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Uptake and Retention of Essential Oils in Double Jersey Knitted Fabric

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Abstract: The population explosion and the environmental pollution in recent years have forced researchers to find new health and hygiene related products for the well-being of mankind. In the past few decades, a wide range of medicinal and aromatic plants has been explored for their essential oils. Essential oils have great potential in the field of biomedicine as they effectively destroy several bacterial, fungal and viral pathogens. In this study, the essential oils uptake and oil retention property on the textile surface were observed. The essential oils were applied at 1%, 3%, 5%, 7% and 9% concentration on cotton/lycra, cotton/polyester/lycra and viscose/nylon/lycra double jersey knitted fabrics. The findings revealed that viscose/nylon/lycra absorbed as well as retained the maximum amount of essential oils.
Keywords: Essential oil, Double jersey knitted fabric, Oil uptake, Oil retention.

I. INTRODUCTION

Micro-organisms ubiquitously cover the environment. This can cause problems in textiles when they are in raw form, while they are in chemical process or during wet treatments, even when they are in warehouse and during transportation (Strand *et al*., 2010). For the growth of the micro-organisms textiles are unfortunately an excellent medium, when moisture and nutrients are present in them. The large surface area of the textiles also allows micro-organisms to grow on it in a considerable amount. The bacteria, fungi and moulds grow in humid conditions and warm temperatures, which is the desired environment for their growth (Yip & Luk, 2016). The transfer of micro-organisms from the surface of contaminated textiles onto food products is possible (Hilgenberg *et al*., 2016), thus, the micro-organism growth on textile material imposes several undesirable effects on textile material and also on the wearer. Therefore, it is important to develop textile materials that avoid the growth of microbes and also give desired antimicrobial effect (Babu & Ravindra, 2015). The micro-organism's growth on the surface of the textile has resulted in the evolution of antimicrobial finishes (Banupriya & Maheshwari, 2013). Antimicrobial finish is a chemical treatment, which inhibits the growth of microbes. In textiles antimicrobial finishes provide two different functions; 1st, protect the wearer against pathogens or micro-organisms; 2nd, protect textile against damage caused by mould, mildew or micro-organisms. The cross-contamination of pathogenic micro-organisms also prevented and from contaminated clothing infectious diseases are suppressed from spreading through the antimicrobial finish (Yip & Luk, 2016).

Presently numerous antimicrobial agents used in the several goods of textile industries are used to impart antimicrobial properties. Commercially synthetic antimicrobial agents are also available, which may be environment affable. The specific defence mechanism and skin immune system are interfered by antimicrobial agents that are used to finish textiles goods. The antimicrobial finish used on the textile should be active towards undesirable microbes, durable to wash, non-toxic and safe. For the biofunctionalization of textiles, natural bioactive agents are important with antimicrobial properties because they enable non-toxic, safe production, skin and environment friendly bio-active textile goods. Most antimicrobial compounds are extracted from the plants, such as, tulsi, tea-tree, aleovera, eucalyptus, grape seed, neem etc. The bio-active compounds also include phenolics and polyphenols, terpenoids, essential oil, alkaloids, lactins, polypeptides and polyacetylenes (Babu & Ravindra, 2015).

Essential oils are natural oils, obtained from the distillation of plant materials such as buds, leaves, flowers, seeds, barks, twigs, herbs, fruits, roots and wood. The essential oils are known for their multiple benefits such as antiseptic, virucidal, fungicidal, bactericidal, antioxidant, insecticidal, antiparasitic, radical-scavenging properties, anti-inflammatory, emollient and healing effects (Hangratanaworakit *et al*., 2018).

The application of essential oils on textile materials allows a controlled release of the active substance and antimicrobial effect. Most preferred textile materials are made of cellulose fibres, the resulting products being used as bandages, wound dressing, absorbent items, hygiene products, etc.

Textile materials when treated with essential oils get valuable specialities such as the feeling of well-being, therapeutic effects and freshness in the wearer. The essential oil treated textiles are used in home textiles, cosmetic products, household cleaning, medical and alternative healing textiles and body care textiles. Essential oils from the textile material are absorbed by the skin through control release mechanism (Cerempei, 2017).

The research work had been carried out with an objective to evaluate oil uptake and oil retention in knitted fabrics.

II. METHODOLOGY

In the present study, three variations of double jersey knitted blended fabrics of different fiber compositions were treated with four essential oils viz., camphor oil, peppermint oil, pine needle oil and wintergreen oil. Three fabrics were blends of cotton/polyester/lycra, viscose/nylon/lycra and cotton/lycra. The blend ratio of cotton/polyester/lycra, viscose/nylon/lycra and cotton/lycra were 60:35:5, 63:32:5 and 95:5 respectively.

Table 1: Codes given to the fabrics used in the study

Name of the Fabrics	Fabric Codes
Cotton/lycra	CL
Cotton/polyester/lycra	CPL
Viscose/nylon/lycra	VNL

A. *Pre-treatment of the Knitted Fabrics*

The scouring process was performed for the pre-treatment of the knitted fabrics. Scouring is the process of removing natural as well as added impurities of essentially hydrophobic character from the textile material. The scouring bath was prepared with 2 g/l commercial detergent and 2 g/l soda ash in 1:40 material liquor ratio for 1 hour at 80°C temperature. Then, the fabric was removed and washed with cold water and dried (Shenai, 1999).

1) *Preliminary Data:* Preliminary data of the knitted fabrics were determined on parameters *viz.*, wale and course count, fabric thickness and fabric weight (GSM) by using standard test methods in the standard atmospheric conditions of 21±2°C temperature and 65±2% relative humidity.
2) *Wale and Course Count:* The ASTM 231-62 standard test method was used and the pick glass was used to count the number of wale and course per inch of the fabric and an average of 5 readings was taken. In this, the fabric was spread on the table and one square inch area was marked at least 2 inches away from the selvedge of the fabric from five different places on the fabric. The number of wale and course were counted within the marked area with the help of pick-up glass.
3) *Fabric Thickness:* Fabric thickness is known as the distance between two equivalent surfaces by placing textile material under it while applying specific pressure through the tester's pressure foot. The BS: 7702-1975 standard test method was used for the determination of the fabric thickness. Thickness tester was used for the measurement of fabric thickness. The thickness tester was set at zero and then the pressure foot was raised and the sample was placed on the reference plate without tension. Then the pressure foot was lowered gently on the sample and the gauge reading was noted down after 30 seconds. An average of 5 readings was taken to measure the thickness of the fabric.
4) *Fabric Weight:* The weight of a fabric can be described in two ways: (a) weight per unit area (ounce/sq yard), (b) weight per unit area length (ounce/linear yard). The B.S: 2471-1954 test method was followed and an average of five readings was taken to measure the fabric weight. The conditioned samples of 5×4 inches were taken and weighed on the electronic balance. The weight per unit area was calculated by using the following formula:

$$W = \frac{\text{weight (gm)}}{28} \times \frac{36 \times 36}{20 \text{ (sq inch)}}$$

B. *Application of Essential oils on the Knitted Fabrics*

The four essential oils viz. camphor, peppermint, pine needle and wintergreen respectively are applied on the knitted blended fabrics through the pad-dry-cure method. This method was comprised of three components: padding, drying and curing. Firstly, the fabrics were immersed in the prepared oil solution of different concentrations i.e. 1%, 3%, 5%, 7% and 9% along with the emulsifier (PEG400) at 10% concentration and then passed between the rollers of padding mangle at uniform pressure of 2kg/cm^2 along with the uniform speed of padding mange *i.e.* 30 rpm. So that the excessive oil solution was squeezed out from the fabrics. Finally, the fabrics were oven dried at 60ºC for 1 hour 30 minutes and then cured at 140ºC for 3 minutes.

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C. Determination of oil Retention of oil Sorbent Knitted Fabrics

The fabric sample (5× 5cm^2) was placed in 150 ml oil for 15 minutes. The sorbent was removed and hung vertically and the oil absorbed by the sample begins to drip. The weight of the sample was measured after 15, 30, 60, 120, 300 and 1800 seconds of drainage. The difference between the weight of the wet sample after drainage and the initial weight of the sample was determined as the amount of oil retention (Ramya *et al.*, 2018)

Oil retention = Weight of the wet sample after drainage – Initial weight of the sample

D. Determination of Uptake of oil in the Treated Knitted Fabrics

The initial fabric weight (fabric weight before the application of oil) and the final fabric weight (fabric weight after the oil application) were determined to estimate the uptake of oil. The per cent of uptake of oil was calculated with the following formula (Ramya *et al.*, 2018):

$$\text{oil uptake (\%)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Initial weight}} \text{X } 100$$

III. RESULTS AND DISCUSSION

A. Preliminary data of Knitted Fabrics

The preliminary data of three double jersey knitted fabrics of different fiber blends were used: cotton/lycra (CL), cotton/polyester/lycra (CPL) and viscose/nylon/lycra (VNL) have been given in Table 2.

Table 2: Preliminary data

Fabric Code	Thread count (per sq. inch)		Thickness (mm)	Weight/unit area (ounce/sq. yard)
	Wale count	Course count		
CL	46.8	67.3	1.14	12.53
CPL	76.2	57.6	0.78	11.79
VNL	76.3	53.6	0.86	11.21

Table 2 shows the result of preliminary data (thread count, fabric thickness and fabric weight) of double jersey knitted fabrics. The CL is the thickest as well as heaviest fabric among all the three fabrics and CPL and VNL have almost similar thread count and CL has lesser thread count in comparison to CPL and VNL.

B. Oil Retention by Knitted Fabrics

Cotton/lycra (CL), cotton/polyester/lycra (CPL) and viscose/nylon/lycra (VNL) double jersey knitted fabrics were dipped in the four essential oils namely camphor oil, peppermint oil, pine needle oil and wintergreen oil. The oil retention at different intervals of time, *i.e.*,15 seconds, 30 seconds, 60 seconds, 120 seconds, 300 seconds and 1800 seconds of knitted fabrics used in the study have been given in Tables 3 to 6 and Figures 1 to 4 .

Table 3: Oil retention test with camphor oil

Fabric Code	Initial weight (gm)	Weight of oil treated sample (gm)	Weight of oil treated sample						Amount of retained oil (Final weight – Initial weight) (gm)
			After 15 sec (gm)	After 30 sec (gm)	After 60 sec (gm)	After 120 sec (gm)	After 300 sec (gm)	After 1800 sec (gm)	
CL	1.57	3.67	3.27	2.96	2.94	2.93	2.92	2.83	1.26
CPL	1.22	2.76	2.62	2.57	2.51	2.49	2.44	2.40	1.18
VNL	1.03	2.81	2.62	2.57	2.50	2.48	2.45	2.36	1.33

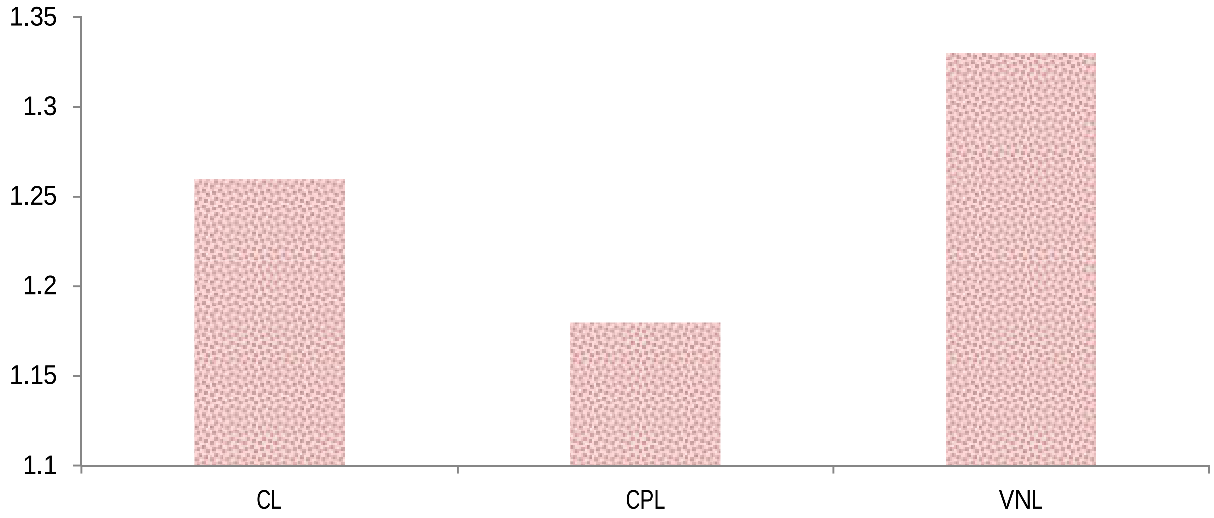

Figure 1: Camphor oil retention

Table 3 and Figure 1 shows results of camphor oil retention in CL, CPL and VNL double jersey knitted fabrics. The amount of retained oil in CL, CPL and VNL is 1.26 gm, 1.18 gm and 1.33 gm. The maximum amount oil is retained by VNL followed by CL and CPL.

Table 4: Oil retention test with peppermint oil

Fabric Code	Initial weight (gm)	Weight of oil treated sample (gm)	Weight of oil treated sample						Amount of retained oil (Final weight – Initial weight) (gm)
			After 15 sec (gm)	After 30 sec (gm)	After 60 sec (gm)	After 120 sec (gm)	After 300 sec (gm)	After 1800 sec (gm)	
CL	1.61	3.56	3.21	3.07	2.99	2.95	2.93	2.89	1.28
CPL	1.21	2.68	2.59	2.52	2.49	2.44	2.41	2.38	1.17
VNL	1.02	2.65	2.62	2.50	2.45	2.42	2.41	2.37	1.35

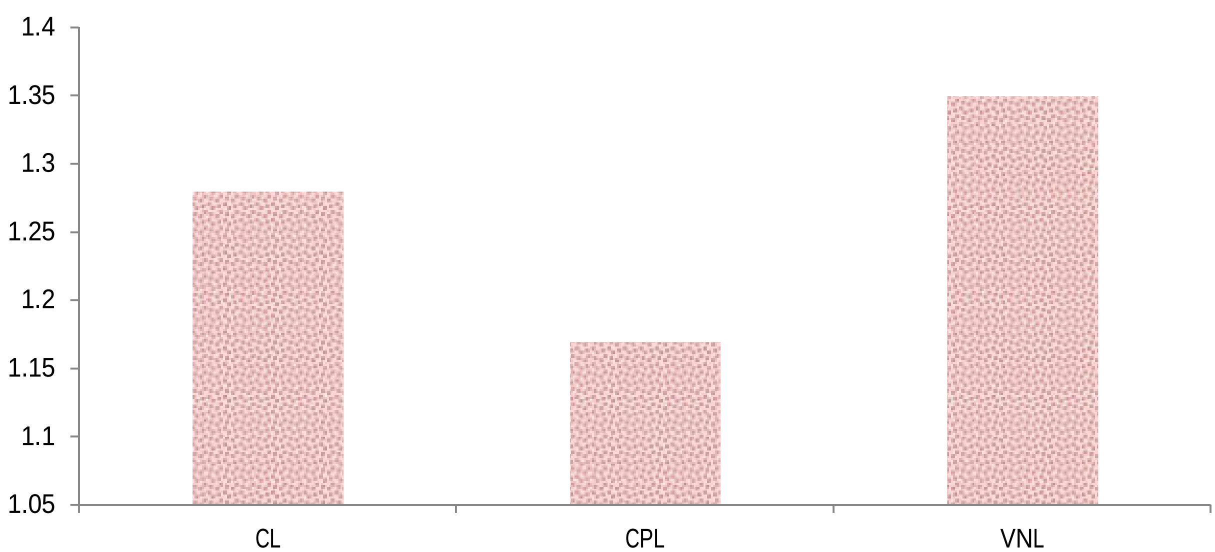

Figure 2: Peppermint oil retention

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Table 4 and Figure 2 shows results of peppermint oil retention in CL, CPL and VNL double jersey knitted fabrics. The amount of retained oil in CL, CPL and VNL is 1.28 gm, 1.17 gm and 1.35 gm. The maximum amount oil is retained by VNL followed by CL and CPL.

Table 5: Oil retention test with pine needle oil

Fabric Code	Initial weight (gm)	Weight of oil treated sample (gm)	Weight of oil treated sample						Amount of retained oil (Final weight – Initial weight) (gm)
			After 15 sec (gm)	After 30 sec (gm)	After 60 sec (gm)	After 120 sec (gm)	After 300 sec (gm)	After 1800 sec (gm)	
CL	1.58	3.94	3.76	3.63	3.55	2.95	2.73	2.69	1.11
CPL	1.22	2.65	2.54	2.49	2.45	2.41	2.36	2.29	1.06
VNL	1.07	2.43	2.38	2.34	2.30	2.28	2.25	2.19	1.12

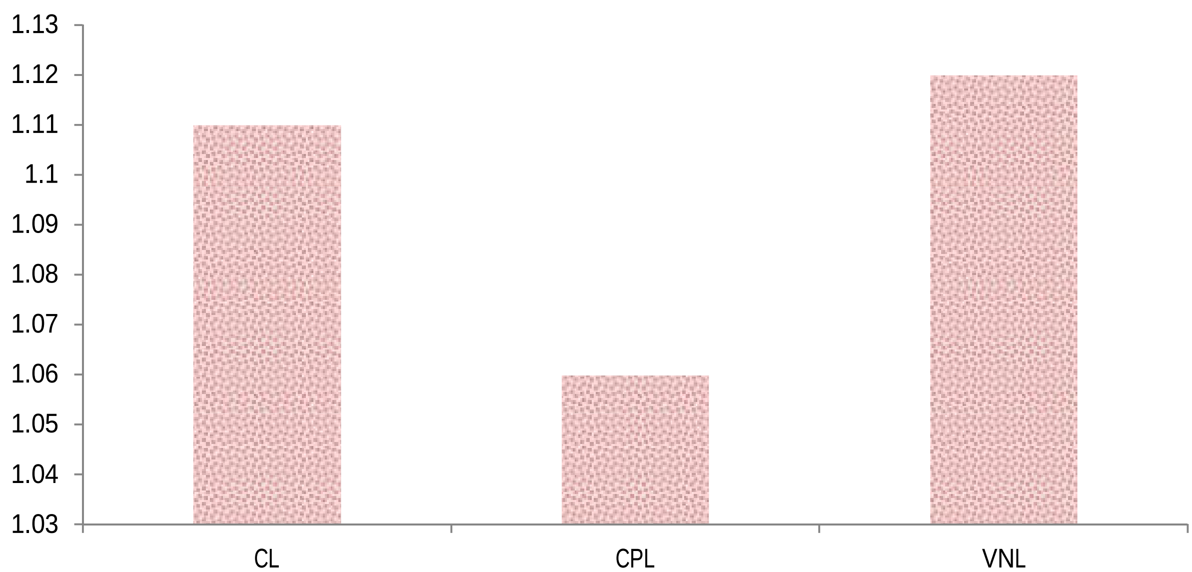

Figure 3: Pine needle oil retention

Table 5 and Figure 3 shows results of pine needle oil retention in CL, CPL and VNL double jersey knitted fabrics. The amount of retained oil in CL, CPL and VNL is 1.11 gm, 1.06 gm and 1.12 gm. The maximum amount oil is retained by VNL and CPL followed by CL.

Table 6: Oil retention test with wintergreen oil

Fabric Code	Initial weight (gm)	Weight of oil treated sample (gm)	Weight of oil treated sample						Amount of retained oil (Final weight – Initial weight) (gm)
			After 15 sec (gm)	After 30 sec (gm)	After 60 sec (gm)	After 120 sec (gm)	After 300 sec (gm)	After 1800 sec (gm)	
CL	1.56	4.27	4.02	3.89	3.66	3.37	3.24	3.11	1.54
CPL	1.25	3.23	3.14	2.99	2.96	2.89	2.83	2.77	1.52
VNL	1.09	2.98	2.91	2.86	2.79	2.72	2.69	2.67	1.58

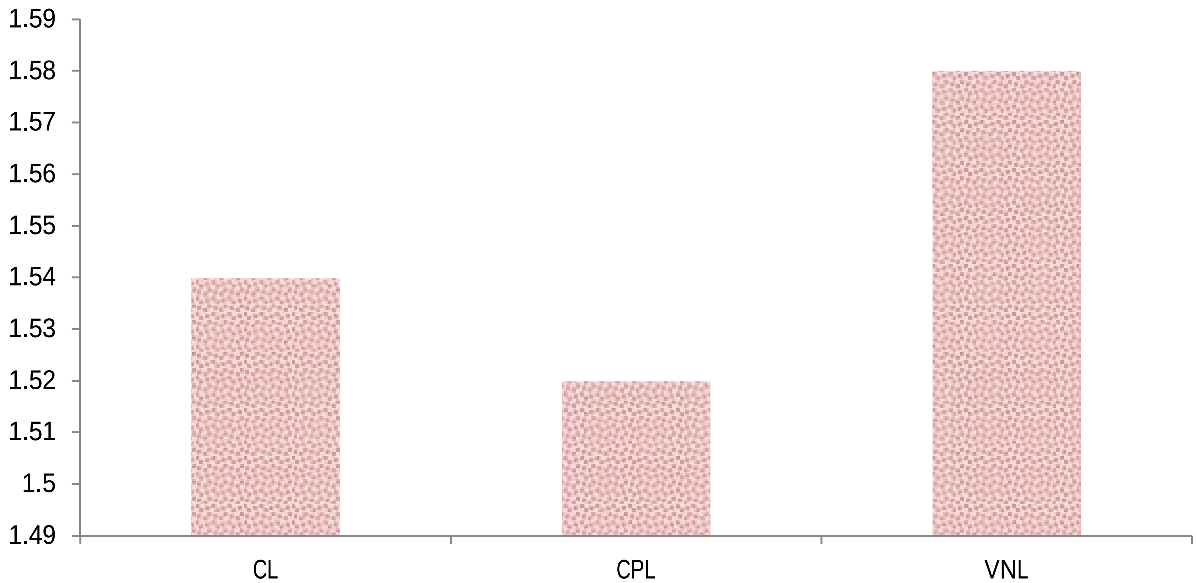

Figure 4: Wintergreen oil retention

Table 6 and Figure 4 shows results of wintergreen oil retention in CL, CPL and VNL double jersey knitted fabrics. The amount of retained oil in CL, CPL and VNL is 1.54 gm, 1.52 gm and 1.58 gm. The maximum amount oil is retained by VNL followed by CL and CPL.

C. Uptake of Oil by Knitted Fabrics

Four essential oils namely camphor oil, peppermint oil, pine needle oil and wintergreen oil were applied on cotton/lycra (CL), cotton/polyester/lycra (CPL) and viscose/nylon/lycra (VNL) knitted fabrics at different concentrations. The oil uptake percentage of different treated knitted fabrics used in the study has been given in Tables 7 to 10 and Figures 5 to 9.

Table 7: Oil uptake percentage of camphor oil

Fabric Code	Concentration (%)	Initial weight (gm)	Final weight (gm)	Oil uptake (%)
CL	1	2.50	2.57	2.80
	3	2.43	2.50	2.88
	5	2.32	2.40	3.44
	7	2.62	2.71	3.45
	9	2.39	2.49	4.18
CPL	1	2.33	2.36	1.28
	3	2.24	2.28	1.78
	5	2.26	2.31	2.21
	7	2.33	2.39	2.57
	9	2.67	2.75	2.99
VNL	1	2.09	2.18	4.30
	3	2.05	2.14	4.39
	5	2.21	2.31	4.52
	7	2.22	2.33	4.95
	9	2.14	2.28	6.54

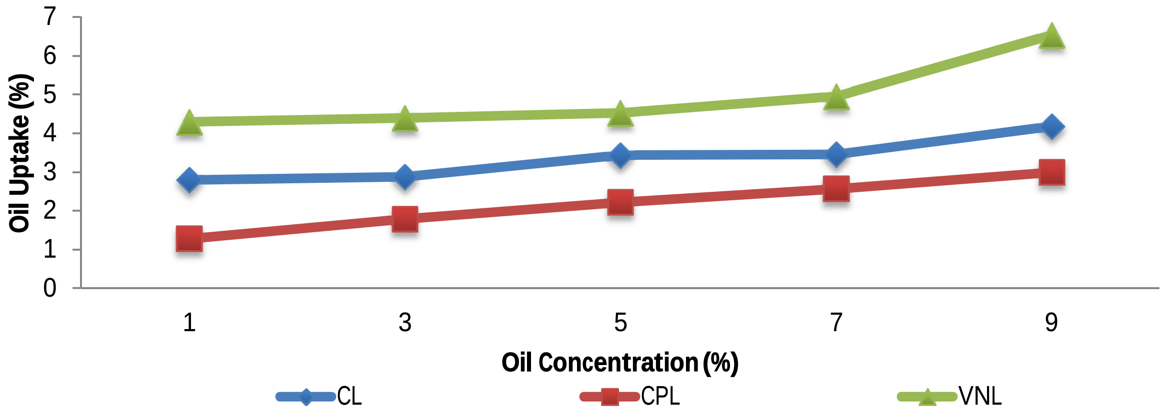

Figure 5: Oil uptake percentage of camphor oil

The result given in Table 7 and Figure 5 shows that the maximum camphor oil uptake percentage is in VNL fabric as compared to CL and CPL at every concentration.

Table 8: Oil uptake percentage of peppermint oil

Fabric Code	Concentration (%)	Initial weight (gm)	Final weight (gm)	Oil uptake (%)
CL	1	2.43	2.49	2.46
	3	2.37	2.43	2.53
	5	2.49	2.58	3.61
	7	2.58	2.68	3.87
	9	2.53	2.69	6.32
CPL	1	2.38	2.42	1.68
	3	2.29	2.33	1.74
	5	2.24	2.29	2.23
	7	2.26	2.32	2.65
	9	2.35	2.44	3.82
VNL	1	2.43	2.52	3.70
	3	2.36	2.48	5.08
	5	1.96	2.08	6.12
	7	1.86	2.04	9.67
	9	2.16	2.46	13.88

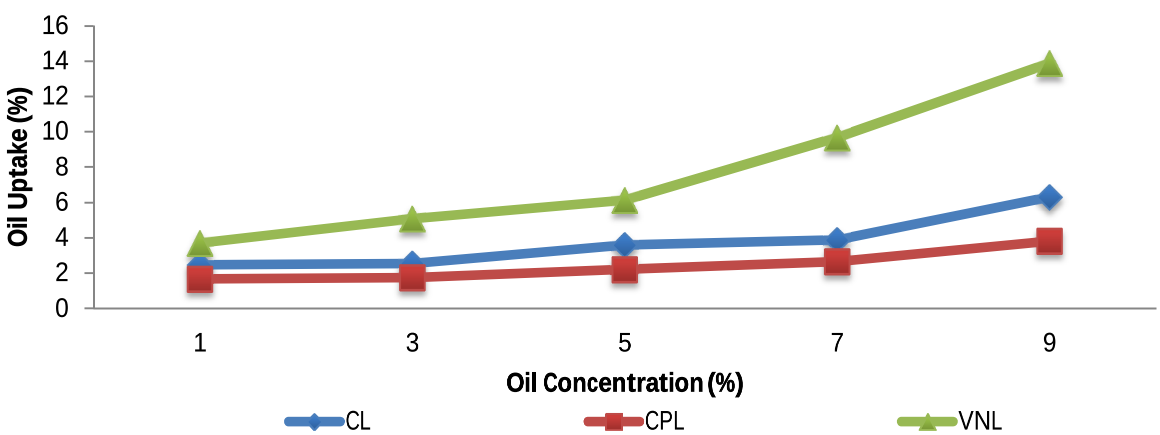

Figure 6: Oil uptake percentage of peppermint oil

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The result given in Table 8 and Figure 6 shows that the maximum peppermint oil uptake percentage is in VNL fabric as compared to CL and CPL at every concentration.

Table 9: Oil uptake percentage of pine needle oil

Fabric Code	Concentration (%)	Initial weight	Final weight	Oil uptake (%)
CL	1	2.51	2.56	1.99
	3	2.51	2.57	2.39
	5	2.49	2.55	2.40
	7	2.47	2.54	2.83
	9	2.50	2.58	3.20
CPL	1	2.41	2.45	1.65
	3	2.30	2.34	1.74
	5	2.29	2.34	2.18
	7	2.27	2.33	2.64
	9	2.50	2.57	2.80
VNL	1	2.07	2.22	7.24
	3	1.94	2.09	7.73
	5	1.95	2.12	8.71
	7	2.12	2.33	9.90
	9	2.11	2.34	10.90

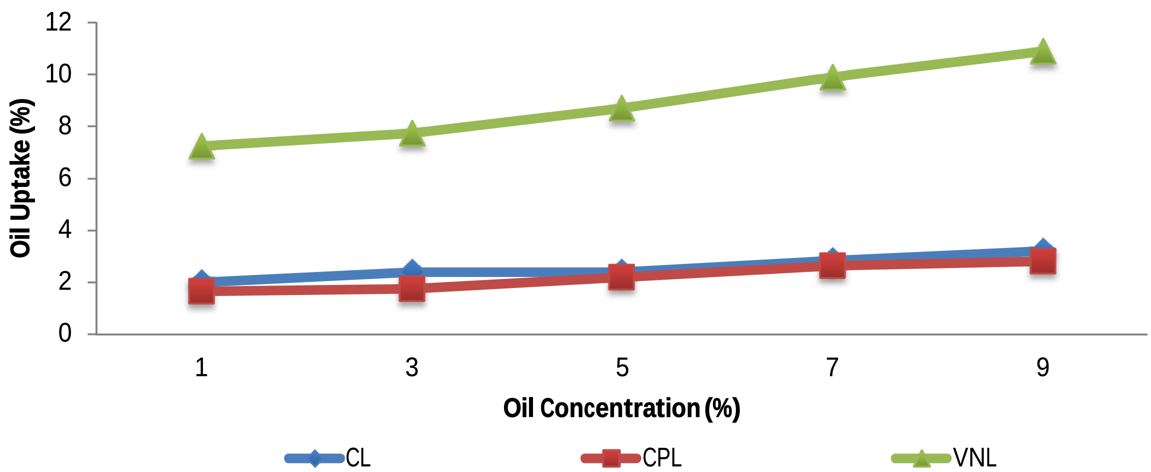

Figure 7: Oil uptake percentage of pine needle oil

The result given in Table 9 and Figure 7 shows that the maximum pine needle oil uptake percentage is in VNL fabric as compared to CL and CPL at every concentration.

Table 10: Oil uptake percentage of wintergreen oil

Fabric Code	Concentration (%)	Initial weight	Final weight	Oil uptake (%)
CL	1	2.29	2.34	2.18
	3	2.17	2.23	2.76
	5	2.31	2.38	3.03
	7	2.51	2.59	3.18
	9	2.49	2.58	3.61
CPL	1	2.24	2.28	1.78
	3	2.30	2.35	2.17
	5	2.30	2.36	2.60
	7	2.37	2.44	2.95
	9	2.24	2.32	3.57
VNL	1	2.11	2.17	2.84
	3	2.23	2.30	3.13
	5	2.09	2.18	4.30
	7	2.16	2.26	4.62
	9	2.22	2.33	4.95

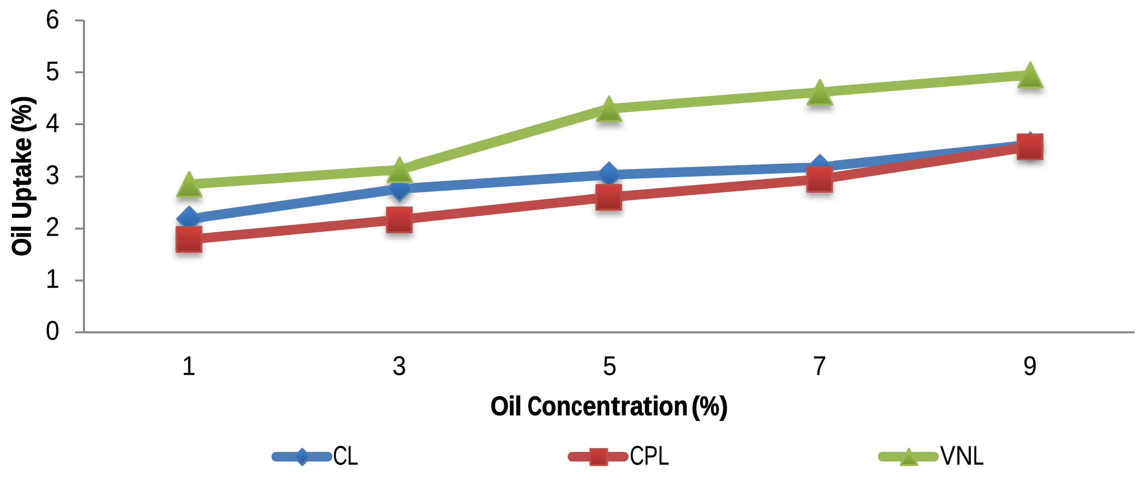

Figure 8: Oil uptake percentage of wintergreen oil

The result given in Table 10 and Figure 8 shows that the maximum wintergreen oil uptake percentage is in VNL fabric as compared to CL and CPL at every concentration.

IV. SUMMARY AND CONCLUSION

It is observed from the above results that VNL fabric retained the maximum amount of all four oils (camphor, peppermint, pine needle and wintergreen) in comparison to the other two fabrics *viz.*, CL and CPL. Similarly, the above results also concluded that the VNL fabric has maximum oil uptake percentage for each oil at every concentration in comparison to the other two fabrics *viz.*, CL and CPL. CPL retains less oil in comparison to VNL and CL may be because of polyester fiber in it which is highly crystalline fiber as well as hydrophobic in nature. In VNL and CL, the reason may be the polymer system of viscose and cotton, the viscose polymer system is rather similar to that of cotton. However, there are some differences. The viscose polymer system is about 35-40% crystalline and about 65-60% amorphous, on the other hand, the cotton polymer system is about 65-70% crystalline and about 30-35% amorphous. In the cotton polymer system, countless polar –OH group makes it absorbent. However, viscose along with polar groups has an amorphous polymer system which makes it the most absorbent fiber in common.

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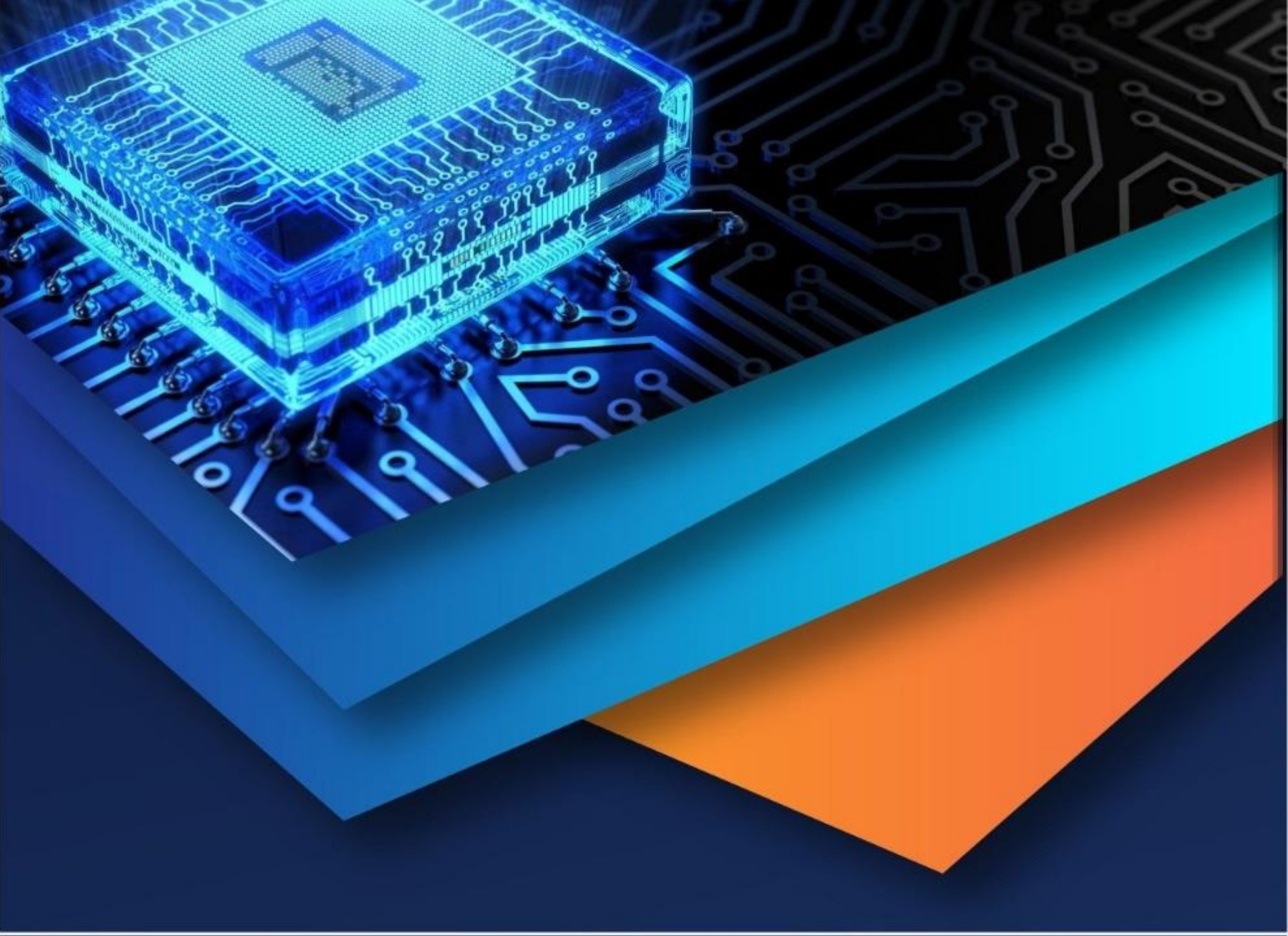

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