Investigation on Flame Retardant Effect of Myanmar Banana (*Musa Sapientum Linn*) Pseudostem Sap on Cotton Fabric

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Abstract: *The main aim of this work is to investigate the flame retardant effect of Myanmar banana pseudostem sap on cotton fabric. The objectives of this work are to extract the banana sap , to produce the flame retardant fabric with different concentrations of alkaline BPS (banana pseudostem sap) ,and to analyse the produced flame retardant fabrics .Firstly the sap is extracted from the banana stem. The extracted sap is made alkaline and applied in mordanted cotton fabrics. Then, the BPS treated fabrics are tested for some physical properties such as weight, and breaking strength. The results show that the BPS treated fabrics improve physical properties. The treated fabric S_{52} gives the best flame retardant as compared to the other treated fabrics. In order to study the wash durability of the treated fabric, the washing test is carried out on the treated sample S_{52}. The test result shows that the cotton fabric treated with BPS solution gives the temporary flame resistant effect.*

Keywords *– Banana pseudostem sap, Cotton fabric, pH, Physical properties, Wash durability, Flame retardant fabric.*

1. INTRODUCTION:

Flame retardant finishes provide textiles with an important performance characteristic. Fire fighters and emergency personnel require protection from flames as they go about their duties. Floor coverings, furnishing fabrics, curtain, bedding, carpets, nightwear and drapery also need protection. The military and the airline industry have multiple needs for flame retardant textiles [1].

Flammability has become one of the interests in safety and protective aspects of textile products. Flammability of textile products refers to their burning behavior, especially eases of ignition and sustained burning after ignition. Except glass fibre, almost all the textile fibres are flammable [2].

Flame retardant fabric is a fabric that has been treatd and/ or holds the natural properties to self –extinguish when exposed to an ignition source [3]. Inherent and treated are two terms that are used a lot in the flame resistant world. The term inherently flame resistant fabric is one that is used for fabrics that do not required the addition of flame retardant chemicals after the yarns have been spun or the fabric has been woven or knitted. The yarns of these fabric use only fibres that are naturally flame resistant. The common theme is no flame retardant chemicals are added to the yarn or fabric.

Unlike inherent fabrics, flame resistant treated fabrics (flame retardant fabrics) have the flame retardant chemicals added to the fabric after it has been woven or knitted.

Most of the chemicals used for fire retardant finishing of cotton textile are synthetic compounds and they are available in the market. These chemicals and their application procedures are hazardous, expensive and non-eco-friendly [4].

Cellulosic cotton textile catches flame readily that is quite difficult to extinguish. This poses a serious risk to the health and life of a living and damages potential to textile products.

Banana is one of most important and common fruits in Myanmar. The crop can be grown throughout the country. It grows wild and also cultivated on a large scale as a field crop as well as backyard crop in household. Banana pseudostem is abundantly available in Myanmar and it is normally considered as waste material. It is eco-friendly and available from renewable source.

In this work, banana pseudostem sap (BPS) extracted from the banana pseudostem is used as flame retardant to impart flame retardant to cotton fabric. An attempt is made to apply the different BPS solutions on the cotton fabric with different treatment times.

2. MATERIALS AND METHODS:

2.1 Collection of Samples

The bleached cotton plain woven fabric was collected from the market. The banana plant (*Musa Sapientum Linn)* selected for the present work were collected from Hlaing Tharyar Township, Yangon Region during the period from June to December, 2016.

2.2 Extraction Sap from Banana Pseudostem

Firstly the leaves and roots are discarded and only the stem portion was used in the present investigation. The sheaths were removed manually from the stem and washed with fresh water to remove dust and rubbish which could affect the purity of the BPS. Each individual pseudostem was crushed by the sugar cane juice extractor in order to extract the sap. After extraction, the extracted sap was filtrated by using the filter to remove the crumbs of pseudostem. It could be stored in the freezer at -18˚C for later use.

2.3 Making Five Different Solutions of BPS

Five different solutions of banana pseudostem sap were made. Firstly, the required amount of BPS was placed in the stainless steel pot and boiled to get the required volume of BPS. The BPS solutions were in acid condition. So, 1% sodium hydroxide solution was added into five different BPS solutions to get alkaline (pH-9). The specific gravity of each BPS solution was shown in Table 1.

Table1. SPECIFIC GRAVITY OF BPS SOLUTIONS

Sr. No.	**Five Different Solutions of BPS**	**Specific Gravity**
1	100% pure BPS (Solution No.1)	0.952
2	100% pure BPS is boiled to get 1/2 of its original volume (Solution No.2)	0.972
3	100% pure BPS is boiled to get 1/4 of its original volume (Solution No.3)	0.979
4	100% pure BPS is boiled to get 1/8 of its original volume (Solution No.4)	1.016
5	100% pure BPS is boiled to get 1/10 of its original volume (Solution No.5)	1.022

2.4 Treatment with Different Solutions of BPS

Plain woven cotton fabric was first mordanted with tannic acid (5% owf) and alum (10 % owf). Thereafter, the mordanted fabrics were impregnated separately in the five different BPS solutions, maintaining material to liquor ratio of 1:10 and alkaline pH of 9 by adding 1% NaOH. The treatment was carried out by varying the treatment times (20 minutes and 40 minutes). The treated fabric samples were padded by laboratory padding machine and followed by drying for 5 min at 80˚C and curing for 2 min at 100˚C by the mini tenter machine. These processes were carried out at the Bleaching and Dyeing Laboratory of the Department of Textile Engineering, Yangon Technology University. The treated samples were presented by symbol 'S'. The first number of subscripts 1, 2, 3, 4 and 5 indicated the solution numbers 1, 2, 3, 4 and 5, respectively. The second number of subscripts 1 and 2 represented the treatment times of 20 minutes and 40 minutes, respectively. Designations of treated sample fabrics are shown in Table 2.

Table2. DESIGNATION OF TREATED SAMPLE FABRICS

Sr.No.	Sample Code	Solution No.	Treatment Time (min)
1	S_{11}	(1)	20
2	S_{12}	(1)	40
3	S_{21}	(2)	20
4	S_{22}	(2)	40
5	S_{31}	(3)	20
6	S_{32}	(3)	40
7	S_{41}	(4)	20
8	S_{42}	(4)	40
9	S_{51}	(5)	20
10	S_{52}	(5)	40

3. RESULTS AND DISCUSSIONS:

3.1 Comparison of Physical Properties of Untreated and Treated Cotton Fabrics

The flame retardant finishing treatments can affect the physical properties of the fabric. In order to determine the effect of BPS treatment on cotton fabric, the following tests are carried out according to the respective ASTM standards and AATTC Test Methods. The summary of the test results are described in Table 3. From this Table, it can be observed that the physical properties of the treated fabrics are increased.

(1) *Weight Test* : By observing on Fig. 1, the weight of the treated fabrics are significantly greater than that of the untreated fabric because the particles contained in the BPS solution may impregnate into the fibre structure and also due to the surface coating of BPS. As indicated in Fig. 1, the weight of the treated fabric S_{52} is the heaviest weight and that of the treated fabric S_{11} is the lightest one. The reason is due to the different concentrations of the BPS solutions. The BPS solution (5) is thicker than the other solutions by visual observation. When the fabric is treated with the thicker BPS solution, more particles adhere to the surface of fabric. The solution (1) is the thinnest solution. So, the weight of fabric treated with solution (1) is the lightest.

Table3. SUMMARY OF THE PHYSICAL PROPERTIES AND BURN RATE TEST RESULTS OF THE UNTREATED AND TREATED FABRICS

SE-Self Extinguish DNI- Does Not Ignite

Test		Untreated Fabric	Treated Fabrics									
			S_{11}	S_{12}	S_{21}	S_{22}	S_{31}	S_{32}	S_{41}	S_{42}	S_{51}	S_{52}
Fabric Weight (g/m^2)		217.7	264.8	278.0	284.5	288.9	292.9	310.6	317.0	348.5	362.1	401.1
Breaking Strength (kg)	Warp	92.9	93.4	93.5	93.6	94.2	94.8	95.2	95.4	96.0	97.1	98.0
	Filling	71.1	72.2	73.0	73.2	73.8	74.8	76.6	77.2	77.6	78.2	79.4
Burn Rate (cm/min)	Warp	11.2	9.7	9.1	8.4	6.3	4.1	0.7	0.3	SE	SE	DNI
	Filling	9.8	9.7	8.5	7.7	6.0	4.1	0.77	0.2	SE	SE	DNI

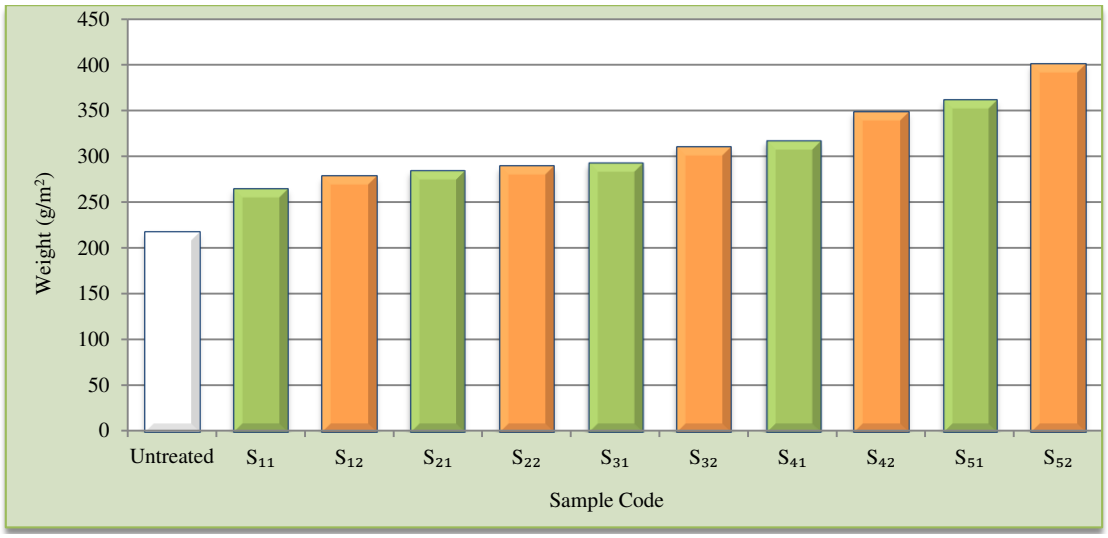
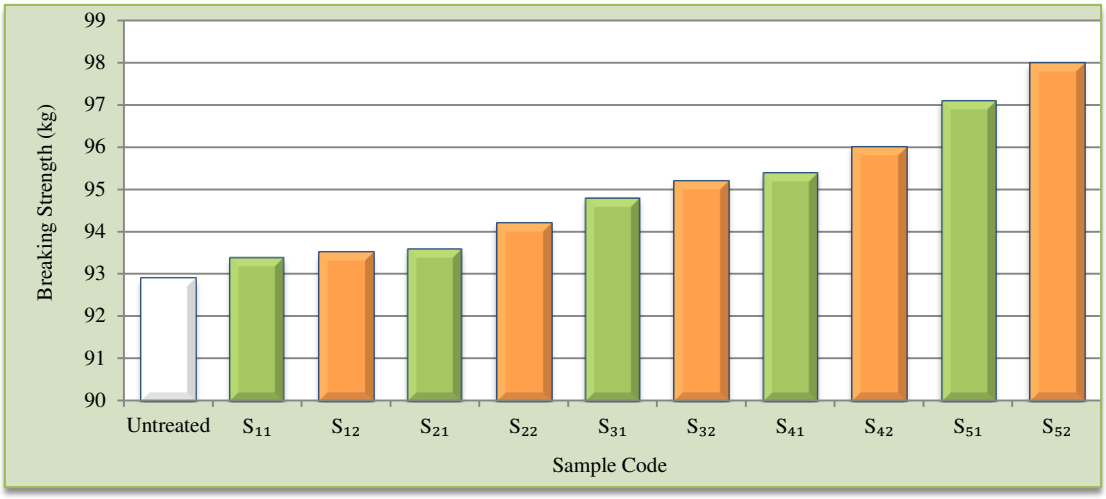


Fig. 1 Weight of Untreated and Treated Cotton Fabrics

(2) *Breaking Strength Test*: Fig.2 and Fig.3 show the results of the mean value of fabric breaking strength in kilograms of warp and filling directions, for both the untreated and the treated fabrics. It is found that the breaking strength of the treated cotton fabrics in both warp and filling directions are gradually increased. It may be due to NaOH used in the treatment. The treatment of cotton with NaOH improves the fabric strength. The sample S_{11} is the least breaking strength and S_{52} is the greatest one.



Fig,2 Breaking Strength of Untreated and Treated Cotton Fabric (Warp Direction)

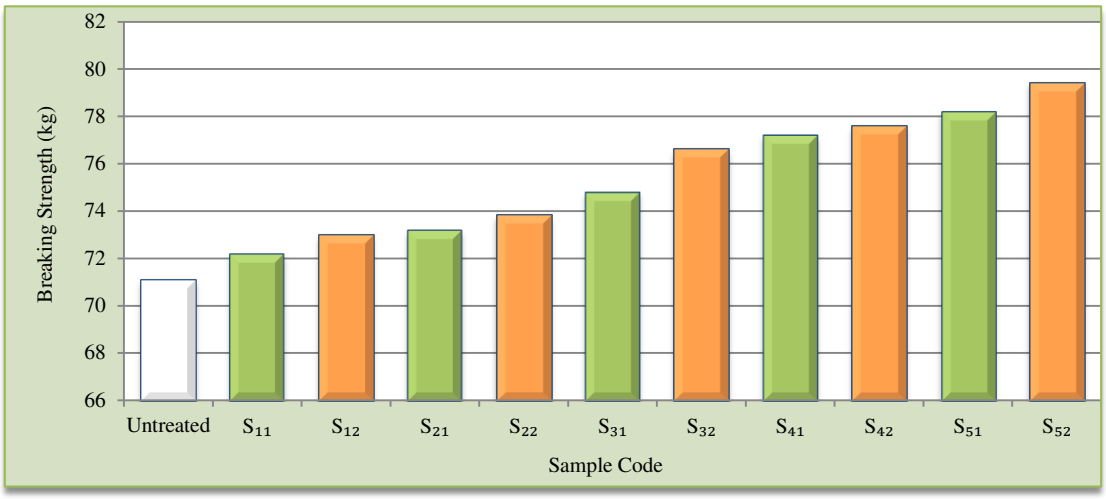
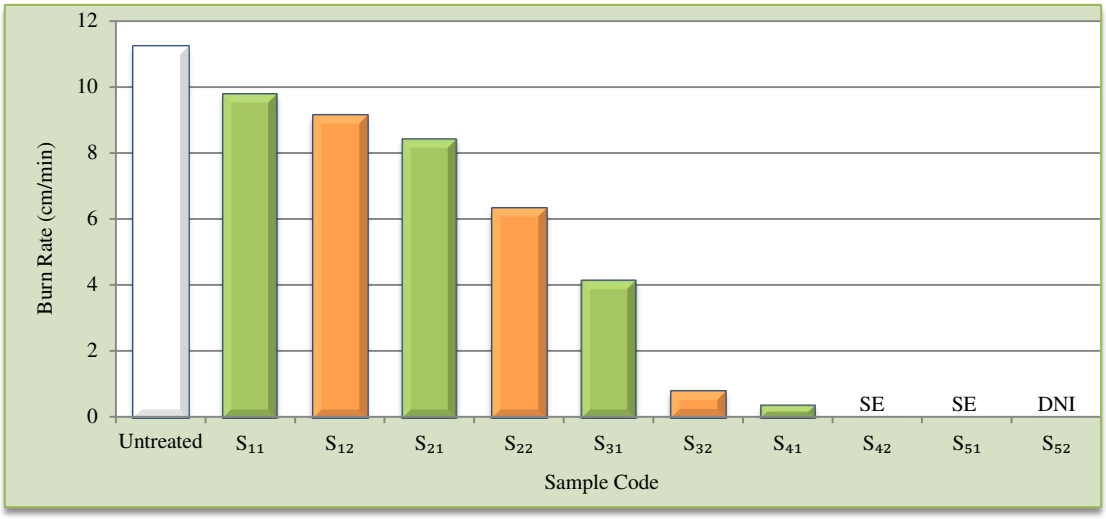


Fig.3 Breaking Strength of Untreated and Treated Cotton Fabric (Filling Direction)

(3) *Flammability Test*: In this paper, the flammability of the samples is measured by using Atlas HMV flammability testing machine and indicated as burn rate (cm/min). As indicated in Fig. 4 and Fig. 5, the untreated cotton being pure cellulosic in nature has a high burn rate of 11.23 and 9.86 cm/min in warp and filling direction, respectively. However, after application of BPS solution in the cotton samples, the burn rate is found to be slow significantly. It is observed that the untreated sample ignites rapidly, and burns entirely with flame within 69.46 seconds. Among the ten different samples, the five different treated samples S_{11}, S_{12}, S_{21}, S_{22} and S_{31} are burnt initially with flame followed by afterglow. The sample S_{32} is burnt with afterglow and the sample S_{41} is partially burnt with afterglow and char length is observed. The samples S_{42} and S_{51} are self-extinguished and the sample S_{52} does not ignite. Flammability test result photos of the samples S_{41}, S_{42}, S_{51} and S_{52} are shown in Fig.6. It may be due to the percent contents of phosphorous and chloride in BPS solution as indicated in Table 4. It is shown that the BPS solution with higher specific gravity gives the higher percent content of phosphorous and chloride. So, the sample S_{11} gives the highest burn rate and the sample S_{52} is the best flame retardant fabric in this study. The burn rate of the sample S_{11} and S_{12} are significantly different. These two samples are treated at different interval of time (20 and 40 minutes). The burning behaviour of the samples treated with same solution at different time intervals are significantly decreased when the treatment times are gradually increased. So, time is an important factor in this research. Treatment time can change the burn rate of the treated sample.

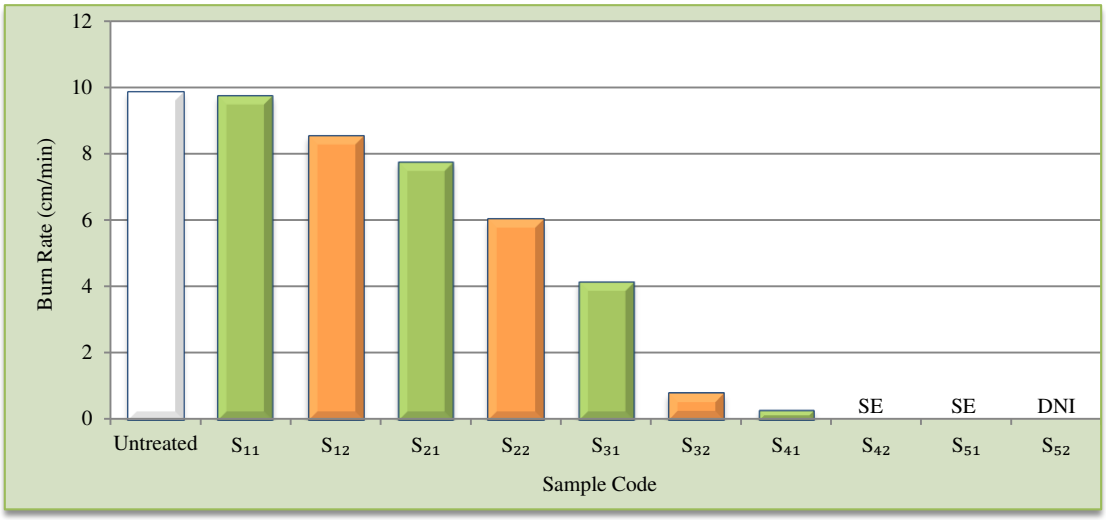
Table4. PHOSPHOROUS AND CHLORIDE CONTENTS IN FIVE DIFFERENT BPS SOLUTIONS

Sr. No.	Solution No.	Phosphorous		Chloride	
		Content (mg/L)	Percent Content (%)	Content (mg/L)	Percent Content (%)
1	(1)	225.84	0.022	135.00	0.014
2	(2)	429.72	0.043	300.17	0.030
3	(3)	860.41	0.086	595.21	0.060
4	(4)	1781.60	0.180	1240.00	0.120
5	(5)	2150.10	0.220	1495.32	0.150



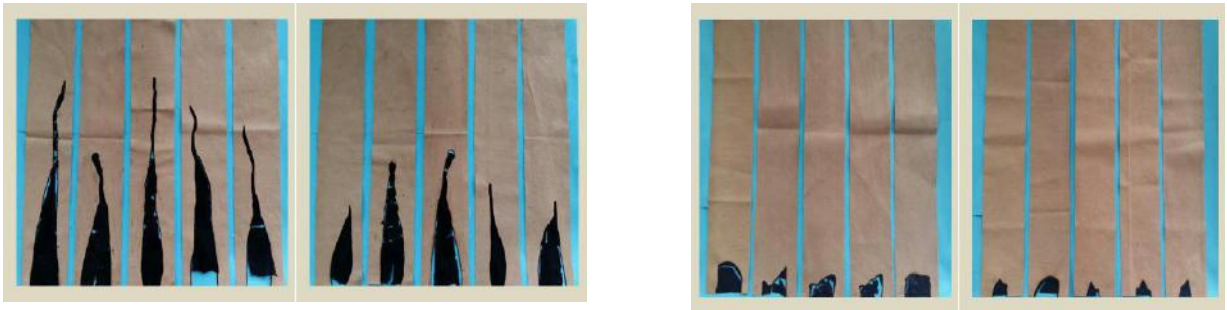
SE – Self Extinguish DNI – Does Not Ignite

Fig.4 Burn Rate of Untreated and Treated Cotton Fabrics in Warp Direction

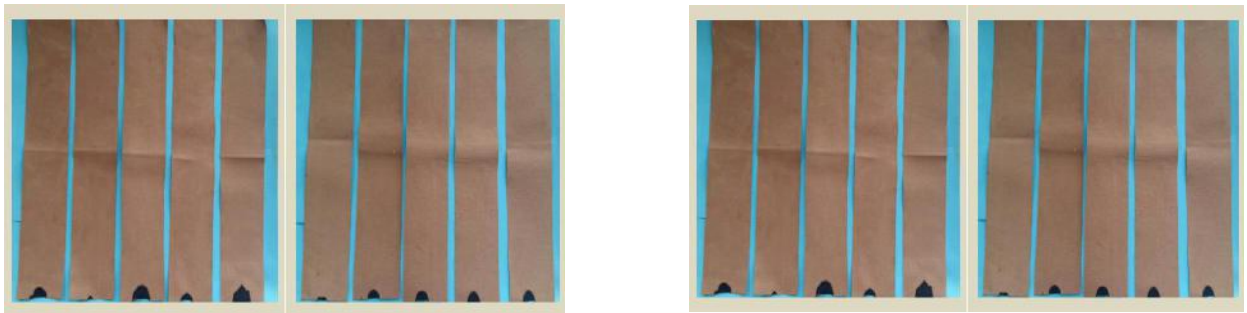


SE-Self Extinguish DNI – Does Not Ignite

Fig. 5 Burn Rate of Untreated and Treated Cotton Fabrics in Filling Direction



S_{41} (warp) S_{41}(filling) S_{42}(warp) S_{42}(filling)



S_{51} (warp) S_{51} (filling) S_{52} (warp) S_{52}(filling)

Fig. 6 Flammability Test Result Photos of Sample

(4) *Wash durability:* Among the ten treated samples, the treated fabric S_{52} is the best flame retardant fabric. In order to determine the durability of the imparted flame retardant finish on the treated fabric S_{52}, washing test is carried out with soap solution. In this research, hand wash method is used because this method is commonly used in the commercial laundry and home. After washing, the burn rate of the sample fabric is determined. The results are shown in Table 5. It can be observed that the flame retardant ability of the treated fabric decreases after washing. It may be the fact that the active compounds of BPS molecules are partially removed by soap solution. It may be noted that the cotton fabric treated with BPS solution cannot resist to washing. The test results indicate that the BPS treated fabric can only be used as temporary flame retardant fabric.

Table.5. BURN RATE OF UNWASHED AND WASHED FABRICS

Flammability		Untreated Fabric	Sample (S_{52})	
			Before Washing	After Washing
Burn Rate (cm/min)	Warp	11.23	DNI	7.32
	Filling	9.86	DNI	7.72

DNI – Does Not Ignite

4. CONCLUSIONS:

The flame retardant fabric can be achieved by using banana pseudostem sap as flame retardant agent. The proposed application process is simple, cost-effective, as no costly chemicals are used. Among the five different solutions, the solution (5) is the most suitable solution to make flame resistant finishing because of its greatest content of phosphorous and chloride. It is found that the flame resistant effect of the fabric treated for 40 minutes is higher than that of fabric treated for 20 minutes. The longer the treatment time, the better the flame resistant effect of the fabric can be achieved. Therefore, the sample S_{52} is the best flame resistant fabric among ten different samples. After being washed by hand, the flame retardant ability of this sample is decreased. So, it can be concluded that the cotton fabric treated with BPS solution gives the temporary flame retardant effect. These BPS flame resistant fabrics can be used as car cushion cover, car accessory, drapery, floor covering and upholstery fabrics that need no laundering.

5. RECOMMENDATIONS:

After the sap is extracted, the crushed sheaths are obtained. These crushed portions contain fibres that can be used to produce ropes and twines.

According to the wash durability test results, it is recommended that the BPS treated cotton fabric can not resist to washing. As for future work, an attempt should be carried out in order to improve the fastness to washing of the BPS treated fabrics.

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