PREPARATION OF MULTI LAYERED BED SPREAD FOR MEDICAL PURPOSE

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Abstract: *Nonwoven materials have a wide range of applications in the medical field to cater diversified requirements of medical textiles[1].These are disposable, sterile, cheaper and of single use[2][3].Bed spreads play an integral role and invariably contribute to the patient being susceptible and prone to any means of infection which could end up fatal. In this research, an attempt was made to develop a multi-layered bed spread which consists of spun bond polypropylene as the top layer which is multi-finished with antimicrobial, anti-static and flame retardant agents and which also acts as a medium to transport urine from immobile patients to the absorptive layer of needle-punched viscose (middle layer) which retains the same, supported by a bottom waterproof film. The multi-layered bed spread also shows to possess necessary physical, thermal and moisture related properties contributing to the essential comfort of the patient. The results revealed that 40gsm PP and 400gsm viscose fabric was found to be more suitable to develop a multi-layered bed spread to meet the above mentioned requirements.*

Keywords: *Bed spreads, Disposable, Moisture absorbency, Comfort, Antistatic, Antimicrobial.*

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1. INTRODUCTION

Textiles have always been a major part of healthcare. The range of products available is vast but typically they are used in the operating room theatre or on the hospital ward for the hygiene, care and safety of staff and patients. New cost-effective ways to protect both hospital staff and their patients from bacteria, viruses and body fluid invasions in operating room environments are being developed[4].The spread of infections whether it is Hospital Acquired Infections or Surgical Site Infections continues to rise. Sporadically, numbers do fall, but this is then followed by an ever-increasing ramp up. This situation is a concern both for the patient and for healthcare establishments. Thus, Nonwoven products remain the component of choice for providing appropriate protection due to their ability to create barriers either from the structure of the nonwoven itself or from an additional active coating for personal protective apparel.

Various bed coverings have been described in the prior art for preventing water and other forms of moisture from penetrating through the lower bed spread and damaging the bed mattress or other bedding. Generally these bed coverings are comprised of a water resistant covering that is placed on the bed beneath the user. As used herein the term water resistant is intended to include materials that completely prevent water penetration as well as materials that allow a small amount of moisture to penetrate under some conditions. The water resistant covering may be directly in contact with the user or covered by a water resistant sheet. This water resistant sheet can be uncomfortable when directly in contact with the user. While the discomfort is reduced by covering the water resistant sheet with water permeable covering there is the necessity to remove the water permeable covering when it is soiled. Single layered bedspread makes the patient highly uncomfortable due to the strain on contact area and excessive heat generated. Excess compression in the contact area damages the blood vessels, leading to bedsores of different degrees with unbearable pain. In order to overcome this issue multilayered bed spreads are developed. It consists of different layers of the fabrics which have the ability to complement and maximize the essential comfort properties for a bed spread. Presence of more number of layers can reduce pressure, temperature; shear and friction developed on body and also enhance the moisture absorbency and moisture vapour transport property [5].

The basic function of the bed spread is to prevent transmission of pathogens. In order to make a fabric to prevent transmission, it is important to know how transmission takes place in hospital environment. There are various ways that lead to transmission of pathogen infections. These are: contact, droplet, airborne, and common vehicle transmission. Contact transmission can happen in two ways; direct-contact transmission involving a direct body-to-surface contact and physical transfer of microorganisms between an infected people with a susceptible host. An example would be touching blood, OPIM or patient tissues with ungloved hands and; indirect-contact transmission that involves contact of a susceptible host with a contaminated intermediate object, such as contaminated instruments, dressings, or contaminated hands/gloves. An example would be contacting a used dental instrument or a removable patient appliance. Droplet transmission happens while coughing, sneezing, talking, etc.

2. MATERIALS AND METHODS

2.1. Materials:

The following materials were selected to study their suitability towards Bedspreads.

- Top Layer- Spun bond Polypropylene (PP) of 15gsm, 23gsm and 40gsm.
- Middle Layer- Needle Punch Viscose Non Woven of 200gsm, 300gsm and 400gsm.
- Bottom Layer- Polyethylene (PE) Waterproof Film of 20gsm.

Chemicals:

- **Antimicrobial agents:**
  1) Benzalkonium chloride (BKC) (10gpl and 20gpl),
  2) Clove oil (5% and 8%)
- **Antistatic agent:**
  1) LIXASTAT LV 40 (10gpl and 20gpl)
     (Procured from yogeshwar chemicals pvt.ltd.)
- **Flame retardant agent:**
  1) LIXOFLAM PDP 10 (300gpl and 400gpl)
     (Procured from yogeshwar chemicals pvt.ltd.)
- **Emulsifier:** Nonyl Phenol Ethoxylate (HLB 9.5),
- **Binder:** Printofix CET (3-5%),
- **ph to maintainer:** Citric acid.

2.2 Methods:

The spun bond polypropylene non-woven fabric proposed for the top layer was coated with Anti-microbial, Anti-static and Flame retardant agents to give multi-functional finish. The coating of Anti-static and Anti-microbial agents was done using padding mangle by 2 dip-2 nip padding method at 2-2.5 kg/cm^2 pressure and cured at 90-110^{0}C. The Flame retardant finish was applied on the PP fabric using Nylon 80 mesh screen (screen printing method). The multi-finished PP top layer, viscose middle layer and bottom polyethylene layer was then sewn together to develop a multi-layer bed-spread.

3. TESTING

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

- Thickness: ASTM D1777-64,
- Air Permeability: ASTM 738-04,
- Bursting Strength: ASTM D3786/D3786M-13,
- Wickabilty: DIN 53924,
- Abrasion Resistance: ASTM D3884-80,
- Tensile Strength: ASTM D2256 (INSTRON),
- Thermal Conductivity: ASTM D 1518-11,
- Thermal resistance: ASTM D 1518-11,
- Water Vapour Permeability: ASTM E 96-1995,
- Antimicrobial Testing: AATCC 147,
- Antistatic Testing: JIS L1094,
- Flame Retardant Testing: (ASTM D6413-13b),
- Drop Absorbency: AATCC 79,
- Water Absorption Capacity STN2: 117/87,
- Water Retention Capacity STN2: 117/87.

4. RESULTS AND DISCUSSIONS

Below table 4.1 shows the physical properties of the spun-bond polypropylene non-woven fabric (proposed top layer) and viscose needle punched fabric (middle absorbent layer). Good abrasion resistance, wicking and tensile properties is desirable for the top layer. Polypropylene of 15, 23 and 40 gsm was tested for all such properties. As the fabric weight increases, more fibres/area is available to take up the load and withstand the abrasion or bursting force. In case of wick-ability 15 gsm samples showed no wicking/absorbency as the inter-fiber spacing in them is high making it not possible for the capillary action to take place, whereas 40 gsm PP shows good results revealing that it has optimum fiber spacing for necessary capillary action to take place as compared to 15 and 23 gsm.

Table 4.1 Physical properties for Treated and Untreated Polypropylene

Fabric particulars		15GSM		23GSM		40GSM	
		Untreated	Treated	Untreated	Treated	Untreated	Treated
Thickness (mm)		0.13	0.14	0.22	0.25	0.33	0.40
Air-permeability ($cm^3/cm^2/S$)		0.44	0.42	0.32	0.30	0.24	0.19
Drop- absorbency (Seconds)		-	-	8	10	2	3
Bursting strength	**Pressure**(bars)	1.78	1.65	2.10	1.92	2.85	2.68
	Time (secs)	6	5	6	6	6	6
Maximum load	**Machine direction** (N)	23.42	17.36	41.15	31.91	63.78	50.50
	Cross direction (N)	14.80	13.58	32.78	29.53	52.96	47.86
Tensile Strain	**Machine direction** (%)	35	29	42	40.17	46	39.25
	Cross direction (%)	42.75	32.75	49.5	46.73	50.25	44
Abrasion resistance	**No. of cycles**	100	75	350	300	750	700
	Weight loss(%)	5.9	3.8	4	2.8	1.8	1.4
Wicking height	**Machine direction** (cm)	0.2	0.2	3.5	3.1	4.9	5.6
	Cross direction (cm)	0.1	0.2	1.8	2.8	4.2	5.1

Table 4.2 Absorbent capacity of viscose non-woven fabric

Fabric particulars	200 GSM	300 GSM	400 GSM
Thickness (mm)	2.10	3.15	4.35
Air-Permeability ($cm^3/cm^2/S$)	0.63	0.57	0.50
Water absorption capacity (%)	1480	1269	1242
Water retention capacity (%)	293	666	690
Drop absorbency (secs)	< 1	< 1	< 1

The contact layer PP was coated with 3 chemicals to give it a multi-functional finish and were tested for the anti-static, anti-microbial and flame retardant tests. The test results show that there exists a significant difference between treated and untreated samples with respect to the physical properties. The coating chemicals form a thin film on the surface, partially covering the fabric pores and thus lowering the Air-permeability and Drop absorbency. During finishing, the samples were cured at 90º-110ºC temperature which initiates a little thermal degradation which is the reason for reduced tensile properties. The formation of the coated film on the fibers reduces the space available for the capillary action and thus reducing the wick-ability of the coated sample as compared to untreated sample.

Table 4.3 Test results of PP treated with functional finishes

Chemicals	Concentration	15 GSM	23 GSM	40 GSM
Anti-static finish*	**10gpl**	0.05 sec	0.10 sec	0.16 sec
	20gpl	0.02 sec	0.02 sec	0.03 sec
Anti-microbial finish**	**10gpl (BKC)**	24.2mm	24.4 mm	25 mm
	20gpl (BKC)	28.8mm	28.9 mm	29.25 mm
	5% (Clove)	22 mm	22.2 mm	22.66 mm
	8% (Clove)	27.5 mm	27.8 mm	28.35 mm
Flame retardant finish	**300gpl**	9.4 cm	8.9 cm	7 cm
	400gpl	9 cm	8.2 cm	6.2 cm

*Half Voltage Decay Time**Zone Of Inhibition for gram positive bacteria.

The samples were coated with chemicals at 2 different concentrations to check their suitability for requirements. 20gpl concentration of Anti-Static finish showed good results with least half voltage decay time of 0.03 seconds showing a minute static charge accumulation. BKC coated with 20gpl concentration showed more efficiency towards Anti-microbial than clove oil and 400gpl of Flame-retardant finish showed lesser burning length than 300gpl. However the samples showed no propagation of flame for both the coating chemical concentration and just shrink away from the flame. Viscose having good moisture regain value showed very good absorption capacity and the drop absorbency time of the viscose fabric was less than one second.

Fig. 4.1 Effect of Concentration of Anti-microbial agent on Different GSM of PP

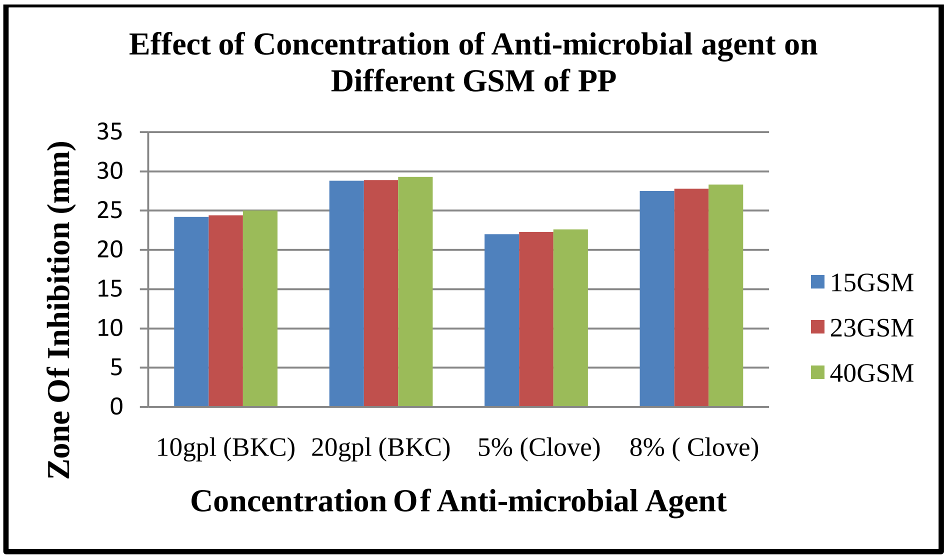
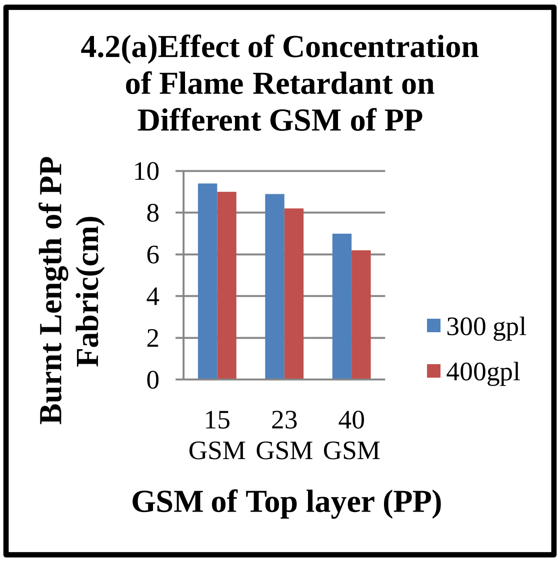
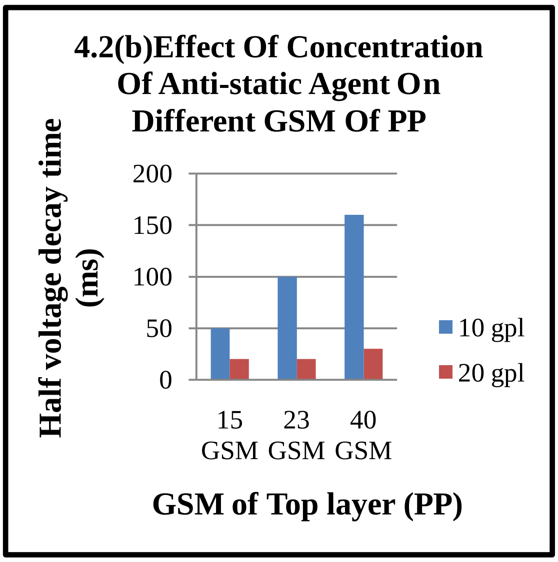


Fig.4.2(a) Effect of Concentration of Flame Retardant on Different GSM of PP,

Fig.4.2(b) Effect Of Concentration Of Anti-static Agent On Different GSM Of PP





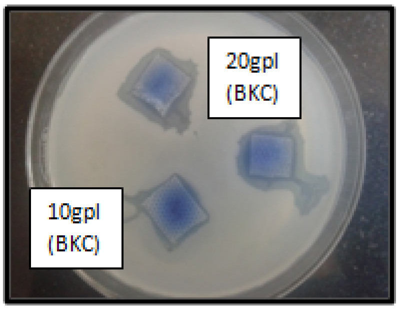


Fig 4.3 (a) Zone of inhibition of gram +ve bacteria on BKC treated samples

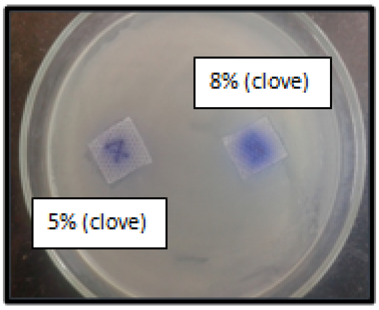


Fig 4.3 (b) Zone of inhibition of gram +ve bacteria on clove oil treated samples

Table 4.3 Multi-Layered Particulars

Thickness		5.3 mm
GSM		478
Drop- absorbency		3 seconds
Thermal properties	**Thermal conductivity**	0.19 m^2K/W
	Thermal resistance	0.37 m^2K/W
Maximum load	**Machine direction**	10.49 N
	Cross direction	8.91 N
Tensile Strain	**Machine direction**	75.50 %
	Cross direction	87.25 %
Antistatic test	**Half voltage**	0.01 KV
	Half voltage (Decay time)	0.00 second
Absorbency (% to its original wgt)	**Absorption capacity**	1156
	Retention capacity	906
Anti-microbial test	**Gram positive**	24.3mmn
	Gram negative	18.2 mm
Water vapour permeability		59.8gms/m^2/day

Fluids and heat secreted by the body creates a moist laden atmosphere which is heaven for the growth of micro-organisms. This drawback in case of single layer bed-spreads is overcome by creating a multi-layered construction in them. For this purpose and from the above discussions of physical properties, 40gsm spun-bond Non-woven fabric and 400gsm Needle punched viscose non-woven fabric were selected to develop top layer and absorbent layer of the multi-layered bedspreads respectively and backed up with the thin polyethylene film at the bottom. This bed-spread was then tested for physical properties including Anti-microbial activity, anti-static, water vapour permeability and thermal conductivity. Table.4.3. shows the test results physical and functional properties of the multi-layered bedspread. Tensile property of the bed-spread was tested using INSTRON, and the results show that the load taking capacity has been decreased though it is a multi-layered construction. This is because, the polyethylene film at the bottom layer has very less load taking capacity compare to viscose and polypropylene and the sample is detected as broken once the PE film is torn. The bedspread showed good zone of inhibition against gram positive (S.aureus) and gram negative (P.vulgaris) microbes. The absorbent capacity of the bed-spreads is more than 10times of its weight which is desirable to serve the purpose of end use. The bedspread allows 59.8gms of water/day as per the test results. Eventually this value is less even in the presence of viscose, which is due to the presence of polyethylene film at the bottom layer that completely prevents water from passing through. However presence of viscose is good enough in holding the water/urine and preventing it to flow to the bed.

5. CONCLUSION

Polypropylene non-woven and viscose non-woven fabric was selected and tested for top and absorbent layer for the multi-layered bedspreads. From the results we can conclude by saying that 40gsm PP as top layer and 400gsm viscose fabric as middle layer were found to be most suitable for the purpose. Waterproof polyethylene film as the bottom layer resists the water from passing through it. The top layer PP multi-finished with 20gpl anti-static, 20gpl BKC and 400gpl Flame retardant agents was found suitable to serve the purpose of a bedspread. The combined effect of PP along with the Viscose in the multi-layered construction of the bedspread was found to be thermally comfortable by absorbing the necessary amount of heat generated by the body.

6. REFERENCES

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