STUDY ON SUBSTITUTION OF CONVENTIONAL EXTENDER/FILLER WITH XTRA BOND OF DIFFERENT GRADES

Sponsored By

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1.0 Abstract

The present study relates the efficacy study of the XTRA BOND used as extender/filler for both amino and phenolic resin in plywood industries in bond quality particularly to improve viscosity and stability properties during the manufacture of plywood and other wood based panel products. In this study four different types of XTRA BOND used as extender/filler which are being widely used in plywood industries in synthetic resin were taken in order to evaluate the efficacy of each extender/filler. The extender/fillers were analyzed for physical and chemical properties like pH and ash content etc. These extender/filler are basically a mixture of portentous, starch and lignocellulosic material out of which two were selected as direct hot pressing and other two were selected as pre pressing quality. Each extender/filler was selected for 1 to 6 percent concentration level on the weight of liquid phenol formaldehyde and urea formaldehyde resin for efficacy study. 12 mm plywood was manufactured by using individual extender/fillers using both amino and phenolic resin. Veneers of Dipterocarpus sp. (Gurjan) were taken in this study for manufacture of plywood. The plywood was tested for glue line durability by dry, wet and mycological test. Data reveals that incorporation of three percent concentration level on the liquid resin weight basis gave satisfactory results on bond quality and flow time, coverage etc. At 5 to 6 percentage concentration level, it showed excellent results on bond quality. For higher concentration level, boiling water resistance, glue shear strength, wood failure and mycological test showed unsuitability for bonding in higher grade of plywood.

2.0 Introduction

Wood Adhesives are classified into two types i) Natural(Starch, dextrin, protein glue, vegetable & animal glues) ii) Synthetic (Thermosetting and thermoplastic resin). Because of the expensive nature of these adhesives, certain materials are often added to reduce the cost of adhesive and also impart special effects on the mixture. These materials are called additive and are classified as fortifier, extender and fillers. These materials are inexpensive and therefore used to cut down the high cost of this synthetic resin. Depending on the nature of the resin, additive and wood species the additive normally make up about 14 percent of the total cost of the adhesive mixture. But taking all together the cost component of adhesive is paramount to manufacture process of plywood.

Adhesive formulations are frequently based on room and high temperature curing for synthetic resins such as phenol-formaldehyde, phenol-resorcinol-formaldehyde, urea-formaldehyde, urea-melamine-formaldehyde, and polyvinyl acetate glues. These resins are extended with additives which can have some adhesive properties in addition to the capable of controlling viscosity or other rheological properties of the formulation. Fillers used in North American structural-plywood adhesives often contain up to 80 percent carbohydrates and therefore they are often referred to as "Extenders". Fillers and extenders are the materials added to synthetic resin adhesive to improve their spreading characteristic to control excessive adhesive penetration into the substrate and to reduce the amount of primary binder required per unit area. The material may be organic or inorganic. In the wood bonding industry, the conventional adhesive extender used is wheat flour. Wheat flour prices have tripled in recent years and supply is getting difficult as it is mainly used as food material. Fillers used are usually the powder of corn cobs, tree barks or walnut shells. Their supply is inconsistent and their prices have also increased rapidly. Wheat flour is used in the art of adhesives as an extender in urea-formaldehyde plywood glues it can represent, for example 25 percent by weight of the total glue. Since wheat flour is a staple foodstuff, it is a relatively expensive ingredient for glue mixes and its availability varies with the world commodities market. A less expensive substitute for wheat flour which will perform similar to wheat flour in such glue mix is therefore desirable for plywood manufacturing and other adhesives applications. The search for a substitute extender

and filler material becomes one of the most important tasks to the plywood and laminating industries.

XTRABOND, a local material formulated by mixing starch, proteineous and lignocellulosic material as an extender in adhesive mix for plywood manufacture developed by M/s Mridul Chemicals Pvt. Ltd, Kolkata, West Bengal. In this study the above material is taken for efficacy study as an extender/filler for adhesive mix for manufacture of plywood.

The basic requirements for an extender to be used successfully in synthetic resin mixes compounded as adhesive for the assembly of multi-layer plywood and other laminates are as follows:

(a) Adequate commercial availability of the extender to fill the large tonnage requirements of the consuming plywood glue mixers at all the times.

(b) The development of predictable and uniform rheological properties of glue mixes by the extender used in the mix under varying plant operating conditions, including changes in atmospheric environment.

(c) The extender must be free of toxic substances harmful to humans and free must be of oversized particles especially those of an abrasive nature. Abrasive extenders dull mill cutting tools and saws.

(d) There must be complete compatibility of the extender with all compounding ingredients used in the synthetic resin adhesive composition.

(e) Although there has been small quantities of extenders offered for use in the plywood industry that contain substantial percentages of inorganic such as clays but extender formulators prefer raw materials of organic origin.

(f) Extenders used in adhesive formulation usually have either an accelerating or decelerating effect on the rate at which glue lines are cured under temperature and pressures applied during the pressing of the assembled plies. Extenders that accelerate the curing time are desired so the rate of production will be increased throughout the pressing stage.

(g) Any organic material used in any extender that is edible by rodents is objectionable. An extender must not attracted by rats, mice or other rodents.

(h) The physical and chemical properties of an extender must remain uniform and unchanged when stored for longer periods of time in commercial packages. Some extenders absorb excess moisture at high atmospheric humidity.

(i) The mixing of aqueous synthetic resin glue compositions is accomplished commercially with a variety of mechanical mixer types that are generally classified into two varieties, viz high shear or low shear. High shear mixing machinery is preferred in the plywood industry. The extender being mixed into the glue solution must not cause foaming or dusting. The extender should also mix and disperse readily into the glue solution in short periods of time. Flocculation, coalescence, or separation of the extender in mixed glues causes settling and clogging in the glue during transportation system which is unacceptable.

(j) The finished glue adhesive is applied to core wood used in plywood assembly by three methods of application, viz roll, spray or curtain coating. Roll coating is now limited to a few plywood mills. Spray coating is most popular followed by curtain coating, a strong competitor. Extenders are known to form discontinuous patterns in spray and curtain application systems. Known in the industry as "throw-out" or "blips" such interruptions disturb the continuity of spray and curtain patterns and cause no uniform glue distribution over the surface of core wood. Such conditions cannot be tolerated in plywood assembly systems.

3.0 Scope and Objectives

Amino and Phenolic Resin are normally used as synthetic adhesive in plywood industries for manufacture of plywood as per different Indian Standards. In plywood industries, adhesive mixed is composed of synthetic resin filler or extender and various other additives depends upon resin and grade of plywood. Formulations with regards to the incorporation of various additives such as catalyst, buffers, preservatives etc. have been fairly standardized. However other important components of adhesive formulations such as filler and / extender vary considerably. This is mainly due to the availability of filler / extender time to time, bond efficiency and cost component. Some of the filler / extenders which have been used / being used are proportionate soya flour (CSF). Tamarind seed powder (PSP), Ground nut cake powder (GNCP), De oiled

maize gluten etc. The use of some of the extenders and / fillers has been considerably reduced or stopped either due to poor performance of these materials to meet the requirement of relevant standards specifications amended to produced better quality. Hence studies on the suitability of new fillers/ extender are a must. The main objective of the project work was to study the efficacy and suitability of XTRABOND a local material formulated by M/s Mridul Chemicals (P) Ltd., West Bengal as an extender/ filler in adhesive mix for manufacturer of plywood and other wood based panel products.

4.0 Literature Review

Wood adhesive extenders are amylase compounds with some protein content that have adhesive action and contribute to the rheological properties of the glue mix. The physico-chemical properties of these extenders are very important to establish. For instance, high ash, high crude fat and high fiber contents pose unpredictable viscosity problems and increase wash water requirement. Protein has been found to influence the water taking capacity of flour (Robertson, J 977).

To reduce costs, synthetic glues are mixed with an extender that can be either imported maize starch (US$650/tons) or food grade wheat flour (US$500/tons). Typically 50 kg of synthetic glue will make 55-60 *1/8"* plywood sheets, with an extender th is increases to 80-85 sheets of *1/8"* plywood sheets. For each 50 kg batch (of synthetic glue), either 10 kg of maize starch or 25 kg of wheat flour is required (Graffuam *et al. 1997).*

Proteinaceous and amylaceous materials are most often called extenders because they can enter into the matrix of the binders. Fillers in North American structural-plywood adhesives often contain up to 80 percent carbohydrates; therefore, they are often referred to as "extenders." Fillers are extensively utilized in adhesives and sealants, coatings, plastics, medicines, and cleaning compounds (Sellers 1994).

One of the main changes that has occurred in wood construction in the last 50 years has been the adoption of glue technology, to bond structures together and to make wood available in a more stabilized, laminated sheet form as plywood. Plywood mills in India use maida/wheat flour as extender in the adhesive mix for plywood production. Maida and Wheat as a commodity is not grown in India and is therefore imported. Its market price keeps soaring up because it has various

uses. It is used in India as a food source particularly for bread and pastries making in addition to its use as extender in plywood mills.

Authors like Narayan Murti et al (1943, 1962), Jain, et al (1963, 1975), Narayan Prasad, et al (1969, 1976), Roy, et al (1971), Mohan Das, et al (1976) has reported the used of various materials such as casein, Ground nut cake powder, Lignin rich materials, paddy husk gel, Tamarind seed powder, Deoiled maize gluten in various form into adhesive formulations based on PF resin for bonding BWR plywood. Raghunath Rao, et al, (1993) have review the effect of commonly used protinious and sturch based fillers and extenders on phenolic resin bonded plywood. Naha, et al (1995) have studied the utilization of various oil seed cakes flours such as Iarati, Mahua, as extenders for UF and PF resin for bonding different grades of plywood.

5.0 About The Product

XTRA BOND EXTENDER

XTRABOND UF / PF is a proven glue extender for the plywood industry. XTRABOND as extender increase initial glue mix viscosity while maintaining stable viscosity over extended periods of time. Both XTRABOND UF/PF extenders are manufactured from different types of starches ground to rigid specififfications resulting in maximum uniformity from bag to bag.

When using XTRABOND UF/PF, the critical properties of the adhesive mix are consistently reproducible resulting in stable viscosity, good pre-press characteristics, controllable penetration into the veneer and resistance to dry out. XTRABOND extender blend smoothly with the ingredients in the glue formula and they are compatible with all phenolic resins and extenders.

In addition, XTRABOND UF/PF extender provide additional benefits :

- The viscosity of the glue is increased to an optimum range within very short period of time for getting proper glue.
- The total glue mix cost is reduced as it gives more coverage in the same quantity of glue.
- Due to our raw material sourcing and handling, XTRABOND UF/PF have a low ash content, thus minimizing wear on cutting tools and spray nozzles.

- XTRABOND UF/PF are dried to a very low moisture level thereby increasing their absorption capabilities but also resulting in the delivery of more

XTRABOND extender is used primarily to reduce costs. An aqueous medium is generally a necessary ingredient when a gluten-containing extender is used in combination with a condensation-type resin adhesive as, for example, when the adhesive is spread over a surface to be glued or assembled. When such gluten-containing vegetable or grain flours are used as extenders, the amount of water required for the mix depends primarily upon the gluten content of the particular flour used.

The different grades of XTRABOND used in plywood industries in adhesive mix during manufacture are:

XTRA BOND UF - 301

XTRA BOND PF - 502

XTRA BOND PRE PRESS - 702

XTRA BOND MR – 999

6.0 Materials and Methods

6.1 Materials :

XTRA BOND of four different grades i.e. UF 301, UF MR 999, PF 502, PF 702 materials for both phenolic and amino resin was supplied by M/s Mridul Chemicals Pvt. Ltd, 7, Burnt Salt Gola Lane, 5thFloor, Flat No-5A,Howrah-711101, West Bengal. Phenol, formalin, caustic, urea etc. used for resin synthesis was collected from local market which were of commercial grade. Wood Veneer used for manufacture of plywood is Dipterocarpus spp. (Gurjan). Other chemicals used during testing were of analytical grade purchased from local market.

6.2 Methods :

6.2.1 Synthesis of UF resin:

230-250 parts by weight of formalin (Formaldehyde content 37%) was charged into resin kettle and made alkaline with 50% sodium hydroxide solution to pH 7.2 -7.5. 100 parts by weight of urea was gradually added to the kettle and stirring started. Stirring continued till the end of the reaction. Temperature was raised by passing steam and then set at 92°±2°C and kept at this temperature under agitation for 1½ - 2 hours. pH was checked time to time and maintained at 7.2 – 7.5.

In the second stage, the pH of the solution was lowered to 5.0 – 5.5 by adding 50% solution of acetic acid and reaction was continued under agitation at the same temperature. The progress of the reaction was followed by measurement of viscosity and water tolerance. For ready result, instead of viscosity, flow time of the reaction mixture was measured in B_4 cup IS: 3944-1982. Water tolerance was a measure of the number of times of weight of water which can be mixed with resin before incipient precipitate was formed. The resin was ready when viscosity is 80-100 cp or having a flow time of 22-30 seconds in B_4 flow cup and water tolerance of 3-4 times. The reaction was arrested by raising pH to 7.5 – 8.0 by adding 50% alkali and then the resin was cooled.

6.2.2 Synthesis of Modified PF resin :

Novolac resin:

100 parts by weight of phenol and 60 parts by weight of formalin (37% formaldehyde) were charged into resin kettle. Stirring started and continued till the end of reaction. 2 parts by weight of oxalic acid in 33 parts by weight of water was added in case of acid catalyzed Novolac resin. The reaction was carried out at 90±2°C for two hours. At the end of first stage reaction white insoluble product was formed which separates from aqueous layer on keeping. The resin was then cooled to 60°C.

Resol resin:

16 parts by weight of sodium hydroxide dissolved in 66 parts of water was added in case of acid catalyzed Novolac resin. 120 parts by weight of formalin (37% formaldehyde) was added

next. Exothermicity was carefully controlled at this stage. Reaction is further continued at 85°C. When viscosity of the resin is 80-100 cp or flow time 20-30 second in B_4 flow cup of IS: 3944-1982, the resin was then cooled and discharged from the kettle.

6.2.3 Formulation of adhesive mix:

Using both synthesized UF and PF resin, each plywood adhesive mix was formulated by mixing synthetic resin, hardener, buffer and XTRABOND at various concentrations from extension level from C_0 to C_6 to standardize the flow time of glue under stirring with a speed regulated stirrer (Ref Table No 2). The mixing was continued for 30 minutes until a homogeneous mixture was obtained. Viscosity of the glue after mixing was taken in B_6 Cup (IS: 3944-1982) for both amino and phenolic resin by taking four different types of extender used for both pre-press and hot pressing purposes (Ref Table No 3). The adhesive mix was taken for glue durability by boiling water and mycological test. The coverage study was carried for both UF and PF resin based adhesive mix after addition of XTRABOND. The glue shear strength in dry, wet and mycological was carried out by Tensometer for different extension level (C_0 to C_6) (Ref Table No 7 & 8).

6.2.4 Physical and chemical properties of Extender (XTRABOND) :

Each extender (XTRABOND) was evaluated for certain physical characteristics as per IS:1508 viz color, moisture content, pH, ash content etc. The size of extender was determined by sieve analyzer as per IS: 460-1962. Sieve designation 100 microns and Sieve designation 80 microns on percent basis was taken for this study. Each extender was also analyzed for fat and protein contents etc (Ref Table No 4).

6.2.5 Viscosity Assessment:

A change in glue viscosity exerts large effects on glue spreader rates. Glue mix with high viscosity is difficult to spread and leads to higher glue spread which is undesirable from quality and economic point of view. For a resin viscosity is a measure to assess the progress and extent of polymerization of the resin either during manufacture or use. In plywood industry, the actual viscosity of the adhesive are studied by use of standard flow cup. In this study the flow time of the adhesive mix was studied by B_6 (IS:3944-1982) flow cup at different concentration level of

XTRABOND using in both phenolic and amino resin. The results for standardization of flow time were given in Table No 3.

6.2.6 Lay-up and Stand time Assessment:

Since lay-up time depends on the no of plies in a panel, type of core, glue formulation, no of panel etc. and stand time depend on veneer moisture content, veneer temperature., pressure, ambient temperature and glue spread. So proper lay-up and stand time is required to maintain during manufacture of plywood. In this study lay-up and stand time for individual XTRABOND extender/filler has been studied and optimized and the time and bond quality has also been studied (Ref Table No 5).

6.2.7 Plywood Manufacture (Laboratory Scale) :

Seven ply plywood was manufactured by taking Gurjan (Dipterocarpus spp.) species as core, face and back veneer of size 2' x2' and 12mm thickness. Each adhesive mix were applied on the veneer and conditioned for moisture content up to 14% with a roller coater at a spread rate 300 – 350 gms/m^2 on both sides. The spread veneers were then pressed in a hot press at pressure 10.5 Kg/cm^2, 14 Kg/cm^2 and temperature 110^{0}C ,140^{0}C for UF and PF resin respectively for 12 minutes to get 12mm thick plywood. The total assembling time, which includes from first adhesive application to hot pressing, was taken one hour (Ref Table No 8).

6.2.8 Pre and Hot pressing Parameter Assessment :

Plywood industries usually use pre-pressed plywood panels in load-bundle fashion prior to hot pressing. Cold glue tack on the glue line sticks to the panels so the separate veneers stay together during loading of hot press pre-loaders and the hot presses which have relatively narrow openings, 30 to 50 in number. Poor pre-press tack prevents proper loading procedures and results in rejection of plywood panels. The degree of pre-press tack in part is determined by resin properties and solvent loss after adhesive application to the veneer. The time after adhesive application includes stand time without pressure and pre-press time under pressure. The adhesive mix solvent loss is influenced by extender properties, water in the glue mix, moisture of veneer, and temperature and viscosity of mix. The numerical value of pre-press properties were determined. The stand/pre-press/stand times used in the test was also studied for two extenders

viz. XTRA BOND- PF-702 and UF –MR-999 which are specially formulated for pre press technique and named as prepress hardener (Ref Table No 9).

6.2.9 Experimental Design :

In the adhesive bond quality evaluation (dry, wet and Mycological tests), a (4 x 5 x 3) factorial experiment in completely randomized design (CRD) was employed which may be defined as (4 types of extender x 5 adhesive extension levels x 3 conditions). This makes a total of 60 nos combinations study. The extender used were XTRABOND of four different grades. The extension levels were 1 to 6% based on liquid resin and the plywood pressing times were 6 and 12 minutes as per the thickness of the plywood. Adhesive mix without extender were taken as control.

6.2.10 Adhesive Bond Assessment:

The manufactured plywood were tested for boiling water resistant and boiling waterproof of plywood. Glue shear strength, résistance to micro-organism, tensile strength, percentage of wood failure and static bending strength were tested as per IS:1734-1983 for assessment of bond quality (Ref Table No 6 & 7).

5.2.11 Storage condition Study :

All the four grades of extender were kept in damped environment packed in polythene sheets of same age so as to use for commercial package for assessing the uniformity of physical and chemical properties which remains unchanged when stored for a long period of time in commercial packages both in open and sealed conditions at a temperature 27 ± 2^0C and 65 ± 5% RH. The physical observations like moisture contents, resistance termite and fungus attack were also carried out periodically.

7.0 Results and Discussion

7.1 Physical and Chemical charactistic of extender / fillers :

The ash content of extender is an important value to assess knife wear test at low ash content which shows low knife wear test and vise versa. Data of this study (Ref Table no 4) reveals the value of ash content varies from 10.6 to 12% in case of 4 types of XTRA BOND. The screen mesh size grain or particle size value of four extenders shows significant result rising from 89.4 to 90.7% as per IS : 460-1962. Sieve designation of 80 micron result clearly shows that the 4 types of extenders are suitable for manufacture of plywood for adhesive mix instead of causing glue spreader problem. Moisture content, protein and fat content result shows satisfactory results.

7.2 Adhesive Mix :

Adhesive mix for plywood manufacture using 4 types of extenders shows homogeneous mixture after mixing of 30 minutes in glue spreader. The four types of extenders doesn't shows any chemical reactions with UF and PF resin even if after mixing with hardener and buffer. So both UF and PF grade extenders of XTRABOND shows satisfactory results for adhesive mix. The concentration of adhesive mix (Ref Table No 2) from extension level C_0 to C_6 shows that the extension level C_3 i.e. 3 percentage concentration of liquid resin in both UF and PF direct hot press grade extender (UF 301 and PF 502) and the extension level C_6 i.e.6 percentage concentration of liquid resin in both UF and PF prepress grade extender (PF 702, UF MR 999) shows satisfactory concentration for glue spreader and adhesive mix viscosity after mixing properly in a glue spreader for minimum 30 minutes.

7.3 Assessment of Viscosity and physio-chemical properties :

Rheological proprieties such as viscosity can be directly co-related to the evolving physical and mechanical proprieties during the resin period. From the study (Ref Table No 3), data shows that viscosity of adhesive mix measured in terms of flow time in B_6 (IS : 3944-1982) shows satisfactory results at extension level C_3 for both UF and PF resin for smooth operation of Glue Spreader. The flow time measured in B_4 Cup for UF -301 at 3 percentage concentration in 13

seconds and for PF-502 it is 12 seconds. From the study, it has been observed that the viscosity of adhesive mix increases with increasing extension level. Solid content of adhesive mix increases as significantly as the concentration of the extender increases in the adhesive mix with satisfactory pH and pot life.

7.4 Lay-up and Stand type Assessment :

Since all gluing operation have to be completed within a giving period of time i.e. from the spreading of adhesive on veneer to the application of pressure in the assembly, so lay-up and stand time of the adhesive mix should resist within the period. Lay-up time should not be too short or too high to avoid solvent loss and time during panel assembly. From the data (Ref Table No 5), it reveals that XTRABOND mixed with adhesive mix showed significant results towards bond quality during boiling water test when total lay-up and stand time lies for 60 minutes. But it shows unsatisfactory results in terms of glue shear strength and percent of wood failure when both lay-up and stand time exceeds 60 minutes.

7.5 Adhesive bond quality Assessment:

From bond quality assessment study (Ref Table No 6, 7 & 10), data of glue shear strength (for both dry, wet and mycological), tensile strength and static bending strength values gave satisfactory results. It is also observed that there is a significant change in results of MOR and MOE of plywood samples made by EXTRABOND during pilot scale study. Glue shear strength (Dry, Wet and Mycological) lies between 800 to 2100 N range for PF resin which is also satisfactory. Data from different coverage rate, it can be concluded that at the minimum coverage 330 gms/m^2 (D.G.L) adhesive bonding strength in dry, wet and mycological gave satisfactory results for PF resin where the wood failure percentage lies between 60 to 85 % .

7.6 Pre pressing and Hot pressing Parameter:

Curing of resin by application of pressure may be effected at room temperature or may be accelerated by simultaneous heating at high temperature during application of pressure. In plywood industries, the former process is known as cold pressing and the later is known as hot

pressing and both the processes leads to curing of resin. From the study for manufacture of plywood to assess the rheological properties of extender/filler the parameters for hot pressing and cold pressing (Ref Table No 9), it shows satisfactory results especially in case of bond quality and surface finishing of plywood. The optimum parameters like temperature, pressure and time for both cold press and hot press has been optimized for both phenolic and amino resin based adhesive mix.

7.7 Storage period :

The storage condition and period of extender/filler in plywood industries refers to any number of technique which prevents the extender/filler from spoiling. Because of most of the times mites, termites and fungus requires moist environment condition for their survival or used as food material. From the study, it has been observed that the said extender/fillers(XTRA BOND) were attacked by mites and fungus after storage in open environment for a period of three months. It was turned to moist condition after absorbing moisture from the atmosphere.

8.0 Conclusion

Advantages and disadvantages of XTRA BOND used as extender/filler in PF/UF resin in plywood industries which were studied under this project may be summarized as follows:

I) It is recommended to incorporate less concentration of XTRA BOND (C_3 extension level) in comparison to used conventional extender/filler for smooth operation of glue spreader and to get better bond quality of both phenolic and amino resin bonded plywood.

II) XTRA BOND was found to be better in comparison to starch based extender with phenolic resin for manufacture of BWR, BWP plywood and other wood based panel products.

III) Glue shear strength value in dry, wet state of plywood bonded with PF and UF resin after incorporation with XTRA BOND increased however the glue shear strength value after mycological test does not gave satisfactory results. So it is recommended to incorporate anti-termite, fungicides as preservative with extender which will not affect the bond quality.

IV) Solid content of the adhesive mix is also very significant which influences the bond quality.

V) Coverage obtained with PF/UF resin extended with XTRABOND is similar to the commonly used extenders which are used in the industry for manufacture of various grades of plywood.

VI) Adhesive consistency and adequate keeping quality of PF/UF resin adhesive extended with XTRABOND in comparison to other proteineous extenders which helps easy and uniform spreading of adhesive on the veneers with the help of mechanical glue spreader and thereby esuring uniform bond quality of plywood.

VII) XTRA BOND in resistant to boiling water test appears to be more severe compared to resistance to micro-organism.

VIII) Higher percentage of XTRABOND in adhesive mix results in non-homogeneous adhesive dispersion thereby creating problem during its application with the help of mechanical glue spreader.

IX) On the point of economical aspect, it is also cheaper in comparison to other conventional extender when calculated on the basis of glue line. Cost .

X) It is recommended to store XTRABOND in sealed condition in dry place away from sunlight, moisture and heat to avoid further unusable condition for longer period.

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Table No 1(a): Properties of synthesized Urea-formaldehyde resin

Gel Time at 100°C (sec)	Flow Time (B4 cup) (sec)	Solid content (%)	Water tolerance	pH	PH of Cured film	Free formaldehyde (%)
69	20	48	1:3	7.2	2.62	0.90

Table No 1(b) : Properties of synthesized Phenol formaldehyde resin

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

Table No 2(a) : Adhesive mix with different concentration of XTRABOND grade UF 301

Component	Parts by weight (Pbw)						
	Level of concentration (%)						
	C_0	C_1	C_2	C_3	C_4	C_5	C_6
UF Resin Liquid 48% solid	200	200	200	200	200	200	200
Extender	0	2.0	4.0	6.0	8.0	10.0	12.0
NH_4Cl	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Liquid NH_4	1.6	1.6	1.6	1.6	1.6	1.6	1.6

Table 2(b) : Adhesive mix with different concentration of XTRABOND grade UF MR 999

Component	Parts by weight (Pbw)						
	Level of concentration (%)						
	C_0	C_1	C_2	C_3	C_4	C_5	C_6
UF Resin Liquid 48% solid	200	200	200	200	200	200	200
Extender	0	2.0	4.0	6.0	8.0	10.0	12.0
NH_4Cl	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Liquid NH_4	1.6	1.6	1.6	1.6	1.6	1.6	1.6

Table 2(c) : Adhesive mix with different concentration of XTRABOND grade PF 502

Component	Parts by weight (Pbw)						
	Level of concentration (%)						
	C_0	C_1	C_2	C_3	C_4	C_5	C_6
UF Resin Liquid 48% solid	200	200	200	200	200	200	200
Extender	0	2.0	4.0	6.0	8.0	10.0	12.0

Table 2(d) : Adhesive mix with different concentration of XTRABOND grade PF 702

Component	Parts by weight (Pbw)						
	Level of concentration (%)						
	C_0	C_1	C_2	C_3	C_4	C_5	C_6
UF Resin Liquid 48% solid	200	200	200	200	200	200	200
Extender	0	2.0	4.0	6.0	8.0	10.0	12.0

Table 3(a) : Properties of adhesive mix with XTRABOND (UF 301)

Properties	Level of concentration (%)						
	C_0	C_1	C_2	C_3	C_4	C_5	C_6
Flow time of adhesive mix in B6 flow cup in seconds	19 (in B_4 cup)	9	10	13	15	16.5	18
Solid content of adhesive mix(%)	48.0	49.4	50.5	51.6	52.4	53.2	53.8
Adhesive pH	6-6.5	6-6.5	6-6.5	6-6.5	6-6.5	6-6.5	6-6.5
Pot life (hrs)	> 6	> 6	> 6	> 6	> 6	> 6	> 6

Table 3 (b) : Properties of adhesive mix with UF MR 999

Properties	Level of concentration (%)						
	C_0	C_1	C_2	C_3	C_4	C_5	C_6
Flow time of adhesive mix in B6 flow cup in seconds	19/B_4	10	12	16	19	21	24
Solid content of adhesive mix (%)	48.0	49.2	50.4	51.4	52.3	53.6	54.1
Adhesive pH	6-6.5	6-6.5	6-6.5	6-6.5	6-6.5	6-6.5	6-6.5
Pot life (hrs)	> 6	> 6	> 6	> 6	> 6	> 6	> 6

Table 3 (c) : Properties of adhesive mix with PF 502

Properties	Level of concentration (%)						
	C_0	C_1	C_2	C_3	C_4	C_5	C_6
Flow time of adhesive mix in B6 flow cup in seconds	22/B_4	9.5	10.5	12.0	13.5	15.0	17.0
Solid content of adhesive mix (%)	48.0	49.1	50.2	51.3	52.5	53.3	54.6
Adhesive pH	10-10.5	10-10.5	10-10.5	10-10.5	10-10.5	10-10.5	10-10.5
Pot life (hrs)	> 8	> 8	> 8	> 8	> 8	> 8	> 8

Table 3 (d) : Properties of adhesive mix with PF 702

Properties	Level of concentration (%)						
	C_0	C_1	C_2	C_3	C_4	C_5	C_6
Flow time of adhesive mix in B6 flow cup in seconds	22/B_4	11.0	12.0	17.0	19.0	21.0	22.5
Solid content of adhesive mix (%)	48.0	49.6	50.4	51.3	52.1	53.2	54.1111
Adhesive pH	10-10.5	10-10.5	10-10.5	10-10.5	10-10.5	10-10.5	10-10.5
Pot life (hrs)	>8	>8	>8	>8	>8	>8	>8

Table No 4 : Physical and Chemical characters of XTRABOND

Physical and chemical properties	Type of XTRA BOND			
	UF -301	UF-MR-301	PF-502	PP-702
Color	Off white	Off white	Off white	Off white
Fitness to Granules (%)	90.1	90.7	89.4	88.4
Moisture content (%)	2.71	2.64	2.36	2.86
Ash Content (%)	10.94	10.68	12.14	11.16
Fat Content (%)	2.3	2.4	1.8	0.94
Protein Content (%)	11.3	13.26	14.96	16.28

Table No 5 : Lay- up and stand time standardization

Sl no.	XTRABOND grade	Level of concentration	Flow time in B_6 flow cup (sec)	Lay out time (min)	Stand time (min)	Quality	
						Cyclic test	% wood failure
1	UF301	C_3	13	20	15	Pass standard	85
				30	15	Pass standard	85
				45	15	Pass standard	75
				60	15	Failed	40
				75	15	Failed	40
2	UFMR999	C_6	24	20	15	Pass standard	85
				30	15	Pass standard	85
				45	15	Pass standard	75
				60	15	Failed	40
				75	15	Failed	40
3	PF502	C_3	12	20	15	Pass standard	85
				30	15	Pass standard	85
				45	15	Pass standard	75
				60	15	Failed	40
				75	15	Failed	40
4	PF702	C_6	22.5	20	15	Pass standard	85
				30	15	Pass standard	85
				45	15	Pass standard	75
				60	15	Failed	40
				75	15	Failed	40

Table No 6 : Effect of coverage on Glue Shear Strength with respect to coverage spread = 350± 10 gms/m^2 DGL

Type of XTRABOND	Concentration Level	Coverage / m^2 DGL/kg Liquid PF resin 50 % solid	Average Glue Shear Strength					
			Dry State		Boiling		Resistance to Mico-organism	
			Load (N)	Wood Failure (%)	Load (N)	Wood Failure, %	Load (N)	Wood Failure (%)
UF301	C_0	5.60	1368	65	729	55	658	50
	C_1	5.61	1391	65	741	55	672	50
	C_2	5.72	1425	65	768	55	691	50
	C_3	5.79	1449	70	785	60	709	55
	C_4	5.83	1465	70	802	60	724	55
	C_5	5.90	1494	70	831	60	739	60
	C_6	5.94	1506	70	848	60	752	60
UFMR999	C_0	5.60	1372	65	757	55	692	50
	C_1	5.61	1395	65	786	55	718	50
	C_2	5.72	1431	65	802	55	739	50
	C_3	5.79	1452	70	837	60	752	55
	C_4	5.83	1473	70	864	60	776	55
	C_5	5.90	1502	70	881	60	789	60
	C_6	5.94	1517	70	908	60	805	60
PF502	C_0	5.54	1765	75	1025	60	814	60
	C_1	5.59	1827	80	1084	60	837	60
	C_2	5.65	1905	80	1108	60	857	60
	C_3	5.70	1995	80	1134	65	881	65
	C_4	5.76	2010	85	1175	65	906	65
	C_5	5.81	2070	85	1192	65	934	70
	C_6	5.87	2087	85	1214	65	942	70
PF702	C_0	5.54	1790	75	1062	60	838	60
	C_1	5.59	1852	80	1081	60	861	60
	C_2	5.65	1894	80	1103	60	882	60
	C_3	5.70	1942	80	1147	65	904	65
	C_4	5.76	1987	85	1182	65	927	65
	C_5	5.81	2059	85	1227	65	967	70
	C_6	5.87	2104	85	1272	65	992	70

Table No 7 : Effect of coverage on Glue Shear Strength with respect to coverage spread = 300 ± 10 gms/m^2 DGL

Type of XTRABOND	Concentration Level	Coverage / m^2 DGL/kg Liquid PF resin 50 % soln.	Average Glue Shear Strength					
			Dry State		Boiling		Resistance to Mico-organism	
			Load (N)	Wood Failure (%)	Load (N)	Wood Failure, %	Load (N)	Wood Failure (%)
UF301	C_0	6.52	1341	65	708	55	616	50
	C_1	6.58	1381	65	726	55	647	50
	C_2	6.65	1409	65	738	55	667	50
	C_3	6.71	1432	70	769	60	691	55
	C_4	6.78	1450	70	781	60	706	55
	C_5	6.84	1474	70	804	60	720	60
	C_6	6.91	1499	70	823	60	747	60
UFMR999	C_0	6.52	1354	65	721	55	672	50
	C_1	6.58	1372	65	749	55	692	50
	C_2	6.65	1412	65	783	55	720	50
	C_3	6.71	1437	70	804	60	739	55
	C_4	6.78	1452	70	832	60	752	55
	C_5	6.84	1487	70	851	60	761	60
	C_6	6.91	1502	70	887	60	785	60
PF502	C_0	6.44	1732	75	996	60	801	60
	C_1	6.50	1792	80	1041	60	829	60
	C_2	6.56	1857	80	1094	60	838	60
	C_3	6.63	1924	80	1108	65	859	65
	C_4	6.69	1986	85	1147	65	892	65
	C_5	6.76	2007	85	1174	65	916	70
	C_6	6.82	2041	85	1199	65	928	70
PF702	C_0	6.44	1752	75	1037	60	820	60
	C_1	6.50	1824	80	1059	60	847	60
	C_2	6.56	1867	80	1088	60	867	60
	C_3	6.63	1906	80	1117	65	894	65
	C_4	6.69	1954	85	1154	65	907	65
	C_5	6.76	2018	85	1193	65	940	70
	C_6	6.82	2084	85	1234	65	951	70

Table No 8 : Composition of the adhesive mix used to prepare 7 ply plywood (1.2 mm thick)

Adhesive mix		Board parameters for 7 ply plywood	
Component	**Parts by weight**	**Characters**	**Board Parameters(mm)**
Resin UF Liquid	200	Number of plies	7
NH_4Cl	1.0	Face longitudinal	1.0
Liquid NH_4	1.6	Cross band (cross grain glued)	2.2
Extender (Xtrabond)	3.0	Long core (Longitudinal grain	2.2
Insecticide(GLP)	0.5	Cross band (cross grain glued)	2.2
		Long core (Longitudinal grain	2.2
		Cross band (cross grain glued)	2.2
		Back (Longitudinal grain)	1.0

Table No 9 : Board Pressing conditions

Parameters	Cold Pressing	Hot Pressing	
		UF	PF
Pressure	12 kg/cm^2	10.5 kg/cm^2	14 kg/cm^2
Temperature	NA	110°C	140°C
Time	30 minutes	12 minutes	12 minutes

Table No 10 : Physico-Mechanical properties of the plywood on the basis of pilot scale using XTRABOND.

Sl. No.	Type of Extender used (%)	Average Glue Shear Strength						Static Bending				Tensile Strength, (N/mm^2)	
		Dry State		Wet State		Resistance to Mico-organism		MOR (N/mm^2)		MOE (N/mm^2)			
		Load (N)	Wood Failure (%)	Load (N)	Wood Failure, %	Load (N)	Wood Failure (%)	Along	Across	Along	Across	Along	Across
1	UF+Conv. Extender	1375	70	780	60	730	55	39.46	32.67	4895	2948	31.25	30.22
2	PF+Conv. Extender	1790	75	1180	65	1025	60	50.24	38.26	7215	5506	56.22	31.24
3	UF301	1450	70	806	60	740	55	44.52	37.08	5057	2945	35.84	34.27
4	UFMR999	1525	70	880	60	790	55	46.12	31.67	5262	3242	31.64	42.95
5	PF502	1880	75	1208	65	1035	60	56.69	40.75	8657	3267	58.62	30.56
6	PF702	1920	80	1260	65	1060	60	55.84	41.28	7155	3232	47.22	42.88

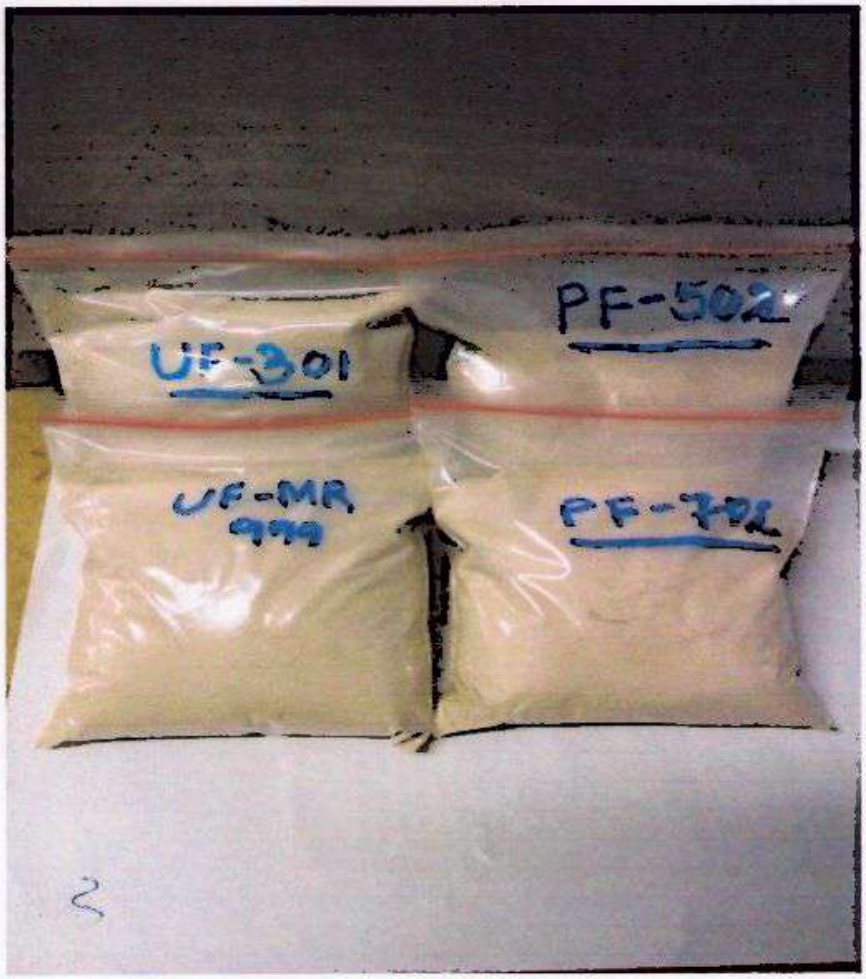

Figure 1 : Appearance of four grade XTRABOND extender/ filler for bonding plywood in PF /UF resin-adhesives.

Left to right: UF -301. UF MR-999, PF-502, PF-702