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Studies in Surgical Mask

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ABSTRACT:
Nonwoven materials have a wide range of applications in the medical field to cater diversified requirements of medical textiles. Numerous types of fibers are involved in the production of medical nonwoven and these fibers are cotton, polypropylene, polyester, viscose, polyethylene. Several antimicrobial treatments are in available to make textile resistant of growth of microbial bio-burden. The function of the surgical mask is to protect wearer from being splashed in the mouth with body fluids and to prevent transmission of body fluids from the medical professional the spreads to the patient. The main objective of this study is to focus on nonwoven surgical masks prepared by nonwovens. An attempt has been made in this work to choose suitable nonwoven and suitable chemicals which can perform this function without affecting the functional properties like antimicrobial and to prepare an affordable yet protective surgical mask used by doctors by adopting nonwoven substrate with an efficient coating of antimicrobial agents.

Keywords: Nonwoven, Disposable, Protective, Antimicrobial, Mask.

1. INTRODUCTION

A surgical mask is a medical device covering the mouth, nose and chin ensuring a barrier that limits the transmission of an infective agent between the hospital staff and the patient. It was originally developed to contain and filter large droplets of microorganisms expelled from the mouth and nasopharynx of healthcare workers during surgery, thereby providing protection for the patient.

Surgical masks, on the other hand, can be labeled as face masks, laser, isolation, dental or medical procedure masks.

Surgical masks are plain masks that cover the nose and mouth and are held in place by fabric ties or with elastic straps around the ears. These are generally available in two configurations, molded cup shape with an elastic cord around the head and non-molded which may be further available as a pleated or a flat paper shield with two ties or ear loops. Furthermore, pleats can be either two ply or three ply. Modern surgical masks are made from paper or other non-woven material, and should be discarded after each use.

Simple surgical masks protect wearers from being splashed in the mouth with body fluids and to prevent transmission of body fluids from the medical professional to the patient. They also remind wearers not to touch their mouth or nose, which could otherwise transfer viruses and bacteria after having touched a contaminated surface.

They can also reduce the spread of infectious droplets (carrying bacteria or viruses) that are created when the wearer coughs or sneezes. They are not designed to protect the wearer from inhaling such particles. They will trap some particles but are much less effective than respirators, which are designed for this purpose.

2. MATERIALS AND METHODS

2.1. Materials:

The following materials were selected to study their suitability towards surgical mask.

- Inner layer- Spun bond polypropylene (pp)
  15gsm, 20gsm, 25gsm, 30gsm
- Middle layer- Melt-blown polypropylene
  18gsm
- Outer layer- spun bond polypropylene (pp)
  15gsm, 20gsm

2.2. Chemicals:

- Antimicrobial agents:
  1) Benzalkonium chloride (BKC)
  2) yogifinsant
  3) Tulsi oil
  4) Clove oil
- Emulsifier: Nonyl Phenol Ethoxylate (HLB 9.5)
- Binder: Printofix CET
- ph to maintainer: Citric acid

2.3. Methods:

The spun bond polypropylene nonwoven fabric proposed for the outer layer was coated with antimicrobial agents to give multi-functional finish. The coating was done using padding mangle by 2 dip-2 nip padding method at 2-2.5 kg/cm^2 pressure and air dried. The finished polypropylene outer layer, melt-blown middle layer and inner polypropylene layer sand-witched for further study.

2.4 Mask Combinations:

GSM						
Fabric layers	Sample 1	Sample 2	Sample 3	sample 4	sample 5	sample 6
Spun bond	15	20	25	30	15	20
Melt-blown	18	18	18	18	18	18
Melt-blown	-	-	-	-	18	18
Spun bond	15	20	20	20	15	20

3. TESTING

The untreated and treated samples were tested for the below mentioned tests

- Bacterial Filtration Efficiency: ASTM F-2101-07
- Breathability :MIL-M-36954 C
- Thickness: ASTM D1777-64
- Air permeability: ASTM D 737-04
- Antimicrobial testing: AATCC147
- Pore size: ASTM D6767-11

4. RESULTS AND DISCUSSIONS

Below table 4.1 & 4.2 shows the physical properties of the spun-bond polypropylene and Melt-blown polypropylene Nonwoven fabric.

4.1 Physical properties for untreated polypropylene

Fabric particulars	15 GSM	20 GSM	25GSM	30GSM
Thickness(mm)	0.12	0.15	0.19	0.23
Air permeability($cm^3/cm^2/s$)	485	376	331	239
Drop absorbency (sec.)	<1	<1	<1	<1
Bacterial filtration efficiency (%)	10	17	20	25
Pore size (microns)	159.34	238.73	183.30	186.34

4.2 Physical properties for Melt-blown filter layer

Material	GSM	Thickness (mm)	Air permeability ($cm^3/cm^2/s$)	Drop absorbency(sec.)	Bacterial filtration efficiency (%)	Pore size (microns)
Melt-blown	18	0.10	40.5	<1	45	117.48

Table 4.3 Effect of Antimicrobial agents on various physical parameters for (15GSM Spun bond- 18GSM Melt-blown- 15GSM Spun bond)

Test chemical	Bacterial filtration efficiency (%)		Breathability(Δp) (mmH_2o/Cm^2)		Air permeability ($cm^3/cm^2/s$)		Pore size (microns)		Drop Absorbency (Sec.)	Thickness (mm)	
	-	% Increase	-	% Decrease	-	% Decrease	-	% Decrease	-	-	% Increase
Untreated	73	-	4.12	-	40	-	145.03	-	<1	0.35	-
BKC	90	18.88	3.15	23.54	38	5	139.36	3.91	<1	0.38	7.89
Yogi-finsant	84	13.09	3.11	24.51	33	17.5	137.21	5.39	<1	0.37	5.4
Tulsi oil	87	16.09	3.09	25	39	2.5	133.01	8.28	<1	0.36	2.77
Clove oil	86	15.11	3.04	26.21	37	7.5	132.23	8.82	<1	0.37	5.4

From Table 4.3, it is seen that the untreated sample shows bacterial filtration efficiency as 73% whereas BKC show 90% and other agents like Yogifinsant, Tulsi oil & clove oil shows 84%, 87%, 86% respectively. These results indicate the increase in bacterial efficiency by 18.88%, 13.09%, 16.09%, and 15.11% respectively when compared with untreated sample.

Amongst all the four antimicrobial agents BKC gives maximum Bacterial filtration efficiency 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.3, indicates the values of pressure drop across face masks (Δp) gives on decreasing when treated with antimicrobial agents. The value of untreated sample shows Δp as 4.12 mmH_2o/cm^2 whereas BKC shows 3.15 mmH_2o/cm^2, Yogifinsant shows 3.11 mmH_2o/cm^2, Tulsi oil shows 3.09 mmH_2o/cm^2, and Clove oil shows 3.04 mmH_2o/cm^2.

The higher Δp values indicate more difficult to breathe through the mask. The result indicates BKC treated sample shows higher Δp value as against other chemicals and Clove oil gives minimum Δp value. This may be due the deposition of chemical like BKC and Yogifinsant on the surface of the fabric (a film formation). Whereas both the oils showed minimum Δp values which to breathe through the mask and this may be due to non-formation of film but coating of fibers and hence this allows more air to pass through the sample as against the BKC and Yogifinsant.

Table 4.3 (a)Antimicrobial test on

(15gsm spun bond-18gsm melt blown-15gsm spun bond)

Chemical coated on nonwoven substrate	Staphylococcus aureus zone in mm
BKC (Benzalkonium chloride)	30mm
Yogifinsant	23mm
Tulsi oil	28mm
Clove oil	25mm

From table 4.3 (a), it is seen that the BKC sample shows 30mm of zone of inhibition and other chemicals like Yogifinsant, Tulsi oil and Clove oil show 23mm, 28mm and 25 mm zone of inhibition respectively.
Amongst all the four antimicrobial agents BKC gives higher zone of inhibition 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.4 Effect of Antimicrobial agents on various physical parameters for
(20gsm spun bond-18gsm melt blown-20gsm spun bond)

Test chemical	Bacterial filtration efficiency (%)		Breathability(Δp) (mmH_2o/Cm^2)		Air permeability ($cm^3/cm^2/s$)		Pore size (microns)		Drop Absorbency (Sec.)	Thickness (mm)	
	-	% Increase	-	% Decrease	-	% Decrease	-	% Decrease	-	-	% Increase

Untreated	75	-	4.01	-	42	-	143.09	-	<1	0.38	-
BKC	89	15.73	3.15	21.44	37	11.9	140.74	1.64	<1	0.43	11.62
Yogi-finsant	83	9.63	3.12	22.19	36	14.28	139.37	2.59	<1	0.42	9.52
Tulsi oil	85	11.76	3.04	24.18	40	4.76	139.32	2.63	<1	0.41	7.31
Clove oil	84	10.71	3.07	23.44	39	7.14	138.27	3.36	<1	0.41	7.31

From Table 4.4, it is seen that the untreated sample shows bacterial filtration efficiency as 75% whereas BKC show 89% and other agents like Yogifinsant, Tulsi oil & clove oil shows 83%, 85%, 84% respectively. These results indicate the increase in bacterial efficiency by 17.97%, 12.04%, 14.11%, and 13.09% respectively when compared with untreated sample.

Amongst all the four antimicrobial agents BKC gives maximum Bacterial filtration efficiency 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.4, indicates the values of pressure drop across face masks (Δp) goes on decreasing when treated with antimicrobial agents. The value of untreated sample shows Δp as 4.01 mmH_2o/cm^2 whereas BKC shows 3.15 mmH_2o/cm^2, Yogifinsant shows 3.12 mmH_2o/cm^2, Tulsi oil shows 3.04 mmH_2o/cm^2, and Clove oil shows 3.07 mmH_2o/cm^2.

The higher Δp values indicate more difficult to breathe through the mask. The result indicates BKC treated sample shows higher Δp value as against other chemicals and Clove oil gives minimum Δp value. This may be due the deposition of chemical like BKC and Yogifinsant on the surface of the fabric (a film formation). Whereas both the oils showed minimum Δp values which to breathe through the mask and this may be due to non-formation of film but coating of fibers and hence this allows more air to pass through the sample as against the BKC and Yogifinsant

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Table 4.4 (a)Antimicrobial test on
(20gsm spun bond-18gsm melt blown-20gsm spun bond)

Chemical coated on nonwoven substrate	Staphylococcus aureus zone in mm
BKC (Benzalkonium chloride)	29mm
Yogifinsant	22mm
Tulsi oil	27mm
Clove oil	23mm

From Table 4.4 (a), it is seen that the BKC sample shows 29mm of zone of inhibition and other chemicals like Yogifinsant, Tulsi oil and Clove oil show 22mm, 27mm and 23 mm zone of inhibition respectively.

Amongst all the four antimicrobial agents BKC gives higher zone of inhibition 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 have 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 Effect of Antimicrobial agents on various physical parameters for

(25gsm spun bond-18gsm melt blown-20gsm spun bond)

Test chemical	Bacterial filtration efficiency (%)		Breathability(Δp) (mmH_2o/Cm^2)		Air permeability ($cm^3/cm^2/s$)		Pore size (microns)		Drop Absorbency (Sec.)	Thickness (mm)	
	-	% Increase	-	% Decrease	-	% Decrease	-	% Decrease	-	-	% Increase
Untreated	77	-	4.07	-	40.3	-	139.07	-	<1	0.43	-
BKC	90	14.44	3.11	23.58	33.7	16.37	132.1	5.01	<1	0.46	6.52
Yogi-finsant	81	4.93	3.08	24.32	31.2	22.58	130.9	5.87	<1	0.45	4.44
Tulsi oil	87	11.49	3.04	25.3	35.6	11.66	127.7	8.17	<1	0.44	2.27
Clove oil	85	9.41	3.06	24.81	34.5	14.39	126.8	8.82	<1	0.44	2.27

From Table 4.5, it is seen that the untreated sample shows bacterial filtration efficiency as 77% whereas BKC show 90% and other agents like Yogifinsant, Tulsi oil & clove oil shows 81%, 87%, 85% respectively. These results indicate the increase in bacterial efficiency by 14.44, 4.93%, 11.49%, and 9.41% respectively when compared with untreated sample.

Amongst all the four antimicrobial agents BKC gives maximum Bacterial filtration efficiency 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 have 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, indicates the values of pressure drop across face masks (Δp) goes on decreasing when treated with antimicrobial agents. The value of untreated sample shows Δp as 4.01 mmH_2o/cm^2 whereas BKC shows 3.11 mmH_2o/cm^2, Yogifinsant shows 3.08 mmH_2o/cm^2, Tulsi oil shows 3.04 mmH_2o/cm^2, and Clove oil shows 3.06 mmH_2o/cm^2.

The higher Δp values indicate more difficult to breathe through the mask. The result indicates BKC treated sample shows higher Δp value as against other chemicals and Clove oil gives minimum Δp value. This may be due the deposition of chemical like BKC and Yogifinsant on the surface of the fabric (a film formation). Whereas both the oils showed minimum Δp values which to breathe through the mask and this may be due to non-formation of film but coating of fibers and hence this allows more air to pass through the sample as against the BKC and Yogifinsant.

Table 4.5 (a)Antimicrobial test on
(25gsm spun bond-18gsm melt blown-20gsm spun bond)

Chemical coated on nonwoven substrate	Staphylococcus aureus zone in mm
BKC (Benzalkonium chloride)	28mm
Yogifinsant	20mm
Tulsi oil	24mm
Clove oil	21mm

From Table 4.5 (a), it is seen that the BKC sample shows 28mm of zone of inhibition and other chemicals like Yogifinsant, Tulsi oil and Clove oil show 20mm, 24mm and 21 mm zone of inhibition respectively.
Amongst all the four antimicrobial agents BKC gives higher zone of inhibition 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.6 Effect of antimicrobial agents on various physical parameters for (30gsm spun bond-18gsm melt blown-20gsm spun bond)

Test chemical	Bacterial filtration efficiency (%)		Breathability(Δp) (mmH_2o/Cm^2)		Air permeability ($cm^3/cm^2/s$)		Pore size (microns)		Drop Absorbency (Sec.)	Thickness (mm)	
	-	% Increase	-	% Decrease	-	% Decrease	-	% Decrease	-		% increase
Untreated	78	-	4.31	-	40.7	-	142.02	-	<1	0.5	-
BKC	87	10.34	3.14	27.14	34.2	15.97	140.01	1.41	<1	0.54	7.4
Yogi-finsant	80	2.5	3.12	27.61	33.6	17.44	139.07	2.07	<1	0.53	5.66
Tulsi oil	84	7.14	3.11	27.84	37.3	8.35	138.09	2.76	<1	0.51	1.96
Clove oil	83	6.02	3.09	28.3	36.7	9.82	137.03	3.51	<1	0.52	3.84

From Table 4.6, it is seen that the untreated sample shows bacterial filtration efficiency as 78% whereas BKC show 87% and other agents like Yogifinsant, Tulsi oil & clove oil shows 80%, 84%, 83% respectively. These results indicate the increase in bacterial efficiency by 10.34, 2.5%, 7.14%, and 6.02% respectively when compared with untreated sample.
Amongst all the four antimicrobial agents BKC gives maximum Bacterial filtration efficiency 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.6, indicates the values of pressure drop across face masks (Δp) goes on decreasing when treated with antimicrobial agents. The value of untreated sample shows Δp as 4.31 mmH_2o/cm^2 whereas BKC shows 3.14 mmH_2o/cm^2, Yogifinsant shows 3.12 mmH_2o/cm^2, Tulsi oil shows 3.11 mmH_2o/cm^2, and Clove oil shows 3.09 mmH_2o/cm^2.
The higher Δp values indicate more difficult to breathe through the mask. The result indicates BKC treated sample shows higher Δp value as against other chemicals and Clove oil gives minimum Δp value. This may be due the deposition of chemical like BKC and Yogifinsant on the surface of the fabric (a film formation). Whereas both the oils showed minimum Δp values which to breathe through the mask and this may be due to

non-formation of film but coating of fibers and hence this allows more air to pass through the sample as against the BKC and Yogifinsant.

Table 4.6 (a)Antimicrobial test on
(30gsm spun bond-18gsm melt blown-20gsm spun bond)

Chemical coated on nonwoven substrate	Staphylococcus aureus zone in mm
BKC (Benzalkonium chloride)	28mm
Yogifinsant	19mm
Tulsi oil	25mm
Clove oil	23mm

From Table 4.6 (a), it is seen that the BKC sample shows 28mm of zone of inhibition and other chemicals like Yogifinsant, Tulsi oil and Clove oil show 19mm, 25mm and 23 mm zone of inhibition respectively.
Amongst all the four antimicrobial agents BKC gives higher zone of inhibition 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.7 Effect of antimicrobial agents on various physical parameters for
(15gsm spun bond-18gsm melt blown-18gsm melt blown -15gsm spun bond)

Test chemical	Bacterial filtration efficiency (%)		Breathability (Δp) (mmH_2o/Cm^2)		Air permeability ($cm^3/cm^2/s$)		Pore size (microns)		Drop Absorbency (Sec.)	Thickness (mm)	
	-	% Increase	-	% Decrease	-	% Decrease	-	% Decrease	-	-	% Increase
Untreated	85	-	4.33	-	35.03	-	141.09	-	<1	0.53	-
BKC	95	10.52	4.28	1.15	28.09	19.81	140.5	0.41	<1	0.56	5.35
Yogi-finsant	90	5.55	4.26	1.61	27.4	21.78	140	0.77	<1	0.55	3.63
Tulsi oil	97	12.37	4.22	2.54	30.7	12.36	139.04	1.45	<1	0.55	3.63
Clove oil	96	11.45	4.21	2.77	29.8	14.93	139.01	1.47	<1	0.54	1.85

From Table 4.7, it is seen that the untreated sample shows bacterial filtration efficiency as 85% whereas BKC show 95% and other agents like Yogifinsant, Tulsi oil & clove oil shows 90%, 97%, 96% respectively. These results indicate the increase in bacterial efficiency by 10.52%, 5.55%, 12.37%, and 11.45% respectively when compared with untreated sample.
Amongst all the four antimicrobial agents BKC gives maximum Bacterial filtration efficiency 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.7, indicates the values of pressure drop across face masks (Δp) goes on decreasing when treated with antimicrobial agents. The value of untreated sample shows Δp as 4.33 mmH_2o/cm^2 whereas BKC shows 4.28 mmH_2o/cm^2, Yogifinsant shows 4.26 mmH_2o/cm^2, Tulsi oil shows 4.22 mmH_2o/cm^2, and Clove oil shows 4.21 mmH_2o/cm^2.

The higher Δp values indicate more difficult to breathe through the mask. The result indicates BKC treated sample shows higher Δp value as against other chemicals and Clove oil gives minimum Δp value. This may be due the deposition of chemical like BKC and Yogifinsant on the surface of the fabric (a film formation). Whereas both the oils showed minimum Δp values which to breathe through the mask and this may be due to non-formation of film but coating of fibers and hence this allows more air to pass through the sample as against the BKC and Yogifinsant.

Table 4.7 (a) Antimicrobial test on (15gsm spun bond-18gsm melt blown-18gsm melt blown -15gsm spun bond)

Chemical coated on nonwoven substrate	**Staphylococcus aureus zone in mm**
BKC (Benzalkonium chloride)	30mm
Yogifinsant	23mm
Tulsi oil	27mm
Clove oil	23mm

From Table 4.7 (a), it is seen that the BKC sample shows 30mm of zone of inhibition and other chemicals like Yogifinsant, Tulsi oil and Clove oil show 23mm, 27mm and 23 mm zone of inhibition respectively.
Amongst all the four antimicrobial agents BKC gives higher zone of inhibition 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.8 Effect of antimicrobial agents on various physical parameters for
(20gsm spun bond-18gsm melt blown-18gsm melt blown -20gsm spun bond)

Test chemical	Bacterial filtration efficiency (%)		Breathability(Δp) (mmH_2o/Cm^2)		Air permeability ($cm^3/cm^2/s$)		Pore size (microns)		Drop Absorbency (Sec.)	Thickness (mm)	
	-	% Increase	-	% Decrease		% Decrease		% Decrease			% Increase
Untreated	87	-	4.81	-	31.07	-	138.09	-	<1	0.54	-
BKC	98	11.22	4.78	0.62	26.09	16.02	135.03	2.21	<1	0.57	5.26
Yogi-finsant	86	1.14	4.76	1.03	26.03	16.22	134.01	2.95	<1	0.56	3.57
Tulsi oil	98	11.22	4.71	2.07	29.01	6.63	133.07	3.63	<1	0.57	5.26
Clove oil	97	10.3	4.69	2.49	27.04	12.97	132.08	4.32	<1	0.55	1.81

From Table 4.8, it is seen that the untreated sample shows bacterial filtration efficiency as 87% whereas BKC show 98% and other agents like Yogifinsant, Tulsi oil & clove oil shows 86%, 98%, 97% respectively. These results indicate the increase in bacterial efficiency by 11.22%, 1.14%, 11.22%, and 10.03% respectively when compared with untreated sample.

Amongst all the four antimicrobial agents BKC gives maximum Bacterial filtration efficiency 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

Table 4.8, indicates the values of pressure drop across face masks (Δp) goes on decreasing when treated with antimicrobial agents. The value of untreated sample shows Δp as 4.81 mmH_2o/cm^2 whereas BKC shows 4.78 mmH_2o/cm^2, Yogifinsant shows 4.76 mmH_2o/cm^2, Tulsi oil shows 4.71mmH_2o/cm^2, and Clove oil shows 4.69 mmH_2o/cm^2.

The higher Δp values indicate more difficult to breathe through the mask. The result indicates BKC treated sample shows higher Δp value as against other chemicals and Clove oil gives minimum Δp value. This may be due the deposition of chemical like BKC and Yogifinsant on the surface of the fabric (a film formation). Whereas both the oils showed minimum Δp values which to breathe through the mask and this may be due to non-formation of film but coating of fibers and hence this allows more air to pass through the sample as against the BKC and Yogifinsant.

Table 4.8 (a) Antimicrobial test on
(20gsm spun bond-18gsm melt blown-18gsm melt blown -20gsm spun bond)

Chemical coated on nonwoven substrate	Staphylococcus aureus zone in mm
BKC (Benzalkonium chloride)	30mm
Yogifinsant	22mm
Tulsi oil	28mm
Clove oil	26mm

From Table 4.8 (a), it is seen that the BKC sample shows 30mm of zone of inhibition and other chemicals like Yogifinsant, Tulsi oil and Clove oil show 22mm, 28mm and 26mm zone of inhibition respectively.

Amongst all the four antimicrobial agents BKC gives higher zone of inhibition 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 have the widest spectrum of anti-infective against bacteria. Also it is convenient to use as it is less irritating and more effective.

5. CONCLUSION

1. From the results and discussion, it may be concluded that 15gsm spun bond- 18gsm melt blown- 18gsm melt blown-15gsm spun bond combination gives slightly lower values of bacterial filtration efficiency as against 20gsm spun bond- 18gsm melt blown- 18gsm melt blown-20gsm spun bond.
2. BKC and Tulsi oil gives good antimicrobial activity when compared with Yogifinsant and Clove oil.
3. The mask combination prepared gives good round properties when treated with BKC or Tulsi oil.

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