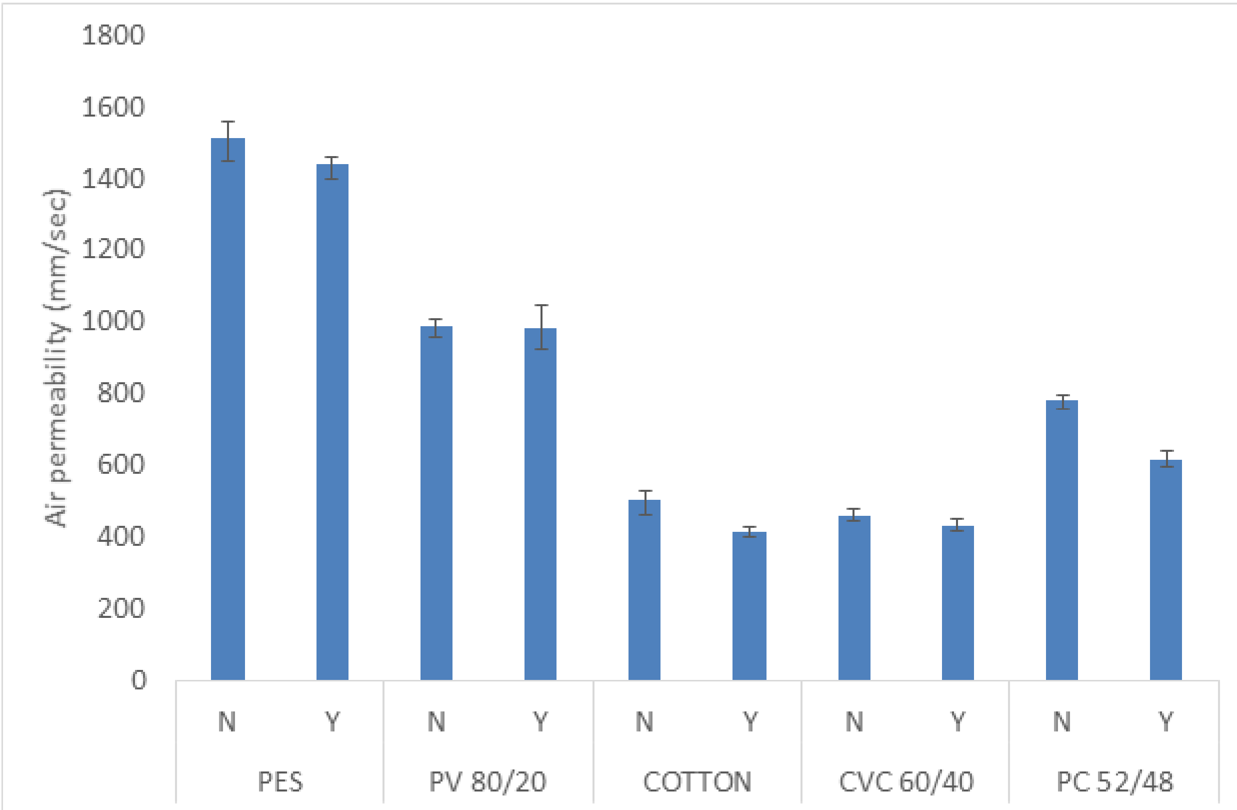


Figure 1. Air permeability results of the fabrics

IV. OMMC

The overall moisture management capability (OMMC) of the fabric indicates the ability of fabric to manage liquid moisture transfer, and is shown in Figure 2. The untreated fabrics have high OMMC value when produced with 100% polyester followed by52:48 PC and PV 80:20 having almost same value, while those with cotton and CVC have lowest value. The better OMMC of polyester fabrics may be attributed to the quick moisture transfer from inner to the outer surface and low absorption. The PC and PV fabrics also have a major constituent of polyester, but the other hydrophilic fiber absorbs and retains some moisture, leading to a low OMMC value.

After the application of silicon based nano-emulsion to these fabrics, the OMMC value has increased as a whole, but the trend is almost the same, i.e. highest for 100% polyester and lowest for cotton and CVC.

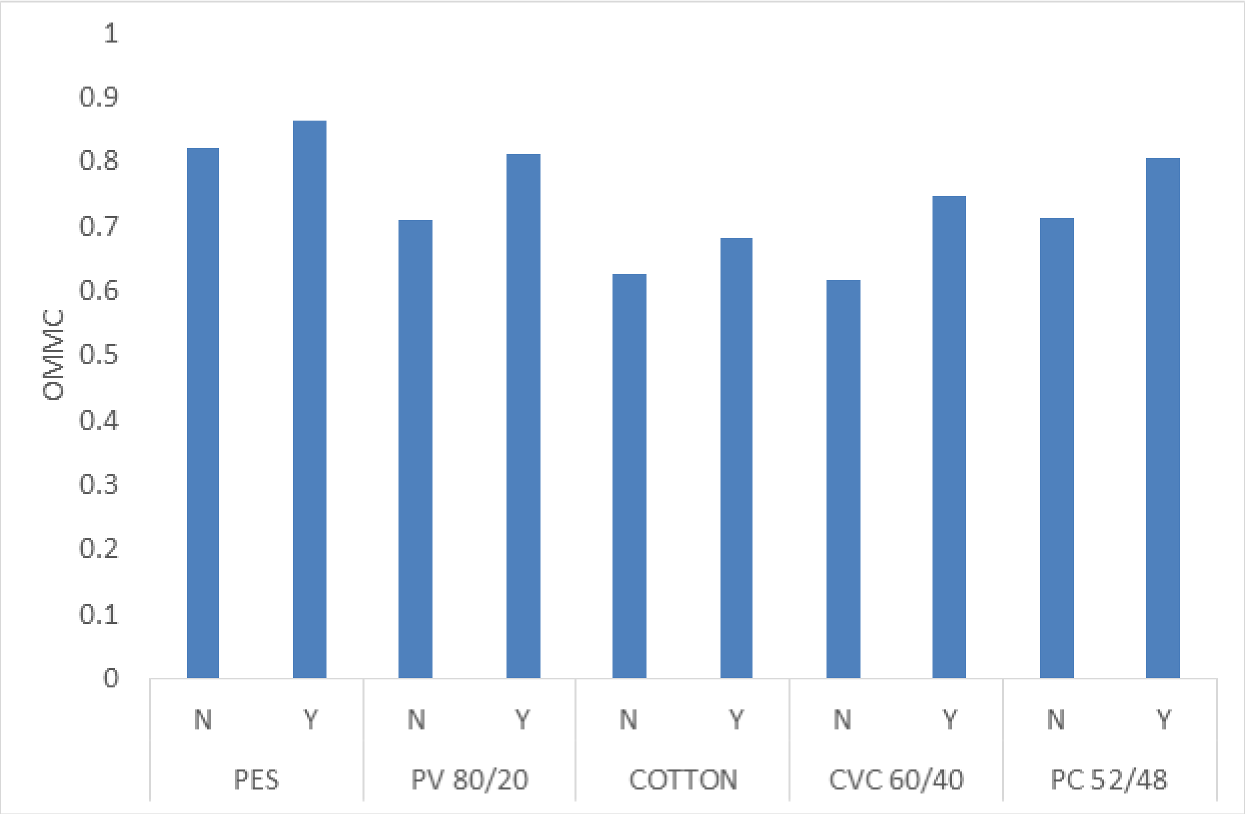


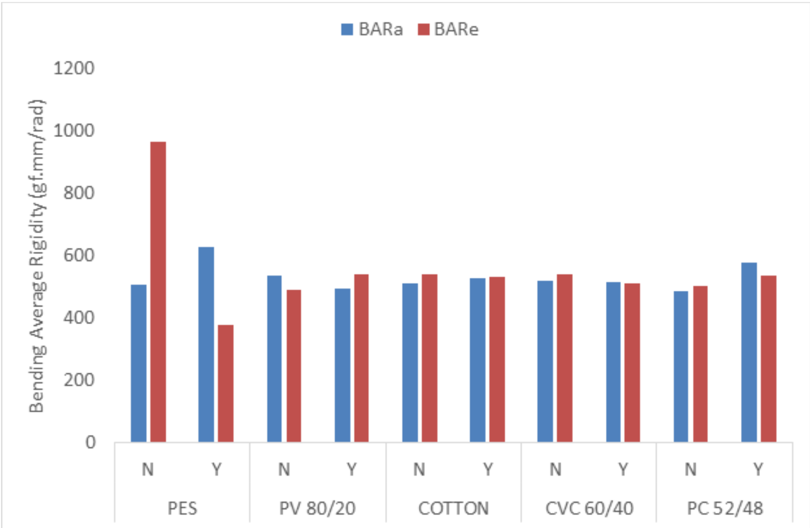
Figure 2. The OMMC results of treated and untreated fabrics

V. Fabric Touch Tester (FTT)

Fabric Touch Tester (FTT) is innovative testing equipment that enables measurement of multiple fabric hand properties in a single test which takes about 2-3 minutes. The FTT has four modules which are integrated in one single equipment and operated at the same time: compression, thermal, bending and surface module. All the indices are then computed to yield the primary hand value, which consists of smoothness, softness and warmness, total hand and total touch. The FTT measures different types of properties as under.

VI. Bending module

The bending module is believed to reflect stiffness of the fabric in terms of Bending Average Rigidity (BAR) and Bending Work (BW). The BAR and BW values of the specimen are given in Figure 3.The BAR and BW value of all the knitted fabrics is almost same. It can also be noted that the BAR and BW values have not been significantly affected by the application of silicon based nano-emulsion. The exception in both cases is the polyester knitted fabrics, which have a very high BW and BAR value, which tends to decrease after the application of silicon based nano-emulsion.



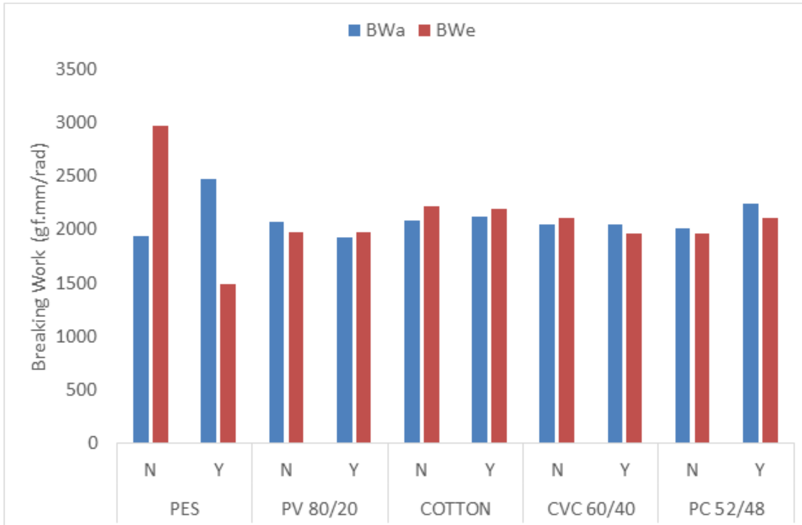


Figure 3. The (a) BAR and (b) BW results of treated and untreated fabrics

VII. Compression Module

Compression properties are commonly used to describe changes in thickness of the fabric when normal forces are applied.

The FTT describes for the compression properties of the fabrics, namely compression work (CW), compression recovery rate (CRR), compression average rigidity (CAR) and recovery average rigidity (RAR). The results of these parameter is shown in Figure 4.

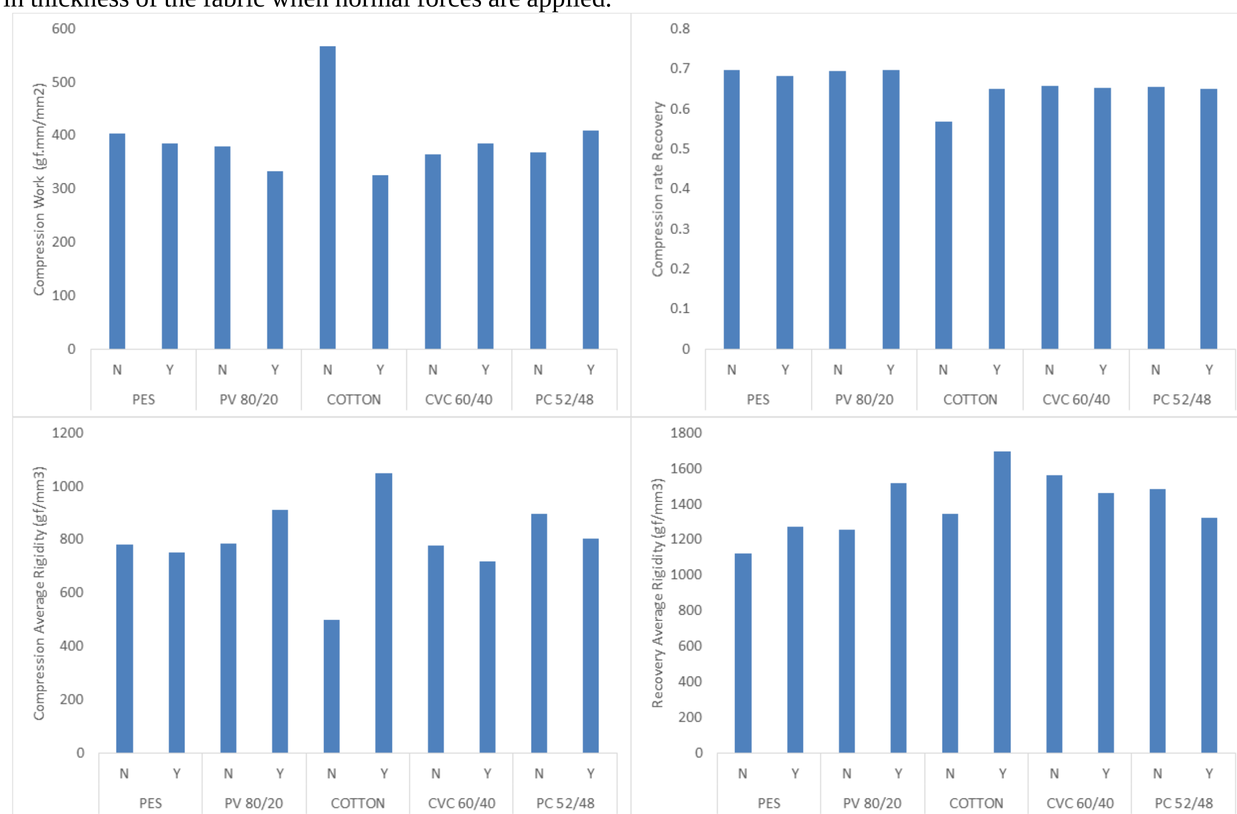


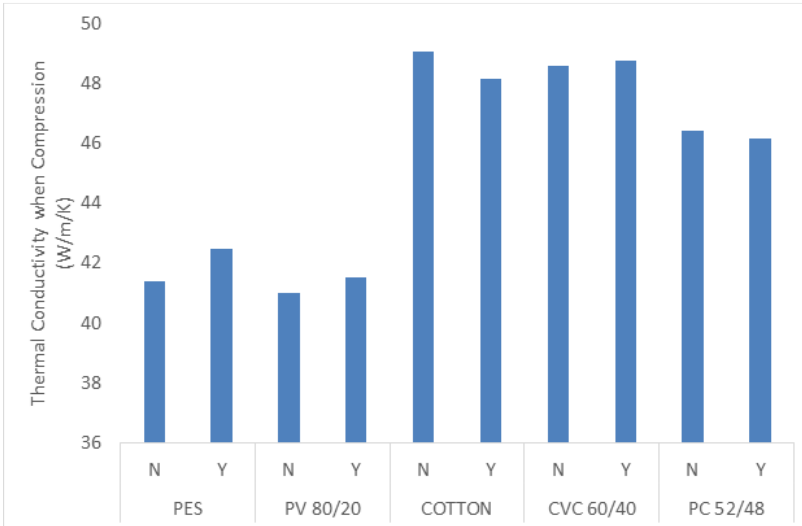
Figure 4. The (a) CW, (b) CRR, (c) CAR and (d) RAR results of treated and untreated fabrics

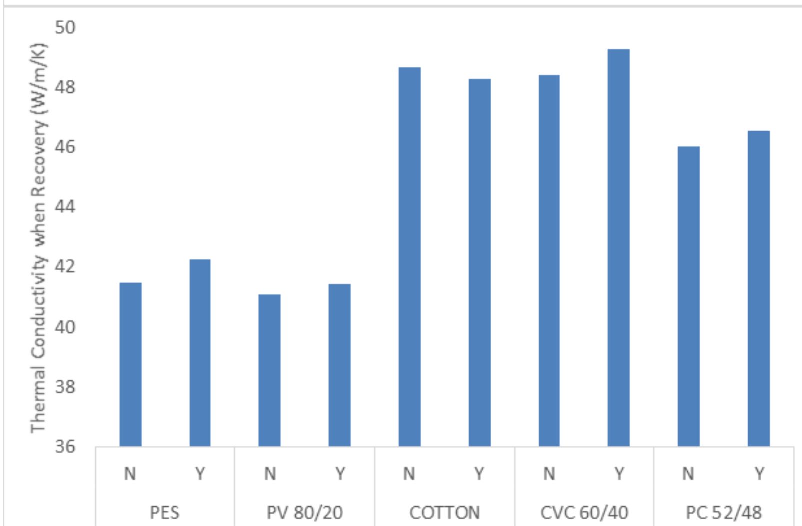
CW is the total work done on specimen during the compression process.CRR is ratio of the recovery work to compression work. CAR is the average force required to compress 1 mm of sample, during middle 60% of compression process. RAR is average force required to compress 1 mm of sample, during middle 60% of recovery process.

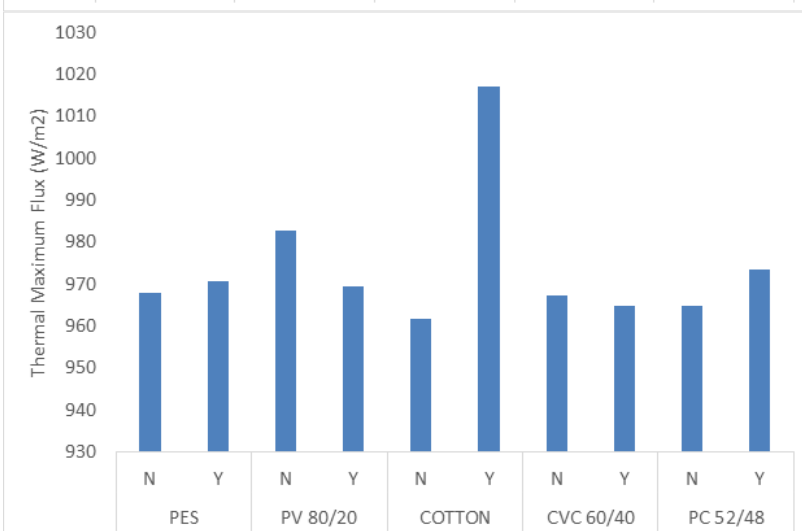
VIII. Thermal Module

Thermal conductivity is the major index defined in this module. It also records the heat flux through fabrics dynamically during compression. Thermal Conductivity when Compression (TCC) is the energy transmitted per degree per mm when compresses the specimen. Thermal Conductivity when Recovery

(TCR) is the energy transmitted per degree per mm when the specimen recovers. Q max is the maximum thermal flux measured.







Conclusions

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