Nano-finishing of low and high GSM single jersey knitted cotton fabrics

Aparna Kumar, Krishna Prasad Nooralabettu*

Abstract— Nano finishes for textile substrates is an emerging promising frontier with immense and numerous scopes both to the industry and consumers. An effort was made to develop nanofinish textiles with potential commercial application and benefits of the nanofinish were established by performing the advantageous features of treated fabrics with those of the untreated ones. Low and high GSM single jersey knitted fabrics were procured and nano-finished with by spray technique through unexposed screen frame. Fabric stiffness, crease recovery angle, drape, colour fastness to washing, antimicrobial assessment, reaction to staining agents and localised application on garment of both treated and untreated fabrics were performed. The results found are favourable and encouraging.

Index Terms— Nanofinish, Fabrics, Flurocarbon, Perfluroalkyl residues, hydrophobicity, Nano-tex, Nanotechnology.

1 INTRODUCTION

TFinishing of materials by nano-constituents greatly enhances the properties of the finished products due to their higher surface area to volume ratio. In nano-finishing, individual atoms and molecules are manipulated precisely to create nano fibres, colour changeable cloths, anti-stain, anti-wrinkle textile and filter fabrics [1]. More attention is shown by the textile industry in finishing fabrics, due to the controllability, effectiveness and precision of the nanotechnology in finishing the textile materials at individual sites of the textile materials in a desired orientation and trajectory using approaches such as thermodynamics and electrostatic. Fluorocarbon finishes is an important class of hydrophobic finishes to impart water and oil repellence. Fluorocarbons are organic chemicals made up of a perfluoroalkyl residue where all the hydrogen atoms are replaced by Fluorine. Fluorocarbons are thermally stabile and less reactive. Fluorocarbons finished on fabrics considerably reduce the surface tension and makes the fabrics in comparision to the conventional fluorocarbon acrylate polymers based finish. These nano-finishes was originally named as Nano Care and marketed by Nano-Tex [2]. Advancement made in manufacturing of fine finishes and using of nanotechnology in textile industry paved the way for commercial application of this cutting edge technology to improve the efficiency of process and product [3, 4]. Aim of the present work is to nano finish low and high GSM of cotton knit fabrics by spray technique, study the properties of these treated fabrics and study the features and benefits of nano finish such as antimicrobial activity [5].

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2 MATERIALS AND METHODS

2.1 Materials

2.1.1 Bamboo /cotton knitted fabrics

In this work, 40 Tex of Bamboo/Cotton 50/50 of single jersey 167 GSM and 20 Tex of Bamboo/Cotton 50/50 of ingle jersey of single jersey 205 GSM of knitted finished fabric was procured from Premier Mills, Coimbatore.

2.1.2 Chemicals

Analytical grade and were manufactured by Merck Limited (Mumbai, India) were used, and solution were prepared using chemicals supplied by Durga Lab Pvt. Ltd, Mangalore as per the current American Chemical Society specifications[6]. Utensils and Glassware manufactured by Borosil (Mumbai, India) were used for the current research. Nutrient Agar medium was procured from Himedia, Mumbai, and prepared as per the manufacturer's instruction. Commercial Hydrophilic finish Hydroperm RPU was procured from Clarient Chemicals, Mumbai.

2.1.3 NUVA N 2155 liquid

NUVA N 2155 liquid was prepared by mixing 100 g in 1000 mL of deionised water and pH of the liquid was maintained at 5.0 using acetic acid 60% at 0.5 - 1.0 ml/L.

2.1.4 Hydroperm (RPU) Liquid

Hydroperm (RPU) Liquid was prepared by dissolving 30 g of hydroperm in a beaker containing 1L of deionised water and pH was adjusted to 5. Then, pH of the solution was adjusted to 5 using acetic acid solution.

2.1.5 Features of Knitting Machine

Knitting Machine used for the present study is single jersey, 36" diameter, 32 npi gauge, 1504 needles, latch needle with single butt German terrot knitting machine. Fabric was constructed as single jersey, honey comb, airtex, and pique

2.1.6 Details of the fabrics

Low GSM fabrics were 16 Wales/cm, 22 Course/cm, 352 Stitch Density/cm, 5.33Loop length in cm, 18.29 Tightness Factor (K) 167 GSM. High GSM fabrics were 14 Wales/cm, 24 Course/cm, 335 Stitch Density/cm, 6.49 Loop lengths in cm, 21.00 Tightness Factor (K) of 205 GSM

2.2 Materials

2.2.1 The Process Flow Chart for Knitting

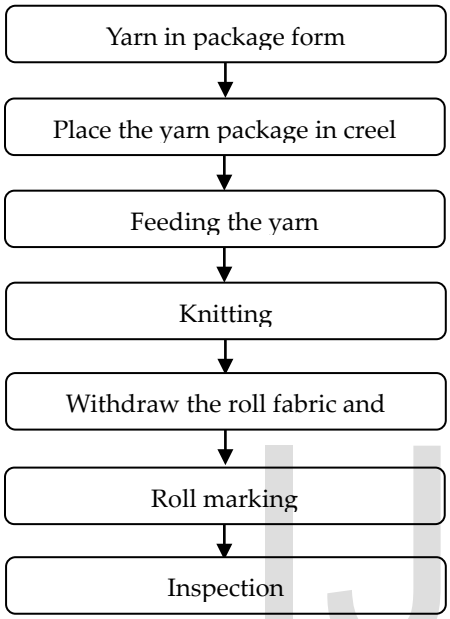

Fig. 2.1: The Process Flow Chart for Knitting

The circular knitting machine used for the current study was made up of three major parts such as yarn supply, knitting elements, and fabric take down. The machine frame contains knitting elements such as needles, sinkers, cams and feeders are supported at the centre by knitting zone. Yarn package affixed on top of creels are fed to the knitting zone through yarn guide, stop motion and feeders. The knitted fabric passes down through the cylinder towards the centre of the machine, taken into the take-down-device, and ultimately settled on a roll winding mechanism. Fabric spreader slowly converts the tubular fabric into double layer folded fabric by resisting the creation of creases. Single knit plain machine at the knitting zone are fitted with a cylinder and sinker ring, however the double knit machine have cylinder and dial.

2.2.2 Application of Nuva HPU liquid

100 gm of NUVA N liquid was transferred to a beaker containing 1000 ml of deionised water and mixed well. Then, pH of the solution was adjusted to 5 using acetic acid solution. Fabric was fixed to the screen frame and placed on the spaying table vertically. Nuva HPU liquid is sprayed on front face of the fabrics above the unexposed screen frame using sprayer. Fabrics were dried using dryer for 15 min and curing is carried out through ironing for two hours.

2.2.3 Application of Hydroperm (RPU) Liquid

Hydroperm (RPU) Liquid was prepared by dissolving 30 g of hydroperm in a beaker containing 1L of deionised water and pH was adjusted to 5. Then, pH of the solution was adjusted to 5 using acetic acid solution. Fabric was fixed to the screen frame and placed on the spaying table vertically. Nuva HPU liquid is sprayed on rear face of the fabrics above the unexposed screen frame using sprayer. Fabrics were dried using dryer for 15 min and curing is carried out through ironing for two hours. Process of nanofinishing of fabrics is illustrated in the Fig. 2.2

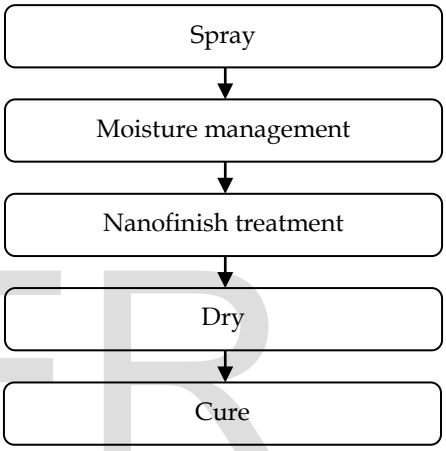

Fig 2.2 Unit process of nano-finishing

2.2.4 Fabric tests

The fabrics were subjected for Crease recovery Angle test using CRA tester as per IS 4681:1981. Fabric stiffness test was performed as per IS 6490:1971 using Shirley stiffness tester. Fabric Drape was performed as per IS 8357:1 using Cusick Drape meter. Colour Fastness To Washing Test was performed using Wash-O-Meter as per ISO105 E01:2013.

2.2.5 Anti-Microbial Test on Bamboo/Cotton Single Jersey Knitted Fabric

Antibacterial effect of the finished fabrics on *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Staphylococcus citreus* and *Pseudomonas aeruginosa* was performed by agar diffusion plate method at 37°C. Test organisms were swabbed over the surface of Nutrient agar plates, and 10 mm diameter discs of the test fabric and control amphicillin standard disc were then gently pressed on to the surface of the plate under sterile condition. The inoculated plates were incubated at 37°C for 24 h. The antibacterial activity of finished fabrics was demonstrated by the diameter of the clear zone of inhibition and compared it to control amphicillin standard disc[5].

2.2.6 Stain Test on Bamboo/Cotton Single Jersey Knitted Fabric

Stain test was performed on both high and low GSM of bamboo/cotton single jersey knitted fabric on the table. Two treated sample were taken on the table and then it was cut in straight form. One drop's of each tea, coffee, oil and ink poured on the test samples and kept for five minutes. Same process is continued after washing for washing cycle till how many washing period it may withstand the stains on the fabric without affecting on the fabric.

2.2.7 Stain Test After Wash on Bamboo/Cotton Single Jersey Knitted Fabric

This process is carried out on the two fabrics of bamboo/cotton single jersey knitted fabric of both low and high GSM. The test is carried out to check whether the fabric withstand after certain washing cycle in the first process of five washing cycle. After each washes the fabric kept for five minutes to check whether it withstands later another five washes carried out in each minute so that stains should not withstand on the fabric.

2.2.8 Stain Test on Shirts Collar

To test the effectiveness of the removal the stains on shirt collar NUVA HPU (nano-finish) liquid is sprayed on the collar through unexposed screen frame and then cured after drying[7]. NUVA HPU nano-finished shirt was worn during the day long workout and tested it to check whether it withstands the stains in it.

3. RESULTS

3.1 Geometrical changes

Consolidated test report of geometrical changes in Untreated low GSM sample (UL), Treated low GSM sample (TL), Untreated high GSM sample (UH), and Treated high GSM sample (TH) is given in table 3.1

Table 3.1 Geometrical changes with treatment.

SN	Particulars	UL	TL	UH	TH
1	Wales per centimetre (WPcm)	6.30	6.30	5.58	5.27
2	Courses per centimetre (CPcm)	8.66	8.27	9.30	9.30
3	Stitch Density/cm²	54.56	52.08	51.88	48.99
4	Loop Length, mm	5.33	6.12	6.49	6.37
5	GSM	167.00	196.00	205.00	230.00
6	Cover factor	18.29	15.36	20.60	21.70

WPcm: Wales per centimetre, CPcm: Courses per centimetre, UL: Untreated low GSM sample, TL: Treated low GSM sample, UH: Untreated high GSM sample, TH: Treated high GSM sample.

We have not registered any perceptible changes in Wales (W) and Course(C) as evident from the table 3.1. The change in the GSM is might be due to the add on chemicals. The percent add on is about 17 for low GSM sample and 12 for high GSM sample. Low GSM sample having more pores are expected to take up more reagents.

3.2 Course Recovery Angle

As indicated through ANOVA, it is clear that Crease recovery angle along the Course and Wales is significantly different and GSM as well as treatment affects the crease behaviour (Table 3.2 and 3.3). Treatment improves the recovery angle along Wales. The effect is not seen along Course direction is obvious as yarn loops along Wales, in Jersey[8].

Table 3.2 Crease recovery Angle, Deg

Sample	Along	
	Wale	Course
UL	78.4	75.6
TL	87.0	72.6
UH	101.8	71.4
TH	117.4	72.0

Table 3.3.ANOVA for the crease recovery test

Source of Variation	F	P-value	F critical
Sample	46.68	8.6E-12	2.901
Direction	405.29	9.81E-20	405.29
Interaction	64.87	1.07E-13	2.90

3.3 Stiffness

Analysis of variance is clearly indicates that Fabric Stiffness along the course and Wales is significantly different and GSM as well as treatment affects the stiffness of fabrics (Table 3.4 and 3.5). Treatment of low GSM fabric becomes very rigid as the fabric takes more chemicals into its pore.

Table 3.4 Bending Modulus, Kg/Sq.Cm

Sample	Along	
	Wale	Course
UL	8.43	5.25
TL	15.60	13.23
UH	5.84	3.44
TH	4.97	4.07

Table 3.5 ANOVA for the Fabric stiffness test

Source of Variation	F	P-value	F critical
Sample	5.89	0.0008	2.68
Direction	9.41	0.0026	3.92
Interaction	0.377	0.7695	2.68

3.4 Drape

Drape is not much affected with the treatment as indicated in the Table 3.6.

Table 3.6 Drape co-efficient

Sample	UL	TL	UH	TH
Drape co-efficient	0.46	0.45	0.52	0.58

3.5 Colour Fitness to Washing

Both low and high GSM fabrics have shown good Colour fastness to washing and do not stain the adjacent fabrics (Table 3.7).

Table 3.7 Staining rating for Colour fastness to washing

Colour Change	TL	TH
Staining On Acetate	4-5	4-5
Staining On Cotton	4-5	4-5
Staining On Nylon	4-5	4-5
Staining On Polyester	4-5	4-5
Staining On Acrylic	4-5	4-5
Staining On Wool	4-5	4-5

3.6 Antimicrobial Activity

Antimicrobial activity of the low and high GSM treated fabrics is given in the Table 3.8.

Table 3.8 Anti microbial test of low and high GSM treated fabrics

Skin bacterial isolates	Zone of inhibition by Spread plate method in mm diameter in mm		
	Ampicillin-10 disc µg (Standard)	TL	TH
Staphylococcus epidermidis	22	26	32
Staphylococcus aureus	19	28	36
Staphylococcus citreus	23	23	32
Pseudomonas aeruginosa	18	28	26

Both high GSM Fabric and GSM Fabric are able to retard the microbial flora isolated from healthy skin, however, high GSM Fabric has more efficient antimicrobial property in comparison to the Low GSM Fabric. This indicates that the treatment is more effective for high weight fabrics [5].

3.7 Staining test for low GSM knitted fabrics

Staining test was performed on low GSM knitted fabrics. The photographs clearly demonstrate the effectiveness of nano treatment (Fig 3.1 and 3.2).

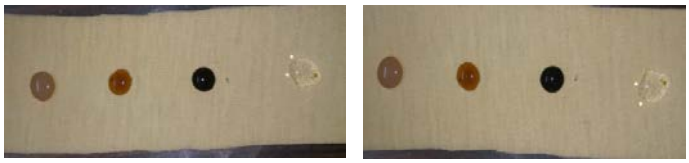

Fig 3.1 Stain test on low GSM fabric before and after five minute

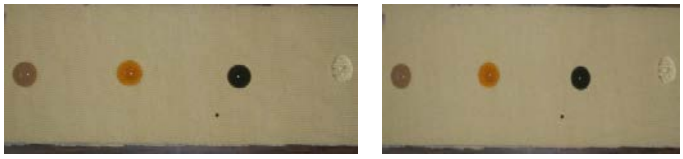

Fig 3.2 Stain test on high GSM fabric before and after five minute

From observation we can say no change occurred on fabric after 5 min, as no staining has occurred. Treatment is effective both on low and high GSM fabrics. The process is carried out further by washing cycle for effectiveness of non- staining [7].

3.8 Staining Test after Washing

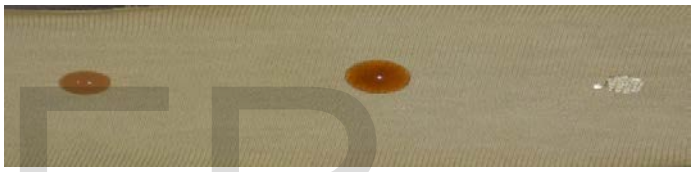

Fig. 3.3 After three washes on low GSM fabric

From the figure 3.3 we can conclude that stain test can withstand on the low GSM fabric after three washing cycle kept for five minutes after pouring drop of stains on it .

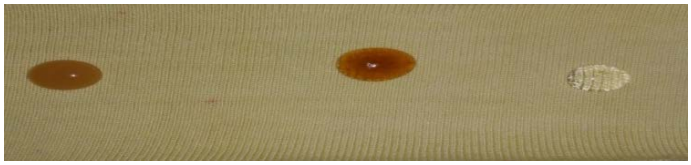

Fig. 3.4 After ten washes on high GSM fabric

From the above figure 3.4 we can conclude that high GSM fabric are more favourable to withstand the stains compared to the low GSM fabric where the test is carried out in which the stain can withstand after ten washings.

3.9 Result on Nanofinish for Shirt's colour

The figures below shows the photograph of shirt collar sprayed with nano finish agent after continuous use

Fig. 3.5 before wearing day 1

Fig. 3.6 after wearing day 1

From the above figure we can conclude that slight improvement is found in outdoor session from normal wearing (Fig 3.5 and 3.6).

Fig 3.7 before wearing day 2 Fig 3.8 after wearing day 2

From the figure 3.7 and 3.8, we can conclude that day two in outdoor session slight stains are formed compared to the normal wearing.

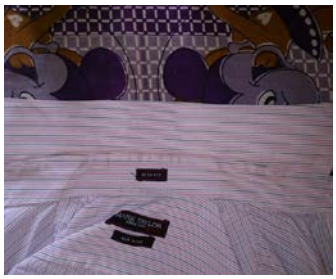

Fig 3.9 before wearing day 3 Fig 3.10 before wearing day 3

From the figure 3.9 and 3.10 we can conclude it is improved from the normal wearing.

4 CONCLUSION

Use of nanotechnology to nanofinish textile fabrics is at infantile stage. Even after having many challenges and opportunities, it is inevitable part of the textile industry. Nanofinishing of bamboo/cotton knitted fabric using hydrophilic chemicals enhances water repelling properties of the finished fabrics. Application of NUVA HPU liquid has exhibited tremendous improvement in nano-finishing of both high and low GSM of bamboo/cotton knitted fabric. Physical test indicates no much change in the in treated fabrics in comparison to the untreated fabrics, except slight increase in stitch density and loop length. Mechanical test indicates that recovery angle for treated fabric of both high and low GSM is moderately increased compared to untreated fabric. However, fabric drape in low GSM treated fabric slightly decreased in comparison to untreated fabric, and in high GSM it is moderately increased in fabric drape compared with untreated fabric. Fabric stiffness test indicates that over all bending modulus of both low and high GSM fabric is slightly increased. Antimicrobial assessment showed more favourable results in high GSM treated fabric compared to low GSM treated fabric. Antimicrobial test indicates that GSM treated fabric shown effective microbial retarding activities. Stain test indicates that no stains were formed on both low and high GSM fabric for certain period of washing cycle hence we could conclude that fabric may be useful for indoor session like kitchen and other places where it might be useful. The localised treatment of garment portions say like collar which is contact with skin, often goes to staining can have improved performance.

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