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NEOTERIC SUSTAINABLE FASHION FOR INFANTS

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ABSTRACT

The objective of eco-friendly textile processing is not only to use organic and nontoxic materials but also to reduce the consumption of natural resources since overcoming environmental challenges is one of the important components of sustainability. Further, ensuring that these processes enhance product functionality. Plasma treatment is one of the innovative and versatile possibility capable of providing a large variety of processes by employing the different attributes of several types of plasma. In this paper water management possibilities using plasma treatment on advanced cellulosic fabric is discussed and its impact on comfort properties is explored. For this purpose, yarns of 20 tex of pure bamboo knitted into single jersey fabrics and subjected to air, argon and oxygen plasma treatments. The important findings were that the water absorption and retention of plasma treated fabrics reduced and there was a reduction in the drying time. This property can be fruitfully utilized for wet processing treatments. Further, plasma treatment contributed significantly to enhance moisture management, air permeability and thermal conductivity properties of selected advanced regenerated cellulosic fabrics and their blends with cotton. The paper also contributes to the sustainable design area by providing an explanation of the product specific properties and attributes for niche items in infant clothing category.

Key words: air permeability, comfort property, plasma treatment, sustainability, thermal conductivity.

INTRODUCTION

"Think globally, Work locally" Sustainable development is about conducting research to promote a healthy environment with vibrant communities for economic growth for now and for the future. A healthy population and safe environment are important preconditions for sustainable future. The issues related to development, environment and health are closely entwined and reflects a complex link between the social, economic ecological and political factors that determine the standards of living, social wellbeing, human health and the quality of life in general.

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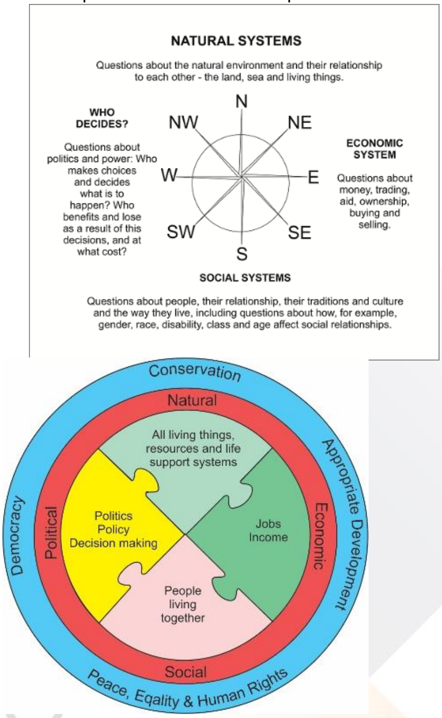

Figure 1 (a) & (b): Natural environment and elements of sustainability.

The aims of education and research is to build on four pillars of learning:

Research and Learning to know – knowledge, values and skills for respecting and searching for knowledge and wisdom

Research and Learning to do – knowledge, values and skills for active engagement in productive employment and recreation

Research and Learning to live together – knowledge, values and skills for international, intercultural and community cooperation and peace

Research and Learning to be – knowledge, values and skills for personal and family well-being

Research and Learning to transform oneself and society – knowledge, values and skills for self-reflection and active citizenship. Considering the all-encompassing scope of education and research for Sustainable Development, and its aim to equip individuals with skills and capacities to transform attitudes and lifestyles. (figure 1)

Figure 2 (a) & (b): Pillars of education and sustainable telecentres.

The sustainable development agenda was initiated in September 2015 during the UN summit. On 1st January 2016 the 17 sustainable Development Goals (SDG" s) of the 2030 Agenda was adopted by world leaders and officially came into force. The SDG's are a new universally set goals, targets and indicators that UN members states will be expected to frame their agendas and political policies over the next 15 years. They are officially known as Transforming our world: the 2030 Agenda for sustainable development is a set of 17 'Global Goals with 169 targets between them that are critical importance to humanity and planet. This research pertains to Goal 4,6,8, and 12 as mentioned in Global goals. (Figure 3)

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Figure 3: Sustainable Development Goals (SDG" s)

It is important to set high environmental standards to ensure that the research not only provide solutions needed to drive economic growth but also foster social wellbeing and secure a stable and healthy environment for the future. It is important to set high environmental standards to ensure that the research not only provide solutions needed to drive economic growth but also foster social wellbeing and secure a stable and healthy environment for the future. Operating in the most efficient manner possible, recycling and reusing materials, disposal of waste safely defines the effectiveness of a research agenda. A research that which addresses life cycle thinking, biodiversity, water, air, energy and chemical management, effective and optimum use of resource, climate change, people and society should be set as top priority. This paper addresses three major issues related to sustainability namely use of ecofriendly fabrics. Reducing energy and water usage. Optimizing usage of chemicals and dyes. Reviving Indian identity and wisdom by supporting the traditional styles of infant layettes. Promoting inclusive and equitable learning opportunity for all. Productive employment and decent work for all.

Bamboo is a tree like woody stem from popular family of grass called Bambuseae.It is a fast-growing plant with some species growth surges to 100 cm per 24 hours. The basic component of Bamboo is cellulose, lignin and hemicellulose. Eco-friendly fabrics are not harmful to environment, they are biodegradable and prevent carcinogenic effect on skin. The use of harmful dyes and chemicals on textiles has led to considerable damage to the environment and efforts to decrease energy usage and reduce carbon foot print is essential (Waite, M. 2009)

Knitted fabrics are commonly used because they are lightweight, flexible and possess excellent mechanical properties. The advantages of using knitted fabrics as opposed to conventional fabrics lie in their low cost, improved barrier properties, adequate strength, and comfort properties. They possess high extensibility under low load allowing comfortable fit on any part pulled. (Mikucioniene et. al., 2010). The fabric texture and the movement of air, moisture and heat through the fabric is extremely important for designing of garments for imparting good comfort. Thus, by use of proper fabric structure it would be possible to design a product with reasonable functional and ergonomic properties. Poonam et al., (2013) have reiterated in their research that textile industry is considered as the most ecologically harmful industry in the world. The eco- problems in textile industry occur during some production processes and are carried forward right to the finished product. In the production process like bleaching and then dyeing, the subsequent fabric makes toxic substances that swell into our ecosystem. During the production process controlling pollution is as vital as making a product free from the toxic effect. The utilization of rayon for clothing has added to the fast

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depleting forests and opened the door to the development in natural sustainable fibres like organic cotton, hemp and bamboo fibres. Petroleum-based products are harmful to the environment. In order to safeguard our environment from these effects, an integrated pollution control approach is needed. Textile industry has a heavy impact on the environment as the current practices are unsustainable; and companies, environmentalist and consumers are looking at strategies for reducing the textile carbon footprint. So, there is need to produce the textile materials which are eco-friendly through using different processes like enzyme technology, plasma technology, super critical carbon-di-oxide dyeing or foam technology.

Plasma treatments were found to have profound effects on the surface properties of bamboo fabric by research carried out by Prakash et.al., (2013). The SEM outcomes suggested, that atmospheric plasma treatment made the surface structure into a rough state because of the etching effect. The surface roughness of bamboo fabric increased with increasing plasma power and treatment time. The change in the air permeability of the plasma-treated fabric was found which was reported probably due to the plasma action changing the fiber surface morphology. The key factor for interpreting the change of the air permeability is the increase in thickness observed after the plasma treatment. This thickening could be one of the reasons for the decrease of air permeability. They also reported that atmospheric plasma treatments improved the water vapor permeability of bamboo fabric and the increase in surface friction was probably caused from the etching effect of atmospheric plasma treatment. Kan (2014) has extensively researched in a number of papers the advantages of plasma treatment on wool fabrics and reported that plasma treatment results in the reduction of air permeability and q(max). Plasma treatment leads to greater moisture absorption, better dye uptake and eco-friendly environment. The research has also explored the low stress mechanical properties of wool fabrics following plasma treatment and have provided extensive data. Further emphasized that functional finishes could be imparted by plasma treatment, which include antimicrobial, soil repellency, stain resistance, soft handle and improved dyeing.

The aim of the work was to study the effect of air, argon and oxygen plasma treatment on the water absorption properties and dyeability of knitted fabrics made from advanced cellulosic materials. The specific objective of this study is:

To study the effect of air, argon and oxygen plasma treatment on moisture management property, wicking, static immersion, and drying characteristics to establish water management possibilities.

To study the dyeability of air, argon and oxygen plasma treatment bamboo fabrics to draw inference on effective usage of coloring materials.

To study the drying behavior of plasma treated fabrics facilitating energy conservation.

Prototype development of Infant bodysuit using knitted and woven bamboo fabrics

MATERIALS AND METHOD

2.1 Fabrics

In the present study, knitted fabrics using pure bamboo, modal and its 50/50% blend with cotton yarns were used. The pure bamboo, modal and their 50/50 % blends with cotton were then used to produce single jersey fabrics.

2.2 Experiment

2.2.1 Plasma treatment

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Based on the review of literature and standard procedures, the research methodology was formulated. The bamboo knitted fabrics were treated using low pressure glow discharge plasma. The glow discharge was generated using an apparatus made by an industry. The DC glow discharge was operated at 0.5 mbar. The various types of plasma treatment used were air, argon and oxygen gas. Cathode was located in the center of the chamber and the chamber walls acted as anode. Samples were placed hanging at a distance of about 18 cm from the cathode. It was operated at radio frequency of 150 to 192 MHz The gas flow was maintained at a constant rate. The duration of plasma treatment was 5, 10 and 20 minutes for the air, argon and oxygen gas plasma treatments. The treated fabric samples were removed from the chamber and then conditioned under 65% RH and 250C standard conditions for 24 hours before testing.

Testing

Geometrical properties of plasma treated bamboo fabrics.

The weight per square metre of the fabrics was determined using GSM cutter as per IS 1962-197.

The number of wales and course per centimetre was recorded as per ASTM standard D 3775.

Thickness was measured at different places in the pieces on different samples as per BS 2544-1954

The loop length measured at different places in the fabric samples as per BS 5441.

SEM Topography

SEM studies were carried out on the samples after mounting them on specimen stubs and coating with AU-PD in a vacuum fine coat ion sputter. For each sample, two specimens were taken. The thickness of the coating and time were optimized before the samples were examined in JOELSEM model 84 OA.

Testing of liquid moisture management properties

The AATCC 195-2009 standard test method was used for the measurement, evaluation and classification of liquid moisture management properties of the untreated and air, argon and oxygen gas plasma treated pure bamboo samples using “SDL-ATLAS Moisture Management Tester”.

(iv) The static immersion test

The static immersion test (BS 3449) is a standard test to assess the hydrophilicity of the sample.

(v) Drying behavior

To determine the drying behavior of the fabrics, the fabrics were wetted according to static immersion method and were dried in drying oven at 30^{o}C to simulate the natural drying. The rate of drying was measured after exposure in the drying oven for 30, 45, 60, 90,120,150 and 180 minutes. The samples were then weighed and the amount of water loss after 30, 45, 60, 90,120, 150 and 180 minutes was calculated as the differences in wet and dry mass.

(vi) Water Evaporation rate

The drying capability was also evaluated for both the untreated and plasma treated fabrics by testing the drying rate of fabric. The specimens were put on the plate of the balance, and dry weight was recorded as w_f (g). The weight of water added on the fabric was equal to 30% of the dry sample weight, before testing designated w_0(g) . The change of water, w_i (g) at regular intervals for 5 minutes was determined. The “water evaporating rate” (WER) was calculated by the equation,

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$$WER(\%) = \frac{(wo - wi) \times 100}{(wo - wf)} \qquad (1)$$

Where

w_i is the change of water at regular intervals

w_f is the dry weight

w_0 is the weight with water

The change of water weight remained in the specimen over time, was used to draw the evaporating curve from 100% to 0%.

2.3 Dyeing of untreated and plasma treated fabrics

2.3.1 Dyeing process

The regenerated cellulosic fabrics were dyed using reactive dyes namely –Levofix A Red.The dyeing profile is given in figure 5.

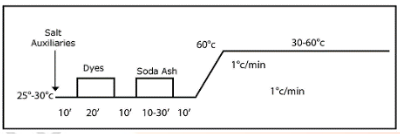
C 

Figure 4: Dyeing profile of fabrics

2.3.2 Measurement of dye exhaustion

The dye exhaustion behavior of the reactive dye on knitted fabrics was investigated. The extent of dye exhaustion for 2% concentration of dye, before and after dyeing was determined using spectroscopic analysis. The analysis was carried out after dilution with distilled water. The wavelength of maximal absorbance were measured for Levofix Red CA at 540 nm.

The dye bath exhaustion percentage (%E) was calculated using Equation (2).

$$\% E = \frac{(A_b - A_a)}{A_b} \times 100 \qquad (2)$$

Where, A_b and A_a are the absorbencies at maximum wavelength (λ max) of dye originally in the dye bath and of the residual dye after dyeing respectively.

2.4 Design development of brand logo and product logo and Infant bodysuit

Designing of the infant layette involved Infant product development using standard measurements and development of brand logo and product logo.

Table 1 Measurement chart infant bodysuit

Item	Measurements(cm)
Body Suit	Chest-28, length-45, sleeve length-28

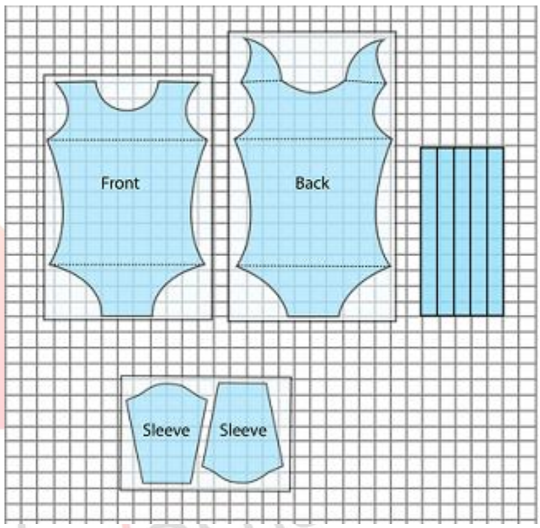


Figure 5: Pattern and layout of bodysuit

3. Result and Discussion

Table 2 gives the geometrical properties of the fabric samples. There is a reduction in fabrics thickness in the of pure bamboo fabric due to surface etching. From the scanning electron

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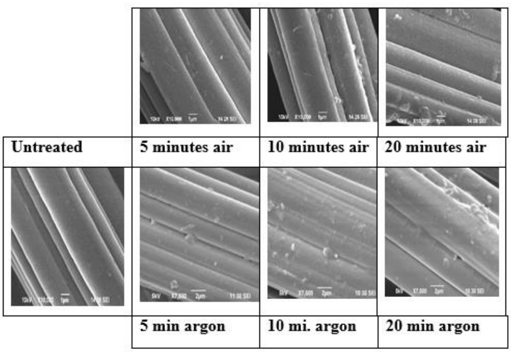
micrographs, it is seen that untreated bamboo has a smoother surface compared to plasma treated bamboo. Plasma treated bamboo appeared to be with random blisters and ripples running parallel to the fiber length. After the plasma treatment surface etching has been detected. The etching is random and not localised. Air plasma treated bamboo have less blister as compared to argon and oxygen plasma treated bamboo. Oxygen plasma treated bamboo appeared to be with kink bands.

The results of moisture management property indicate that although there is an increase in the rate of absorption as the duration of treatment increases from 5, 10, 20 minutes, the difference is not very significant. There is a significant change in the absorption rate in case of argon and oxygen gas plasma treated samples. This is in agreement with the findings of Wong *et al.*(1999),who have studied the effect of oxygen plasma treatment on cotton. Formation of voids and cracks on fibre surface are the reasons for this phenomenon.

Table 2 Geometrical properties of untreated and plasma treated bamboo fabrics

Sample Description	Course/ Cm	Wale/ cm	Stitch density (cm^2)	Loop length(mm)	Tightness factor ($tex^{0.5}$ mm^{-1})	Loop shape factor	Thickness (mm)	Mass per unit area (g/m^2)
Untreated control	22.0	16.0	352	2.09	2.14	1.38	0.50	160.70
5 Mins. Air	22.0	15.5	341	2.07	2.16	1.42	0.40	154.00
10 Mins. Air	17.6	15.0	264	2.70	1.65	1.17	0.44	156.00
20 Mins. Air	17.0	15.0	255	2.76	1.62	1.13	0.45	154.00
5 Mins. Argon	20.0	15.0	300	2.33	1.92	1.33	0.41	153.00
10 Mins. Argon	20.3	17.0	345	2.03	2.20	1.19	0.41	153.00
20 Mins. Argon	18.6	14.6	272	2.56	1.75	1.27	0.41	152.00
5 Mins. Oxygen	21.3	15.0	320	2.19	2.04	1.42	0.41	153.00
10 Mins. Oxygen	21.0	14.3	300	2.32	1.93	1.47	0.40	152.00
20 Mins. Oxygen	21.0	14.0	294	2.38	1.88	1.50	0.40	153.00



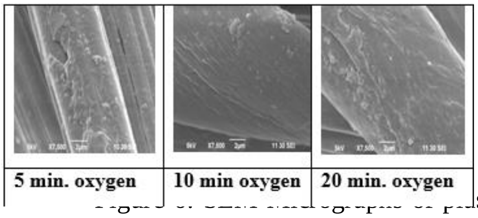


Figure 6: SEM Micrographs of plasma treated 100% Bamboo fabric

Comparing the absorption rate of top and bottom surfaces of the plasma treated knitted fabric there is higher absorption by bottom surface as compared to the top surface in all the treatments and time variations. There is an improvement in the moisture management property of plasma treated fabrics.

Table 2 Moisture Management data of 100% plasma treated Bamboo

Sample Description	Wetting Time (sec)		Absorption Rate (%/sec)		Maximum Wetting Radius (mm)		Spreading Speed (mm/sec)		One Way Transport Capability	OM
Samples	Top surface	Bottom surface	Top surface	Bottom surface	Top surface	Bottom surface	Top surface	Bottom surface		
Untreated	3.79	3.95	31.51	33.20	20.00	20.00	3.21	3.05	38.71	0.
5 min Air	4.67	4.70	34.22	34.55	15.00	15.00	2.10	2.44	31.05	0.
10 min air	5.00	4.70	33.45	34.71	20.00	20.00	2.90	2.70	22.71	0.
20 min air	5.31	5.40	34.82	39.72	20.00	20.00	2.80	2.82	35.84	0.
5 min Argon	4.52	4.59	42.28	50.66	20.00	20.00	2.91	2.72	136.27	0.
10 min Argon	7.80	8.20	54.77	64.99	20.00	20.00	2.33	2.22	172.63	1.
20 min Argon	4.59	4.59	41.44	52.08	20.00	20.00	2.63	2.65	198.50	1.
5 min Oxygen	5.95	6.20	46.73	56.44	20.00	20.00	2.78	2.69	130.32	0.
10 min Oxygen	9.41	7.88	42.16	61.62	20.00	20.00	2.19	2.25	265.45	1.
20 min Oxygen	6.44	6.84	41.71	59.09	20.00	20.00	2.59	2.46	137.20	0.

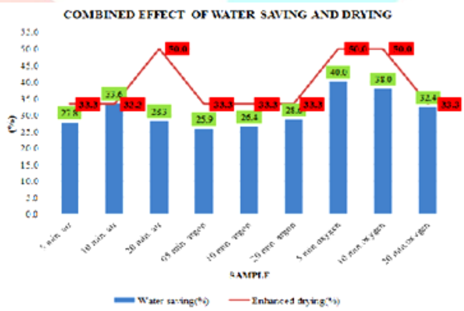


Figure 7: Static immersion and drying

Figure 7 highlights the combined effect of static immersion and drying and clearly indicates that the plasma treated fabrics soak less water and dry faster. In the case of 5 minutes oxygen plasma treatment on bamboo fabrics there is a

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40% saving of water and 50 % enhancement in drying rate ensuring effective use of both water as well as energy since excess energy is not required for complete drying. The water evaporation rate is higher in the case of air, argon and oxygen plasma treated bamboo fabrics. (figure 8).

Figure 9 gives the dye exhaustion of untreated and plasma treated samples. The percentage dye exhaustion of all the plasma treated fabrics is higher as compared to untreated sample. This indicates better dyeability, effective use of dye quantity and minimizing wastage.

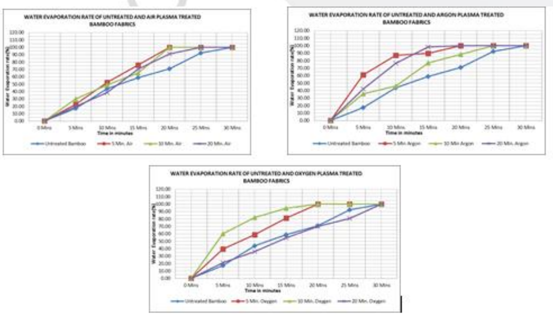

Figure 8: Water evaporation rate of plasma treated 100% bamboo fabrics

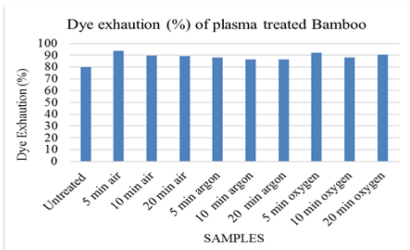

Figure 9: Percentage dye exhaustion of plasma treated 100% bamboo fabrics

Endow... ...Infants layette
"Comfort with Conscience"

Bamboo
Smile with nature

Figure 10 Logo Design for brand and product.

Figure 10 Logo Design for brand and product.

An infant bodysuit is a garment designed to be worn by infants as an outer garment much like a T-shirt. It is a one-piece form fitting garment that covers the torso and the crotch. It extends below the waist with snaps that allow it be closed over the crotch. The presence of snap buttons helps in diaper change. A fusible web is used to prevent abrasion due to embroidery.

Figure 11 Baby suit: Appearance and description:

Infants body suit for extra absorbency and to dry the babies fast. The edge piping gives dimensional stability and grip while carrying the baby.

CONCLUSION

Education, research and design are essential tool for achieving sustainability. People around the world recognize that current economic development trends are not sustainable and that public awareness, education, research and training are key to moving society toward sustainability. The distribution of air space influences the air permeability and the porosity of the plasma treated knitted structure and will influence its physical properties, such as bulk density, moisture absorbency, mass transfer and comfort properties. Improvement in dye bath exhaustion is due to fibre breakage and embrittlement following plasma treatment. Also, the changes that have occurred on fibre surface due to plasma treatment might have contributed to improved dye absorption. This also serves as a career for improving the dye uptake. This is pertinent to note that this has been achieved without any water consumption and additional energy during the dyeing.

Plasma treatment is a first solvent free technique. The operation procedure is simple and well controlled. It is also easy to create any ambient of oxidation for reductive or inactive reasons by changing the feed gas. Today, with changing awareness of environmental concerns, a significant amount of ecological legislation has been introduced regarding

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fiber treatment that use huge amounts of chemicals, water and release toxic effluents. This research is a comprehensive effort that progresses from lab trials to market possibilities for sustainable fashion for infant category. This is very valuable information and useful to the industry. This study effectively integrates the environmental, social and economic resource management issues that forms the core of sustainability.

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