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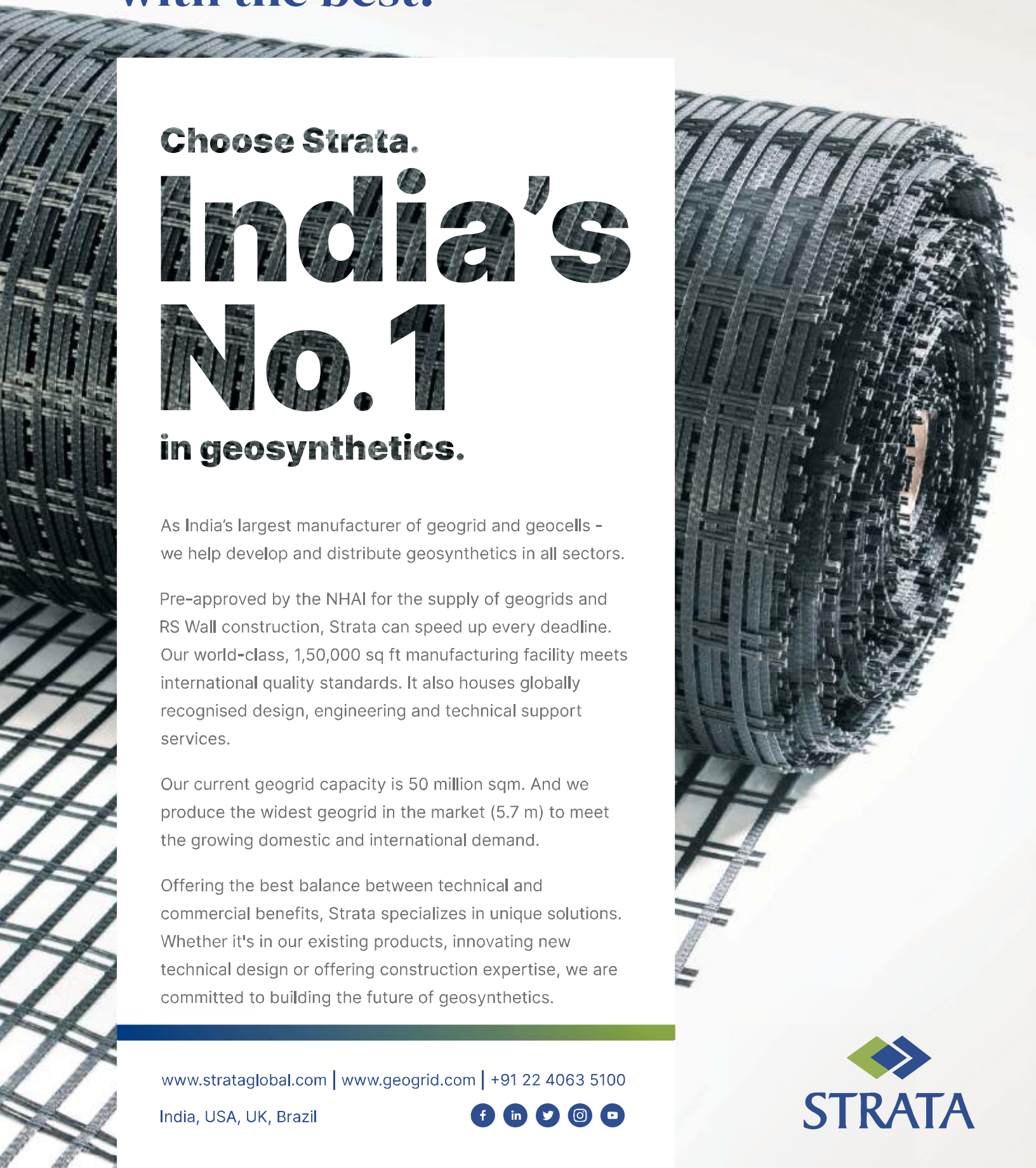

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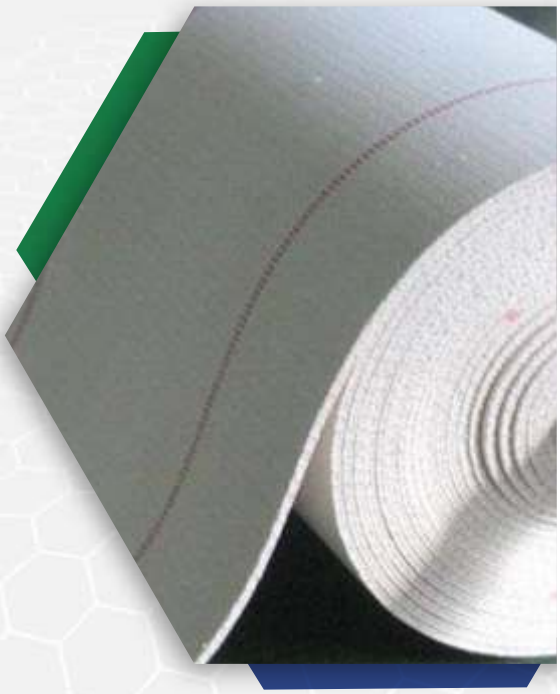

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EDITOR'S DESK

Dear Readers,

Greetings!!

Research with persistent and focused efforts lead to a positive result. Fostering research and providing a platform to publish quality research papers and related articles has been a continuous effort of BTRA Scan. In continuation to this effort, I am delighted to present to our readers the 2nd issue of 51 Edition of BTRA SCAN. We have overcome the pandemic and almost free from the imposed restriction on the way of our development. It is the time to bring our progress and development work to the earlier track and find the best opportunity.

This issue has papers from the different domains such as protective facemask, dying of aramid yarn, Microbiological testing and yarn from soya protein fiber. Now we are open for authors from outside so researchers can send their original articles, case studies, research reviews or empirical contributions for publication in our journal.

I feel we will have a great time ahead. Hope, we all are following the safety practices our own for few months more to avoid next wave of pandemic.

Our sincere thanks to all the reader and contributors for their support and interest.

T V Sreekumar, PhD
Director, BTRA


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Effect of Blending Parameters on Properties of Yarns Produced from Soy Protein Fiber (SPF) and Wool Waste

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[2]Department of Apparel and Textile Science, Punjab Agricultural University, Ludhiana

Abstract

Ludhiana is the hosiery hub of Northern India housing more than 200 spinning and knitting units producing a sizeable amount of waste wool. Conventionally, this waste wool is used as filling material, felting, and manufacturing substandard woolen products. An effort has been made to reutilize the waste wool has been made by blending it with the soyabean protein fiber and evaluating the effect of blending parameters on properties of yarns produced. The blending was carried by varying fibre ratios (20:80, 30:70, and 50:50), yarn count, twist and blending system. The blended yarns were tested for yarn evenness and hairiness, single yarn strength, elongation and yarn twist and as the yarns were prepared for fabric manufacturing, therefore the developed spun yarns were further tested for their suitability in knitting. Based on yarn properties, appearance and production feasibility, the blend ratio 30:70, blended in worsted system with count 10 Nm and Z twist was adjudged as the optimum parameters for producing blended yarns from SPF and wool waste. It is concluded that the physical yarn properties were nearly similar for the blend ratios 20:80 and 30:70 but change in yarn count and twist played an important role and affected the quality of yarns produced for knitting purpose.

Keywords:

Blending, single yarn strength, SPF, yarn count, yarn evenness, yarn hairiness

Citation

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1. Introduction

Sustainable approaches are being talked about and tried to be executed in the textile industry to reutilize the waste generated. These approaches tend to utilize the fibers for manufacturing composites, regenerated fibers and as reinforcements in bioplastics. Blending has been a traditional method of physically mixing the fibers to obtain a uniform yarn structure. The blending of fibers has also emerged as an economical alternative for conjugating the desired attributes of two or more fibers of different origins with the least chemical exposure [1]. Blending is done to improve the quality and performance of fiber, get desired properties for the required end uses, and reduce the cost but the result of the final yarns depends upon many blending parameters.

A prominent legume crop, soyabean is a rich source of protein and is used as a dairy substitute. The protein of soyabean is being utilized to manufacture textile fiber. The amino acid composition of soy protein makes it suitable to be spun into a fiber. Soy protein fiber (SPF) is the only plant protein fiber [2]. SPF is commercialized as soy silk as it exhibits the luster and softness similar to silk. Shiny luster, fine count, low density, high tensile strength, and anti-microbial properties are some of the salient features of SPF. Soy protein fiber is extensively used in medical and wound healing applications [3]. The cost of extracted protein is only one-third of silk and one-fifteenth of cashmere. Hence, soyabean protein fiber is cheaper than both pure silk and cashmere [4]. SPF is presently being used for shirting, blankets, infant clothes, etc. [5]. Ludhiana, a hub of the woollen and hosiery industry in North India houses a large number of fiber processing and knitting units. Along with a good production of woollen and hosiery goods, this industry generates a large amount of waste, which is mainly called wool waste. Presently, this wool waste is used to manufacture low-grade woollen products and for filling purposes which have got limited uses and is less marketable.

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The present study is an attempt to suggest an environment-friendly approach to utilize wool waste and study the effect of blending parameters on physical and mechanical properties of yarns produced from blending SPF and wool waste. The study also suggests the optimum blending parameters for blending SPF and wool waste for suitability in producing knitted fabric.

2. Material and Methods

About 10 kilograms of soy protein fiber (SPF) was imported from China as it was not available in fiber form in India and simultaneously 20 kilograms of wool waste (WW) in the form of tops was procured from the local spinning units of Ludhiana (2018). SPF and wool waste were blended in ratios 20:80, 30:70, and 50:50 using the ring-spinning method and labeled as sample WS1, WS2 and WS3 respectively. A fiber mix of 10 kg was prepared for each blend ratio.

Table 1: Blend ratios of Waste Wool and SPF

Samples	Blend ratio	Fiber mix (kg)
WS1	20:80	2 kg SPF + 8 kg WW
WS2	30:70	3kg SPF +7kg WW
WS3	50:50	5kg SPF+5kg WW

The blending was carried out in following phases:

i. Mixing: The fibers were fed into the blowing room in the pre-decided proportions for thorough cleaning and mixing with each other.

ii. Carding: In the carding machine, the fibers were put in a parallel form and a uniform sliver was obtained. From the carding machine, the slivers were collected in large cylindrical drums.

iii. Combing: The carded slivers were combed. In this process, the slivers were further arranged in a highly parallel orientation and aimed at removing any residual entangled fibers and also eliminating the neps.

iv. Doubling and drawing: These were done to impart strength as well as obtain a fine yarn.

v. Spinning: Roving was obtained for each blend ratio which was then spun into a yarn.

The rovings were spun in different systems by changing the blending parameters. The parameters were altered as per the suggestions of knitting experts keeping in mind the quality of roving obtained. The sample WS1 (blend ratio 20:80) and sample WS2 (blend ratio 30:70) were taken for worsted spinning whereas the sample WS3 (blend ratio 50:50) was spun in the woolen system. More details about blending parameters have been presented in table 1.Sample WS1 was a double-ply yarn of 18 Nm twisted in 'S' direction while

Table 2: Physical properties of blended yarns

Samples	Blend ratio	Spinning system	Yarn count (Nm)	Ply	Twist
WS1	20:80	Worsted	18	Double	S
WS2	30:70	Worsted	10	Single	Z
WS3	50:50	Woolen	0.50	Single	Z

sample WS2 was spun into single-ply yarn of count 10 Nm and 'Z' twist. Yarn sample C was spun with a coarser count and was a single-ply yarn. Physical and mechanical parameters were studied for the developed blended yarns. The yarn sample WS3 came out to be very coarse and had the presence of slubs throughout its length hence, it was eliminated from yarn testing as it was not considered fit for making knitted fabric. It was however evaluated for production feasibility to be taken up for end uses like carpets as suggested by the technical experts.

WS1 and WS2 were tested for physical properties like yarn evenness and hairiness and mechanical properties like single yarn strength and elongation and yarn testing was carried out according to the standards specified by the American Society for Testing Materials (ASTM).

WS1 (20:80)

WS2 (30:70)

WS3 (50:50)

Figure 1: Blended yarns

3. Results and Discussions

The yarn samples WS1 and WS2 were tested for various physical and mechanical properties and the results have been summarized in table 3 and statistical analysis have been presented in table 4 and 5 respectively.

Table 3: Physical and mechanical properties of developed blended yarns

Properties	WS1 (20:80)	WS2 (30:70)
Twist per inch (tpi)	6.2	9.8
U% (imperfections/km)	15.16	15.18
H(hairiness index)	10.42	10.25
Single yarn strength (gf)	1071.9	811.79
Elongation (%)	12.78	11.90

Yarn sample WS1 had an S twist and 6.2 twist per inch. Yarn samples WS1 and WS2 had similar yarn evenness (U%). However, the yarn hairiness of yarn sample WS1 was higher than that of yarn sample WS2. Both of these properties could be attributed to high twist and higher yarn count. This explained that the higher count of yarn sample WS1 gave it an even appearance. On the other hand, the number of fibers protruding from the yarn of sample WS2 was higher; hence, the hairiness index of sample WS2 was lesser than sample WS1.The yarns developed from the blend of SPF and wool waste exhibited excellent tensile strength as well as sound physical properties. The nature of the yarn and its count directly affected the tensile strength of the yarns. Yarn sample WS1 was a double-ply yarn with a higher count while sample WS2 was a single-ply yarn, hence, lesser elongation and single yarn strength.

Table 4: Statistical analysis of mechanical properties of blended yarns

Properties	WS1		WS2		Critical Difference
	Mean	S.D.	Mean	S.D.	
Yarn twist	6.20	0.45	9.80	1.10	1.037888
Single yarn strength	1071.9	109.93	811.79	78.95	1610.304
Elongation	12.78	2.10	11.90	0.95	4.702534

Table 4 revealed that there is a significant difference in the mean yarn twist of the blended yarns. Although there is quite a difference between the calculated values of single yarn strength of the blended yarns WS1 and WS2, there is no statistically significant difference between the two. This gap is evident because the sample size is lesser and there is very little difference in the calculated values.

As far as yarn elongation is concerned, there is no significant difference between blended yarns WS1 and WS2. However, both single yarn strength and elongation of yarn sample WS3 is significantly different than the blended yarns A and B.

Table 5: Statistical analysis of physical properties of blended yarns

Yarn properties	WS1			WS2			t value	p value
	Mean	S.D	Std. Error Mean	Mean	S.D	Std. Error Mean		
U% (imperfections / km)	15.16	1.41	0.63	15.18	1.65	0.74	-0.02	0.98
Thin (-50%/km)	42.00	48.04	21.48	40.00	36.91	16.51	0.07	0.94
Thick (+50%/km)	34.00	7.42	3.32	61.00	31.90	14.27	-1.84	0.10
Neps (200%)	18.00	5.70	2.55	35.00	23.45	10.49	-1.58	0.15
Hairiness index	10.42	0.34	0.15	10.25	0.38	0.17	0.76	0.47
Significant hairiness	2.34	0.12	0.06	2.64	0.13	0.06	-3.78	0.01
Lea strength	301.33	11.41	5.10	261.40	27.23	12.18	3.02	0.02
Count strength product	1606.40	51.69	23.12	1464.23	76.34	34.14	3.45	0.01

Table 5 explains that there is no significant difference between the yarn evenness and hairiness index of yarn sample WS1 and WS2. However, the difference between lea strength and count strength product of the blended yarns WS1 and WS2 is significant at 5%.

4. Analysis of production feasibility of blended yarns for developing a knitted fabric

The developed blended yarns were evaluated for production feasibility and commercial viability. Feedback was collected from ten respondents which comprised of five Production Heads and five Design Supervisors of randomly selected knitting units at Ludhiana. The analysis included recording the response of the experts on parameters like ease of production, waste generation, cost of production, aesthetic appeal, and texture for blended yarns. The feedback was evaluated on a 3-point scale.

Table 6 reveals that the majority of respondents preferred moderate ease of production for blended yarn samples WS1 and WS3 but 50 percent of the respondents preferred the ease of production to be higher for sample WS2. Eighty percent of the respondents reported that wastage while production was low for samples WS1 and WS2 whereas a similar percentage of respondents were of the view that there was a higher waste generation in the production of yarn sample WS3.

Table 6: Analysis of production feasibility of blended yarns

n=10

Parameters	Rating	WS1		WS2		WS3	
		f	%	f	%	f	%
Ease of production	High	3	30	5	50	-	-
	Moderate	7	70	3	30	6	60
	Low	-	-	2	20	4	40
Waste generation	High	-	-	-	-	8	80
	Moderate	2	20	2	20	1	10
	Low	8	80	8	80	1	10
Cost of production	High	2	20	3	30	5	50
	Appropriate	8	80	7	70	5	50
	Low	-	-	-	-	-	-
Aesthetic appeal	Very good	7	70	8	80	2	20
	Good	3	30	2	20	3	30
	Fair	-	-	-	-	5	50
Texture	Harsh	8	80	9	90	3	30
	Soft	2	20	1	10	5	50
	Fuzzy	-	-	-	-	2	20

Cost of production was found appropriate for the yarn samples WS1 and WS2 by 80 and 70 percent of the respondents respectively. However, for yarn sample WS3, the cost of production was reported to be high and moderate by an equal percentage of the respondents. The aesthetic appeal of yarn samples WS1 and WS2 was rated as very good by 70 and 80 percent of the respondents respectively whereas the appeal of yarn sample WS3 was considered to be fair by the majori ty of the respondents. The texture of blended yarns WS1 and WS2 was reported to be harsh by a majority of the respondents. However, yarn sample WS2 was less harsh as compared to yarn sample WS1. This was due to more SPF content in it.

5. Optimization of blending parameters for SPF and wool waste

Amongst the developed blended yarns, yarn sample WS2 with a blend ratio of 30:70, count 10 Nm and 'Z' twist blended in worsted system showed balanced physical and mechanical properties required to be taken up for making a knitted fabric. Production feasibility of blended yarns was also found to be moderate to high for yarn sample WS2. Hence, it can be concluded that the blending parameters of yarn sample WS2 were most appropriate to be utilized for making knitted fabric for apparel purposes.

6. Conclusion

It can be concluded based on the physical appearance of yarns and test results that SPF and wool waste can be successfully blended in different ratios and counts. However, sample WS2 with a blend ratio of 30:70, count 10 Nm and 'Z' twist blended in worsted system were suggested as the optimum blend parameters for producing a good yarn for knitting purpose. Higher twist, finer count, and good tensile strength are a few of the properties which make this particular blend ratio suitable for apparel as well as upholstery applications. A blended yarn of SPF and wool waste, when used to construct fabric, will incorporate a soft handle with warmth. The presence of small fibers on the yarn surface will impart a fuzzy look to the fabric constructed from it.

This study has suggested a novel approach for utilization of waste wool, which can lead to production of good quality of fabric and give a good profit to the hosiery industry. The fabric constructed from the suggested optimum yarn of soyabean and waste wool can be taken up for commercial production in knitwear industries for sustainable production.

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Effect of pre-treatment and dyeing parameters on Dyeing of meta-aramid Yarn

Komal Kukreja, Prasanta K Panda*
Bombay Textile Research Association, L B S Marg, Ghatkopar (W), Mumbai 400086

Abstract

The meta-aramid fiber is well accepted raw material for high-performance applications. Uses of products include apparel fabrics to protect against flash fire and electric arc exposure firefighter garments, filtration applications, insulation in flame-resistant (FR) thermal protective apparel, rubber reinforcement, and transportation textiles such as aircraft carpeting. For industrial applications, there is no need to dye the fiber but for the garment, there is a need to dye the material. This is difficult to dye the fiber due to its high crystalline and compact structure. In this study, aramid yarn is pre-treated with the solvent Dimethylformamide to facilitate the dyeing process and then dyeing is done with cationic dye. Pre-treatment and dyeing were done at different temperatures and times to see how these parameters affect the process. The fastness properties of dyed fibers were found good at high dyeing time and temperature followed by high pretreatment time and temperature.

Keywords

Aramid, pretreatment, dyeing, low temperature

Citation

Komal Kukreja, Prasanta K Panda - Effect of pre-treatment and dyeing parameters on Dyeing of meta-aramid Yarn, BTRA Scan - Vol. LI No. 2 APRIL 2022, Page no. 5 to 10

1.0 Introduction:

Aramid fibers are aromatic polyamides that were developed by DuPont in the early 1960s. Meta aramid fibers are commercially available under the trade name Nomex. These fibers are being used for making high electrical and thermal protective apparel because of their high strength, high modulus and heat resistance property. These fibers can be dyed in different colours through the dope dyed process. When small batches of dyeing in different shades are required, exhaust dyeing needs to be done. But exhaust dyeing of these fibers is difficult due to its thermostable crystalline structures having a high degree of molecules orientation in the polymer chain and strong hydrogen bonding between amide groups in adjacent chains. Various attempts have been made to dyeing of aramid fibers. One feasible method of them is the treatment of fibers with polar solvents such as dimethylformamide, dimethylacetamide, and dimethyl sulfoxide which helps in structure opening and easy penetration of dyes [1]. M.T. Islam et al. [2] used N-methyl formanilide as a swelling agent in the cationic dyeing process of meta-aramid fibers and has demonstrated an increase in dyeability. S. Y. Han et al. [3] did acid dyeing of meta-aramid yarn after pre-treating it with PEO45-MeDMA diblock copolymer derived from [2-(methacryloyloxy)ethyl] trimethylammonium chloride. This pre-treatment creates dyeing sites that can bond with anionic dyes. Para-aramid fibers can be dyed with disperse dye as shown by A. A. Vassiliadis et al. [4], however, exhaustion was lower than 79%. N. Oiwa et al [5] have discussed a method of dyeing aramid fibers with sulphur or vat dye after treatment with a polar solvent. F. Azam [6] showed the dyeing behaviour of cationic dyes at different parameters. M. Morris et al [7] have shown the effect of pretreatment of the para-aramid fabric with soyabean oil and nonthermal plasma on cationic dyeing. In the present study, aramid fibers have been pre-treated with dimethylformamide and dyed with cationic dye. A systematic study on the effect of pre-treatment and dyeing temperatures and time has been done. The effect of change in such parameters in colour value, when exposed to light and washing, is also studied.

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2. Materials and Methods

2.1 Material

100% Nomex yarn of count 3/30 was procured from Arvind Limited. Dimethylformamide 99.8% purity, sodium carbonate and sodium dithionite were procured from Merck Chemicals. Coralene red cationic dye was procured from ColourTex.

2.2 Pretreatment of m-Aramid Yarn

m-Aramid yarns were pre-treated with DMF with MLR 1:15 at a definite temperature for a definite time in a water bath. To study the effect of pretreatment temperatures, the temperature was varied as 45^{O}C, 65^{O}C and 90^{O}C and to study the effect of pretreatment time, it was done at 15, 60 and 120 minutes. Samples were then hot washed for 15 minutes followed by normal wash and open-air drying.

2.3 Dyeing of m-aramid yarn

Dyeing of pretreated aramid yarn was done with 3% shade, MLR 1:25, pH 3-4 at a definite temperature for a definite time. To study the effect of dyeing temperatures, the temperature was varied as 100^{O}C, 120^{O}C and 140^{O}C and to study the effect of dyeing time, it was varied as 45, 90 and 150 minutes.

Dyed Samples were then treated with a 1gpl solution of sodium carbonate and sodium dithionite at a temperature of 100^{O}C for 15 minutes followed by normal wash and open-air drying.

2.4 Testing of prepared samples

Samples were exposed to Xenon arc light of energy 500W/m^2 and the change in colour value after 1, 2, 5 and 8 hours of light exposure is evaluated. For analysis of change in colour value after washing, Soap solution is prepared with standard soap of 5 gpl and sodium carbonate 2 gpl. Samples were then subjected to washing with MLR 1:50 at a temperature of 95^{O}C for 4 hours in a laundometer followed by normal wash and open-air drying.

2.5 Colour value measurement

Prepared samples were then analysed for colour value using Macbeth color-Eye 7000 A spectrophotometer.

3. Results and Discussion

3.1 Effect of change in parameters on a colour value

Table 1 shows the colour value of the samples prepared with different parameters and a graph showing the change in colour value with the change in parameters is shown in figure 1. The results show that with the increase in pretreatment temperature, pretreatment time, dyeing temperature and dyeing time colour value of the sample increases. However, the percentage increase in colour value in case of an increase in dyeing temperature is higher compared to the dyeing time.

This shows that dyeing temperature plays important role in the dyeing of aramid fibers. Similarly, the effect of pretreatment temperature is more compared to the pretreatment time.

Table 1: Colour Value of samples at different parameters

Parameters	K/S Value	% Increase in colour value
Pretreatment Temp (^{0}C)		
40	12.77	
65	16.73	31.0
90	19.41	52.1
Pretreatment Time (min)		
15	14.73	
60	17.25	17.2
120	19.64	33.4
Dyeing Temp (^{0}C)		
100	4.10	
120	9.31	123.0
140	14.33	264.0
Dyeing Time (min)		
45	13.62	
90	14.61	7.3
150	17.39	30.3

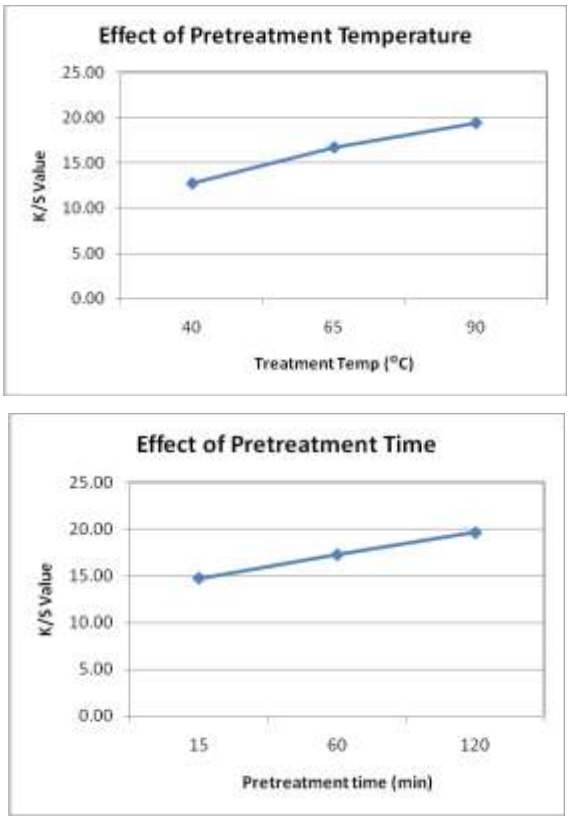
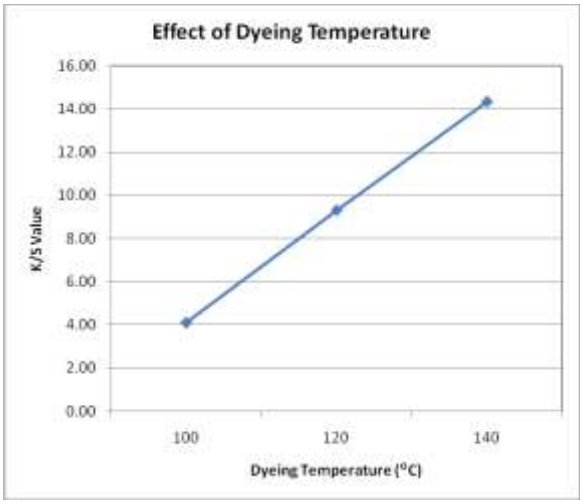


Figure 1: Effect of change in parameters on a colour value



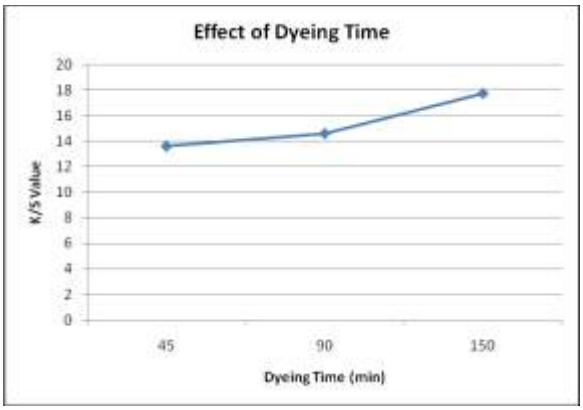


Figure 1: Effect of change in parameters on a colour value

3.2 Effect of change in parameters on colour value with light exposure

3.2.1 Effect of pretreatment temperature:

Effect of change in pretreatment temperature on colour value and percentage change in colour value with exposure to light is shown in table 2, figure 2 and figure 3. With the increase in exposure to the light colour value of all samples decreases. With the increase in pretreatment temperature, the percentage change in colour value after light exposure decreases, which shows that a higher pre-treatment temperature helps to improve the fastness to light.

Table 2: Effect of pretreatment temperature in colour value and percentage change in colour value with light exposur

Time of Exposure (Hr)	Colour Value			% Change in colour value		
Pretreatment Temp	45° C	60° C	90° C	45° C	60° C	90° C
0	12.77	16.73	19.41			
1	8.64	11.76	14.99	32.3	29.7	22.8
2	7.98	11.71	15.83	37.5	30.0	18.5
5	6.67	9.70	12.43	47.7	42.0	36.0
8	5.31	7.75	10.24	58.4	53.7	47.3

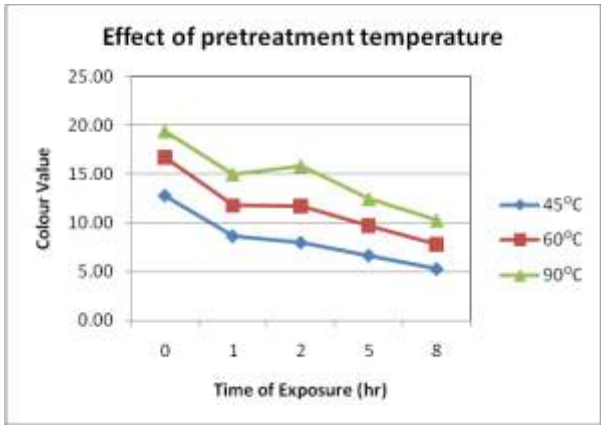


Figure 2: Effect of pretreatment temperature on colour value after light exposure

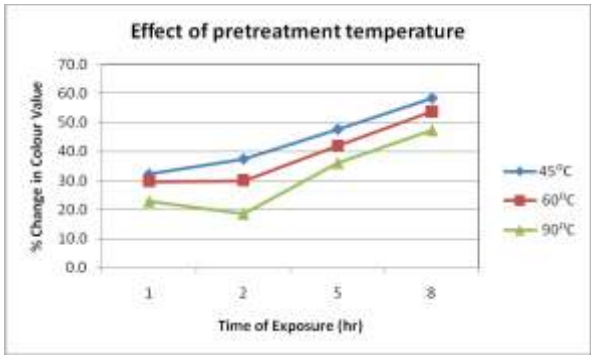


Figure 3: Effect of pretreatment temperature in percentage change in colour value after light exposure

3.2.2 Effect of change in pre-treatment time:

The effect of change in pre-treatment time in colour value and percentage change in colour value with exposure to light is shown in table 3, figure 4 and figure 5. With the increase in exposure to light, the colour value of all samples decreases. However, with 60 minutes of pretreatment time, the percentage change in colour value is less at 15 minutes and 120 minutes of pretreatment time which shows that pretreatment of fibers for a longer duration does not help in fixing the dye. From the observed values, the standardised time for treatment of fiber was kept for 60 minutes.

Table 3: Effect of pretreatment time in colour value and percentage change in colour value with light exposure

Time of Exposure (Hr)	Colour Value			% Change in colour value		
Pretreatment Time	15 min	60 min	120 min	15 min	60 min	120 min
0	14.73	17.25	19.64			
1	10.54	13.36	13.54	28.5	22.6	31.0
2	10.11	12.89	12.97	31.3	25.3	34.0
5	8.09	10.45	10.10	45.1	39.4	48.6
8	6.73	8.90	8.60	54.3	48.4	56.2

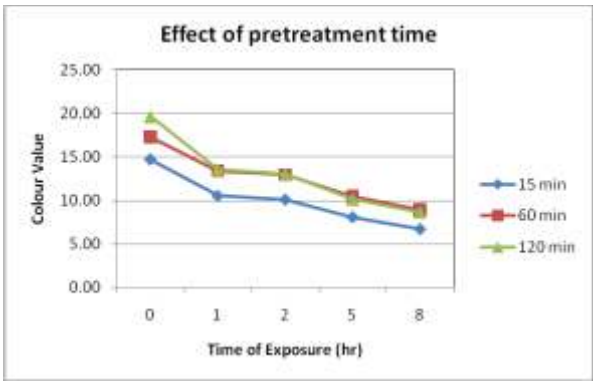


Figure 4: Effect of pretreatment time in colour value with light exposure

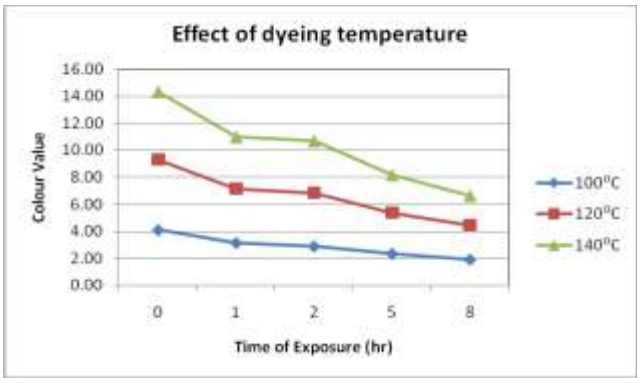


Figure 6: Effect of dyeing temperature in colour value with light exposure

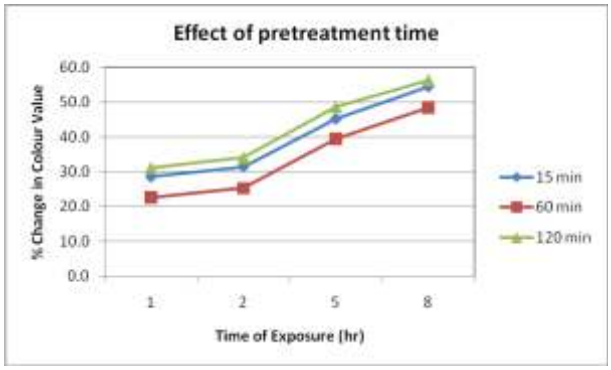


Figure 5: Effect of pretreatment time in percentage change in colour value with light exposure

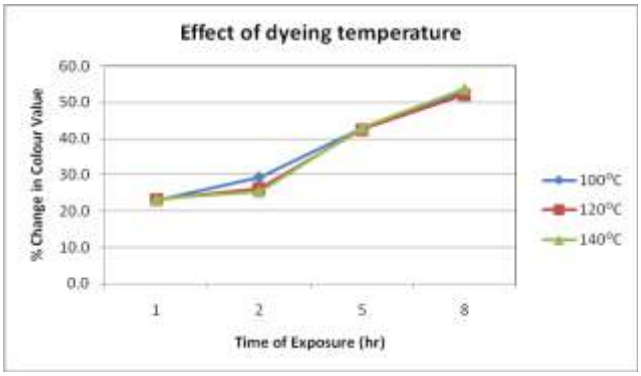


Figure 7: Effect of dyeing temperature in percentage change in colour value with light exposure

3.2.3 Effect of change in dyeing temp:

The effect of change in dyeing temperature on colour value and percentage change in colour value with exposure to light is shown in table 4, figure 6 and figure 7. With the increase in exposure to light, the change in colour value and percentage of the colour value of all samples shows a similar decreasing trend.

Table 4: Effect of dyeing temperature on colour value and percentage change in colour value with light exposure

Time of Exposure (Hr)	Colour Value			% Change in colour value		
Dyeing Temperature	100° C	120° C	140° C	100° C	120° C	140° C
0	4.10	9.31	14.33			
1	3.16	7.15	10.98	22.99	23.15	23.35
2	2.89	6.86	10.69	29.43	26.29	25.39
5	2.35	5.35	8.17	42.80	42.49	42.98
8	1.92	4.45	6.63	53.20	52.17	53.71

3.2.4 Effect of change in dyeing time:

The effect of change in dyeing time on colour value and percentage change of colour value with exposure to light is shown in table 4, figure 6 and figure 7. With the increase in exposure to the light colour value of all samples dyed at different temperatures decreases. Above the 90 minutes f dyeing, There is no significant improvement in fastness to light.

Table 5: Effect of dyeing time in colour value and percentage change in colour value with light exposure

Time of Exposure (Hr)	Colour Value			% Change in colour value		
Dyeing Time	45 min	90 min	150 min	45 min	90 min	150 min
0	13.62	15.22	17.39			
1	10.05	11.68	13.06	26.17	23.22	24.87
2	9.74	11.33	13.40	28.45	25.57	22.94
5	7.74	9.13	10.45	43.18	39.98	39.90
8	6.30	7.66	8.70	53.72	49.66	49.96

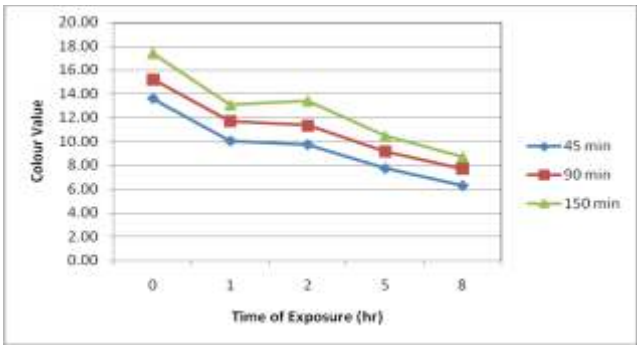


Figure 8: Effect of dyeing time in colour value with light exposure

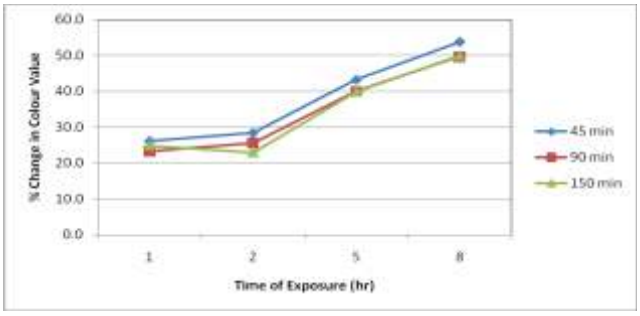


Figure 9: Effect of dyeing time in percentage change in colour value with light exposure

3.3 Effect of change in parameters on colour value with washing

3.3.1 Effect of pretreatment temperature:

The effect of change in pretreatment temperature on the colour value of samples after washing is shown in table 6 and figure 10. At higher temperatures of 65°C and 90°C, the percentage change in colour value is similar.

Table 6: Effect of change in pretreatment temperature in colour value after washing

Pretreatment Temp	Colour Value before wash	Colour Value after wash	% Change in colour value
40° C	12.77	8.61	32.56
65° C	16.73	12.99	22.35
90° C	19.41	15.07	22.38

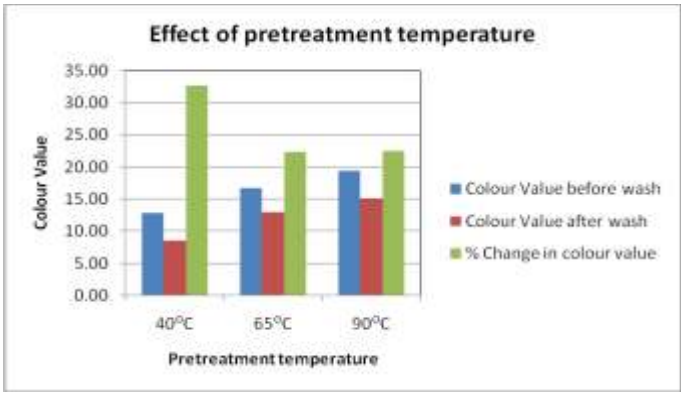


Figure 10: Effect of change in pretreatment temperature in colour value after washing

3.3.2 Effect of pretreatment time:

The effect of change in pretreatment time on the colour value of samples after washing is shown in table 7 and figure 11. At 60 minutes of pretreatment, the percentage reduction in colour value is less as compared to 15 minutes and 120 minutes of pretreatment, which shows that 60 minutes pretreatment is an optimum pretreatment time. This result is an agreement to change in colour value to light exposure.

Table 7: Effect of change in pretreatment time in colour value after washing

Pretreatment Time	Colour Value before wash	Colour Value after wash	% Change in colour value
15 min	14.73	10.779	26.81
60 min	17.25	13.918	19.33
120 min	19.64	14.466	26.34

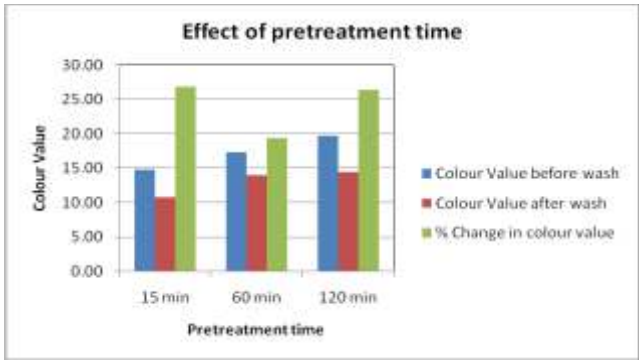


Figure 11: Effect of change in pretreatment time in colour value after washing

3.3.3 Effect of dyeing temperature:

The effect of change in dyeing temperature time on the colour value of samples after washing is shown in table 8 and figure 12. At temperature 140°C percentage reduction in colour after washing was observed compared to low-temperature values.

Table 8: Effect of change in dyeing temperature in colour value after washing

Dyeing Temp	Colour Value before wash	Colour Value after wash	% Change in colour value
100° C	4.10	3.10	24.34
120° C	9.31	6.50	30.17
140° C	14.33	11.56	19.36

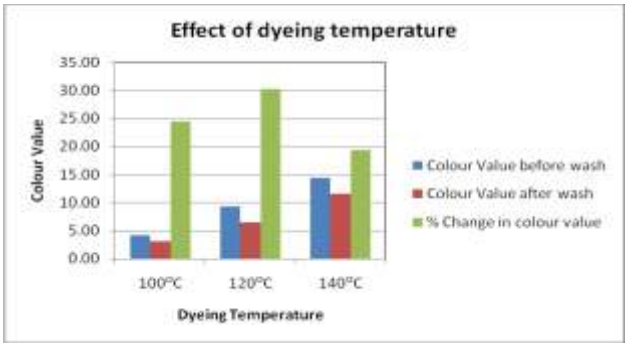


Figure 12: Effect of change in dyeing temperature on colour value after washing

3.3.3 Effect of dyeing time:

The effect of change in dyeing time on the colour value of samples after washing is shown in table 9 and figure 13. At 150 minutes of dyeing time, the percentage reduction in colour was found less after washing.

Table 9: Effect of change in dyeing time in colour value after washing

Dyeing Time	Colour Value before wash	Colour Value after wash	% Change in colour value
45 min	13.62	10.51	22.85
90 min	14.61	11.14	23.77
150 min	17.39	15.503	10.85

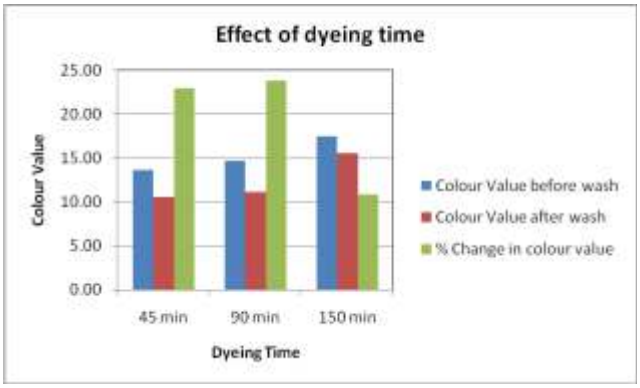


Figure 13: Effect of change in dyeing time in colour value after washing

4. Conclusion

In this study, the effect of pretreatment temperature, pretreatment time, dyeing temperature and dyeing time on the dyeing of aramid fibers was studied. It was found that the effect of dyeing temperature is prominent among others. Higher pretreatment temperature with standard pretreatment time and higher dyeing time leads to a darker shade. In this study, standard parameters were pretreatment at 90^{o}C temperature for 60 minutes with dyeing at 140^{o}C for 2.5 hours. These results were supported by the percentage of colour change after light exposure and washing. High dyeing temperature and time help to improve the fastness of washing. At the pretreatment temperature of 90^{o}C and time of 60 min there is comparatively less fading of samples to light and wash fastness.

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Determination of Minimum Inhibitory Concentration by Broth Dilution Method - A Review

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Abstract

Microbial resistance to antimicrobial agents is a growing problem, especially in the medical sector. Application of proper antimicrobial agent is important as resistance can develop quickly. For this reason, the concentration of antimicrobial agents has to be properly adjusted. Providing a higher than normal concentration can lead to organisms developing resistance quickly and transforming into 'superbugs'. Higher concentrations of antibiotics are biologically harmful. On the other hand, if the concentration of antimicrobial agents is too low, it may be ineffective. To tackle these issues, determination of the Minimum Inhibitory Concentration of antimicrobial agents is required. A review of the method to determine MIC is done. The tube (or broth) dilution method is used to determine the MIC of a known compound. Further, the same test is used in the case of the formulation of an unknown compound. A confirmatory test is done to support the results.

Key words

Minimum Inhibitory Concentration, Broth dilution method, Susceptibility, Antimicrobial agent, Diffusion.

Citation

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1.0 Introduction

To determine the susceptibility of any antimicrobial agent, diffusion tests are done. These tests only provide qualitative information. These tests cannot be used to quantify the concentration of antimicrobial agents that can inhibit the growth of a harmful agent but only if the agent possesses antimicrobial properties. Minimum Inhibitory Concentration (MIC) gives us the exact concentration of an antimicrobial agent that can inhibit the growth of a microorganism (1). Once the MIC of an antimicrobial agent is determined, it can be further implemented into drug dosage, etc.

There are two methods to determine MIC:

1.1 Broth dilution method

The broth dilution method is performed in tubes where the antimicrobial agent is serially diluted in a nutrient medium. To each tube, a known concentration of test culture is added and incubated. Post incubation, the lowest concentration which shows the absence of turbidity is considered the minimum inhibitory concentration. It has two advantages over the agar dilution method: the method can be used for determining Minimum Bactericidal Count and it minimizes the solidification risk that is possessed by the agar dilution method. (2)

1.2 Agar dilution method

The Agar dilution method is performed by preparing serial dilutions of the stock compound and pouring molten agar over it. The advantage of this method is that more than one organism can be tested simultaneously on one plate.

This review contains the broth dilution method. It was originally published by the University of Maryland. It is also known as BSCI 424 Method(4). It makes use of 2 fold dilutions. This method was adopted with certain changes wrt culture preparation changes. The review of the method was performed by maintaining proper environmental conditions.

2. Materials and equipment

Weighing balance, Laminar Airflow, and Biosafety cabinet was required for testing. The materials were incubated in an incubator capable of maintaining 37 ± 2˚C temperature. 10 test tubes with caps for each set, micropipettes that can measure 0.1-1.0 ml of liquid, test tube racks, and bottles were sterilized before use. Mueller Hinton Broth and Soyabean casein digest agar were chosen media which were also sterilized.

3. Method

The protocol was designed following the standard method (2).

3.1 Preliminary test:

Before identifying the MIC of the unknown compound, the compound was tested against Staphylococcus aureus to ensure its antimicrobial activity.

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Figure 1: Agar well diffusion method to determine Antimicrobial nature of the compound

3.2 Preparation of stock:

A known stock of commercial 100 µg/ml of penicillin G was used. For the unknown compound, PM, the stock of solution was calculated as below:

Calculation of stock solution:

$$W = \frac{1000}{P} \times V \times C$$

Where,

W = Weight of antimicrobial to be dissolved in V (in µg)

V = Volume required (in ml)

C = Final Concentration of solution (in µg/ml)

P = Potency of the compound (given by manufacturer)

$$W = \frac{1000}{990} \times 100 \times 100$$

W = 10101.01 µg

Thus, W = 0.01 mg

0.01mg of the unknown compound was weighed in dissolved in 100 ml of ethanol (solvent chosen by manufacturer).

3.3 Preparation of nutrient medium and sterilization:

The chosen nutrient medium for the test was Mueller Hinton Broth. Mueller Hinton Broth (Hi-Media brand) was prepared as per instructions on the bottle and dispensed into borosilicate bottles before sterilizing. The sterilization process was carried out at 121˚C for 15 minutes by autoclaving. For the confirmatory test, Mueller Hinton Agar (Hi-Media brand) plates were prepared by autoclaving the medium and pouring 15 ml each into sterilized plates. The plates were pre-incubated at 37 ˚C for 18-24 hours.

3.4 Preparation of stock culture:

4 bacterial cultures were used for the test. They were:

3.4.1 Staphylococcus aureus

3.4.2 Klebsiella pneumoniae

3.4.3 Escherichia coli

3.4.4 Pseudomonas aeruginosa

Klebsiella pneumoniae and *Escherichia coli* are well known for their resistance to Penicillin and Beta lactams and are used as negative controls. Many *Staphylococcus* species are resistant to Penicillin and a sensitive strain of *Staphylococcus aureus* was used. *Pseudomonas aeruginosa* is sensitive to penicillin and was used as a positive control.

Individual colonies from each culture were added to separate sterilized flasks with sterilized Mueller Hinton Broth and incubated at 35 ± 2˚C for 18 hours. After the incubation period is over, the cultures were adjusted with McFarland's standard to obtain a density of 1.8×10^8 CFU/ml. This density was further diluted to 10^5 CFU/ml for better visibility since the cultures were no longer turbid at this density(3).

3.5 Preparation of stock dilution:

12 sterilized and capped tubes numbered from 1 to 12. To the first tube, 2 ml of 100µg/ml of penicillin stock was added. 1 ml of sterilized Mueller Hinton Broth was added to tubes 2 to 10. 1ml of stock penicillin was transferred from tubes 1 to 2 with a micropipette and mixed well. Once mixed, 1 ml of the mixed stock was transferred from tube 2 to 3 and so on to tube 10. The first tube containing equal amounts of 100 µg/ml of Penicillin and culture was labeled as 50 µg/ml. Tube no. 2 was considered as 25 µg/ml and so on till tube no 10 was labeled as 0.391 µg/ml.

Micropipette tips were discarded after every tube to avoid

The following table shows tube numbers corresponding to the concentration of penicillin used.

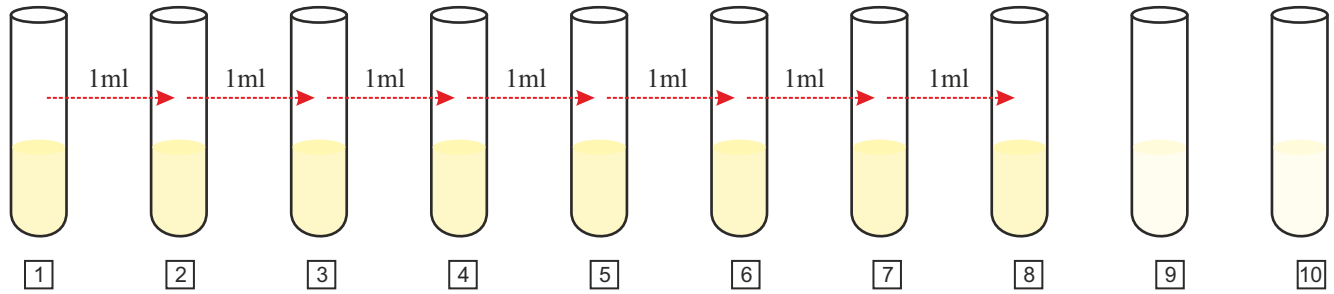
Tube No.	1	2	3	4	5	6	7	8	9	10
Concentration of antimicrobial agent (µg/ml)	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.196	0.098

the transfer of penicillin from the outer surface of the tip. 1 ml from tube 10 was discarded. Tube 11 and 12 consisted only of Mueller Hinton Broth. Tube 11 was a positive control for the culture. Tube 12 was medium control. The procedure was repeated for all cultures.

For an unknown compound, PM, the procedure was slightly altered as per the manufacturer's instructions that the compound's MIC was not low. Hence, concentrations of 0.196 µg/ml and 0.098 µg/ml concentration tubes were skipped.

The following table shows tube numbers corresponding to the concentration of unknown compound, PM, used.

Tube No.	1	2	3	4	5	6	7	8
Concentration of antimicrobial agent (µg/ml)	50	25	12.5	6.25	3.125	1.563	0.781	0.391



Diagrammatic representation of tube dilutions of an unknown compound, PM.

3.6 Culture addition:
1 ml each of prepared culture of 10^5 CFU/ml was added to all tubes except for medium control. The procedure was repeated for all cultures and unknown compounds, PM.

3.7 Incubation:
All tubes were incubated in racks at 35 ± 2˚C for 18-24 hours. After the incubation period was over, the tubes were observed for turbidity.

3.8 Confirmatory tests

Based on the results of the broth dilution test, tubes were selected and streaked on sterile Mueller Hinton Agar. The tubes were incubated at 35 ± 2˚C for 18-24 hours.

4. Results and discussion

4.1 Tube dilution results:

4.1.1 Known compound (Penicillin) results:

For standard penicillin, all tubes showed turbidity when tested against *Klebsiella pneumoniae* and *Escherichia coli*. Both cultures are popularly known to be resistant to Penicillin G and hence were used specifically as negative controls. Tubes inoculated with *Pseudomonas aeruginosa* showed no turbidity, apart from the positive control tube which contained no Penicillin. The tube containing 0.098 µg/ml penicillin showed turbidity. Other tubes showed growth.

Table 1: Observations of MIC test for Penicillin G

Culture	Dilution of Penicillin G (µg/ml)											
	50	25	12.5	6.25	3.125	1.563	0.781	0.391	0.196	0.098	Culture control	Media control
K. pneumoniae	+	+	+	+	+	+	+	+	+	+	+	-
E. coli	+	+	+	+	+	+	+	+	+	+	+	-
S. aureus	-	-	-	-	-	-	-	-	+	+	+	-
P. aeruginosa	-	-	-	-	-	-	-	-	-	+	+	-

Key: "–" = No growth; " + " = Growth (turbidity)

Based on the observation, Penicillin G has a Minimum Inhibitory Concentration of 0.391 µg/ml for *Staphylococcus aureus* and 0.196 µg/ml for *Pseudomonas aeruginosa*. Both, *Klebsiella pneumoniae* and *Escherichia coli* are resistant to Penicillin G. This result is from studies of Penicillin G which shows that the method can be used for other compounds.

4.1.1 Unknown compound (PM) results:

For an unknown compound, PM, tubes 5 to 8 showed turbidity in case of *Klebsiella pneumoniae* and tubes 4 to 8 showed turbidity in case of *Escherichia coli, Staphylococcus aures*, and *Pseudomonas aeruginosa*.

Table 2: Observations of MIC test for unknown compound, PM

Culture	Dilution of PM (µg/ml)									
	50	25	12.5	6.25	3.125	1.563	0.781	0.391	Culture control	Media control
K. pneumoniae	-	-	-	-	+	+	+	+	+	-
E. coli	-	-	-	+	+	+	+	+	+	-
S. aureus	-	-	-	+	+	+	+	+	+	-
P. aeruginosa	-	-	-	+	+	+	+	+	+	-

Key: "–" = No growth; " + " = Growth (turbidity)

Based on the observation, Sample PM has a Minimum Inhibitory Concentration of 6.25 µg/ml for *Klebsiella pneumoniae*, 12.50 µg/ml for *Eschericha coli*, 12.50 µg/ml for *Staphylococcus aureus*, and 12.50 µg/ml for *Pseudomonas aeruginosa*.

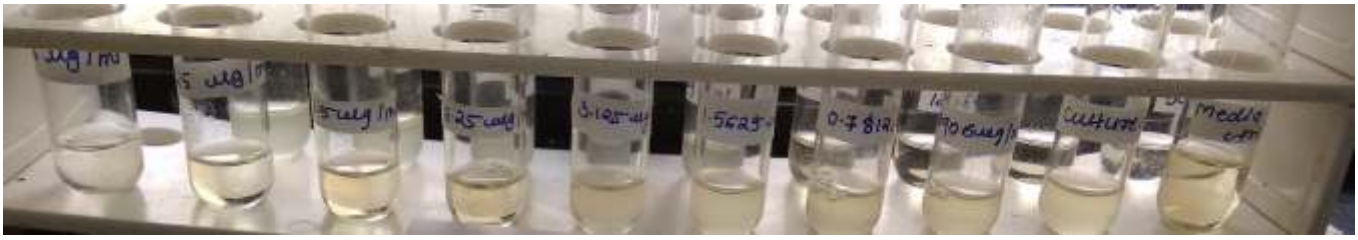


Figure 2: Tubes showing dilutions of PM tested against Klebsiella pneumoniae

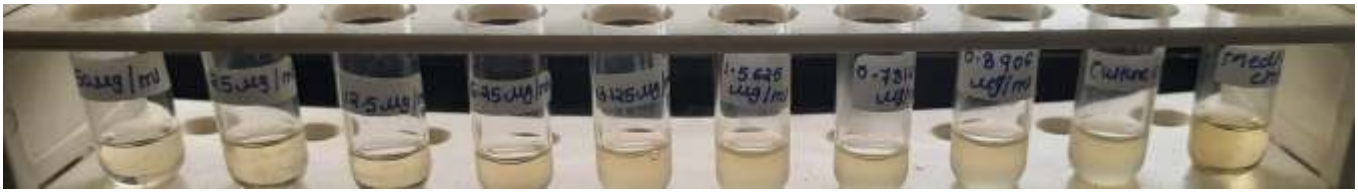


Figure 3: Tubes showing dilutions of PM tested against Escherichia coli

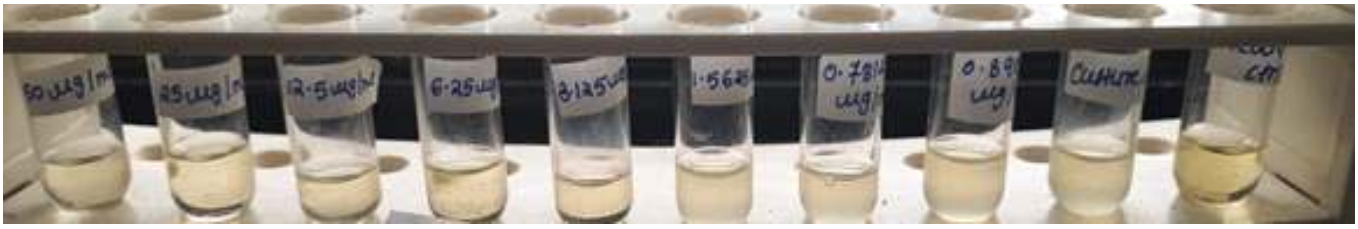


Figure 4: Tubes showing dilutions of PM tested against Staphylococcus aureus.

Figure 5: Tubes showing dilutions of PM tested against Pseudomonas aeruginosa.

4.2 Confirmatory test results:

4.2.1 Confirmatory result of Penicillin G

In the case of Penicillin G, the tubes containing 0.391 µg/ml, 0.196 µg/ml, and 0.098 µg/ml concentration of Penicillin G were streaked on Mueller Hinton Agar medium plates. The results matched with the broth dilution test.

Table: confirmatory results of broth dilution test.

Culture	Dilution of Penicillin G (µg/ml)		
	0.391	0.196	0.098
K. pneumoniae	+	+	+
E. coli	+	+	+
S. aureus	-	+	+
P. aeruginosa	-	-	+

Key: "–" = No growth; " + " = Growth (turbidity)

Based on the results, the resistance of *Escherichia coli* and *Klebsiella pneumoniae* to *Penicillin G* was confirmed. The MIC of Penicillin G of 0.391 µg/ml for *Staphylococcus aureus* and 0.196 µg/ml for *Pseudomonas aeruginosa* was confirmed.

4.2.2 Confirmatory result of PM

In the case of PM, the tubes containing 3.125 µg/ml, 6.25 µg/ml, 12.5 µg/ml, and 25 µg/ml were streaked on Mueller Hinton Agar medium plates. The results matched with the broth dilution test.

Table: confirmatory results of broth dilution test.

Culture	Dilution of PM (µg/ml)			
	25	12.5	6.25	3.125
K. pneumoniae	-	-	-	+
E. coli	-	-	+	+
S. aureus	-	-	+	+
P. aeruginosa	-	-	+	+

Figure 6: Confirmatory test broth dilution test of PM against Klebsiella pneumoniae

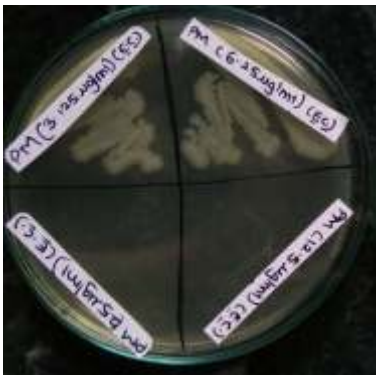


Figure 7: Confirmatory test broth dilution test of PM against Escherichia coli.

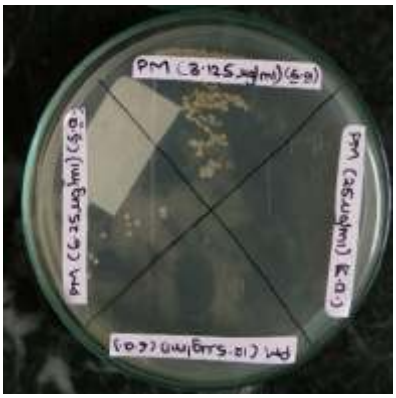


Figure 8: Confirmatory test broth dilution test of PM against Staphylococcus aureus

Figure 9: Confirmatory test broth dilution test of P M against Pseudomonas aeruginosa

5. Conclusion

Minimum Inhibitory Concentration was successfully determined using the BSCI 424 Method(4). MIC of the previously known antibiotic (Penicillin G) was confirmed. MIC of an unknown compound (PM) was found. Four bacteria were used for testing and all four showed varying reactions to the products tested. The method was reviewed and it works by the behavior of the compounds.

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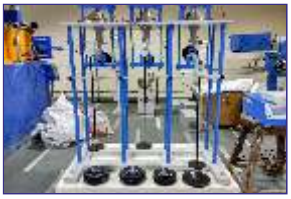
Installation Damage of Geosynthetics

The geosynthetics are prone to some amount of damage during their installation. To assess the quantity of the installation damage, a standard method was initially developed by Watts and Brady of the Transport Research Laboratory in the United Kingdom. The procedure has also discussed in the ASTM D 5818 with similar requirements. We are at BTRA doing the test following same ASTM D 5818 method followed by respective tensile strength. For the time being we are using the construction site for the sample preparation. If customer will agree, BTRA will collect the sample from site after standard procedure and provide ethe report.









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RR +++ 108 Active Nanosilver Field Mask for Improved Protection Against Bacteria, Virus, and Fungi

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Abstract

As the protective mask available in the market claims only for bacterial filtration efficiency and does not guarantee the virus protection since the size of the virus is much smaller than the pore of the material used in the mask. An effective virus protective face mask was developed using activated nano silver technology. The five layers mask was developed wherein the first and fifth layer was coated with activated nanosilver to impart the antibacterial and antiviral properties.The developed mask (RR+++ 108) has been tested for a reduction in various pathogens. It was found that the developed mask has 99.9% bacterial filtration efficiency (BFE);; 96.3% particulate filtration efficiency (PFE);; 99.4% virus reduction efficiency (VRE);; 99.9% virus filteration efficiency (VFE);; 64.8 % fungus reduction efficiency;; and also resistance to MILD DEW and ROT up to 96 hours. It has also been found to be very effective against H3N2 INFLUENZA A VIRUS , HCOV 229E, which are from the enveloped family similar to SARS COV 2 . The developed mask has shown virus reduction in just 30 seconds only . It is comfortable to wear for a long duration of time up to 8hrs and is Hypoallergenic. .

Keywords

Nano Silver, Bacterial Filtration Efficiency (BFE), PFE and VRE

Citation

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1. Introduction

Maharashtra has become the first state to lift all Covid curbs almost after two years. Now the mask is not mandatory in public places. At the same time, it has been advised to keep wearing a mask for the health and safety of all. On the contrary, China has again declared an emergency and imposed the lockdown in Shanghai after a new surge in asymptomatic cases in April 2022. According to the available information, the first case of coronavirus was reported in Wuhan, China in November 2019, and soon after it was found to be rapid spread all over the world and has been set off a global pandemic by World Health Organisation (WHO). The pandemic has necessitated body protection from virus, mainly nose and mouth. N95 was tested as the best option as it was available immediately since it was developed almost 20 years back as protection from dust and large aerosol particulates [1,2]. As we have witnessed three waves of Covid 19 in India and there are debates on the upcoming 4th wave. Under such circumstances, it is important to take necessary steps to safeguard yourselves as well as every individual.

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WHO has given 15 Covid appropriate behaviors to maintain health and safety. Out of which wearing a mask is the simplest and easiest way to follow. Though the Maharashtra Government has announced relief on wearing a mask it is always good to take care of ourselves as the new stream of Coronavirus is seen in Shanghai currently and there are high possibilities that it may again spread worldwide within no time. Under such circumstances, it is advised to wear a mask no matter if it is mandatory or not. Now the question arises, what kind of mask is good and who should wear what type of mask? At present, there are a variety of masks available in the market. Those masks are broadly categorised as fabric masks, protective masks (3ply), and a respirator (N95 type). The differences between each with its advantages and limitations are given in table 1. As seen from the table it is clear that a respirator (N 95 type) gives a higher level of protection but it is recommended to be used by healthcare professionals and frontline workers only. However, we have seen that many doctors and frontline workers are contracting the virus and getting infected by the corona virus. The main reason behind this is the testing standard requirement. Most of the N95 masks are tested for Bacterial Filtration Efficiency and Particulate Filtration Efficiency (BFE & PFE %) against the particulate size of 0.30 micron. Nonetheless, SARS COV2 Covid 19 virus is of size between 0.05 to 0.12 micron. This itself is self-explanatory that the virus can pass through the layers of the N95 mask [3-5].

Table 1. Understanding the difference between various masks available on the market

Particulars	Cloth Mask	Protective Mask (3ply)	Respirator (N95 type)
Intended use	Common people	Medical purpose	Health providers and front-line workers
Filtration level	Low level No fluid resistance Leakage thought fabric	Moderate level Resistance to fluid Leakage from sides	High level Resistance to small airborne particles No leakage
Fitting	Loose depends on the design	Loose fit	Tight fit
Usability	Reusable, need to wash after every use	Discard after every use	Discard after every use

Considering the above fact, we have developed an improved mask RR+++ (108) based on active nano silver coating. Silver ions are microbial and bind irreversibly with the electron transport components. They suppress the respiratory enzyme and interfere with the DNA function, thus, not only destroying virus & bacteria but also preventing proliferation and effectively giving long-duration microbial protection.

2. RR+++ Mask Vs N95 mask

A step-wise comparison of the RR+++ Mask with the N95 mask is given below. Normally, N 95 masks are made by combining 5 different layers of nonwoven material mostly using polypropylene (PP) fibers. The first and 5th layers are made up of 40 GSM PP nonwoven, 2nd and 4th layers are of 30 GSM melt-blown nonwoven and the middle layer is needle punched nonwoven. RR+++ mask also has five layers.

2.1 Comparison of the 1stand 5th layers

The 1stlayer is coated with activated nanosilver by electrospinning method to fight against the microbes present in the atmosphere. The mechanism of the silver ions on the nonwoven fabric is shown in figure 1.

As can be seen from figure 1B the nonwoven used in the N95 mask has a large pore size that the virus and bacteria can easily pass through as they are very small in size in the range of 0.05 to 0.12 micron. moreover, the viruses in Brownian movements can easily pass through the layers of the N95 mask. On the other hand, figure 1A represents the RR+++ mask developed using nanosilvernonwoven fabric. It is coated with an active nano-silver which has a positive charge on it and works as an Israel missile shield by electrostatic attraction. Nanosilver also has the affinity to the sulfur protein present in the bacterial and virus-cell and hence gets attached to the cell wall and envelop gets ruptured rendering it neutralised and ineffective [6-8]. Silver ions interfere with the DNA function , preventing the bacteria, virus , pathogens from performing the most basic function and also preventing proliferation and effectively giving long-duration microbial protection.

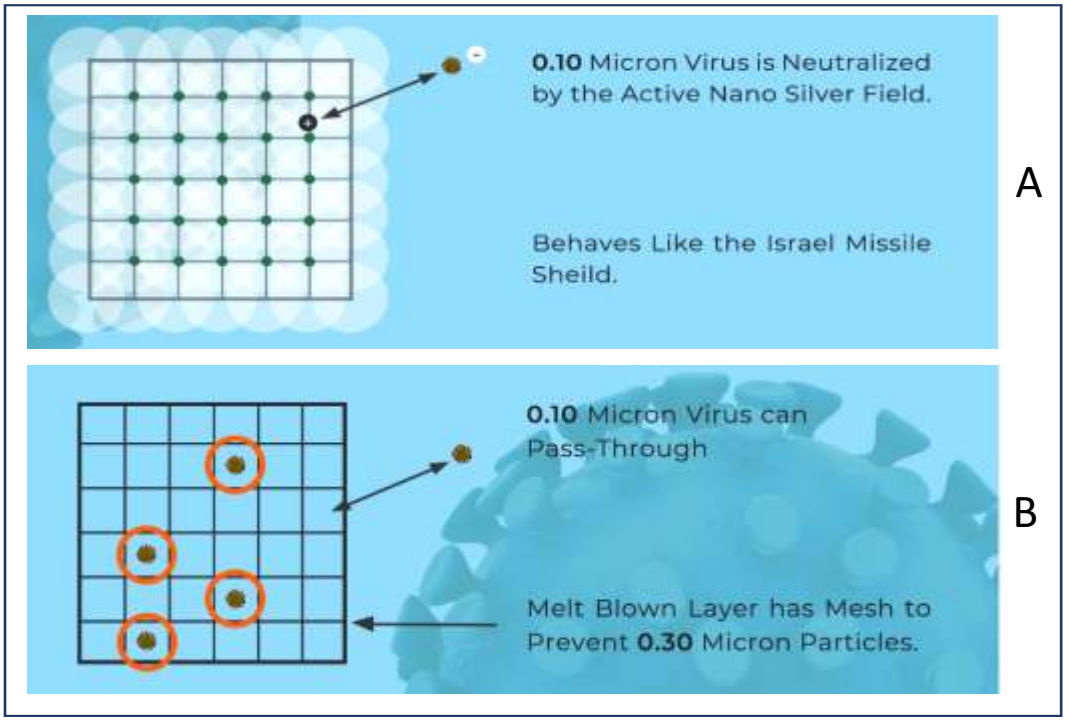
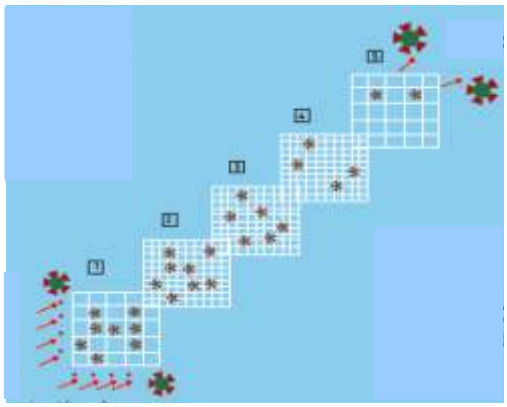


Figure 1 Comparative magnified look/behavior of nonwoven material used in the first layer of mask A- RR+++ mask, B- N95 mask

2.2 Comparison of the 2nd and 4th layer

In general, 30 GSM melt-blown nonwoven material is used in the N95 mask as the 2nd and 4th layer which acts as a filter for the bacterial, virus, and any dust particles. In the RR+++ mask, we have fine filters to prevent the penetration of any bacterial and virus. Typically, filtration mechanisms of any particulate are classified using four basic theories. Thoseinclude a. Impaction; b. Interception; c. Diffusion and d. Electrostatic attraction

A



B

Figure 2 Filtration mechanism of the different layers A- RR+++ mask, B- N95 mask

Normal N95 masks work on the basic filtration mechanism of interception. Wherein the particulates, bacteria, and viruses larger than the pore size get filtered out and the remaining get passed on to the next layer. As we can see from figure 2B the viruses are passing throughout the layers and reaching to the nose of the wearer hence, we saw many doctors and frontline workers contracting the virus and getting infected.

RR+++ mask has the first layer treated with active nano-silver which kills the maximum bacteria and virus at the 1st layer only by Electrostatic attraction mechanism as the spick of the viruses has a negative charge and silver ions are positively charged. Further, the fine filters used in the 2nd and 4th layers removed the remaining pathogens leaving only clean air to reach the wearer's nose. The middle layer in both masks is a soft pad of needle punched nonwoven material to provide comfort.

3. Testing and results:

Table 2 summarises the test requirement as per various national and international standard specifications for a protective face mask. Most of the standards mentioned requirements of breathing resistance, bacterial filtration efficiency (BFE), and particulate filtration efficiency (PFE). It should be noted that none of the standards mentioned the requirement for virus filtration efficiency (VFE). The viruses are much smaller than the bacteria and more resistant to killing than bacteria. The size of bacteria is about 0.4 microns whereas the size of virus ranges from 0.02 to 0.25 microns. Hence, the mask which is claimed to provide a very good BFE of about 99% may not be as effective against the SARS COV2 Covid 19 virus, Alpha, Beta, Gamma, and Delta (fungus infection) to Omicron variant family.

Table 2 Test required as per the specification of various national and international standards

Tests	ASTM F3502	ASTM F2100	IS 16289	IS 9473	EN 14683
Breathing resistance	✓	✓	✓	✓	✓
Bacterial filtration efficiency (BFE)	×	✓	✓	×	✓
Virus filtration efficiency (VFE)	×	×	×	×	×
Particulate filtration efficiency (PFE)	✓	✓	✓	✓	×
Splash resistance	×	✓	✓	×	×
Microbial cleanliness	×	×	×	×	✓
Virus Reduction efficiency (VRE)	×	×	×	×	×

We have tested our developed mask RR+++ for the BFE, PFE, VRE (Virus Reduction Efficiency), VFE, FRE (Fungus reduction efficiency), MILD DEW, and ROT Resistance up to 96 hours and also tested for HCOV 229E virus reduction. We have found very good results for each test. In every test, we have received an almost 99% reduction. From those results, it may be concluded that our developed mask has improved protection against most pathogens and is very comfortable to wear for a long duration. Further, the RR+++ has been found to have a 99.99% reduction for the H3N2 INFLUENZA virus which is a much smaller size virus than SARS COV2. This implies the super virus reduction properties.

This implies the super virus reduction properties specially against enveloped viruses . It is to be noted that Non

Enveloped Viruses are not as harmful as compared to the enveloped Viruses (SARS COV 2) which are highly transmissible and lethal .

4. Conclusions:

Activated nanosilver was coated onto the nonwoven fabric that is used as 1st and 5th layers for the development of a virus protection mask. The developed RR+++ (model 108) mask was tested for its performance for filtration of bacteria and particulate and reduction of various viruses. The results showed a very good efficiency for bacteria and particulate filtration. Test Results of the mask has shown very good efficacy of virus reduction from SARS COV 2 and its subsequent evolved variants of Alpha , Beta, Gamma, Delta (fungus infection) to the Omicron Variant and all othe Variants in future will also be neutralisied . Sars COV 2 , H3N2 Influenza A , HCOV 229 E viruses are from different segments of same family and Omicron is a new emerged variant . Also the new BA1 , BA 2 variants emerging will be neutralised by this mask

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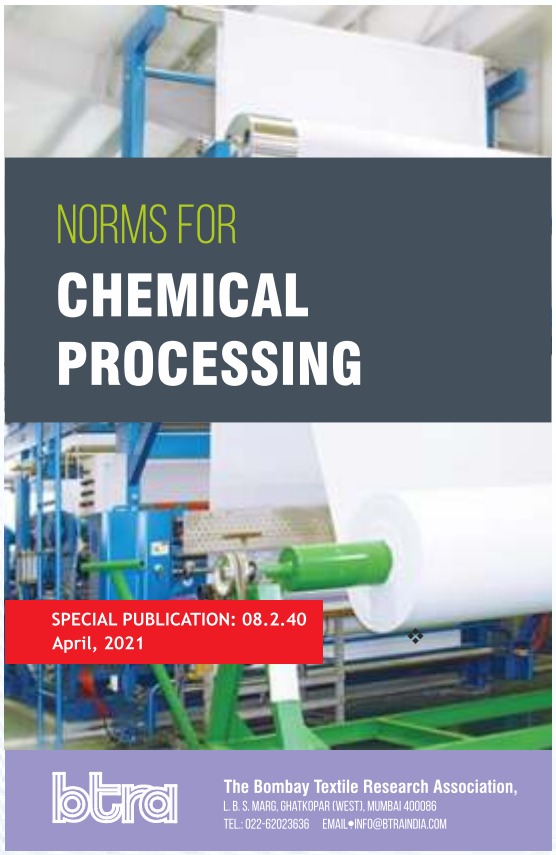

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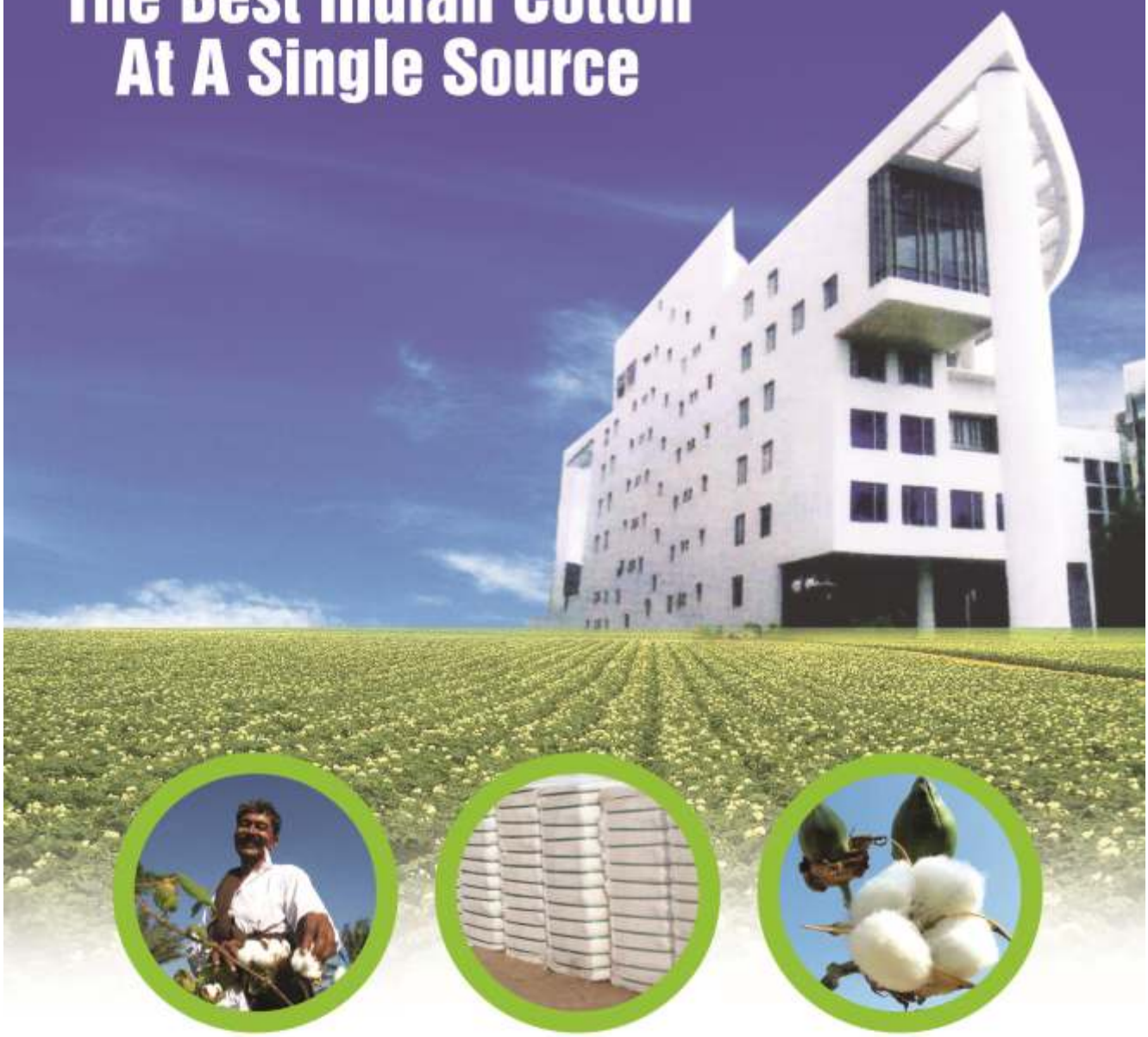

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