Studies on Flame Retardancy Properties of a Novel Epoxy-Polysulphide based Coating on Wood Panel Products and Bamboo Composites

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Abstract- The objective of the study is to develop a Poly sulphide –Epoxy resin based halogen free novel flame retardant coating which forms an insulating layer in the event of fire and its flame retardancy properties on wood based panel products and bamboo composites .The coating formulation was optimized by poly sulphide based epoxy resin as binder, ceramic material, carbohydrate and halogen free fire retardant which forms an insulating layer on the surface and blowing agent . In order to evaluate the flame retardancy properties the optimized coating was coated on the surface of plywood and bamboo composites and flame retardancy properties was carried as per both IS/BS Specifications . The data revels that the excellent flame retardancy properties like flame penetration, flammability was achieved, however the rate of burning was satisfactorily when tested as per IS: 5509. A Flame of LPG was allowed to play on the surface of coated and uncoated specimen to test Ignitability .and surface spread of flame .Result shows excellent flame retardancy properties compare to conventional flame retardant coating used .From physical observation it was observed that Thick coatings insulate the treated material against high temperatures. the coating melts under the action of heat, covering the treated material with an impermeable insulating crust that deprives the wood of oxygen. However the study reveals the generation of some gases on event of fire though there was no halogen and ammonium gases and coating was intumscent in nature.

Keywords:-Polysulphide–Epoxyresin, Halogenfree novel flame retardant,IS/BS Specifications,intumscent .

I. INTRODUCTION

A survey of the literature shows that one of the main limitations of using wood based panal products for industrial and institutional applications is their flammability, as wood is a naturally growing material that consists mainly of combustible organic carbon compounds. Woodbased panal products like plywoods are widely used nowadays, especially in buildings, furniture, and cabinets. Fire-retardant treatment of plywood and other wood panal products is therefore a crucial part of public and commercial building design for decades.

However, only limited fire resistance can be achieved in wood, because no wood material is completely fireproof.[1].Wood is one of the most sustainable, aesthetically pleasing and environmentally benign materials.

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The demand to use wood and wood-based products for applications in both residential and non-residential building construction has been increasing over recent years. However, due to the inherent flammability of such products, they often contribute to unwanted fires, resulting in numerous injuries and fatalities. The use of wood is, therefore, limited by various safety requirements and regulations pertaining to its flammability and spread of fire characteristics. [2].Many studies have investigated the effectiveness of various fire retardant treatments on wood and wood particleboards. For example, the use of a solution containing urea, phosphoric acid, and ethanol as a fire retardant for wood resulted in excellent fire retardation . Flame-retardant impregnants based on alkaline silicates to treat wood and obtained high fire-retardant efficiency as well as high water insolubility.[4] A mixture of ammonium sulphate, diammoniumphosphate, borax, boric acid, and ammonium bromide was used as fire-retardant agent to treat recycled wood-waste particles prior to use in particleboards manufacture[5]. The fire performance and decay resistance of solid wood evaluated and plywood treated with quaternary ammonia compounds and common fire retardants. Heat release rates were lower for treated than untreated specimens.[3] The most important properties of flammable material are time to ignition, heater lease rate, extinction flammability index and thermal stability index, mass loss, smoke toxicity, limiting oxygen index, surface spread of flame and fire resistance .Among the many polymeric materials used, epoxy resins are one of the most problematic: they are used in sectors such as electronics or public transportation, where standards are particularly restrictive. Unfortunately, they tend to burn easily while releasing high quantities of smoke and gases [8].

While halogen-containing chemicals can make effective retardants, the potential that they have for emitting toxic fumes has led users to seek alternatives. In the search for effective halogen-free solutions there is a large focus on char-forming organophosphorus[4]compounds.In the present study, the effort for enhancing the reaction to fire of epoxy-polysulphide based fire retardant coating has been further developed and innovative solutions have been looked for. This review focuses on the most recent developments in this field and the reported literature has been selected in order to cover the major trends in the flame retardancy of epoxy-polysulphide based coating materials. This object is achieved by a flame-retardant coating of the type described at the outset which forms an insulating layer,

which comprises a melamine polyphosphate as blowing agent and as substance forming a foam layer.

II. MATERIALS AND METHODS

A. Materials

Veneers of guarjan (Diptocarpus sp.)of thickness 1.8 mm as core and having thickness 0.3 – 0.5 mm as face veneers were cutting into 30 X 30 cm size, the average moisture content after drying and before manufacturing of plywood was maintained to 6 to 8 percentage. Commercially produce phenol formaldehyde was used as adhesive for manufacturing of plywood with suitable extender and filler as an additive. 250gm to 300gm glue was applied on the core veneer on D.G.L..Epoxy resin (5452) with hardener MH85 was fromMarshal Polymers, Kolkata – 700 036 and Poly sulphide resin from Anabond Limited, Kolkata – 700 029 was taken for experimental work.

B. Preparation of Specimen

12 mm plywood was manufactured by using Gurjan Sp. as core and face veneer in 75Ton Hydraulic hot press. The plywood specimen were conditioned for 07 days to achieve equilibrium mixture at 23^0C and 50% RH before coating were applied.Specimens were conditioned for again 07 days after coating. The initial weight and thickness was recorded before coating and after coating to assess the coverage and thickness of the coating .

C. Coating formulation

Poly sulphide-Epoxy based fire retardant coating was developed by mixing both resin with hardner and other fire retardant additive to improve the fire retardancy properties. The additive route has always been widely used to fire-retard polymers, in particular epoxies. It is generally a cheap and easy way of achieving sufficient levels of flame retardancy.

D. Incombustibility test

The untreated and fire retardant coating treated plywood were tested according to IS:5509:2000. To assess the fire retardancy properties of the plywood after coating, flammability, Flame Penetration, and Rate of Burning was carried. All the test has been carried as per IS: 1734 (Part - 3).

III. EQUIPMENT

IV. RESULT AND DISCUSSION

A. Effect of fire retardant coating on incombustible properties :-

It has been observed that in the presence of heat or flame the coating puffs up (intumesces) and forms a thick, sponge like cellular foam layer, this foam layer insulates the substrate reducing the penetration of heat, thus retarding the flame spread and delaying structural failure. The results of fire retardancy complies with the requirement of IS ;5509(Tab - 3) ..Coating dries by evaporation to a tough, flexible, matte finish and does not leach(lose fire retardancy) on exposure to damp environment. While a single coat of the fire retardant coatings only produced a minimum gain of 60s, a gain of 1200s was achieved with multiple coats in terms of flammability tested as per IS:5509:2000. As expected, the fire resistive coatings provided more protection than the fire retardant coatings. A high thickness coating appx.5 mm epoxy – polysulphide coating was provided and kept for burning test, 20% of treated plywood was observed after 1800s of a 300 x 300 x 12mm treated coating plywood which shows a marked improvement compared to uncoated plywood.. The improvement in tire resistance provided by the coating depended upon the type and thickness of the coating and the thickness of the plywood. The amount of smoke released from wood burning was measured. Unsatisfactory smoke developed index was observed which need to be improve. The physico-mechanical properties of the coated plywood shows there is no noticeable change in mechanical properties value then uncoated plywood, however results complies with the requirement value of IS:5509:2000.

V. CONCLUSIONS

In conclusion since a wide range of fire retardant treatment and coating systems for wood have been studied throughout recent years andmany others are currently under development and Combinations of phosphorus and nitrogen continue to prove themselves as very powerful solutions for wood-based applications, whileEpoxy-polysulphide based materials which are having fire resistance capability shows good flame retardancy properties.The addition of a fire retardant additive containingmelamine, pentaerythritola, silicate mixtureimproves flammability properties, For specifications on rate of coverage and properties, a manufacturer should be consulted. These products can be applied by brush, roller, or sprayer. Because fire-retardant coatings are high viscosity (thick) liquids, they should be maintained at room temperature, especially when spray applied, to ease application. These coatings, are generally used for architectural woodwork applications .

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Table no. 1 - Properties of synthesized Phenol formaldehyde resin

Gel Time (minutes)	Flow Time (B4 cup) (seconds)	Solid content (%)	Water tolerance	pH	Free phenol (%)
22	22	48	1:4	10.14	0.20

Table no. 2-Coating Formulation

Type of Material	Quantity
Epoxy resin /Hardner	48 Parts
Polysulphide resin/Hardner	20 parts
Fire retardant Additive (Mixtur of MAP, Pentaerithritol, melamine and boron compounds with filler.)	18 parts and and to100 parts by weight of thickener, fillers,.

Table no. 3

Samples	No. of Coats	Dry coating thickness(mm)	Flame penetration(min)	Flammability(min)	Burning(min)
A(untreated)	----		32	22	14
B(treated with single coat)	01	0.1	45	34	18
C(treated with single coat)	02	0.2	58	43	20
D(treated with single coat)	03	0.3	62	49	21
E(treated with single coat)	04	0.4	67	52	21
F(treated with single coat)	05	0.5	70	58	22

Table: 4-Physico-Mechanical properties of the plywood after coated

Sl. No.	Sample Type	Average Glue Shear Strength						Static Bending				Tensile Strength, N/mm2	
		Dry State		Wet State		Resistance to Mico-organism		MoR, n/mm2		MoE, N/mm2			
		Load, N	Wood Failure, %	Load, N	Wood Failure, %	Load, N	Wood Failure, %	Along	Across	Along	Across	Along	Across
1	A	1270	70	760	60	730	55	39.44	32.67	4895	2948	31.25	30.22
2	B	1220	75	980	65	1025	60	40.28	38.26	7215	5506	56.22	31.24
3	C	1440	70	806	60	740	55	44.53	37.08	5057	2945	35.84	34.27
4	D	1310	70	880	60	790	55	46.14	31.67	5262	3242	31.64	42.95
5	E	1420	75	900	65	935	60	46.65	40.75	8657	3267	58.62	30.56
6	F	1420	80	960	65	960	60	45.82	41.28	7155	3232	47.22	42.88