

IMPARTING ANTIMICROBIAL FINISH BY MICROENCAPSULATION TECHNIQUE

Dr. S.K.Chinta, Ms.Pooja P. Wane

DKTE Textile and Engineering Institute, Ichalkaranji, Maharashtra, India

Abstract: Microencapsulation is a process in which tiny particles or a coating to give small capsules with many useful properties surrounds droplets. There are many methods to impart various end use applications like antimicrobial property, flame proof and many more functional properties to the various substrates like polyester, nylon, polypropylene etc., and it may be that most of the application methods may be durable or temporary. The microencapsules can introduce important new qualities to garments and fabrics, such as enhanced stability and the controlled release of active compounds. Microencapsulation technique is a unique one where a controlled release of these properties as and when required are possible and also regarding the durability it can withstand for a longer duration. The present work was carried out with an objective to study the effect of clove oil, neem oil, aloe Vera powder, Benzalkonium Chloride (BKC) with certain physical and performance properties on woven fabrics like cotton, P/C blend fabric and Non-woven Polypropylene fabric by the imparting antimicrobial finish by microencapsulation technique

Keywords: Microencapsulation, Antimicrobial finish, Clove oil, Neem oil, Benzalkonium Chloride.

I. INTRODUCTION

Necessity to meet the growing demand of consumers led to the revolution in functional finishes worldwide. Cotton is widely used for apparel due to its comfort property, but it has two main drawbacks, susceptibility to creasing and bacterial degradation. Human sweat provides a suitable shelter for bacterial growth, containing 1.4 million bacteria per gram which increases to 9000 million at 50% moisture level.

Chemical compounds are used as antimicrobial agents but they also influence the natural flora of the human skin. Microencapsulation provides a mean of packaging, separating and storing materials on a microscopic scale for triggered release under controlled conditions, such as mechanical rupture, electrical or chemical means or by leaching action in an appropriate liquid environment. Core substances may be perfumes, any healthcare active ingredients or even liquid crystal and solid one. Microencapsulation offers many advantages as compared to conventional processes, in terms of economy, energy saving, eco-friendliness and controlled release of substances. Microencapsulation process act as a means of imparting finishes and properties on textiles which were not possible or cost effective using other technology.

II. MATERIALS AND METHODS

2.1 Materials

2.1.1 Fabric

Scoured and bleached 100% cotton fabric (104 ends/inch, 68 picks/inch, and plain weave) and P/C blend (70:30, 96 ends/inch, 72 picks/inch, and plain weave), & Nonwoven Polypropylene (136 GSM) were used for the application of antimicrobial finish.

2.1.2 Chemicals for core material

Benzalkonium Chloride, Aloe Vera, Clove oil, Neem oil all these chemicals were of Industrial Grade.

2.1.3 Chemical

Carboxy Methyl Cellulose (CMC), Sodium sulfate, Formaldehyde, Sodium carbonate, Synthetic Binder, Sodium Alginate, all these chemicals were of LR grade.

2.2 Methods and Process Variables:

2.2.1 Method: Padding-Drying-Curing

The padding was carried out on the fabric with the following process variables:

- Methods of treatment- Padding, Coating
- Temperature - 100°C, 120°C, 140°C, 160°C
- Concentrations of core material- 5%, 10%, 20%

2.2.2 Synthesis of Microencapsulation solution by Phase Separation Method

- Take X grams of Sodium alginate and CMC in 100 ml. of water.
- Raise temperature to 50°C dissolve Sodium alginate and Carboxy Methyl Cellulose(CMC) completely in water.
- Slowly add required amount of antimicrobial agent, and fragrance oil under continuous stirring.
- Stir it for 20 minutes.
- Add sodium sulfate to this solution.
- Finally, raise the pH to 8.5-9.5.
- Add formalin to harden the walls.

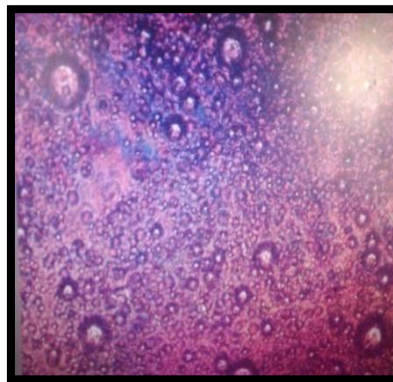


Fig. 1. Light microscope image of microcapsules formed in microencapsulation solution

2.2.3 Application of Microencapsulation solution on the fabric

Padding the fabric samples through padding mangle with the solution containing
10 gm of Microencapsulation paste,
10 ml of synthetic binder &
80 ml of water.

III. TESTING AND ANALYSIS

3.1 Efficacy of the antimicrobial treated textile -

Antimicrobial property was evaluated by the qualitative evaluation by Agar Diffusion Method (AATCC-147-1998).

3.2 Air Permeability -

The air permeability of fabric samples was tested by using ASTM B 737 on Air Permeability Tester.

3.3 GSM -

The GSM of fabric samples were measured according to ASTM B 3776 The test specimens were according to the template.

3.4 Bending length -

A Fabric samples were evaluated for bending length on Stiffness Tester as per the ASTM D 1388-96 method, the test specimens were according to the template.

3.5 Wrinkle recovery -

A Fabric samples were evaluated for wrinkle recovery on MAG RECOVERY Tester as per the IS 4681-1968 method.

3.6 Washing fastness -

For washing treatment the 5 gpl soap solution was used and washed in the Launderometer machine for 30 min at 40°C by using standard ISO-III.

3.7 Perspiration fastness -

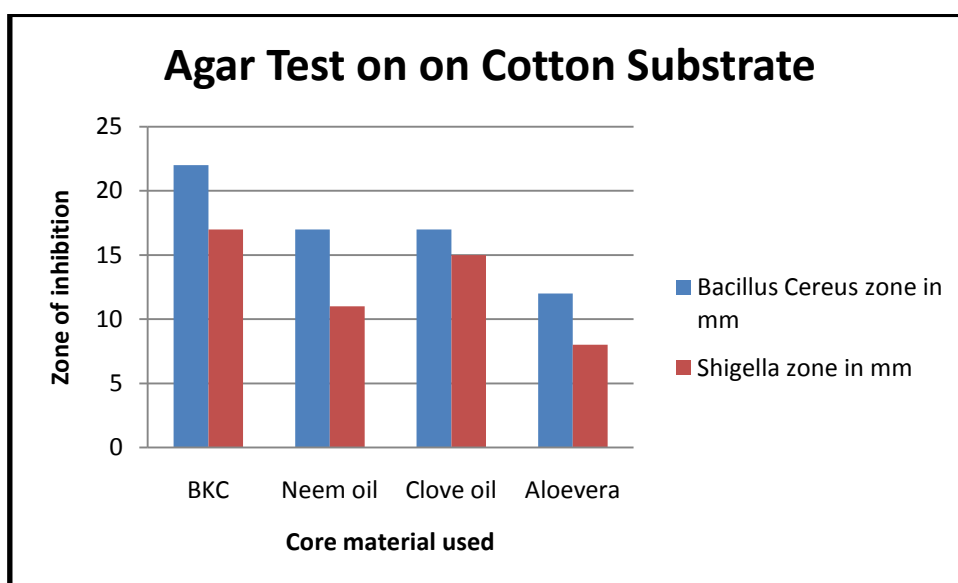
A Fabric samples were evaluated for perspiration fastness by using perspirometer as per the ASTM D1925 method.

IV. RESULT AND DISCUSSION

Antimicrobial Test: Zone of Inhibition

Table 4.1:-Antimicrobial Test on Cotton Substrate:

Zone of Inhibition in mm				
Core material used	Benzalkonium Chloride(BKC)	Neem oil	Clove oil	Aloe Vera
Bacteria used				
Bacillus cereus(Gram+)	22	17	17	12
Shigella (Gram-)	17	11	15	8



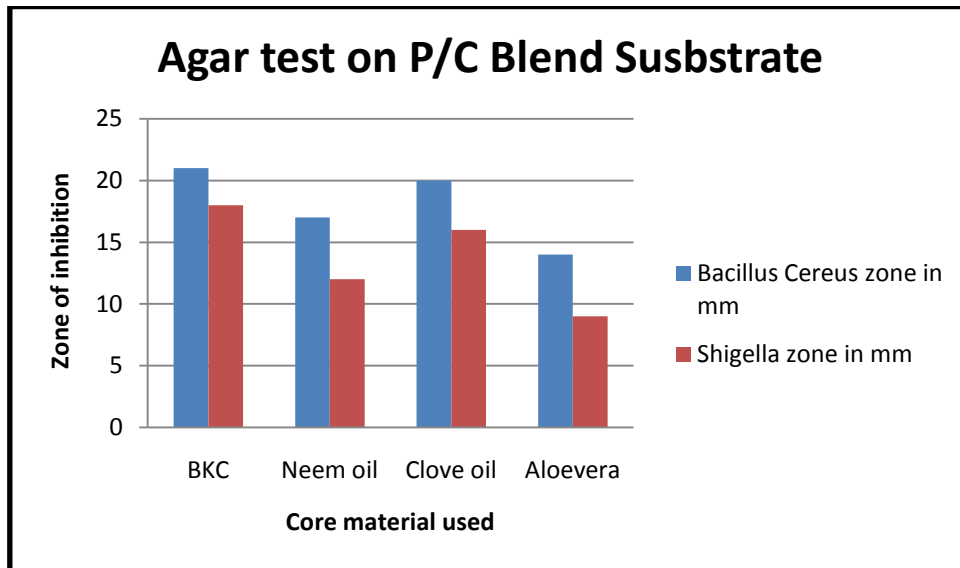
Graph 4.1:- Antimicrobial Test on Cotton Substrate

Results of Table 4.1 and Graph 4.1 indicate that for cotton fabric tested against gram +ve bacteria, the zone of inhibition shown by Benzalkonium Chloride (BKC), Neem oil, Clove oil, and Aloe Vera are 22mm,17mm, 17mm, 12mm respectively. The same trend has been formed for gram –ve bacteria, the zone of inhibition shown by Benzalkonium Chloride (BKC), Neem oil, Clove oil, and Aloe Vera are 17mm,11mm, 15mm, 8mm respectively.

From the results it is observed that Benzalkonium Chloride (BKC) shows the highest zone of inhibition for both gram +ve and gram –ve bacterias and Aloe Vera shows minimum zone of inhibition among the all antimicrobial agents used as a core material for microencapsulation. The possible reason for high antimicrobial property of Benzalkonium Chloride (BKC) is may be due to the central nitrogen atom which is joined to four organic radicals (alkyl, aryl or aralkyl and nitrogen) and one acid radical present. Because of this it has the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective. The other antimicrobial agents like Neem oil, Clove oil and Aloe Vera have shown slightly less antimicrobial properties when compared with the antimicrobial properties of Benzalkonium Chloride (BKC).

Table 4.2:-Antimicrobial Test on P/C Blend Substrate:

Zone of Inhibition in mm				
Core material used	Benzalkonium Chloride(BKC)	Neem oil	Clove oil	Aloe Vera
Bacteria used				
Bacillus cereus (Gram+)	21	17	20	14
Shigella (Gram-)	18	12	16	9

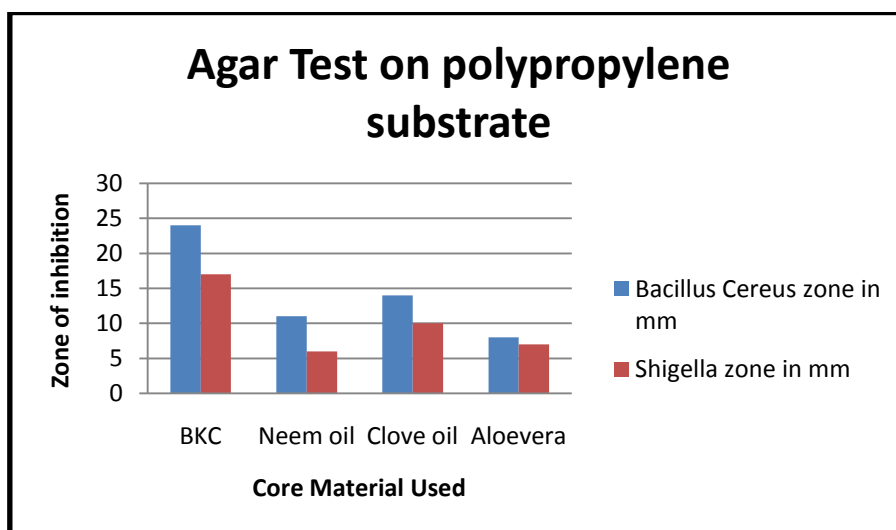


Graph 4.2:- Antimicrobial Test on P/C Blend Substrate

Results of Table 4.2 and Graph 4.2 indicates that for P/C blend fabric tested against gram +ve bacteria, the zone of inhibition shown by Benzalkonium Chloride (BKC), Neem oil, Clove oil, and Aloe Vera are 21mm,17mm, 20mm, 14mm respectively. The same trend has been formed for gram -ve bacteria, the zone of inhibition shown by Benzalkonium Chloride (BKC), Neem oil, Clove oil, and Aloe Vera are 18mm,12mm, 16mm, 9mm respectively. From the results it is observed that Benzalkonium Chloride (BKC) shows the highest zone of inhibition for both gram +ve and gram -ve bacterias and Aloe Vera shows minimum zone of inhibition among the all antimicrobial agents used as a core material for microencapsulation. The reason for this may be due to the better antimicrobial property of Benzalkonium Chloride (BKC) as explained in previous discussion.

Table 4.3:-Antimicrobial Test on Polypropylene-Nonwoven Substrate

Zone of Inhibition in mm				
Core material used	Benzalkonium Chloride(BKC)	Neem oil	Clove oil	Aloe Vera
Bacteria used				
Bacillus cereus (Gram+)	24	11	14	8
Shigella (Gram-)	17	6	10	7

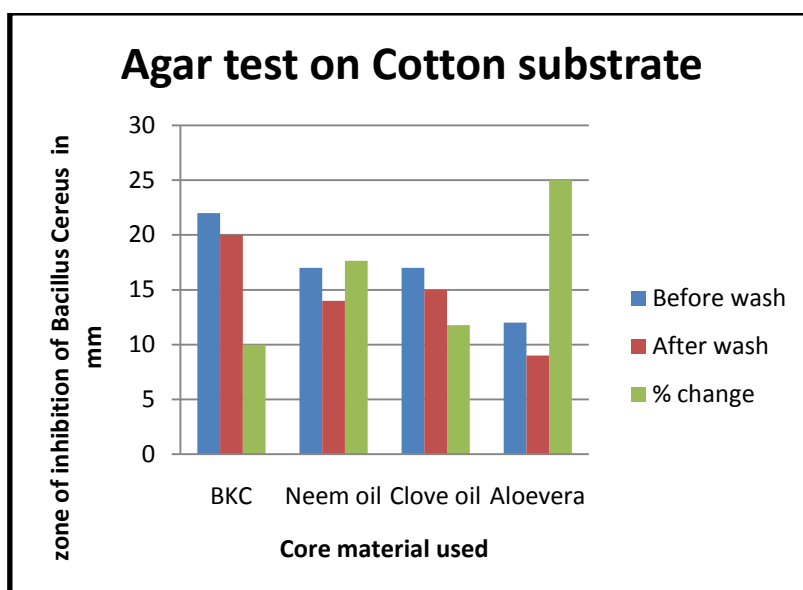


Graph 4.3:-Antimicrobial Test on Polypropylene-Nonwoven Substrate

Results of Table 4.3 and Graph 4.3 indicates that for Polypropylene Nonwoven fabric tested against gram +ve bacteria, the zone of inhibition shown by Benzalkonium Chloride (BKC), Neem oil, Clove oil, and Aloe Vera are 24mm, 11mm, 14mm, 8mm respectively. The same trend has been formed for gram -ve bacteria, the zone of inhibition shown by Benzalkonium Chloride (BKC), Neem oil, Clove oil, and Aloe Vera are 17mm, 6mm, 10mm, 7mm respectively. From the results it is observed that Benzalkonium Chloride (BKC) shows the highest zone of inhibition for both gram +ve and gram -ve bacterias and Aloe Vera shows minimum zone of inhibition among the all antimicrobial agents used as a core material for microencapsulation. The other antimicrobial agents like Neem oil, Clove oil and Aloe Vera have shown slightly less antimicrobial property when compared with the antimicrobial properties of Benzalkonium Chloride (BKC).

Table 4.4:- Durability of Antimicrobial Finish to Washing on Cotton Substrate

Core material used	Zone of Inhibition in mm for Bacillus cereus			
	(Gram +ve)			
	BKC	Neem oil	Clove oil	Aloe Vera
Fabric before wash	22	17	17	12
Fabric after wash	20	14	15	9
%Change	10	17.64	11.76	25

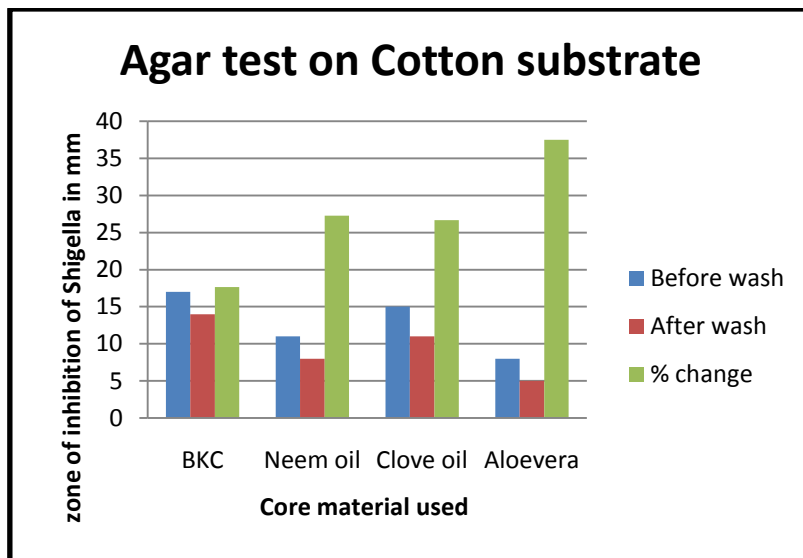


Graph 4.4:- Durability of Antimicrobial Finish to Washing on Cotton Substrate

Table 4.4 and Graph 4.4 gives the results of cotton fabric tested for durability of the antimicrobial finish to washing for Gram +ve bacteria. The results show that zone of inhibition shown by cotton fabric treated with Benzalkonium Chloride (BKC) as a core material before wash and after wash are 22mm and 20 mm respectively and % change is found to be 10%. For Neem oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 17mm, 14mm and 17.64% respectively. For Clove oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 17mm and 15 mm and 11.76% respectively. For Aloe Vera used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 12mm, 9mm and 25% respectively. From the results it is observed that Benzalkonium Chloride (BKC) shows the best results for zone of inhibition in gram +ve bacteria. Aloe Vera shows minimum zone of inhibition for gram +ve bacteria. These results indicate marginal loss of antimicrobial properties even after washing. The possible reason for high antimicrobial property of BKC is may be due to the central nitrogen atom which is joined to four organic radicals (alkyl, aryl or aralkyl and nitrogen) and one acid radical present. Because of this it has the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.5:- Durability of Antimicrobial Finish to Washing on Cotton Substrate

Core material used	Zone of Inhibition in mm for Shigella (Gram -ve)			
	BKC	Neem oil	Clove oil	Aloe Vera
Fabric before wash	17	11	15	8
Fabric after wash	14	8	11	5
%Change	17.64	27.27	26.66	37.5



Graph 4.5:- Durability of Antimicrobial Finish to Washing on Cotton Substrate

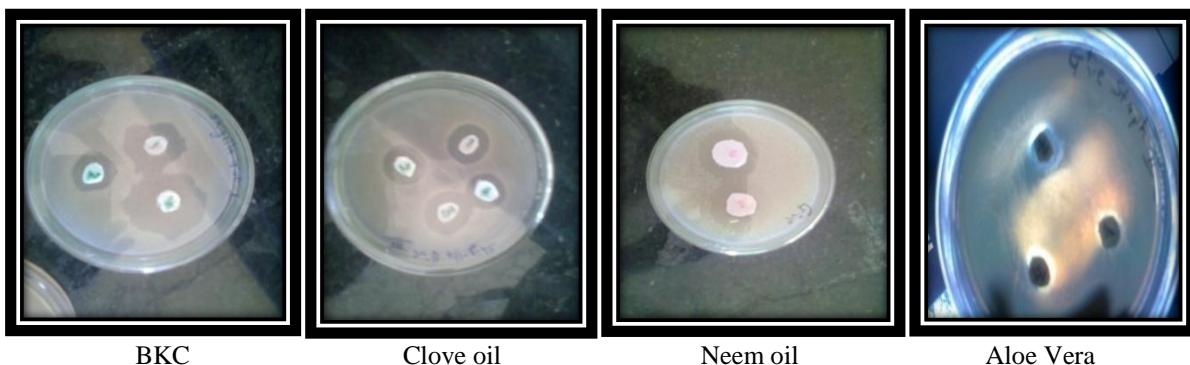


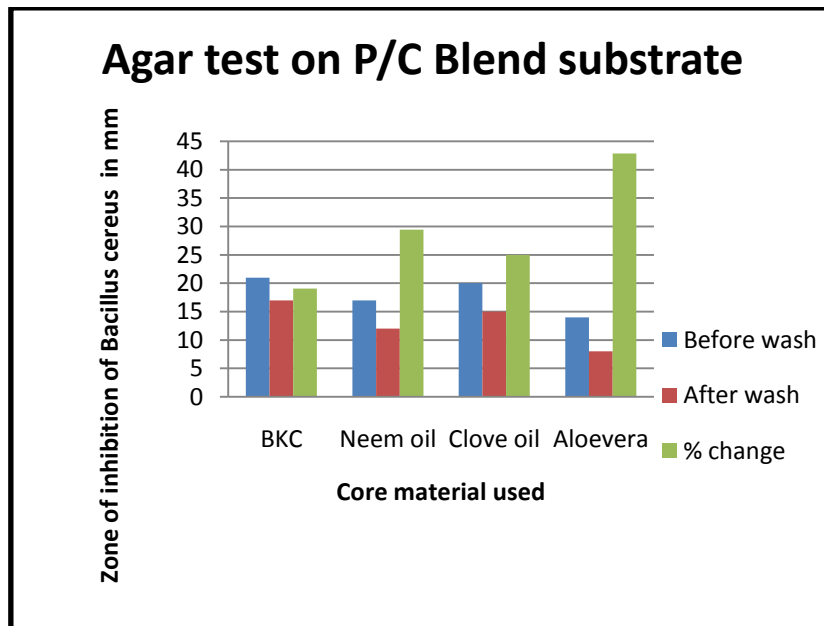
Fig. 2. Zone of inhibition shown by different core materials on cotton fabric

Table 4.5 and Graph 4.5 gives the results of cotton fabric tested for durability of antimicrobial finish to washing for Gram -ve bacteria. The results show that zone of inhibition shown by cotton fabric treated with Benzalkonium Chloride (BKC) as a core material before wash and after wash are 17mm and 14 mm respectively and % change is found to be 17.64%. For Neem oil used as a core material for microencapsulation the zone of inhibition for fabric before was, after wash and percentage change are 11mm, 8mm and 27.27% respectively. For Clove oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 15mm and 11

mm and 26.66% respectively. For Aloe Vera used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 8mm, 5mm and 37.5% respectively. From the results it is observed that Benzalkonium Chloride (BKC) shows the best results for zone of inhibition in gram -ve bacteria also. Aloe Vera shows minimum zone of inhibition for gram -ve bacteria. These results show that after washing treatment also there is no more change in antimicrobial properties of the fabric. BKC is found to be a best antimicrobial agent and for this reason is explained in previous discussion.

Table 4.6:- Durability of Antimicrobial Finish to Washing on P/C Blend Substrate

Core material used	Zone of Inhibition in mm for Bacillus cereus (Gram +ve)			
	BKC	Neem oil	Clove oil	Aloe Vera
Fabric before wash	21	17	20	14
Fabric after wash	17	12	15	8
%Change	19.04	29.41	25	42.85



Graph 4.6:- Durability of Antimicrobial Finish to Washing on P/C Blend Substrate

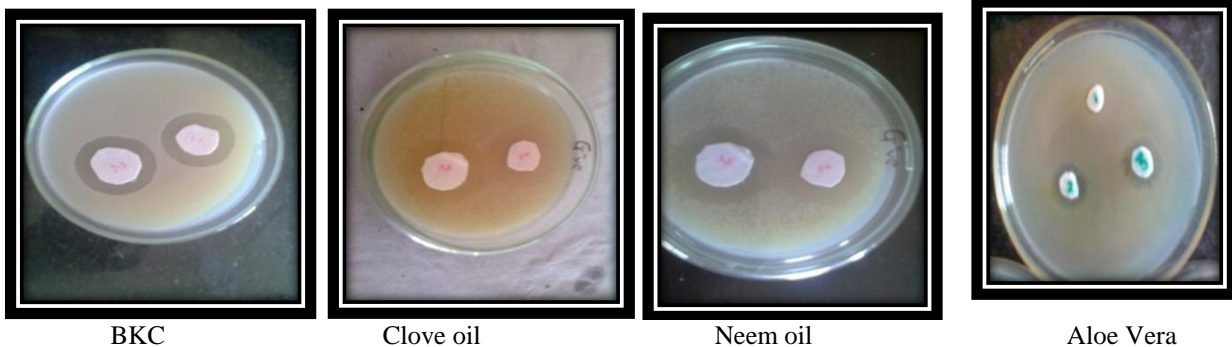


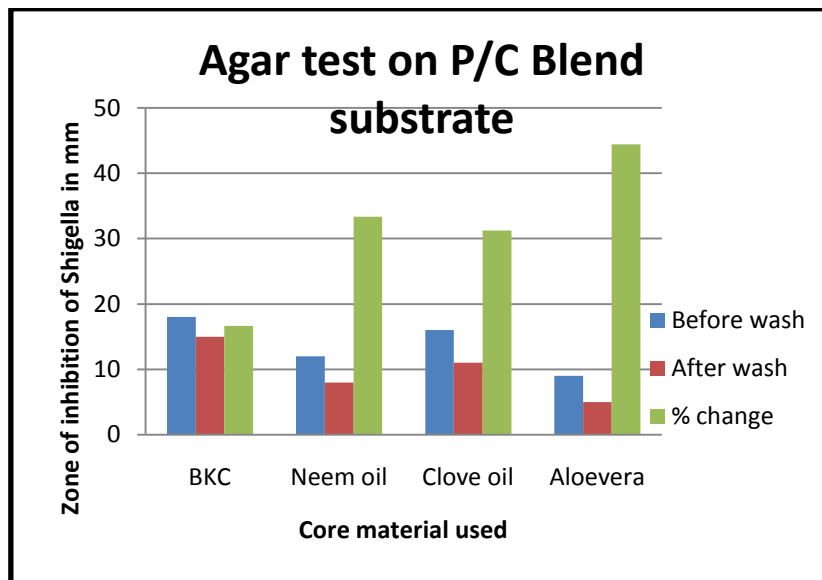
Fig. 3. Zone of inhibition shown by different core materials on P/C Blend fabric

Table 4.6 and Graph 4.6 gives the results of P/C blend fabric tested for durability of the antimicrobial finish to washing for Gram +ve bacteria. The results show that by treating the P/C blend fabric with Benzalkonium Chloride (BKC) as a core material for microencapsulation the zone of inhibition before wash and after wash are 21mm and 17 mm respectively and % change is found to be 19.04%. For Neem oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 17mm, 12mm and 29.41% respectively. For Clove oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 20mm and 15 mm and 25% respectively. For Aloe Vera used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 14mm, 8mm and 42.85% respectively.

From the results it is observed that Benzalkonium Chloride (BKC) shows the best results for zone of inhibition in gram +ve bacteria. As compared to all other core material used for microencapsulation process, Aloe Vera shows minimum zone of inhibition for gram +ve bacteria. These results also indicate marginal loss of antimicrobial properties even after washing due to increase in the durability of finish applied by microencapsulation technique.

Table 4.7:- Durability of Antimicrobial Finish to Washing on P/C Blend Substrate

	Zone of Inhibition in mm for Shigella (Gram -ve)			
Core material used	BKC	Neem oil	Clove oil	Aloe Vera
Fabric before wash	18	12	16	9
Fabric after wash	15	8	11	5
%Change	16.66	33.33	31.25	44.44



Graph 4.7:- Durability of Antimicrobial Finish to Washing on P/C Blend Substrate

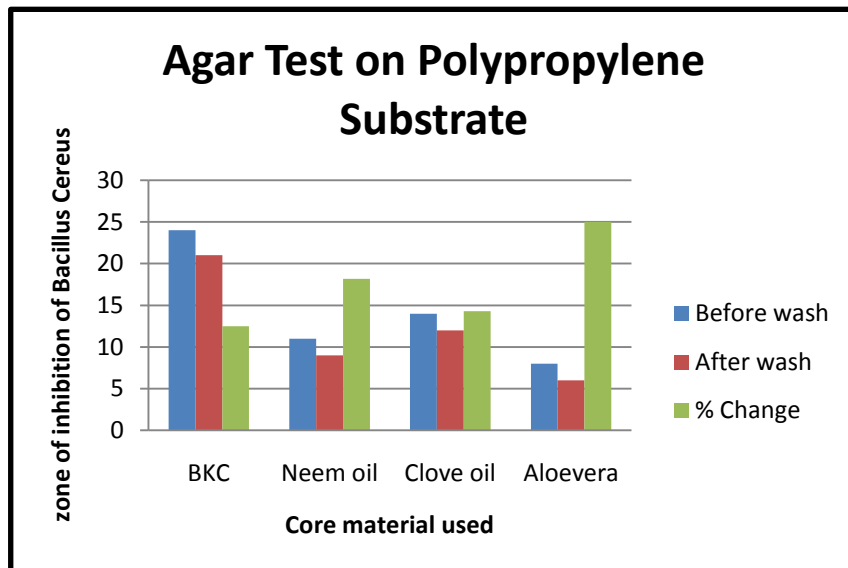
Table 4.7 and Graph 4.7 gives the results of P/C blend fabric tested for durability of antimicrobial finish to washing for Gram -ve bacteria. The results show that zone of inhibition shown by P/C blend fabric treated with Benzalkonium Chloride (BKC) as a core material before wash and after wash are 18mm and 15 mm respectively and % change is found to be 16.66%. For Neem oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 12mm, 8mm and 33.33% respectively. For Clove oil it is 16mm and 11 mm and 31.25% respectively and for Aloe Vera used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 9mm, 5mm and 44.44% respectively.

From the results it is observed that Benzalkonium Chloride (BKC) gives the highest zone of inhibition in gram -ve bacteria also. Aloe Vera shows minimum zone of inhibition for gram -ve bacteria as compared to other core material

used for microencapsulation. These results indicate marginal loss of antimicrobial properties even after washing. Benzalkonium Chloride (BKC) is found to be a best antimicrobial agent among all other agents used.

Table 4.8:- Durability of Antimicrobial Finish to Washing on Polypropylene-Nonwoven Substrate

Core material used	Zone of Inhibition in mm for Bacillus cereus (Gram +ve)			
	BKC	Neem oil	Clove oil	Aloe Vera
Fabric before wash	24	11	14	8
Fabric after wash	21	9	12	6
%Change	12.5	18.18	14.28	25



Graph 4.8:- Durability of Antimicrobial Finish to Washing on Polypropylene-Nonwoven Substrate

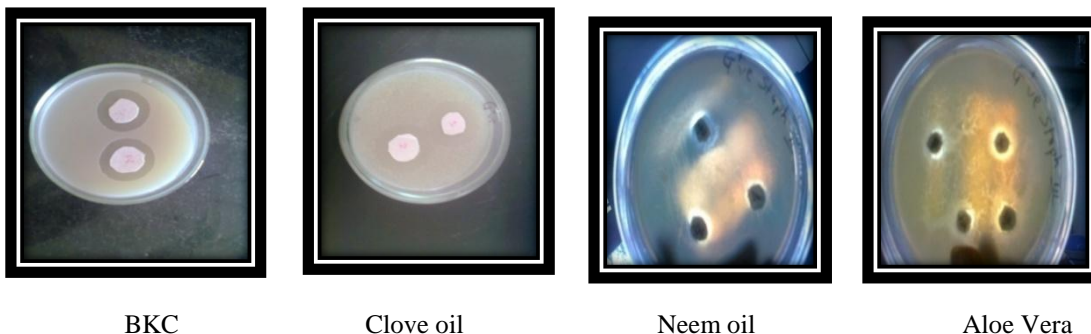


Fig.3. Zone of inhibition shown by different core materials on Nonwoven polypropylene fabric

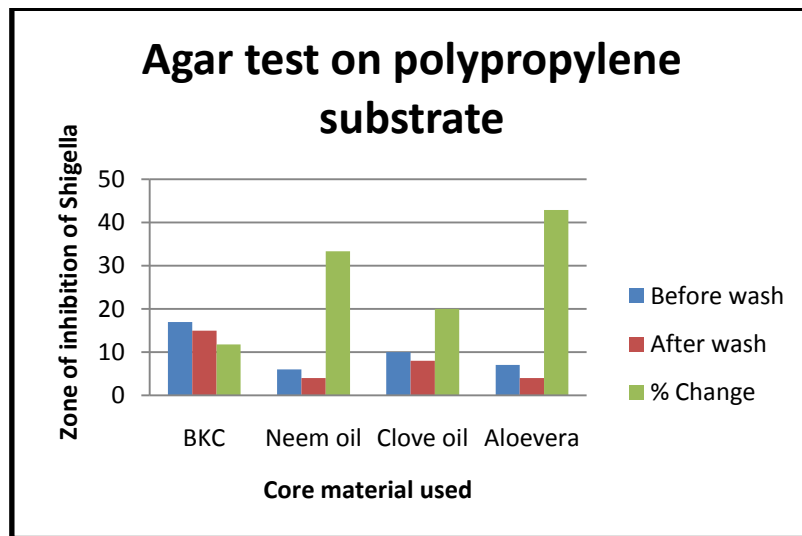
Table 4.8 and Graph 4.8 gives the results of Polypropylene-Nonwoven fabric tested for durability of antimicrobial finish to washing for Gram +ve bacteria. The results show that zone of inhibition shown by Polypropylene-Nonwoven fabric treated with Benzalkonium Chloride (BKC) as a core material before wash and after wash are 24mm and 21 mm respectively and % change is found to be 12.5%. For Neem oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 11mm, 9mm and 18.18% respectively. For Clove oil it is 14mm and 12 mm and 14.28% respectively. For Aloe Vera used as a core material for

microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 8mm, 6mm and 25% respectively.

From the results it is observed that Benzalkonium Chloride (BKC) shows the best results for zone of inhibition in gram +ve bacteria. Aloe Vera shows minimum zone of inhibition for gram +ve bacteria. These results indicate marginal loss of antimicrobial properties even after washing. The other antimicrobial agents like Neem oil, Clove oil, Aloe Vera have shown slightly less antimicrobial properties when compared with antimicrobial property of Benzalkonium Chloride (BKC).

Table 4.9:- Durability of Antimicrobial Finish to Washing on Polypropylene-Nonwoven Substrate

	Zone of Inhibition in mm for Shigella (Gram -ve)			
Core material used	BKC	Neem oil	Clove oil	Aloe Vera
Fabric before wash	17	6	10	7
Fabric after wash	15	4	8	4
%Change	11.76	33.33	20	42.86



Graph 4.9:- Durability of Antimicrobial Finish to Washing on Polypropylene-Nonwoven Substrate

Table 4.9 and Graph 4.9 gives the results of Polypropylene-Nonwoven fabric tested for durability of antimicrobial finish to washing for Gram -ve bacteria. The results show that zone of inhibition shown by cotton fabric treated with Benzalkonium Chloride (BKC) as a core material before wash and after wash are 17mm and 15 mm respectively and % change is found to be 11.76%. For Neem oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 6mm, 4mm and 33.33% respectively. For Clove oil used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 10mm and 8mm and 20% respectively. For Aloe Vera used as a core material for microencapsulation the zone of inhibition for fabric before wash, after wash and percentage change are 7mm, 4mm and 42.86% respectively.

The results indicate that Benzalkonium Chloride (BKC) shows the best results for zone of inhibition in gram -ve bacteria also. These results indicate marginal loss of antimicrobial properties even after washing that is durability of finish get increases by microencapsulation technique. Benzalkonium Chloride (BKC) is found to be a best antimicrobial agent. Aloe Vera shows minimum zone of inhibition for gram -ve bacteria than the zone of inhibition shown by Neem oil and Clove oil.

V. CONCLUSION

The treated fabrics showed antimicrobial efficacy against both *Bacillus Cereus* (Gram+ve) and *Shigella* (Gram–ve) bacterias. However, the Benzalkonium Chloride (BKC) possesses effective antimicrobial efficacy against both *Bacillus Cereus* (Gram+ve) and *Shigella* (Gram –ve) bacterias when compared to all other antimicrobial agents like Neem oil, Clove oil and Aloe Vera used in microencapsulation process. The durability of antimicrobial finish is increased by microencapsulation technique in all fabrics used. Compare to other fabrics Polypropylene-Nonwoven fabric showed better antimicrobial activity than Cotton and P/C blend fabrics.

REFERENCES

- [1] Thilagavathi And T Kannaian, *Combined Antimicrobial And Aroma Finishing Treatment for Cotton, Using Micro Encapsulated Geranium (Pelargonium Graveolens L' Herit . Ex Ait.) Leaves Extract*. Indian Journal Of Natural Products And Resources. Vol.1, Issue 3, pp.348-352, September 2010.
- [2] Anjali Karolia & Snehal Mendapara, *Imparting Antimicrobial And Fragrance Finish On Citton Using Chitosan With Silicon Softner*, Indian Journal Of Fibre & Textile Research Vol.32, pp.99-107, March 2007.
- [3] Ms. S.K.Vyas , Mr V.P.Patil ,Ms. R. J. Khandelwal, Ms. R.D. Samdani Mr. A. P. Ubarhande & Mr. K. N. Kapse, *Multifunctional finishes on cotton fabric by microencapsulation technique*. Asian Dyer.
- [4] Maraia M. Miro Specos, German Escobar, Patricia Marino, Cesar Puggia, M. Victoria, Defain Tesoriero and Laura Hermida, *Aroma Finishing of Cotton Fabrics by Means of Microencapsulation Techniques*. Journal of Industrial Textiles, vol. 40 no. 1 pp.13-32, April 13, 2010.
- [5] R. V. Adivarekar, N. Kanoongo, M Nerurkar, N Khurana, *Application of Herbal Extracts for Antimicrobial Property*, Journal of the Textile Association, Vol.71, No. 6, pp.324-330, March-April 2011.
- [6] C. R. Meena, K. Avinash, P. B. Tayade, J. B. Soma, *Microencapsulation: Revolution in Modern Textile Era*, Journal of the TEXTILE Association, vol.72 No.5, pp.300-307, January-february 2012.
- [7] Rama Dubey, T.C. Shami and K.U. Bhasker Rao, *Microencapsulation Technology and Applications* Defence Science Journal, Vol. 59, No. 1, January, pp. 82-95, 2009.
- [8] Gordon Nelson *Application of microencapsulation in textiles*, International Journal of Pharmaceutics 242 ,2002, pp.55–62.
- [9] B. Boh, E. Knez, *Microencapsulated Antimicrobials On Non-Woven Textiles For Shoe Insoles*, Xvth International Workshop On Bioencapsulation, Vienna, Au,P4-01 – Page 1, . Sept 6-8, 2007.
- [10] Pablo Monllor, Lucia Capablanca, Jaime Gisbert, Pablo Diaz, *Improvement Of Microcapsules Adhesion To Fabrics*, Textile Research Journal Vol. 80, Issue7, pp.631-635, 2010.
- [11] G.Thilagavathi, G Bala, S Krishna, *Microencapsulation Of Herbal Extracts For Microbial Resistance In Healthcare Textiles*, Indian Journal Of Fibre & Textile Research Vol.32, pp.351-354, September 2007,.
- [12] Shiqi Li, Joy E. Lewis, Neil M. Stewaet, Lei Qian and Henry Boyter , *Effect of finishing methods on washing durability of microencapsulated aroma finishing*..TJTI Vol. 99, Issue 2, pp.177-183, 21 March 2006.
- [13] Grace Soares, Raquel Vieira, Isabel Cardoso, Jorge Santos, Jaime Rocha Gomes Ana Lanca, Pablo Pereira. *Studies of Durability And Effect on Material Properties of Different Antibacterial Products*, ATC 04-31 Aachen Textile Conference, November 24-25, 2004.
- [14] Patricia Calvo, Teresa Herna Ndez, Mercedes Lozano And David Gonza Lez-Go Mez, *Microencapsulation Of Extra-Virgin Olive Oil By Spray-Drying: Influence Of Wall Material And Olive Quality*, Eur. J. Lipid Sci. Technol, Vol. 112, pp.852–858, 2010.
- [15] Kijeong Hong, Soomin Park, *Preparation of Poly(L-Lactide) Microcapsules for Fragrant Fiber and their Characteristics*, Polymer Vol. 41, pp.4567–4572, 2000.
- [16] Jun-Seok Hwang, Jin-Nam Kim, Young-Jung Wee, Hong-Gi Jang, Sun-Ho Kim, And Hwa-Won Ryu, *Factors Affecting the Characteristics of Melamine Resin Microcapsules Containing Fragrants Oils*, Biotechnology And Bioprocess Engineering, Vol.11, pp.391-395, 2006.
- [17] Niranjan Kumar Manna And Nimesh Kumar, *Preparation And Evaluation Of Mucoadhesive Microcapsules Of VerapamiL*, International Journal Of Pharmaceutical Science And Research, Vol. 2, Issue 3, pp.664-670, 2011.
- [18] Wiesława Bendkowska, Henryk Wrzosek *Experimental Study Of The Thermoregulating Properties Of Nonwovens Treated With Microencapsulated PCM*, FIBRES & TEXTILES In Eastern Europe, Vol. 17, Issue 5 (76) ,pp. 87-91, 2009.
- [19] Sunderlal Tiwari, Achrish Goel, Keshri Kishore Jha, Akhil Sharma *Microencapsulation Techniques And Its Application: A Review*, The Pharma Research (T. Ph. Res.), Vol. 3, Pp. 112-116, June 2010.
- [20] Swapan Kumar Ghosh *Functional Coatings and Microencapsulation: A General Perspective*. <http://onlinelibrary.wiley.com/doi/10.1002/3527608478.ch1/summary>
- [21] S. S. Bansode, S. K. Banarjee, D. D. Gaikwad, S. L. Jadhav, R. M. Thorat. *Microencapsulation : A Review*, Volume 1, Issue 2 ,Article 008, pp. 38-43, March – April 2010.
- [22] M.Sumithra And N.Vasugi Raaja, *Antibacterial Efficacy Analysis of Ricinus Communis, Senna Auriculata and Euphorbia Hirta Extract Treated on the Four Variant of Denim Fabric Against Escherichia Coli And Staphylococcus Aureus*, Textile Science & Engineering, Vol. 2, Issue 3, 2012, pp.1-4.
- [23] Ristic, Lidija Fras Zemljic, Monika Novak, Marjetka Kralj Kuncic, Silva Sonjak, Nina Gunde Cimerman And Simona Strnad, *Antimicrobial Efficiency Of Functionalized Cellulose Fibres As Potential Medical Textiles Science Against Microbial Pathogens*, Communicating Current Research and Technological Advances FORMATEX, Pp.36-51, 2011.
- [24] Gordon Nelson, *Microencapsulation In Textile Finishing*, Rev. Prog. ration Vol. 21 , pp. 72-85, 1991.
- [25] Ghulam Murtaza , Mahmood Ahamd, Naveed Akhtar And Fatima Rasool, *A Comparative Study Of Various Microencapsulation Techniques: Effect Of Polymer Viscosity On Microcapsule Characteristics*, Pak. J. Pharm. Sci., Vol.22, Issue.3, pp.291-300, July 2009.
- [26] Ms. S. M. Bairagdar & Ms. P M Katkar, *Microencapsulation in textiles*, Colourage August 2009.
- [27] A. K. Patra and S. Dahiya, *Microencapsulation – Technique And Application*, Man- Made Textiles In India, pp.224-231, July 2009.