NOTE

Flammability of Blended Jute Nonwovens. I

Among modern thermoplastics, polypropylene fibers are finding increasing use in textile applications. Among its attractions are low cost, mildew resistance, light weight, excellent wet and dry strength, and advantages in bulk and coverability. Staple fibers are used in blends with cotton, rayon, and wool. It has also been successfully blended with jute fiber in developing carpet composition materials.[1] However, because of the marked difference in physical and chemical properties of the two fibers involved, the jute/polypropylene blends pose a number of very special problems (e.g., in dyeing, printing, etc.). The thermal properties of the fibers also vary to a significant degree. Jute tends to char on heating, but generally maintains some structural integrity while polypropylene burns with flaring molten drops, leaving little or no residue. Because of this, it is impossible to predict the flammability of such blended fabrics and the effect of some flame-retardant (FR) systems on the basis of knowledge of the behavior of the individual component fibers. Further, in bonded fabric, the adhesive also plays an important role in the burning characteristics. Hence, in an effort to determine the nature of burning of the jute/polypropylene blended adhesive-bonded nonwoven fabrics and to assess the effect of some FR chemicals on their flammabilities, the present work was undertaken.

MATERIALS AND METHODS

Fibres used were (1) W_2 grade capsularis jute fiber (13.5–22.5 denier) and (2) polypropylene fiber (100 mm stapled 15 denier). Polyacrylate (commercial grade primal HA 24) was the binder. FR chemicals used were ammonium chloride + diammonium hydrogen orthophosphate (2 : 3).

Preparation of the Fabric

Breaker card sliver of W_2 grade capsularis jute was opened in the Midhurst opener. Different proportions of polypropylene fiber were blended with the opened jute in the Callaghan nonwoven machine. The random layed webs were prepared as usual using an air-laying technique and the area densities of the webs were maintained at 110 g/m^2.

The binder was applied by saturation technique. The webs were cut into small pieces of dimension 28 × 19 cm and were sandwiched between two pieces of nylon nets. The sandwiched webs were completely immersed in the binder system and the excess of the binder was squeezed out by pressing them between two rollers. The solid content of the impregnation bath was maintained at 10% (w/v) and the pressure of the squeezer was so adjusted that the binder content was maintained at 30 ± 2% in all the treated fabrics. The saturated webs were dried in the drying oven at 100°C for 10 minutes and cured at 115°C for 3 mins.

Application of FR Chemical

A 5% (w/v) polyacrylate binder solution was taken in the impregnation bath and to it the above mentioned FR chemical was added in the proportion 2 : 3 (w/w) and the total solid concentration of the liquor was thus maintained at 10% (w/v).

Test Procedure

Vertical Flammability Test. Prior to flammability testing, the fabric samples were conditioned for 3 days at 65% relative humidity (RH), at 20°C.

Conditioned fabric strips (21.5 × 8.5 cm) were suspended vertically in a vertical flammability tester which was fabricated in the laboratory as per ASTMD 3659 and the bottom edge was ignited using a gas burner. The ignition time, the burning time and the charlengths (where possible) were recorded in each case.

SEM Studies. The nonwoven fabric samples were mounted on standard aluminium stubs of 1.0 cm diameter with 'quick fix' as the adhesive. These were then coated with a sliver layer of thickness 20–30 mm in vacuum evaporator at a pressure of about 2×10^{-5} torr. The coated samples were examined in a Hitachi S-430 scanning electron mi-

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Table I Burning Characteristics of Jute/Polypropylene Blended Nonwovens

Sample	Jute % in the Blend	Polypropylene % in the Blend	Ignition Time (s)	Burning Time (s)	Char Length
Polyacrylate bonded jute/	100	0	Instantaneous	21	Completely burnt
polypropyelene blended	90	10	Instantaneous	29	Completely burnt
nonwovens	80	20	Instantaneous	40	Completely burnt
	70	30	Instantaneous	55	Completely burnt

croscope with an accelerating potential of 5–20 kV at 0° tilt angle and representative micrographs were taken.

RESULTS AND DISCUSSION

Three varieties of jute; polypropylene blended (90 : 10, 80 : 20, 70 : 30) adhesive-bonded nonwovens were prepared. The flammabilities and burning characteristics of the blended fabrics (without FR chemical), as determined by a vertical flammability tester, are given in Table I. All the three varieties of blended fabrics catch fire and burn with a heavy smoke with occasional molten dropping which is more pronounced in a blend of higher polypropylene content. However, as the proportion of polypropylene increases, though there is no difference in ignition time, the burning time increases considerably, suggesting that incorporation of polypropylene decreases the burning rate of the fabric which is further established when the burning time of all jute nonwoven is compared (Table I). However, all jute systems during burning does not evoke as much smoke compared with a blended one. Decreased flammability of the blended fabric may be explained by assuming that pyrolysis of the jute cellulose is prevented by polypropylene which melts nearly at 170°C, much below the decomposition temperature of jute (between 300 and 353°C) and shields the jute fiber. Similar phenomenon of melting and coating was observed by Drews[3] in electron microscopic studies of cotton/PE blends. However, Tesoro[5] determined limiting oxygen indices for a variety of fibers and reported that blends were more flammable (lower LOI) than either component in case of cotton/PE blends.

In order to study the surface characteristics of the blended nonwovens, electron micrographs have been taken and are reproduced in Figures 1, 2, 3, and 4 which represent, respectively, the surface of all jute and 90 : 10, 80 : 20, and 70 : 30 blends of jute and polypropylene.

From Figure 1 it appears that the fibers which are close to each other are bonded by the adhesive which forms a thin film in between. However, the film is not continuous. It is observed also that there is an abundance of adhesive film near the fiber crossovers. Further, it is observed that the proportion of polypropylene fiber increases in the fiber blend (Figs. 2, 3 and 4), there is preferential migration of the finer polypropylene fiber toward the outer surface. Due to an abundance of polypropylene fiber on the outer surface of the blended, fabric of higher polypropylene content, during the burning of the fabric the polypropylene fibers melt and form an outer coating which protects the jute fiber to some extent. This explains the decreased flammability of polypropylene-blended jute fabrics.

Effect of FR Chemicals on the Flammability of Jute/Polypropylene-Blended Adhesive-Bonded Nonwovens

Normally phosphorus–chlorine combinations serve as the effective catalyst for a variety of organic reactions and are useful as FR systems. In our study also a combination of diammonium hydrogen orthophosphate and ammonium chloride in the ratio 2 : 3, when incorporated in the binder

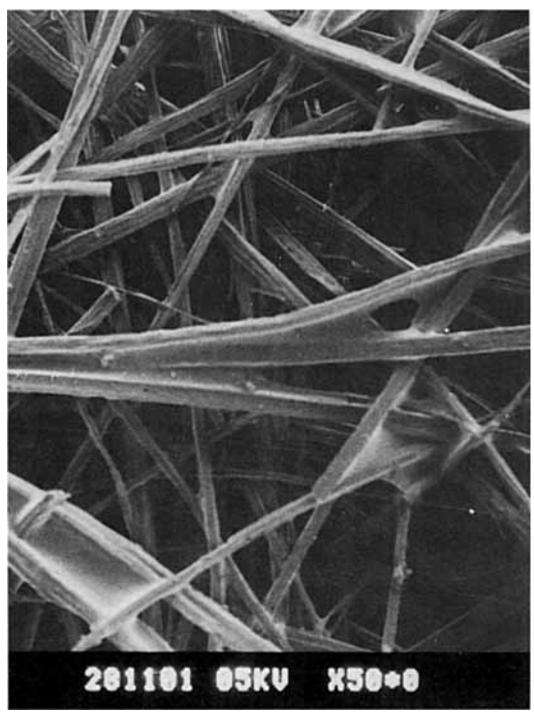

Figure 1 SEM of the surface of polyacrylate-bonded 100% jute nonwoven (×50).

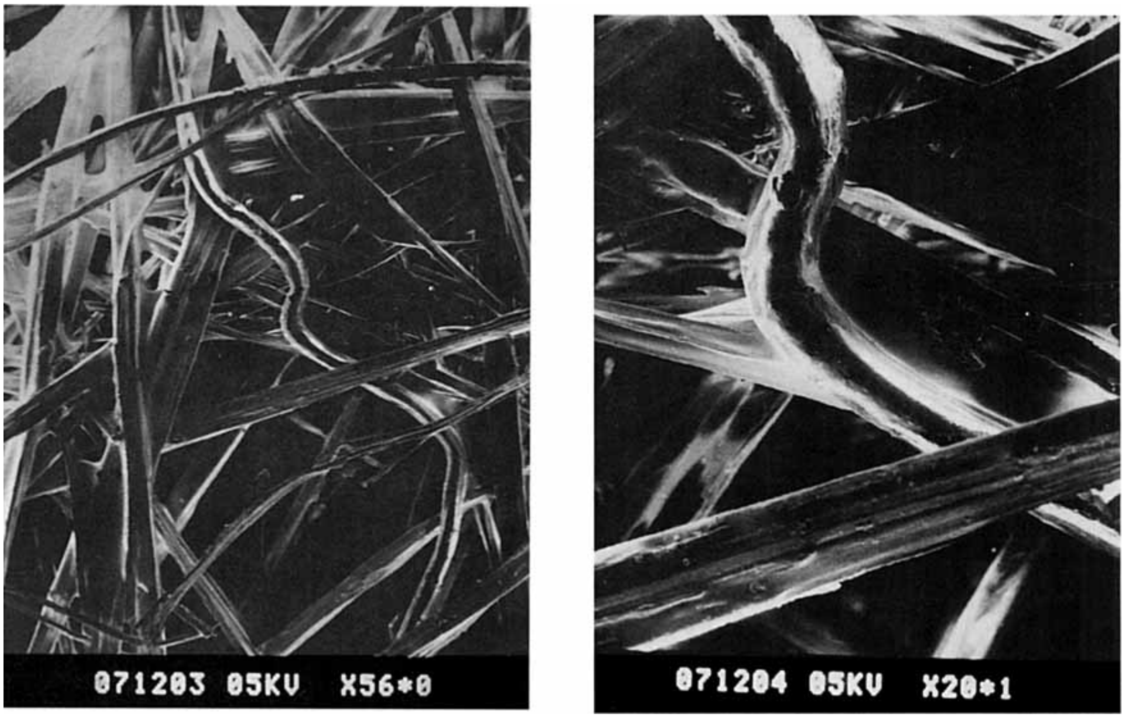

Figure 2 SEM of the surface of polyacrylate-bonded jute/polypropylene blended (90:10) nonwoven (×56, ×200).

system during the impregnation process, was found to be an effective FR. The quantity of FR chemical in all the bonded fabrics was the same as the binder uptake level was kept constant during the preparation of the fabric. The flammability characteristics of these fabrics have been determined and are given in Table II. It is observed that the effect of FR system was maximum in the case of the blend containing 10% polypropylene as indicated by char length (11.5 cm). However, when the proportion of polypropylene was increased from 10 to 20%, the above effect was less pronounced and the char length increased (12.7 cm). Though, additive phosphorous compounds usually are supposed to be the most useful FR system for cellulosics and act by nominal dehydration mechanism, in some cases,[2] it contributes to fuel production process by catalyzing solid-phase degradation and condensation process in a pyrolyzing polymer of any type including polyolefins. In case of jute/polypropylene-blended nonwovens however, it appears that the effect or FR system is more pronounced on the cellulosics than on the olefins. However, this may be explained by the phenomenon of migration of phosphorus residues from olefins to cellulosics during heat treatment of drying and curing as suggested by Bajaj et al.[4] while explaining the phenomenon of decreased weight add-on with increasing polyester component during phosphorylation of cotton polyester blends.

Figure 3 SEM of surface of polyacrylate-bonded jute/polypropylene blended (80:20) nonwoven (×150).

When the proportion of polypropylene was further increased from 20 to 30% in the blend, the fire retardancy of the blended fabric was higher (low char length, 11.8 cm) compared with that of blended fabric of 20% polypropylene content. In this case, probably the abundance of polypropylene fiber on the outer surface of the fabric (Fig. 4) plays a significant role in the restricted flam-

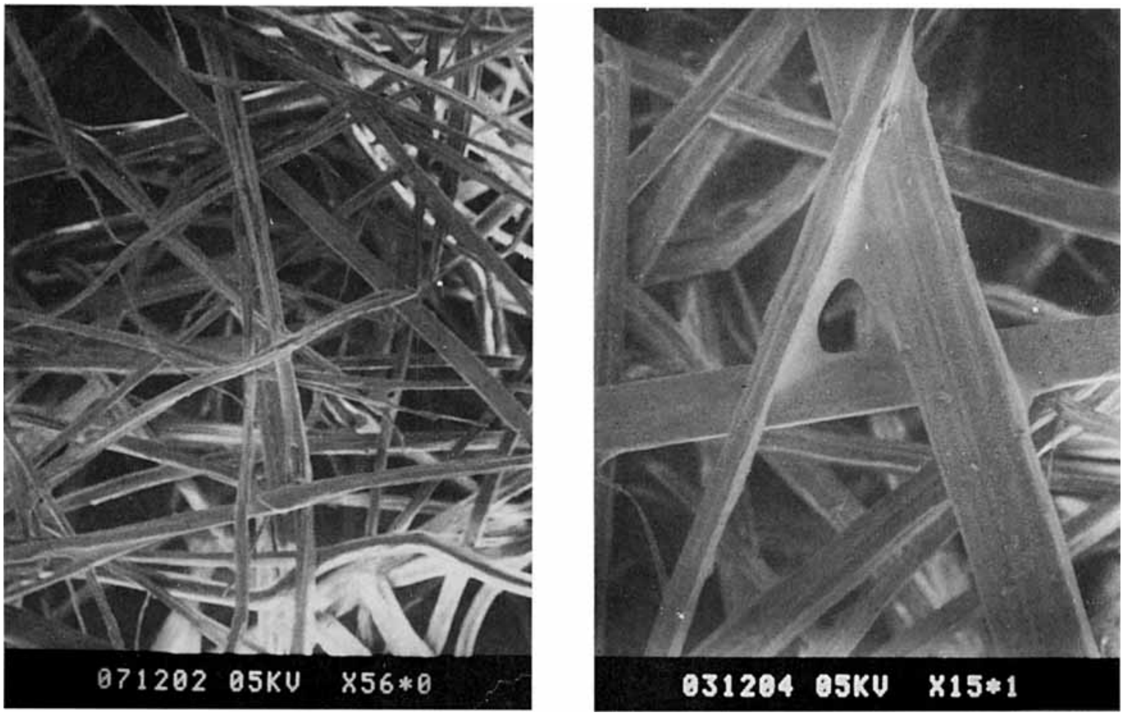

Figure 4 SEM of surface of polyacrylate-bonded jute/polypropylene blended (70:30) nonwoven (×56, ×150).

mability of the fabric. The finding that the fabric of 30% polypropylene content (without FR) has a higher burning time corroborates this. Here the jute fibers are protected not only by the presence of FR chemicals, but also by the molten polypropylene fiber. Hence, there is a twofold effect and one of the component fibers serves as a fire retardant to some extent. However, the flammability of this fabric is higher than that of the blended fabric containing 10% polypropylene where the effect of the FR chemical is mainly manifested. Comparison of these two observations suggest that, in a blend of higher polypropylene content through the polypropylene indirectly acts as FR to some extent, the flammability of the blended fabric is mainly governed by the FR chemical.

CONCLUSION

From the above study it is concluded that in the jute/polypropylene blended nonwovens, there is preferential migration of the finer polypropylene fibers toward the outer surface. During burning, though these fibers melt and protect the jute fiber to some extent, the fire retardancy of the blended fabric is mainly governed by the FR chemical applied.

Table II Flammability Characteristics of FR-Treated Jute/Polypropylene-Blended Adhesive-Bonded Nonwovens

Type of Blend	Fiber Blend Proportion (Jute:PP)	Flammability Characteristics		
		Ignition Time (s)	Burning Time (s)	Char Length (cm)
Jute/ polypropylene	90:10	Just a flicker appeared and then extinguished	Did not burn. The source of ignition kept in contact with the fabric for 30 s	11.5
	80:20	Just a flicker appeared and then extinguished	Did not burn. The source of ignition kept in contact with the fabric for 30 s	12.7
	70:30	Just a flicker appeared and then extinguished	Did not burn. The source of ignition kept in contact with the fabric for 30 s	11.8

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