Fire Retardant Finishing Of Jute Fabric

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Abstract

Flammability of fibrous products is one of the major problems posed to scientists and technologists at the present time. The U.S national projection for fires caused by textiles per year based on averages computed for 1977-1978 is 214,800 [1]. Fires would cause deaths, injuries. All fiber and textile products may be involved in starting of fires. A fire involving wear clothing appears to be the most dangerous and shows the highest rate of deaths per fire. Hazards from flammable fabrics were recognized for many centuries and repeated attempts have been made to cope with them[2] .one of the first recorded efforts in this direction was made in 1735 by Jonathan wyld of England , who patented a flame retarding mixture of alum, ferrous sulfate and borax.[3]. Gay-Lussac [4] in 1821 developed a flame retarding finish for jute and linen based on borax, ammonium phosphate and chloride. Many further attempts were made by scientists to reduce fire hazards by introducing fire retardant treatment and suitable clauses in fabric specifications [5]. In this paper we are focused on the fire retardant treatment of jute fabrics with different chemicals and observing fabric physical parameters.

Introduction

Jute is a natural fibre composed of cellulose, lignin, hemicellulose, waxes and protein mineral matters.[6] Due to inroad of synthetic fibres the conventional use of jute products is declined. Hence it needs diversification. This is why it is essential to make jute fabric attractive by different value added finish. For promotions of uses of jute as protective textiles it can be made fire retardant. Hence in the present work jute fabrics has been subjected to different type of fire retardant treatment to get fire retardant jute based fabrics for the said purpose and research has been undertaken to study the physical parameters of fire retardant jute fabrics.

Materials and Method

100% bleached jute fine Hessian fabric , having plain weave (E.P.C- 6, P.P.C- 6, Warp cout-200tex, Weft count- 240 tex, G.S.M-230) has been used for this study. Finishing methods were carried out by various fire retardant chemicals like DAP (Di-Ammonium phosphate), Borax, Thio-urea, Rochell salt, Tetra sodium pyrophosphate, along with DMDHEU based resin and $Mgcl_2$ catalyst.

Solution formulation with fire retardant chemical

Padding bath was prepared with the following recipe:

- Borax-7%**,** Boric acid- 3% DAP- 4%, 6%, 8%, 12%Resin- 4%Catalyst- 1%
- Thio-Urea- 4%, 6%, 8%, 12%, DAP- 8%, Resin 4%, Catalyst-1%
- Rochell salt- 4%, 6%, 8%, 12%, DAP- 8%, Resin- 4%, Catalyst-1%
- TSP- 4%6%, 8%, 12%, DAP- 8%, Resin- 4%, Catalyst-2%

Application of mixed solution to jute fabrics

The prepared mixed solution was poured to the padding bath of two bowl padding machine and bleached jute fabric was padded (impregenated) through the above formulations to yield a wet pick up 70%. The fabrics were then dried at 105^0C for 5 minutes and cured at 140^0C for 4 minutes. In brief the sequence of operation was as follows

Padding> Drying> Curing> Washing

Testing Method

All the bleached differently finished jute fabric samples were conditioned for 48 hour at 65% RH and 27^0C.

Determination of weight loss or gain

This property was determined by gravimetric principle following oven dry weight method, taking bone dry weight of the sample before and after the treatments and expressing the results as a percentage of the initial bone dry weight of the material taken.

$$\text{Weight loss (or gain) } \% = M_2\text{-}M_1 / M_1 * 100$$

Where M_1 and M_2 are the oven dry weight of the untreated and treated fabric samples respectively. The reported results are average of 5 tests in each case.

Evaluation of tensile properties

Warp way and weft way breaking strength of untreated and treated jute fabric samples were determined after conditioning the samples by standard methods following the ravelled strip method as per IS:1969:1968 procedure using Instron (model-1445) CRT universal tensile tester with a traverse speed of 100 mm/min and a pretension of 0.5N. The final gauge length of the fabric sample was 50mm* 20mm after raveling. The test results reported are an average of 10 tests for each sample.

Evaluation of shrinkage properties of fabric

10cm marking (L1) was done on both warp and weft way of the untreated Bleached Jute fabrics. The length of the similar line (L2) was measured after FR treatment and conditioning of the samples.

$$\text{Shrinkage } \% = L_2\text{-}L_1 / L_1 * 100$$

Determination of whiteness index and Yellowness index

Whiteness and brightness index of untreated and selectively treated jute fabric samples were determined from the measured reflectance value and the corresponding tristimulas values of the samples recorded using a computer aided Macbeth 2020 plus reflectance spectrophotometer and associated software under D65 standard illuminant and 10^0 standard observers testing.

Flame spread time

Flame spread time of the fabric was measured in 45^0 flammability tester by ASTMD1776-98 method. Six samples of 6.5*2 sqinch were cut out from both warp and weft direction. All the fabric samples are oven dried for 105^0C for 20 min. we got the average reading of six samples in both directions.

Limiting Oxygen Index

LOI values of the fabric samples were measured by A.S.T.M standard. The samples are placed into a hinged U shaped holder while the free end of the holder is held with clamps known mixture of O_2 and N_2 in varying ratios are passed upward through the chimney at a velocity of 50mm/sec for 2 minute each. A burner was used for the ignition of the samples. The concentration of O_2, which is just sufficient to sustain the flame, is determined and its volume fraction in the gas mixture s designated as LOI.

Wash fastness

This test has been carried out as per AATCC test method 61

Results and Discussion

Bleached jute fabrics have been subjected to treatment with four different fire retardant formulations under specific treatment condition & the important textile related properties of the treated fabrics have been evaluated and reported.

Table 1 Physical properties of different chemical treated fire retardant fabric

Type of fabric	Particulars	DAP (%)	G.S.M	Wight gain (%)	Shrinkage (%)		Tensile property		Appearance property	
					warp	weft	warp	weft	W.I	Y.I
Bleach Jute fabric	control	-	208.3	-	-	-	7	5	62	34.8
	Formula A	4	210.5	1.07	4	1.5	4.1	3.8	66	34
		6	211	1.1	6	1.5	3.8	3.7	64	34.5
		8	211.3	1.4	6	1.5	3.5	3.5	63	35
		12	211.5	1.5	7	1.5	3.4	3.3	61	36
		THIO UREA (%)	Effect of THIOUREA content of textile related properties							
	Formula B	4	210	0.8	4	2	4.2	4.1	57	39
		6	210.4	1	4.7	2	4.2	4.2	54	42
		8	210.9	1.25	4.7	2	4.1	3.9	52	44
		12	211	1.3	6	2	3.8	3.7	50	45
		`								
		SALT (%)	Effect of ROCHELL SALT content of textile related properties							
	Formula C	4	209.1	0.4	4	2	6.9	4.6	63.9	32.7
		6	210	0.75	5	2	6.28	4.5	64.5	36.9
		8	211	1.25	5	2	5.8	4.4	64.3	37.3
		12	211.3	1.4	6	2	5.7	4.1	60	38
		TSP (%)	Effect of TSP content of textile related properties							
	Formula D	4	209.3	0.5	2	1	4.2	4.1	68	32.3
		6	210.4	1	2	1	4.1	3.9	65	34.2
		8	210.9	1.25	3	1	4	3.7	64	36.7
		12	211.5	1.5	4	1	3.8	3.7	63	36.3

It has been observed from the Table 1 that with the increase in percentage application of chemical in all formulations weight gain has found to be gradually increased in jute fabric. In all cases shrinkage in warp direction has been increase gradually but in weft direction it remains unchanged. Warp way and weft way tensile strength values are found to be gradually decreased. But loss of tensile strength is almost 20% higher in case of Formulation B&D compared to Rochell salt treated jute fabric. DAP treated fabric samples show poor strength parameters compared to all other FR treated fabrics. It may

be presumed that because of mild acidic hydrolysis of jute cellulose & glassy stiff layer of B_2O_3 on the surface of the fabric this fall of tenacity has been observed.
From the surface appearance properties it has been noticed that yellowness index increase and whiteness index decrease with increasing percentage application of chemical. In case of Thiourea yellowness index is slightly higher and Whiteness index is lower than other three formulations.

Flammability properties

Limiting oxygen index (LOI) indicates the measure of flame retardancy level of any material. Higher the LOI (above 27 it is consider as flame retardant). It is observed from Table 2 that LOI values show increase in trend in all formulation with percentage increase of chemical. LOI is higher in case of DAP and TSP at 8% application. From Fig 1& 2 it has been observed that flame spread time gradually increases with increase the percentage application of chemical in all four formulation whereas control fabric catch fire and burn continuously within 10 sec . TSP and DAP treated fabric shows higher flame spread time compared to other two chemicals.

Table 2 LOI value of fire retardant fabric samples

Type of fabric	Particulars	DAP (%)	LOI
Bleach Jute fabric	control	-	21
	Formula A	4	27
		6	29
		8	31
		12	31
		THIO UREA (%)	
	Formula B	4	26
		6	28
		8	29
		12	31
		SALT (%)	
	Formula C	4	27
		6	28
		8	29
		12	29
		TSP (%)	
	Formula D	4	29
		6	31
		8	33
		12	33

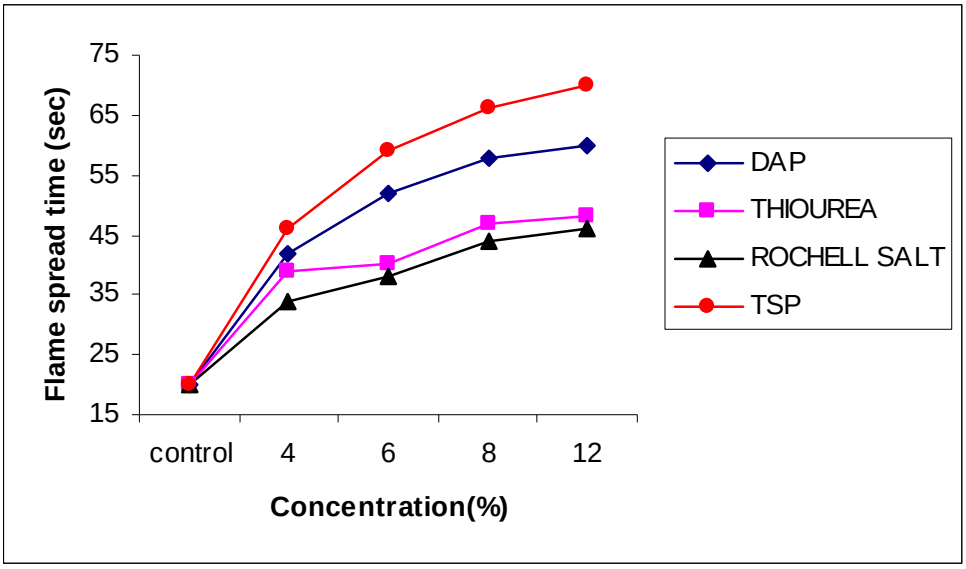

Fig 1: Warp wise flame spread time of fire retardant fabric

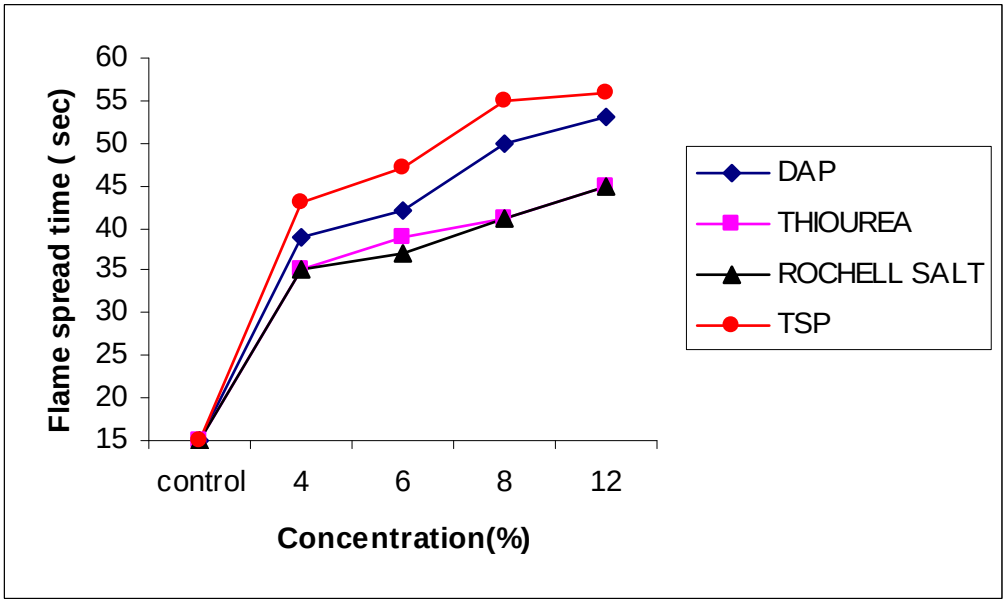

Fig 2: Weft wise flame spread time of fire retardant fabric

Several chemical reactions are responsible for fire retardance effect of jute fabric treated with different formulation. In case of formulation A physicochemical effect help the fabric to behave like fire retardant. At high temperature DAP form Phosphoric acid which blocks the primary OH group of cellulose and prevent the formation of flammable gases with addition to this a glassy layer of B_2O_3 also from on the surface of the fabric which restrict the fabric to come in contact of heat. In formulation B sulfation and

phosphorylation both occur simultaneously. Sulphur compounds appear to operate via a carbonium ion dehydration scheme. [7] Here nitrogenous compound urea facilitates the phosphorylation of cellulose to provide a FR fabric. It was found that with increasing the amount of nitrogen containing compound Thio-urea at fixed DAP regularly improve flame retardance. Rochell salt i.e Sodium potassium tartarate ($KNaC_4H_4O_6$, $4H_2O$) used in Formulation C was not much effective as a flame retardant or in reducing heat sensitivity but the treated fabric is soft and tensile strength of the treated fabric is more than other three formulations. Tetra sodium pyrophosphate ($Na_4P_2O_7$) also called sodium pyrophosphate is a organic P derivatives contains the pyrophosphate ion and sodium cation which forms linkage with anionic Uronic acid and free carboxyl group present in jute fabric. It exhibits the flame retardancy effect on cellulose by esterification mechanism. [8]

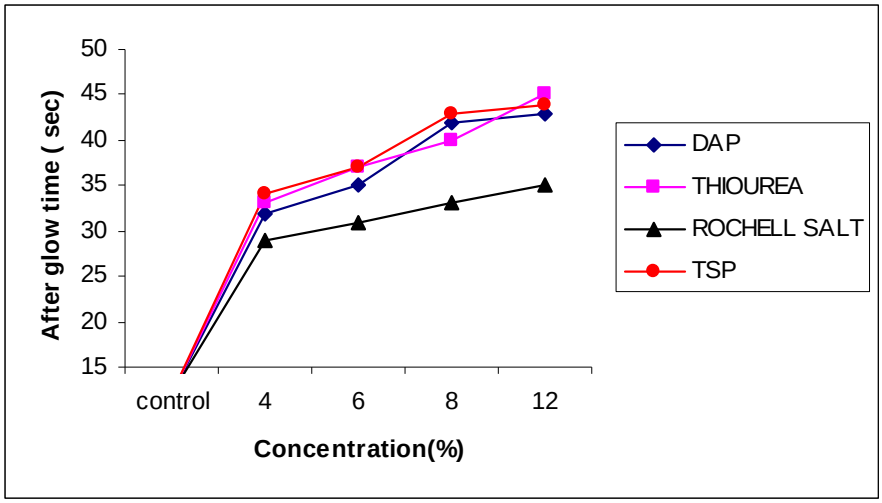

Fig3 Warp wise Flame spread time after 5 home laundering

It can be observed from Fig3 that in all cases flame spread time decreases after 5HL except in the case of Thiourea because nitrogenous compound urea facilitate the phosphorylation of cellulose and improved the durability of FR action to washing. [9]

Conclusion

Comparing the results of treated fabrics, applying four different formulations it has been observed that treatment with formulation D containing 8% Tetra sodium pyrophosphate gives highest LOI value and more flame spread time without much detoriating the fabric tenacity and surface appearance characteristics. It also gives satisfactory flammable properties after home laundering.

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