FIRE RETARDANT LIGNIN BASED ADHESIVES FOR WOOD BASED MATERIALS

Dr. N.K. Saxena and Mrs. Abha Mathur of Fire Research Laboratory, CBRI, Roorkee and Dr. D.R. Gupta, Professor Deptt. of Chemistry, University of Roorkee are familiar to readers of "The Fire Engineer." This remarkable team of Scientists who have devoted much of their energies for fire research, present in this paper the great need and feasibility to develop fire retardant adhesives derived from black liquor a by-product of paper industry - which goes to waste at present.

Editor.

INTRODUCTION

The use of wood based panel products like plywood, particle board and fibre board etc. is increasing day by day. These materials are manufactured by using wood and agricultural wastes by bonding with a suitable binder under appropriate conditions of temperature, pressure and catalyst. There are two main aspects to be considered while using these materials i.e. the combustible nature of the product and the cost of adhesives. Synthetic resins namely urea-formaldehyde (UF) and phenol formaldehyde (PF) are main adhesives of wood panel industry. The advantages of UF resins are their low cost and short curing times. However, the glue-line does not remain waterproof. On the other hand, although PF resins are weather resistant, these are quite expensive.

Therefore, there is an urgent need for developing a cheap adhesive which may also be fire retardant in wood based panel industry. The present communication reviews the potentiality of developing cheaper fire retardant adhesives from indigenous phenol rich materials for wood based products.

SOURCE OF LIGNIN

Lignin is generally obtained as a by product from wood during paper pulping process. Its major source is black liquor from paper industry. Paper mills largely use bamboo, hard woods and agricultural wastes for pulp and paper production. During pulp and paper making processes, only 50% of the lignocellulosic material is converted into the final product while the rest 50% is present in the black liquor. In India, about two million tonnes of wood is pulped every year yielding about 0.4 million tonnes of black liquor (solid basis). Any yield in terms of thiolignin may be taken as 80,000 tonnes. Presently black liquor is either burnt or dumped into water-ways creating pollution hazards. This drainage of black liquor is a waste of valuable organic matter containing mainly lignin. There is hardly any unit in India which exploits a gainful use of black liquor which is a good source of lignin.

R AND D ACTIVITIES IN THE FIELD OF DEVELOPMENT OF BINDERS BASED ON BLACK LIQUOR AND ISOLATED LIGNIN

Research work on the chemistry and technology of black liquor and lignin has amply established that these are versatile raw materials with vast potential for commercial developments with numerous applications in the field of oil well drilling muds, cement and concrete additives, grinding aid for portland cement, air entraining agent, emulsifiers and stabilizers, ore flotation and binders.

Lignin being phenolic in nature can replace phenol in the production of various resins resulting in production of cheaper resins. Black liquor and isolated lignins have been used in the preparation of a large number of resins and resinous compositions offering possibilities as a substitute for phenol in the development of phenol substituted resins. There are several references to crosslinking reaction between Kraft lignin and chemicals such as epoxies, ethylenimines and formaldehyde. Abe, Isao pre-

pared a resole type resin by reacting lignins with phenol and formaldehyde. The properties of a lignin resin as a binder for particle board/-plywood were also studied. Ivanenko prepared lignin-phenol formaldehyde resin by replacing 30% phenol from the PF resin and used as an adhesive in plywood industry. Rieche and Redinger have condensed lignin with phenol in the presence of H_2SO_4, obtaining a product which can be further condensed with formaldehyde and sodium hydroxide. A thermosetting resin is obtained, claimed to be suitable for laminating fibrous material. Naryanamurti and co-workers developed phenolic resins by utilising the lignins obtained from bark, decayed wood and agrowastes. The resin so developed have been utilized for producing plywood of BWR (boiled water resistant) grade. Nam.ch. Maku has studied the properties of resin afforded from lignin phenol and formaldehyde. They prepared resins by different methods under different conditions and taking different proportions of components with a view to study the bonding strength. E. Roffael et.a. studied lignin containing PF resins as adhesives for gluing veneers. They used sulphite waste liquor in combination with alkaline phenolic resins. K.C. Shen studied spent sulphite liquor modified with a strong mineral acid to be used as a resin binder for producing exterior grade of wafer boards.

Kaj G. Fross developed a lignin based adhesive for particle board or plywood. In this adhesive, high molecular weight lignin derivatives are isolated from spent black liquor. They are copolymerized during the hot pressing stage with PF resin. John L. Phillippou et al studied the properties of the particle boards prepared by bonding with hydrogen peroxide and then crosslinking was carried out with a mixture of ammonia lignosulfonate, furfural alcohol and maleic anhydride. Chia M Chen successfully synthesized copolymer resins of phenol formaldehyde and chemicals including lignin from the forest and agricultural wastes. The resultant copolymer resins were evaluated for their bonding property in gluing the plywood. Sehgal V.K. and Shah R.S. revealed that phenol-lignin-formaldehyde resin could be developed with 66% replacement of phenol with black liquor, for making boiled water resistant plywood.

R AND D ACTIVITIES IN THE FIELD OF FIRE RETARDANCY OF LIGNIN AND ADHESIVES

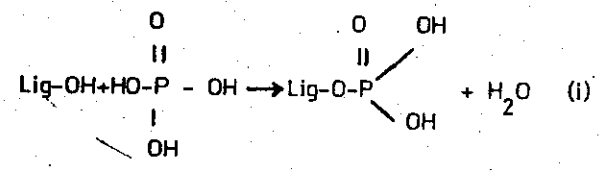
Esters of lignin were prepared by reacting with phosphoryl or thiophosphoryl halides and phosphorus oxides. They have been claimed as flame retardants for paper and textiles. Lignosulphonate solutions have been chlorinated to yield compositions suitable for flameproofing and fungusproofing of wood. Horguchi and Shojiro reported that the reaction products of sodium lignosulfonates or lignosulfonic acid or lignin with urea and in some cases with H_3PO_4 were useful as fire proofing agents for wood, paper, rubber, plastics and textiles. Pershina and co-workers found that the hydroxyl groups of lignin and lignin derivatives enter into transesterification reactions with dialkyl chlorothiophosphate to give insecticidal compositions such as o-methyl-oethyl-o-lignin thiophosphate and o-o-diethyl-o-nitro-lignin thiophosphate. In addition to insecticidal properties, the resulting compounds may possess fire retardant properties due to the presence of sulphur phosphorus and nitrogen. Although several reviews, monographs and publications have appeared on the utilization of black liquor and lignin for the development of adhesives suitable for the production of particle board/plywood, no major break-through has been achieved in the field of fire retardancy of lignin and lignin based adhesives and their applications on a large scale.

FURTHER SCOPE AND PROSPECTS OF INVESTIGATIONS

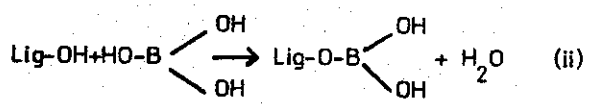
A brief literature survey reveals that synthetic resins namely UF and PF are widely used for making plywood and particle boards. These resins (particularly PF) are quite costly in India. Due to their high cost, wood based panel industries have not been fully developed. Therefore, there is a great need for the development of a cheap and effective resin/binder for wood panel industry.

Another area which has not been much explored is to develop resins possessing fire retardant characteristics. If the materials like plywood, particle board etc. which are extensively used in buildings are rendered fire retardant, huge losses of life and property can be minimized.

Lignin being phenolic in nature can replace phenol in the production of various resins. The hydroxyl groups of lignin molecule can be esterified with phosphoryl thiophosphoryl halides and amides of trivalent phosphorus, boric acid phosphoric acid and urea to obtain products with fire retardant characteristics. Aminated lignin may be react with tetrakis (hydroxy methyl) phosphonium chloride to produce fire retardant materials. Chloro or bromo products obtained from black liquor or lignin can be used to achieve fire retardancy: (equations 1-3).



(i)



(ii)

$$Lig\text{-}OH + P(OC_2H_4X)_3 \rightarrow Lig\text{-}O\text{-}P(OC_2H_4X)_2 + HOC_2H_4X$$

X = Cl or Br

Thus there is plenty of scope for research in the economic development of lignin based fire retardant adhesives suitable for making particle boards and plywood with improved fire retardant characteristics.

CONCLUSION

Wood based panel products are very much used in buildings for diverse applications. These materials are highly combustible and pose great fire hazard. The resins used for making these products are also very costly in India. Therefore, there is a great need for the development of cheaper wood based products with fire retardant properties.

Black liquor which is a by-product of paper industry is a very good and cheap source of lignin and may be utilised in developing inexpensive adhesives. Black liquor or lignin may be phosphorylated and halogenated to impart fire retardancy to the resulting resin, thereby, reducing the burning characteristics of the materials.

Such investigations may prove extremely useful due to the following two main reasonst

i) Black liquor which presently poses disposal and environmental pollution problems can profitably be utilized to obtain cheaper as well as fire retardant adhesives.

ii) Materials i.e. plywood particle board etc. having improved fire performance can be developed. Thus, fire hazards may be reduced and consequently loss of life and property can be minimized.

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