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FIRE PROTECTION OF WOOD BASED PRODUCTS BY COATING

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Summary

A few fire retardant coatings based on phosphate and borate salts, amides, polyhydric alcohols, VC/VA copolymer and antimony oxide along with a binder have been developed for wood and wood-based products. Fire performance and emission of smoke have been evaluated employing different BS and ASTM Standards. The results were found well within the limits. On exposure, the coated specimens showed neither any surface spread of flame nor any afterglow combustion. On the other hand the paint films swelled to form spongy, cellular insulating foams which acted as effective barriers against the conduction of heat.

Introduction

Wood and wood-based products such as plywood, particle board, Celotex boards etc. are generally used in buildings for doors, windows, partitions, thermal and acoustic treatments as well as for decorative purpose. These materials are intrinsically combustible and hence pose fire hazards. If they are suitably treated for fire retardance, the growth period of fire and the spread of flame will be reduced thereby obviating fire hazards, loss of life and property.

In order to retard the ignition and surface spread of flame on these materials to a considerable extent, different methods such as chemical impregnation, spray, surface treatment and incorporation of fire retardants during manufacture of the product are often used. Fire protection by a coating applied on surfaces is a very useful and practical proposition and has engaged the attention of research workers and industrialists. There are generally two types of coatings, that retard the spread of flame. One type of coating, called a fire retardant coating, uses additives such as borax, boric acid, antimony trioxide and chlorinated compounds (Baker 1977 & 1981, Dua 1982, Mishra & Srivasamban 1979) which do not support combustion. The other type is called an intumescent coating, which, when heated produces residues that are puffed up or are swelled by escaping gases. A combustion residue can be efficiently puffed up in order to produce a tough insulating foam over the surfaces to protect the material (Mishra & Srivasamban 1979, Lyons 1970, Bhatnagar & Vergnaud 1983). These coatings generally perform better than fire retardant coatings.

The present paper is concerned with the results of the investigations on fire retardant intumescent coatings.

Experimental

Materials and Methods

Fire retardant ingredients used in this investigation were of commercial grade. The binders used were obtained from Calico Chemicals Ltd., Bombay and Synthetic and Polymer Industries, Ahmedabad.

*Preparation and application of coatings**

Fire retardant coatings were prepared by mixing different fire retardants in different ratios. The ingredients* were as follows :

Antimony oxide	5 – 10%
Borate salt	4 – 7%
VC/VA copolymer	10 – 15%
Phosphate salt	21 – 30%
Amides	16 – 20%
Polyols	8 – 12%
Thickening agent	2 – 4%
Pigment	2 – 4%
Binder	16 – 20%
Solvent (water)	8 – 14%

The coatings were prepared by mixing ingredients of 325–400 mesh size with a 2 percent solution of sodium salt of d-mannuronic acid and appropriate quantity of binder. Requisite amount of water was added in order to obtain brush consistency. It was stirred vigorously with heavy duty stirrer. The coatings were applied by brush on combustible surfaces such as plywood, wood, particle board and Celotex board etc. In order to obtain an effective fire retardancy the paint was applied at the rate of 2.5 m^2/lit.* on wood, plywood and particle board and 1.8 m^2/lit.* on the fibre board which could be achieved by applying two or three successive coats. The surfaces of the materials were rendered water repellent by applying a coat of a copolymer of vinyl chloride and vinyl acetate in ethyl acetate at the rate of 220 ml/m^2.

* Information regarding precise compounds used and their application rates per m^2 has been withheld by the authors as the findings are proposed to be covered under a patent.

Testing and Evaluation of coatings

Flame spread rate, afterglow time, char volume and weight loss under fire exposure are the main criteria of effectiveness. Different standard tests were employed to evaluate the coatings.

(a) *Fire Retardancy*

The test specimens of plywood, deodar wood, particle board and Celotex board (15 × 300 mm) with smooth surfaces, free from knots and other imperfections were prepared. The coated and uncoated specimens were tested for their fire performance employing ASTM D-1360 method (Anon. 1979).

(b) *Surface spread of Flame Test*

Coated and uncoated specimens of deodar wood, plywood, particle board and Celotex board (230 × 900 mm) were subjected to gas fired radiant panel of approximately 900 mm^2. The time of spread of flame for measured distances along the specimens was recorded for 10 minutes according to BS 476 Part 7 standard (Anon. 1971).

(c) *Smoke Emission Test*

Tests were carried out in the NBS (National Bureau of Standards) smoke density chamber. The coated and uncoated specimens of 76 × 76 mm size were arranged to face the electrically heated radiant energy source which is mounted within an insulated ceramic tube and positioned so as to produce an irradiance level of 2.5 w/cm^2 averaged over the central 38.1 mm diameter area of vertically mounted specimen. Maximum specific optical density (SOD) was determined according to ASTM E 662 method (Anon. 1979).

The results are reported in Table-1.

Results and Discussion

It is clear from Table–1 that fire retardant coatings are very effective in reducing the burning characteristics of wood and wood-based products. The coated specimens showed neither any surface spread of flame nor afterglow or smouldering on exposure. Weight loss and char volume were found in the range of only 2–4 gms and 5–8 cc respectively. The burning test data from BS 476 part 7 show that the performance of coated deodar wood, plywood and particle board improves from class 3 to class 1. The Celotex board can also be placed in class 1, from class 4. The coating was also found quite effective in reducing the rate and the amount of smoke formed.

The main constituents of fire retardant intumescent coating under study are amides, polyols and phosphate salt (catalyst). When this combination is exposed to fire, the catalyst decomposes to phosphoric acid which acts as a dehydrating agent. The polyol is dehydrated by the acid forming a large amount of carbonaceous char which produces a non-combustible barrier to protect the substrate. Amide gives off non-flammable gases causing the foamable carbon to produce a honey comb blanket resulting in a highly effective insulation (Lyons 1970). The binder on softening forms an expandable skin over the carbonaceous char to resist the escape of gases produced by amide. All these reactions take place within the coating. The material is thus well protected from heat.

Conclusion

The fire retardant coatings employed are found quite effective in reducing the flammability of wood-based products. Coated specimens satisfy class 1 characteristics while uncoated ones are placed in class 3 and 4. It is also concluded that coatings are quite effective in reducing smoke generation considerably.

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TABLE I

Performance of coatings

Material & treatment	Performance as per			
	ASTM D-1360 Wt. loss (gm)	Char Volume (cc)	BS 476 Part 7 Classification	ASTM E-662 Specific Optical Density (SOD)
Coated				
— deodar wood	3.18	5.85	Class—1	39.20
— plywood	2.86	5.38	Class—1	37.60
— particle board	3.05	6.21	Class—1	40.50
— Celotex board	3 86	7.82	Class—1	38.80
Uncoated				
— deodar wood	22.52	54.20	Class—3	338.4
— plywood	26.14	69.54	Class—3	176.7
— particle board	30.65	94.10	Class—3	415.2
— Celotex board	Burnt completely with flaming and afterglow combustion.		Class—4	308.2

Values are averages of six specimens.

— Class 1, 2, 3 and 4 represent surface of 'very low' 'low', 'medium' and 'rapid' flame spread respectively.

— Lower value of SOD indicates that performance is better.