FABRICATION OF SPUNLACE MATERIAL USING NATURAL FIBERS FOR HEALTH AND HYGEINE PRODUCTS

[1*]J. Pearly, [2]Dr.S.GraceAnnapoorani, [3]K. Saranya

[1*]*Researchscholar, Department of Textiles and Apparel Design, BharathiarUniversity, Coimbatore, TamilNadu, India.*

[2]*Professor, Department of Textiles and Apparel Design, BharathiarUniversity, Coimbatore, TamilNadu, India.*

[3]*Research scholar, Department of Textiles and Apparel Design BharathiarUniversity, Coimbatore, TamilNadu, India*

[1*]*Corresponding Author :* J. Pearly

ABSTRACT

Investigations reveal that spunlace technology produce nonwovens for the medical and hygiene sectors. Nonwoven materials for medical applications offer numerous advantages both with regard to user requirements and material properties. The hygienic spunlaced nonwoven fabrics developed by the natural fibers are *Areca catechu, Typha latifolia, Ceiba pentanda, and Urtica dioica* The influence of a 50:50 combination of natural fiber and viscose fibers on the ability of spunlace fabrics to control moisture is examined in this study. One of the most important performance factors in figuring out how comfortable a cloth in moisture control. In order to explore the prospect of its application in medical products, it is crucial to analyze the moisture management properties of spunlaced fabrics. The nonwoven fabric under study was found to have an overall good moisture management coefficient. According to the evaluation of the

moisture management indices, the Moisture Management Fabric scored extremely well on AV, CV, KV, and NV. Considering the moisture management tester's findings, a nonwoven fabric with a composition of 50% natural fiber and 50% blended viscose was considered suitable for the apparel sector as well as healthcare and cleanliness items.

Keywords: *Nonwoven spunlaced fabric, hygienic material, moisture management, viscose fiber, natural fibers.*

1. INTRODUCTION

The growing consumer demand for apparel has forced the development of newer woven and knitted products. To meet the demand, nonwovens have also found its application in this sector(Dutton K. C. et al.,2009) . Spunlace nonwoven finds its use as bacteria proof clothing, cleaning room clothing, wet wipes, and health and hygienic fabric(Jain et,al.,2019) . Spunlace nonwoven shows good physical and mechanical properties and hence considered as most promising alternative fabric for apparel sector.(R.K.Jainet et al., 2017) The choice of fibre from which to prepare a web for spunlace is directly related to eventual fabric application and governed by such considerations as the need for moisture absorption.(Purdy, A.T., et al.,1983) The manner in which the fibres are assembled into a web has a profound effect on the web properties. The fibre configuration will have an effect on packing, pore size, capillary dimensions, capillary orientation, etc.; the absorbency properties of the nonwoven structure can also be expected to be sensitive to the nature of fibre arrangement in the web. So the natural fibers have been selected for this study, In a recent study, the thermal resistance and moisture management behavior of nettle/polyester nonwoven fabrics

has been reported (Rengasamy et al.,2011). Kapok fiber shows hydrophobic characteristics, and kapok fiber assemblies possess good buoyancy and cannot be sunk in mixtures of oil and water (Sinha, et al.,2019). Therefore, kapok fiber can be potentially applied as a filter product for deep-bed filtration to achieve oil/water separation. Cattail (T. Latifolia) cellulose are considered as a new vegetable fiber source (Sana et al., 2014). Further, the chemical constitutions of Typha latifolia are composites of predominantly 63% cellulose, 8.7% hemicellulose, 40% fiber, 8.9% moisture content, 9.6% lignin and pectin and other water soluble matters such as 1.4% wax and 2% ash (Sopit, V. et al., 2007). The fully biodegradable nature of betal nut fibre fits the aim of producing more biodegradable spunlaced fabric to support the present environmental awareness. Hence, the goal of this research is to study the Physical properties and moisture management properties of spunlaced fabric which will determine the suitability of health and hygienic sector.(L. Yusriah , et al., 2014)

2. MATERIALS AND METHODS

2.1 Sourcing and Extraction of fiber

Processing agro-waste fibers for the hygienic product using eco-friendly methods like cleaning, giving pre-treatment to the fiber. Areca nut husk obtained from fruit harvesting at mature stage was collected from Thondamuthur Coimbatore. The retting process is carried out for 3 weeks. Then the shell is dried at room temperature for $27^0$and the fibers removed manually from the shell. The epidermis of the fruit is thrown out as an agro waste or been used as a material for burning. This outer husk is a rich source of cellulose that has been used to develop spunlace materials for this study. Typha latifolia were collected from bank of Noyal River,

Tirupur district, Tamil Nadu, India. It is widely seen growing on marshes, pond, lakes and river banks. Nettle is sourced from Uttarakhand. Kapok fiber is sourced from Maytupalayam, Coimbatore; Viscose is purchased from Avinashilingam University, Coimbatore.

2.2 Web Formation and Spun lace development

Fibers must be placed in a loose sheet structure called web forming. The dry laid processes are carding which is applied in this study. This process uses a rotating main cylinder covered with wire teeth that carry the fibers past stationary flats, revolving flats, or rolls that are also covered with wire. The fast moving cylinder moves the fiber past the slower moving stationary flats or rolls . This combs and parallels the fibers and places them in a web structure. The fibers are primarily in the machine direction, which produces a web. The formed web is then developed into spunlaced fabric.

2.3 Physical Parameters

2.3.1 Moisture Management

To objectively characterize the spread of moisture and the transfer properties on and between fabric surfaces, a new instrument, named the moisture management tester (MMT), was developed (B.-g. Yao et al.,2006) reported the measuring principle and apparatus design of the MMT and the definition of performance indices, and studied the relationships between subjective perceptions of moisture sensations in sweating, such as ‘‘clammy’’ and ‘‘damp’’, and the liquid moisture management properties measured by MMT. (Jun-yan Hu et all., 2005) The liquid moisture management properties of a textile are evaluated in this tester by placing a fabric specimen between two horizontal (upper and lower) electrical sensors each with seven concentric pins. A predetermined amount of test solution that aids the measurement of electrical

conductivity changes are dropped onto the center of the upward-facing test specimen surface. The test solution is free to move in three directions, namely radial spreading on the top surface, movement through the specimen from top surface to the bottom surface, and radial spreading on the bottom surface of the specimen. During the test, changes in electrical resistance of specimen are measured and recorded. The electrical resistance readings are used to calculate fabric liquid moisture content changes that quantify dynamic liquid moisture transport behaviors in multiple directions of the specimen. The summary of the measured results are used to grade the liquid moisture management properties of a fabric by using predetermined indices.(R.Rathinamoorthy et al., 2016).

Table 1: Grading of different indices obtained from the moisture management tester

Index	Grade				
	1	2	3	4	5
Wetting time - top (s)	≥ 120	20-119	5-19	3-5	<3
	No wetting	Slow	Medium	Fast	Very fast
Wetting time - bottom (s)	≥ 120	20-119	5-19	3-5	<3
	No wetting	Slow	Medium	Fast	Very fast
Absorption rate – top (%/s)	0-10	10-30	30-50	50-100	>100
	Very slow	Slow	Medium	Fast	Very fast
Absorption rate – bottom (%/s)	0-10	10-30	30-50	50-100	>100
	Very slow	Slow	Medium	Fast	Very fast
Max. wetted radius – top (mm)	0-7	7-12	12-17	17-22	>22
	No wetting	Small	Medium	Fast	Very fast

Max. wetted radius – bottom (mm)	0-7	07-12	12-17	17-22	>22
	No wetting	Small	Medium	Fast	Very fast
Spreading speed – top (mm/sec)	0-1	1-2	2-3	3-4	>4
	Very slow	Slow	Medium	Fast	Very fast
Spreading speed – bottom (mm/sec)	0-1	1-2	2-3	3-4	>4
	Very slow	Slow	Medium	Fast	Very fast
One – way transport capability (OWTC)	<-50	-50-100	100-200	200-400	>400
	Very poor	Poor	Good	Very good	Excellent
One – way moisture management coefficient (OMMC)	0-0.2	0.2-0.4	0.4-0.6	0.6-0.8	>0.8
	Very poor	Poor	Good	Very good	Excellent

2.3.2 Wicking

Wicking of spun laced non-woven fabrics was measured by ISO 9073–6:2000 standard, the water transport height was determined by a vertical strip wicking test [N.D. Yilmaz, et al., 2016]. The wicking test was determined in warp and weft directions with time intervals of 10, 30, and 60 seconds.

Table 2: Fabric classification based on the result of the moisture management tester

Sr. No.	Type of Fabric	Properties
1.	Water Proof Fabric (WF)	Very slow absorption Slow spreading No one-way transport, no penetration
2.	Water Repellent Fabric (WRF)	No wetting No absorption No spreading Poor one-way transport without external forces
3.	Slow Absorbing and Slow Drying Fabric (SA&SDF)	Slow absorption Slow spreading Poor one-way transport
4.	Fast Absorbing and Slow Drying Fabric (FA&SDF)	Medium to fast wetting Medium to fast absorption Small spreading area Slow spreading Poor one-way transport
5.	Fast Absorbing and Quick Drying Fabric (FA&QDF)	Medium to fast wetting Medium to fast absorption Large spreading area Fast spreading Poor one-way transport
6.	Water Penetration Fabric (WPF)	Small spreading area Excellent one-way transport
7.	Moisture Management Fabric (MMF)	Medium to fast wetting Medium to fast absorption Large spread area at bottom surface Fast spreading at bottom surface Good to Excellent one-way transport

In the development of testing standards for industrial applications, it is required to grade the test results of the tested samples, the tested fabrics were classified into seven categories which is presented in Table 2 (Mayur B et al., 2018)

3. RESULTS AND DISCUSSION

3.1 Air Permeability

It may be gleaned from the data in Figure 1 the result shows that the NV blend fabric have shown higher air permeability of 81.33cm^3 /sec/cm^2, due to yhe presence of pores in the fiber.(Amit Rawal et al., 2010) In the case of CV blend fabric 71.41cm^3 /sec/cm^2. shows less air permeability due to its hydrophobic nature. The difference in air permeability of NV, fabric and CV fabric is also due to their structural property. [G. A. Tadele et al.,.2016], this could be the possible reason for significantly improved air permeability.

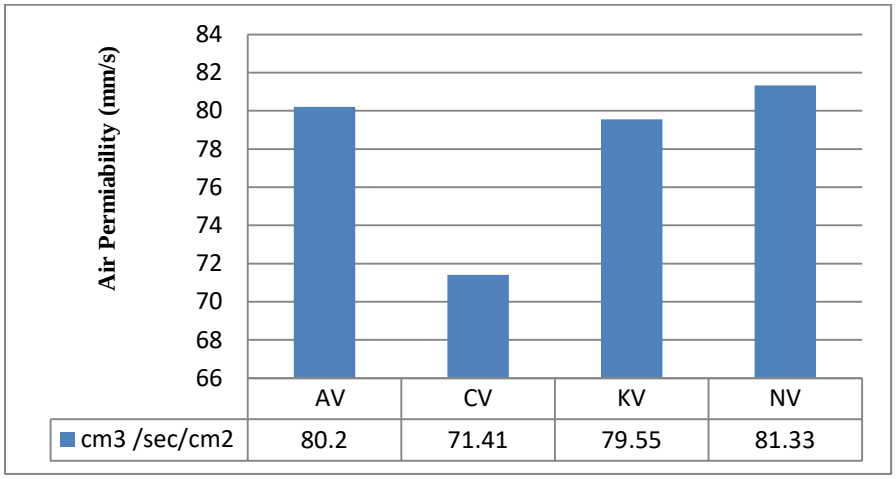


Figure 1: Air permeability values for the spunlaced fabric

3.2 Wicking

The average vertical wicking value in Figure 2 of NV blend fabric is noted after 5 min is 8cm and It is observed that the liquid moisture transport in vertical direction is higher in the case of NV blend fabric This is mainly due to the characteristics of the fibers. Wicking efficiency increases with an increase in the mass per unit area. In the case of NV blend fabrics, moisture was absorbed by the fibers instead of being transferred due to the hydrophilic nature of the fibers.

(Morotn et al., 2008). In the case of CV fabric contains less humidity and contains wax that is slowly response for wicking (Teik-Thye Lim,et al.,2007.) which leading to the inefficient transfer of liquid through wicking. As a result NV, is the significant factor for the good performance demonstrated by blended nonwoven spun laced fabrics.

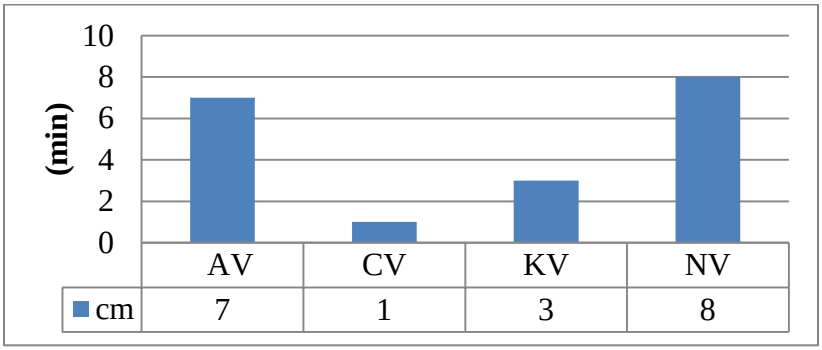


Figure 2: Wicking Test of spunlaced fabric

3.3 Moisture Management

The result of moisture management properties of AV, CV, KV, & NV fabric samples are summarized in Table 3.

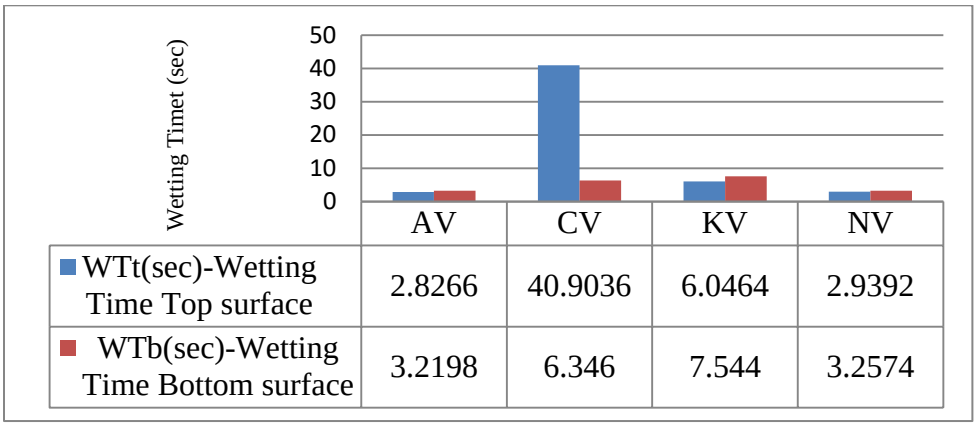
Table 3: MMT Test result of spunlaced fabrics as grades

Blended Fabric	WT_t(s)	WT_b(s)	AR_t	AR_b	MWR_t	MWR_b	SS_t	SS_b	R	OMMC
AV	5 very fast	4 fast	2 slow	5 very fast	4 fast	5 very fast	5 very fast	5 very fast	4 fast	4 fast
CV	2 slow	3 medium	2 slow	3 medium	2 slow	2 slow	1 no wetting	1 no wetting	5 very fast	3 medium
KV	3 medium	3 medium	3 medium	3 medium	5 very fast	5 very fast	5 very fast	5 very fast	3 medium	3 medium
NV	4 fast	4 fast	4 fast	2 slow	3 medium	3 medium	4 fast	4 fast	4 fast	4 fast

Wetting Time

The wetting time values in seconds of the top and bottom surface of the fabrics are given in Figure 3. It is absorbed that in CV blended fabric have slowest (i.e., slow to medium) wetting time for both top and bottom fabric surfaces. It is also clear that for NV shows the fastest wetting time for both top and bottom surface of the fabric. The top and bottom wetting time of a fabric

depends on its affinity to liquid and on the amount of available space in the structure for the movement of a liquid. Nettle fiber is hydrophilic in nature, so quickly absorbs water and demonstrates a shorter wetting time. The CV blend demonstrated the highest wetting time due to its wax content.(Y.Jhanji, et al., 2015).

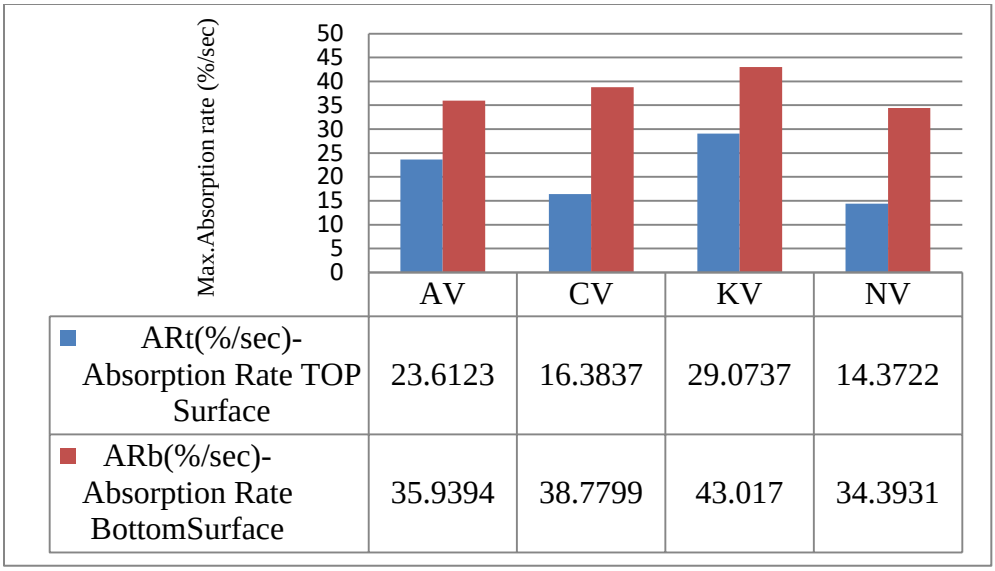


	AV	CV	KV	NV
WTt(sec)-Wetting Time Top surface	2.8266	40.9036	6.0464	2.9392
WTb(sec)-Wetting Time Bottom surface	3.2198	6.346	7.544	3.2574

Figure 3: Top and bottom wetting time (sec) values of the spunlaced fabrics.

3.4 Absorption Rate

The absorption rates of the top and bottom surface of the fabrics are given in Figure 4. The absorption of liquid by a fabric is influenced by the type of fiber, fabric structure and porosity. (Sujit Kumar, et al.,2019.) The bottom absorption rates of the fabrics are higher than top surfaces. This indicates that most of the liquid moisture is distributed on the bottom surface of the fabric. The lowest absorption rate is absorbed for NV blend 14.3722 at top and 34.03931 at bottom. This may be due to lower porosity and comparatively less entrapped air in the structure. While the highest absorption rate is observed for the KV blend 29.0737 top and 43.017 bottom. The more the amount of air entrapped the more effort the water may have to make in the first place to replace the entrapped air.

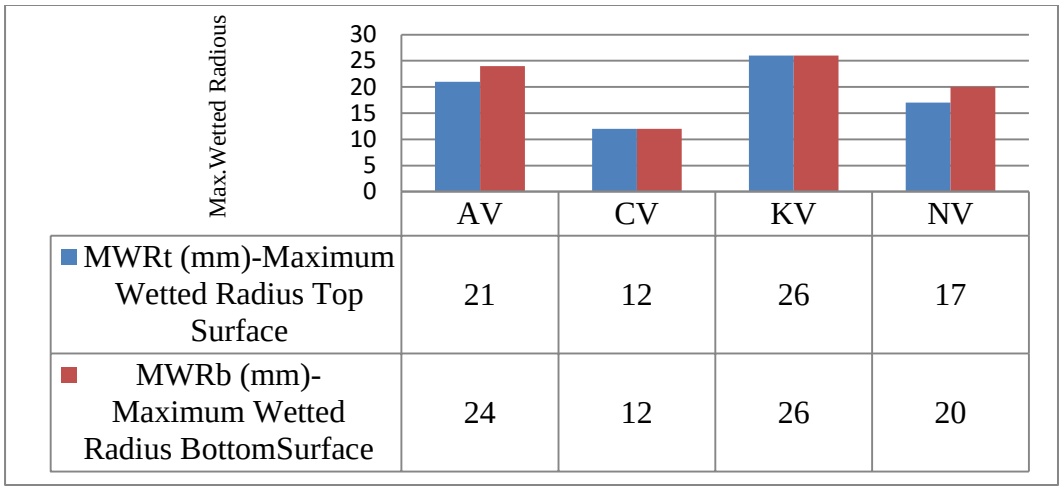


	AV	CV	KV	NV
ARt(%/sec)-Absorption Rate TOP Surface	23.6123	16.3837	29.0737	14.3722
ARb(%/sec)-Absorption Rate BottomSurface	35.9394	38.7799	43.017	34.3931

Figure 4: Top and bottom absorption rate (%/sec) values of the spunlaced fabrics.

3.5 Maximum Wetting Radius

Maximum wetted radius results of all the fabrics are given in Figure 5. According to maximum wetted results, it can be seen that the value decreases for the CV fabrics made from higher wax content, as compared with other three fabrics which is hydrophilic in nature, the liquid is absorbed by the fiber and penetrates into the fiber structure, which results higher moisture spreading along the KV fabric. This is because of viscose fiber is blended with kapok fiber. Therefore, a lower value of MWR reflects good moisture transport property and a dry feeling.

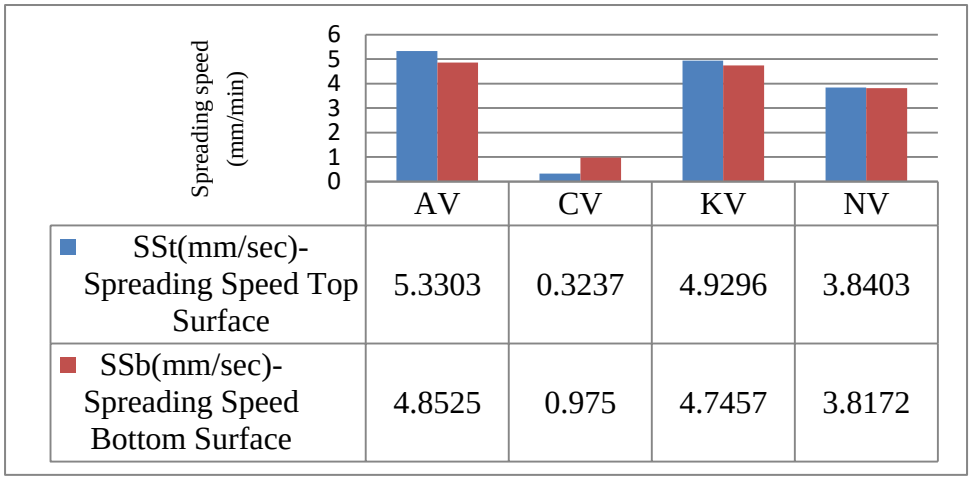


	AV	CV	KV	NV
MWRt (mm)-Maximum Wetted Radius Top Surface	21	12	26	17
MWRb (mm)-Maximum Wetted Radius BottomSurface	24	12	26	20

Figure 5: Top and bottom maximum wetted radius (mm) values of the spunlaced fabrics.

3.6 Spreading Rate

The water spreading speed test results for the fabrics are given in Figure 6, The spreading speed of the cattail fabric reduced due to the low porosity. As per the grading scale of the moisture management AV shows very fast spreading speed, CV shows very slow as well as no speed, this is due to their fiber structure and the porosity of the fiber.



	AV	CV	KV	NV
SSt(mm/sec)-Spreading Speed Top Surface	5.3303	0.3237	4.9296	3.8403
SSb(mm/sec)-Spreading Speed Bottom Surface	4.8525	0.975	4.7457	3.8172

Figure 6: Top and bottom spreading speed (mm/mm) values of the spunlaced fabrics.

3.7 One-Way Transport Index & Overall Moisture Management Capacity

One way transport capacity is the difference in the accumulative moisture content between the two surface of the fabric in the unit testing time. The overall moisture management capacity (OMMC) is an index to indicate the overall ability of the fabric to manage the transport of liquid moisture The value for KV is 177.0624, and CV is 573.7052. As per the grade chart indicates that the values CV indicates “Excellent” and KV indicates “Good”.

Higher overall moisture management capacity indicates better overall moisture transport ability of the fabric. Figures 7 and 8 shows the value of (AOTI) & (OMMC) and the values are compared with the grading scale in Tables 1 (C. Prakash et al., 2013). and 2 CV and KV indicates0.4-0.6 Grade-3 shows “ good” .

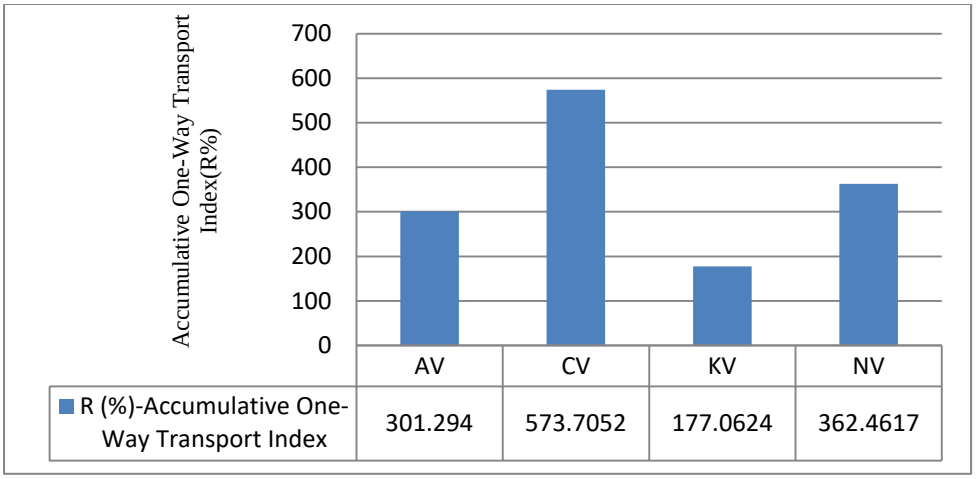


Figure 7: Accumulative one – way transport index (%) values of the spunlaced fabrics.

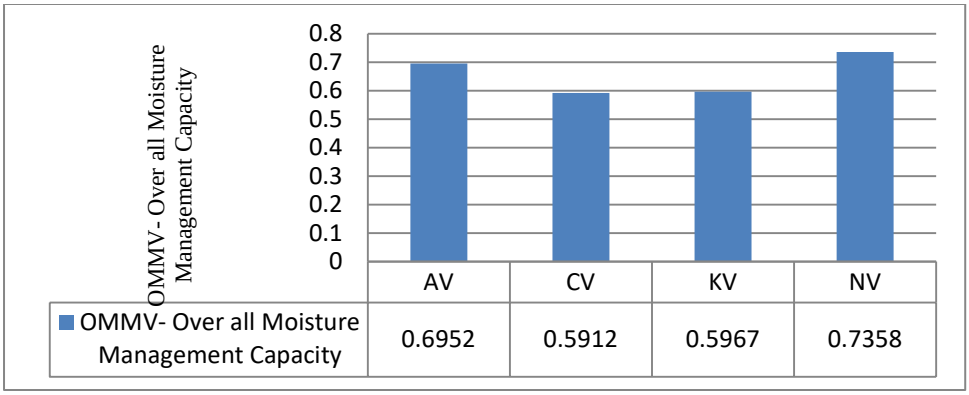


Figure 8: Over all moisture management capability values of the spunlaced fabrics.

4. CONCLUSION

This research examined how well spun lace nonwoven materials manage moisture. It also discusses how different preparation variables affect how well spun lace nonwoven materials manage moisture. This research reveals that a fabric's ability to manage moisture is significantly influenced by the web's composition. It significantly affects every feature of the moisture management tester.

- It was demonstrated that the mixed AV spun laced fabric was effective in managing moisture.
- It was demonstrated that the CV blended spun laced fabric acted as a Water Resistant Fabric.
- It was demonstrated that the KV blended spun laced fabric was a Rapidly Absorbing and Rapidly Drying Material.
- It was demonstrated that the NV blended spun laced fabric was a moisture management fabric.

The results of the MMT show that each of the four nonwoven fabrics had certain qualities. So, spun laced fabric with a blend of AV, CV, KV, and NV can be used to make a health and hygiene product with the right properties for managing moisture.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Not Applicable

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