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Development of an Innovative Product from Plasma Treated Cotton Fabrics to Manage Incontinence

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ABSTRACT:- *An investigation of the effect of plasma treatment on air permeability, water vapour permeability and thermal resistance of plain and twill weave cotton fabrics is reported. It is noticed that air permeability, water vapour permeability and thermal resistance show a significant increase for the plasma treated fabric. The results suggested that the plasma treated fabrics are more suitable materials for managing incontinences for medical textiles.*

Keywords*: Bamboo, Cotton, Fabrics, Incontinence, Plasma.*

I. INTRODUCTION

Plasma treatment is generally applied to modify the surface of textile materials. Plasma is generated when gas is exposed to an electromagnetic field. There is a plethora of literature available on plasma treatment to fibers, yarns and fabrics, Karahan etal. [1] have reported on the effect of atmospheric pressure plasma treatments on the properties of cotton fabrics. Cotton fabrics were treated with air and argon type of plasmas and properties such as pilling, thermal resistance, water vapour permeability, thermal conductivity, air permeability and friction were investigated. It was found that there was an increase in thermal resistance and relative water vapour permeability and a drop in air permeability Kan etal.[2] have reported on the plasma treatment applied to wool fabrics and provided extensive data. Functional finishes such as antimicrobial, soil repellency, stain resistance could be imparted Ada Ferri etal.[3] have reported on thermal properties of wool fabrics treated in a atmospheric pressure post- discharge. An increase in thermal resistance of treated fabrics has been noticed following plasma treatment. Also, there was an increase in surface friction. Treated fabrics were found to be slightly softer and warmer than those of the untreated ones, Jaishree etal. [4] report on the effect of air plasma treatment on comfort characteristics of bamboo fabric, Plasma treatment applied has led to an increase in air permeability and thermal resistance. Lower values of Q_{max} were observed which imply better comfort. Thus plasma treatment was found to be feasible for bamboo fabrics.

Incontinence refers to the lack of voluntary control of excretory functions. There is a very good market now for adult incontinence products and the requirements of these are mainly comfort. Absorption rate and wicking are essential components of AIP (Adult Incontinence product). Friction of product against skin and softness are important properties. Incontinence has been a taboo topic and many are reluctant to discuss this subject in depth.

The only way of tackling this problem is to use a fabric which is endowed with good moisture absorbing property. Cotton materials have excellent absorbing capacity of moisture. If these materials are treated with low temperature plasma, the absorbency shows still better. Bamboo excels cotton in moisture absorption.

On the subject of incontinence, there is a plethora of literature available, Sabrina [5] conducted an extensive study on the non woven fabrics particularly on their frictional properties. Although friction is considered to be an important property, other properties such as breathability thermal insulation and moisture vapour transmission are important Cottendon and Cottendon and Asimakopoulos [6] have dealt with the friction between non woven fabrics and skin. If some material like woven cotton is stitched with a nonwoven fabric pad inside to provide absorption, it will be an ideal product to manage incontinence.

Air permeability is a transport property which is important for thermal insulation. A fabric having low air permeability has good thermal insulation. Also fabrics in which thermal resistance shows a higher value have higher thermal insulation. A number of papers published on these areas have clearly shown the importance on these properties. Pull ups are normal looking pant with an absorbent material incorporated into the design either at the crotch or throughout incontinence under pant. The design varies to cater for different types of incontinence. Under pads, which have different sized rectangles of absorbent material, are placed on beds and chairs. They are highly prone to infection if they are not washed properly

Incontinence associated dermatitis (IAD) occurs when the skin comes into contact with urine and or faeces for a longer time. This causes inflammation of skin which will provide irritation.

Urinary incontinence (UI), namely, the involuntary loss of urine is rampant among women. Complications in pregnancy, old age and lack of control prostate hyper plasma problem among men are the chief causes for it. The term urinary incontinence consists of stress and urgency which accounts for about 90% cases. In view of the gravity of the situation, there is an urgent need for development of products which can cater to men and women. Panty made of cotton and treated with plasma can be used for stitching with pad which is a nonwoven.

Overflow incontinence is not considered and it is a type of incontinence which involves chronic retention of the urine in the bladder. Insert diapers, pull-ups and under pads are used to manage this incontinence. Bamboo fibres can be used in the products which are used to combat incontinence problems in view of its antimicrobial nature. The advantages of this fibre over cotton and viscose have been succinctly discussed by Mishra etal.[7]. Bamboo fibre is endowed with high moisture content and elongation compared with other fibres and thus it is eminently suitable as a candidate. Textile materials are used in healthcare of patients who consume drugs. Drugs are expected to cure the disease and the patients need comfort. The pharmaceutical industry is supposed to discover products for healthcare and the product used to treat incontinence comes under this category. Lou etal. [8] have developed woven fabric intelligent diapers with woven fabrics interlayer of cloth in polyester as warp and cotton as weft. A smart material, which will alert when water content is present, has been developed. The aim of this study is to investigate the properties relevant to comfort in respect of cotton fabrics treated with low temperature plasma. The properties studied are air permeability, thermal resistance and moisture vapour. This paper also investigates the suitability of plasma treated fabrics for using as incontinence materials.

II. MATERIALS AND METHODS

The fibers used were bamboo and cotton the properties of which are given in Table 1.

Yarns of 30 Ne (19.98) were spun and five yarns 100% bamboo, 75B/25C, 50B/50C, 25B/75C and 100% cotton were produced. They were used for producing plain and twill fabrics. Table 2 gives the geometrical properties of fabrics. They were tested for air permeability, water vapour permeability and thermal resistance by following appropriate standards.

Table 1: Details of the fibre properties

Fibers	Fibre length(mm)	Tenacity (g/tex)	Elongation (%)	Fibre Uniformity (%)	Moisture Content (%)
Cotton	29	37.3	6.7	80.5	7.4
Bamboo	35	34.2	16	92.4	12.42

Table 2: Geometrical properties of fabrics

	Fabric Sett		Thickness (mm)		Areal Density (g/m^2)		Porosity (%)	
Blending Ratio	**Warp (Ends/cm)**	**Weft (Picks/cm)**	**Plain weave**	**Twill weave**	**Plain weave**	**Twill weave**	**Plain weave**	**Twill weave**
Bamboo 100%	31	31	0.300	0.391	111	116	77	81
Bamboo/Cotton 75/25	31	31	0.391	0.452	116	117	82	84
Bamboo/Cotton 50/50	31	31	0.381	0.435	121	123	80	82
Bamboo/Cotton 25/75	31	31	0.382	0.478	123	125	77	80
Cotton 100%	31	31	0.333	0.421	125	127	76	81

III. RESULT AND DISCUSSION

Tables 3, 4 & 5 present data on air permeability, water vapour permeability and thermal resistance.
Data on geometrical properties such as porosity, thickness and GSM are given in Figure 1, 2 & 3.

3.1Transport properties

Air permeability is an important property for thermal insulation of fabrics. The air permeability also gives an indication of thermal insulation. Lower air permeability causes less air flow and provides more thermal insulation. The air permeability of plain and twill fabrics following plasma treatment and bleaching is presented in Figure(4). It is noticed this air permeability decreases with an increase in fabric thickness and areal density. Porosity shows an increase following plasma treatment in both the cases. The porosity shows an increase which may be attributed to the reduced yarn diameter following plasma treatment. With the increase in cotton content, air permeability decreases due to increased thickness and areal density. Twill fabrics have lower air permeability as compared to plain fabrics. This may be attributed to higher fabric thickness and areal density. The results of air permeability show that the relation between thickness and air permeability of woven fabrics is linear. These are in substantial agreement with the results reported by Mohanapriya Venkataraman etal. [9] and Kothari etal.[10]. Porosity of twill weaves is lower than those of plain weave fabrics and thus account for a decrease in air permeability.

Figure (5) shows the relationship between the blend composition and water vapour permeability of fabrics. Water vapour permeability shows an increase following plasma treatment in both the cases. Twill weave fabrics show lower value of water vapour permeability in comparison to plain woven fabrics. Plasma treatment has led to an improvement in water vapour transport due to the etching. Thermal resistance, as a function of areal density and thickness of plain and twill fabrics, is shown in Figure (6). It is noticed that thermal resistance shows an increase following plasma treatment in both the cases. These are in substantial agreement with the finding of Karahan etal. [1] An increase in thermal resistance would indicate better thermal insulation. The increase in air permeability is found to be higher in plain weave comprising 100% bamboo in comparison to twill weave. In the case of thermal resistance, it is noticed that the twill weave produced with 100% bamboo the value is found to be have higher value in comparison to plain weave. In the case of thermal resistance, plain woven fabrics show relatively higher values. With regard to water vapour absorption, it is noticed that plain woven fabrics show higher value those of twill weave.

Table 3: Values of Air permeability for plain and twill woven fabrics before and after plasma treatment

Air Permeability 1/min/20cm^2						
	Plain weave			Twill weave		
Blending Ratio	**Before Plasma**	**After Plasma**	**Percentage Increase**	**Before Plasma**	**After Plasma**	**Percentage Increase**
Bamboo 100%	117.5	137.2	16.765	111.6	128.5	15.143
Bamboo/Cotton 75/25	103.4	116.1	12.282	92.3	97.4	5.525
Bamboo/Cotton 50/50	92.6	96.3	4	75.6	79.2	4.979
Bamboo/Cotton 25/75	66.5	73.8	10.977	72.3	74.7	3.319
Cotton 100%	37.1	48.7	31.266	51.5	55.7	8.155

Table 4: Values of Water vapour permeability for plain and twill woven fabrics before and after plasma treatment

Water Vapour Permeability (g/m^2/day)						
	Plain weave			Twill weave		
Blending Ratio	Before Plasma	After Plasma	Percentage Increase	Before Plasma	After Plasma	Percentage Increase
Bamboo 100%	3153	3442	9.165	3154	3224	2.536
Bamboo/Cotton 75/25	2841	3132	10.242	2856	3061	7.171
Bamboo/Cotton 50/50	2742	2947	7.476	2578	2783	7.951
Bamboo/Cotton 25/75	2459	2636	7.198	2342	2491	6.362
Cotton 100%	2250	2412	7.2	2134	2281	6.888

Table 5: Values of Thermal resistance for plain and twill woven fabrics before and after plasma treatment

Thermal Resistance (m^2.mk/w)						
	Plain weave			Twill weave		
Blending Ratio	Before Plasma	After Plasma	Percentage Increase	Before Plasma	After Plasma	Percentage Increase
Bamboo 100%	39.5	42.9	8.6	28.6	31.3	9.4
Bamboo/Cotton 75/25	41.4	43.4	4.83	31.7	32.8	3.47
Bamboo/Cotton 50/50	42.8	43.9	2.57	33.5	35.4	5.67
Bamboo/Cotton 25/75	43.2	46.1	6.71	37.8	39.7	5.02
Cotton 100%	45.1	49.7	10.19	39.2	42.3	7.9

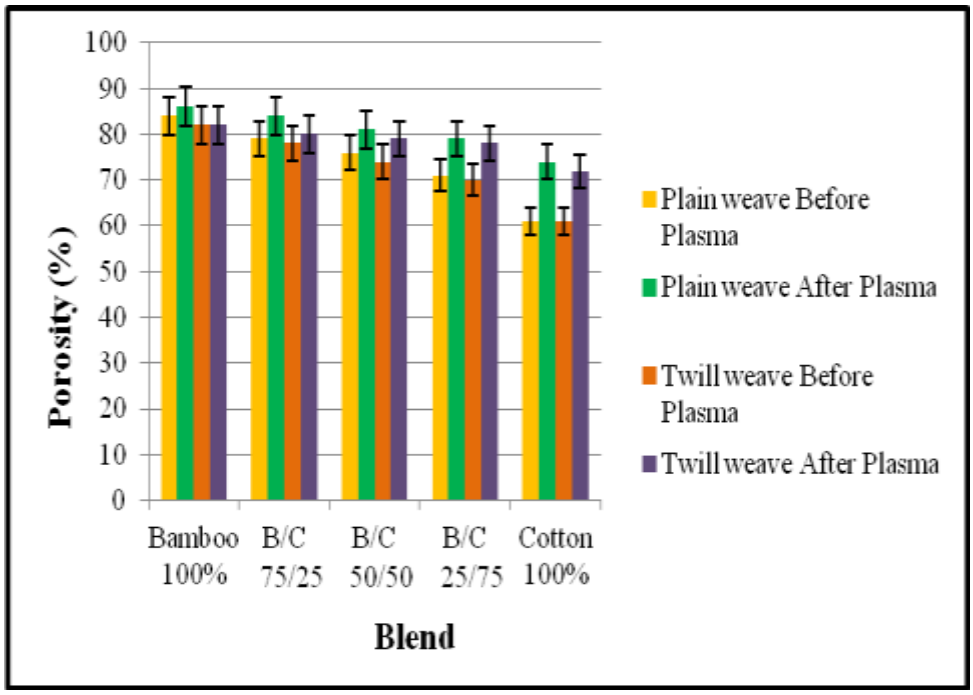

Figure 1:Porosity values for plain and twill weave fabrics before and after plasma

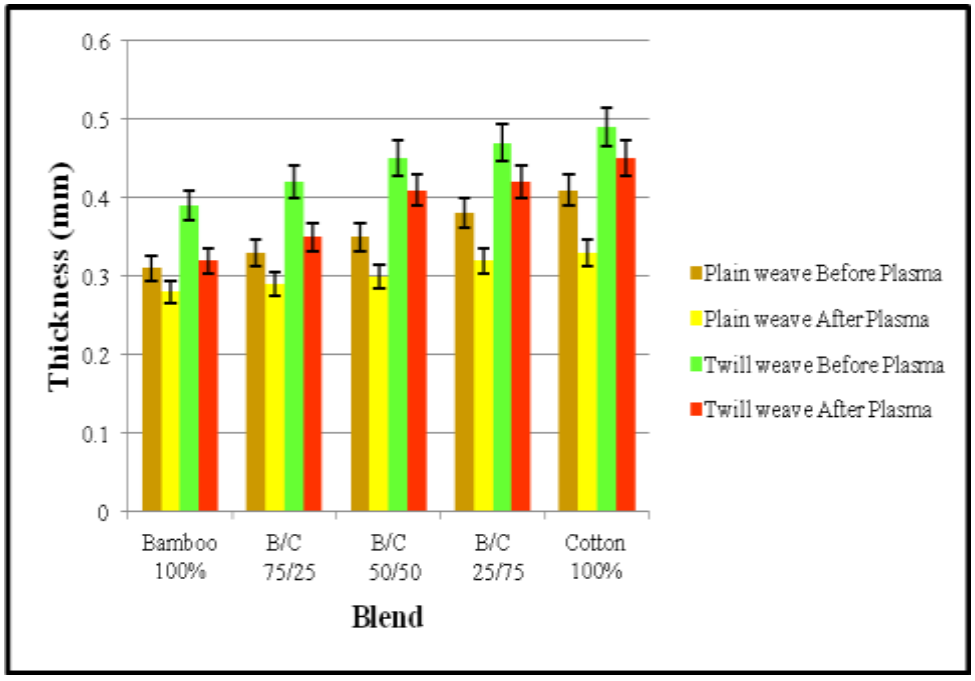

Figure 2:Thickness values of plain and twill weave fabric before and after plasma

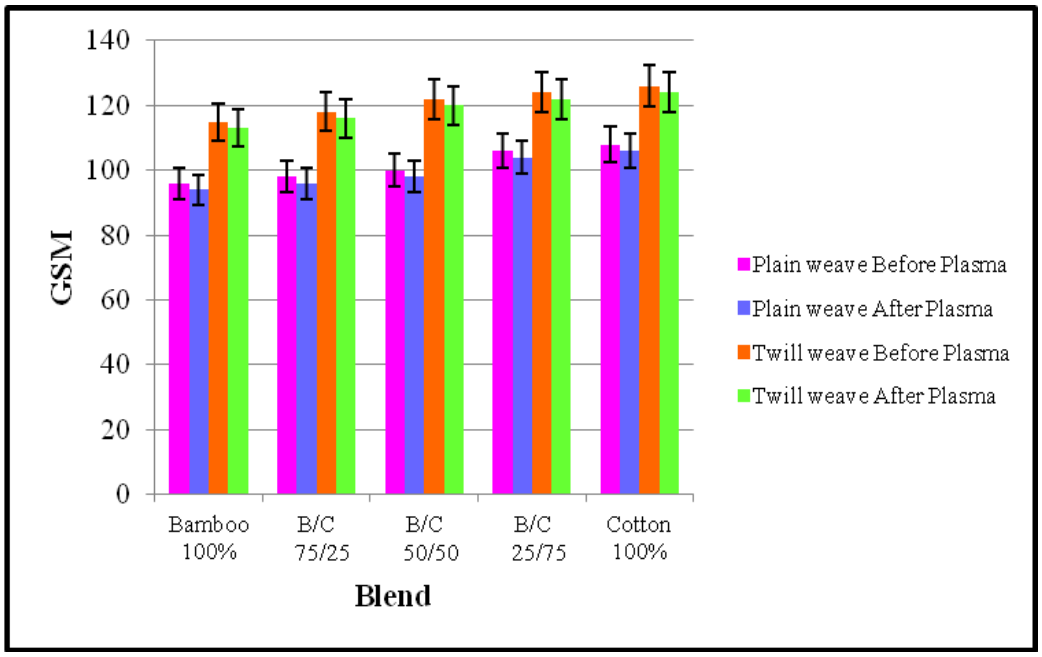

Figure 3: GSM of plain and twill weave fabrics before and after plasma

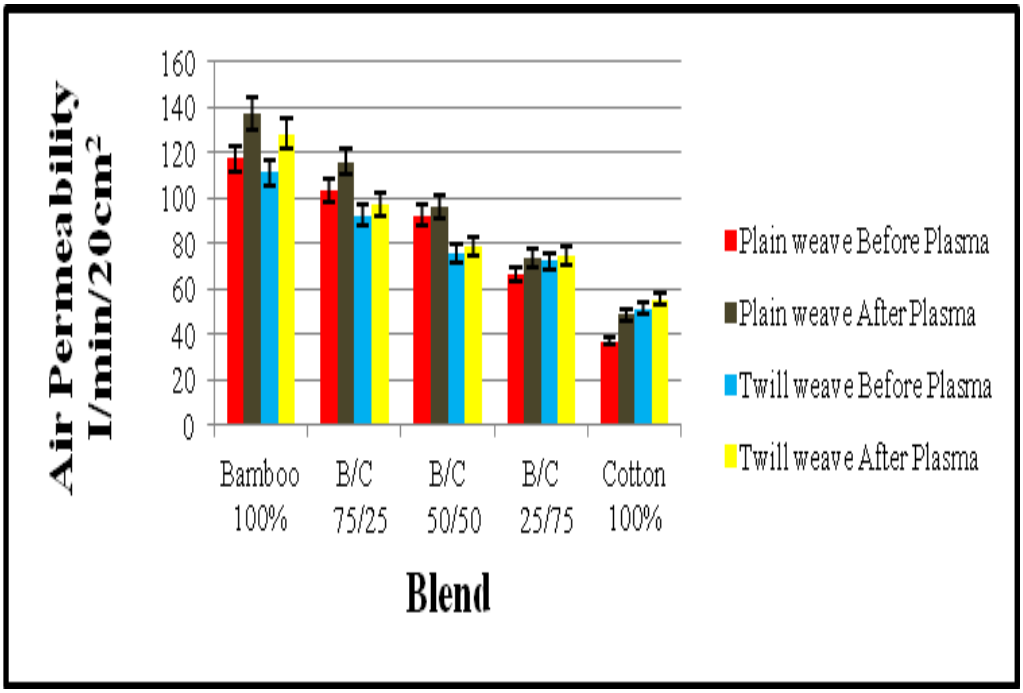

Figure 4: Air permeability of plain and twill woven fabrics before and after plasma treatment

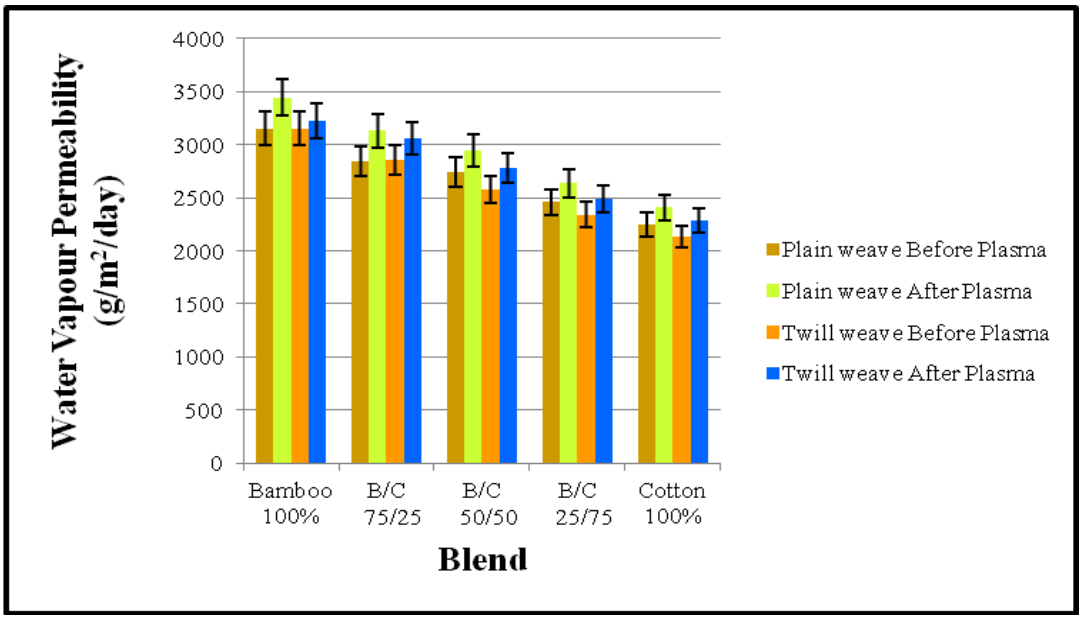

Figure 5: Water vapour permeability of plain and twill woven fabrics before and after plasma treatment

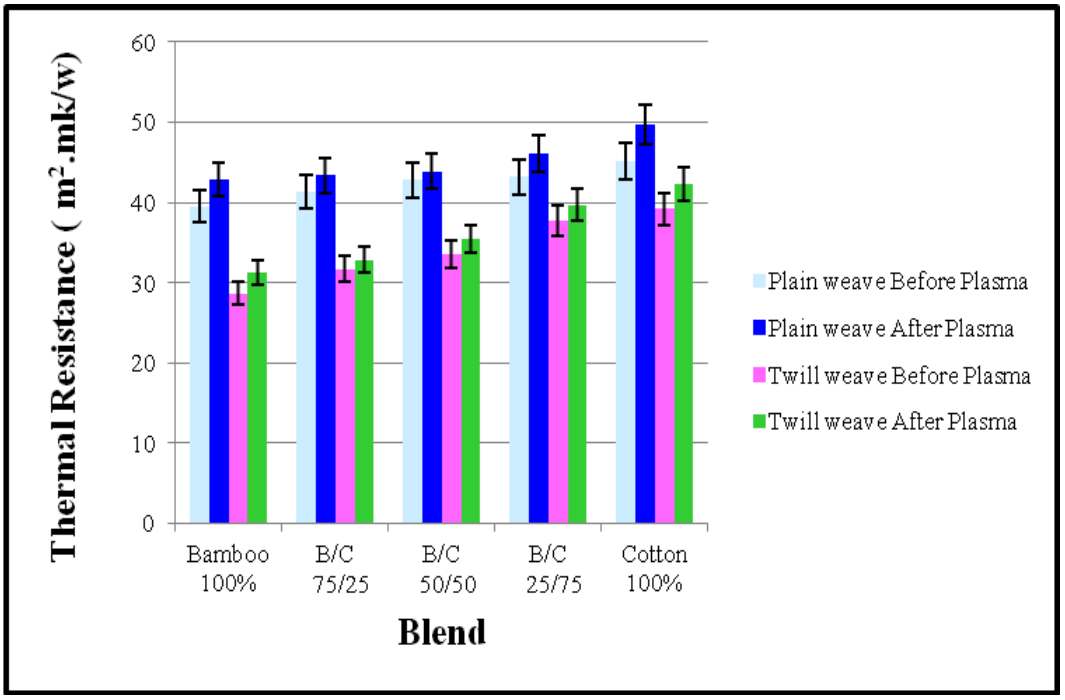

Figure 6: Thermal resistance of plain and twill woven fabrics before and after plasma treatment

IV. CONCLUSION

The results show that the plasma treated plain and twill fabrics have higher air permeability, water vapour permeability and thermal resistance. Hence they are more suitable material for managing incontinences for the medicals textiles.

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