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THE USE OF NATURAL RUBBER LATEX–RESIN BLENDS AS AN ADHESIVE FOR PLYWOOD ‡

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SUMMARY

Approximately 1,300 *tons of urea formaldehyde* (*UF*) *and* 100 *tons of phenol formaldehyde* (*PF*) *resins involving a foreign exchange expenditure of* 2½ *million rupees are expected to be imported annually into Sri Lanka for bonding plywood. This project is an endeavour to substitute part if not all of this with a locally available adhesive. The basis of this work is the use of natural rubber* (*NR*) *latex-UF resin blends or of NR latex-PF resin blends as the adhesive for plywood.*

China clay or wheat flour or a mixture of both is used as the extender and it is found that a minimum adhesive total solids content of 55% *is necessary to obtain minimum plywood bond strength specifications. Formaldehyde is used as the stabilizer for NR latex as its use enables the blending of UF resin with NR latex without any coagulation of the latex and gives an acidic pH which is necessary to cause polymerization of the UF resin.*

Using NR latex-UF resin blends, it should be possible to substitute satisfactorily 2/3rds of the imported UF resins by NR. This would result in an annual saving to the Plywoods Corporation of Rs. 800,000 *and of a foreign exchange involvement of approximately* 1½ *million rupees. It also finds a new use for NR in Sri Lanka.*

Using NR latex-PF resin blends it should be possible to replace half of the imported PF resin for use in commercial plywood. This would result in an annual saving of approximately Rs. 100,000 *to the Ceylon Plywoods Corporation and of a foreign exchange involvement of approximately Rs.* 100,000.

INTRODUCTION

Plywood consists of three or some odd number of thin sheets of wood called veneers glued together face to face, alternate veneers or plies being arranged with their grain at right angles to each other and cured under pressure and heat. The success of plywood depends on effective gluing to a great extent. If the bond is badly made up or if it fails in service, the board gets reduced to a mass of splinters, for individual veneers are extremely weak (Knight, 1952).

The ratio by weight of timber to glue in plywood is 10 : 1 (Buttrey, 1964). The characteristic feature is the application of a thin layer of adhesive as thin as is practicable. Pressure is applied to ensure close and uniform contact between surfaces and a predetermined temperature and time applied with a degree of precision ensures proper curing. The main resin used by the Ceylon Plywoods Corporation (CPC) is urea formaldehyde (UF). Formulations of glue mixtures are given in Table I.

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* Ceylon Plywoods Corporation.

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TABLE 1

Formulation of glue mixtures (by weight)

	Glue formulation for tea chest panels :	
	Urea formaldehyde	— 100
	Water	— 60
	Extender (flour or kaolin or a mixture of both)	— 75
	Water	— 80
	Ammonium chloride	— 0.05
	Glue formulation for commercial plywood :	
(1)	*Ordinary* — Non water proof	
	Urea formaldehyde	— 100
	Water	— 60
	Ammonium chloride	— 0.2
(2)	*Water proof*	
	Urea formaldehyde	— 100
	Water	— 60
	Ammonium chloride	— 0.5
(3)	*Weather & Boil proof*	
	Phenol formaldehyde	— 50
	Water	— 40
	Paraformaldehyde	— 0.5

The annual requirement of synthetic resin of the CPC is approximately 1,400 tons as urea and phenol formaldehyde with their corrresponding hardeners involving a foreign exchange expenditure of 2½ million rupees. This project was designed to find whether at least part, if not all of the imported glue could be substituted with a locally available adhesive.

Since the raw materials for synthetic resin adhesives are not manufactured in Sri Lanka it is necessary to consider natural adhesives. The natural adhesives are animal glues, blood albumin, casein, sodium silicate, starch derivatives, vegetable protein derivatives and natural rubber latex. The most suitable and readily available local raw material is natural rubber (NR) latex. There is no published data on the use of NR field latex as an adhesive for plywood. However, centrifuged latex-casein mixtures have been used in the manufacture of plywood for indoor application, (Salzberg, 1962; Wake, 1967). The Ceylon Institute of Scientific and Industrial Research has also done work (Silva, 1971—private communication) on the use of compounded centrifuged ammonia preserved latex as the probable adhesive for plywood.

The usual stabilizer for field latex against bacterial action is ammonia. McGavack (1959) has recommended the use of 0.15 to 0.20% formaldehyde, and after 15 to 30 h, the addition of ammonia. In this project, formaldehyde is used alone as the stabilizer. Sodium hydroxide at 0.01% on the latex is mixed with the formalin, before its addition to the latex. The addition of a very small amount of formaldehyde kills within a few minutes (about 15 min) all the bacteria present in the tapped latex. Field latex has about 2% to 3% protein and the formaldehyde present reacts with this to form a formaldehyde-protein complex, that enhances the stability of the latex. Neutralised formaldehyde at 0.2 to 0.3% of the latex is used alone for stabilization and this is claimed by us to be a new method of stabilization. The treated latex is stable even after one year's storage.

If NR latex is used as the adhesive, it will be necessary to reinforce it to get the necessary bond strength to meet plywood specifications. Le Bras & Piccini (1951) were the first to show the possibility of obtaining direct reinforcement of latex by mixing resin dispersion or solutions of various types, to stabilized latex, these resins being preformed at a low stage of condensation. Van Alphen (1954) has described the preparation of resin/rubber masterbatches. The resins were formed *in situ* in acidified latex, stabilized with non ionic or cationic stabilizers and then coagulated. A simple possible method of reinforcing NR latex is to mix it with UF resin and permit the polymerization to take place in the latex. Houwink & Van Alphen (1955) state that during the formation of the resin in the aqueous phase of the latex, it builds up a somewhat cagelike structure. This rigid structure reinforces latex films. For a noticeable reinforcement by resins, chemical bonds between the rubber and the resin particles are desirable. In UF the free NH_2 group is of great importance in the formation of such chemical bonds.

An adhesive system that contains a mixture of a resin and an elastomer is called a two polymer adhesive. Although each compound has adhesive properties by itself, considered overall the conjoint system forms a stronger and more versatile adhesive. The two polymer systems have been particularly successful as film adhesives. The use of synthetic rubber as the elastomer has been studied (Rayner, 1965). In this project NR has been used as the elastomer. On the basis of the work done, a Sri Lanka patent has been applied for on the "The use of natural rubber-resin blends as an adhesive for plywood" (Eliatamby, Nadarajah, Amarasinghe & Liyanage, 1972).

Stabilization of field latex for blending with urea formaldehyde resin

A latex stabilizer must prevent bacterial activity, suppress enzyme action and preserve the latex protein which is the stabilizing factor of the rubber hydrocarbon. The use of formaldehyde as a preservative has been attributed to its reaction with the amino groups in protein forming a protein-formaldehyde complex. This is less liable to bacterial or enzymatic action. The formaldehyde-protein complex does not break down even on intense heating. A drop in pH has been observed with the addition of formaldehyde, which is caused by the release of free carboxyl groups in the protein. The lower pH completely eliminates any oxidation (McGavack, 1959). Nadarajah *et al.* (1972), have shown that tocotrienols are important antioxidants present in NR and that alkali has an adverse effect on the anti-oxidant action of tocotrienols. Alkalies act on the tocotrienols only slowly and treatment for longer periods has been found to have a more adverse effect. Hence the failing load of plywood bonded with casein and ammonia preserved centrifuged latex would be expected to decrease with storage time. This adverse effect will no be expected in formaldehyde preserved field or centrifuged latex. It is noted that at least 0.2% formaldehyde is necessary to preserve latex for periods over a month, but percentages above 0.3% tend to reduce to some extent the viscosity of the final glue mixture.

It is possible to use fresh field latex with UF resin as the stabilizer, but the storage properties have not been satisfactory. Fresh unstabilized field latex has been mixed with UF resin and used as the adhesive in mixtures containing 65% NR and 35% UF resin. Bond strengths of 150 psi were obtained. Though this method is suitable for laboratory experiments, it is unsuitable for commercial application. In the experiments conducted, both field and centrifuged latex, containing 0.3% formaldehyde, have been used. After centrifuging the formaldehyde content is brought up to 0.3% on the centrifuged latex. Field latex containing 0.3% formaldehyde is allowed to stand for at least two days before being used as an adhesive for plywood or before centrifuging, to enable the formaldehyde to react with the amino group in the protein present in the field latex to form a protein formaldehyde complex.

Use of kaolin as the extender

Buttrey (1964) states that for 70 parts of UF resin, extenders like china clay, slate powder or flour could be used at 10 to 50 parts. Since china clay (kaolin) is a locally available raw material its use as the extender has been evaluted.

EXPERIMENTAL

1) *Use of UF resin-NR latex blends*

Increasing proportions of UF as a dispersion were blended with field latex, dry rubber content (d.r.c.) 32.5%, and with centrifuged latex (d.r.c.) 52.5%. These blends were used in bonding plywood and tested for bond strength.

2) *Use of UF resin-NR latex-kaolin blends for plywood manufacture*

The method of mixing the NR latex, UF resin and kaolin is important and it was done as follows :—

UF resin is made into a suspension with sufficient water. The extra water necessary to maintain total solids content at 55% in the final mix is calculated and added to the suspension; kaolin is stirred into the UF resin suspension and the UF resin-kaolin slurry is run into the NR latex and mixed. These blends were used in bonding plywood and tested for bond strength.

3) *Replacement of 25% UF resin by melamine formaldehyde*

Twenty five percent of the UF resin in a UF resin-NR-kaolin blend was replaced by melamine formaldehyde (MF) and its effect on the bond strength of the wood species, *Rubber—Malaboda—Rubber* and *Bomie—Kokum—Bomie* investigated.

4) *Use of PF resin-NR latex blends*

One part of PF resin as a suspension was blended with one part of NR as centrifuged formaldehyde stabilized latex. The blend was used in bonding plywood and tested for bond Strength.

RESULTS AND DISCUSSION

Use of UF resin-NR latex blends

The results of bond strengths by the use of UF resin-NR latex blends are given in Table 2.

TABLE 2

PHYSICAL PROPERTIES OF GLUE LINE USING DIFFERENT PROPORTIONS OF UF/RUBBER BLENDS

Type of latex	UF/Rubber ratio	Total solids of the glue as %	Glue adhesion in psi		Water resistance
Field latex	10/90	34.5	36		failed
	25/75	38.4	70		medium
	35/65	42	92		good
	50/50	45.2	252		excellent
			Malaboda	*Thiniya*	
Centrifuged latex	0/100	52.5	68	81	—
	15/85	51	214	—	excellent
	25/75	55	164	100	excellent
	35/65	55	276	90	excellent
	50/50	55	210	168	excellent

The minimum failing load is 150 psi as according to I.S. 10—1964

It will be noted that the total solids content is an important factor for bond strength. Many battles between adhesive materials are being won or lost on the basis of a difference in solids content of a few percent (Skeist, 1962). By using centrifuged formaldehyde stabilized latex it was possible to maintain desired total solids content of the UF resin-NR latex glue by the addition of water, and the results of bond strengths are also given in Table 2.

Use of UF resin-NR field latex-kaolin blends for plywood manufacture

The results for bond strengths using UF resin-NR field latex-kaolin blends as the adhesive are given in Table 3.

TABLE 3

EFFECT OF KAOLIN AND % TOTAL SOLIDS CONTENT ON BOND STRENGTHS

FIELD LATEX OF D.R.C. 32.0% USED		
Ratio of Resin : Rubber : China clay	Total solids content %	Failing load psi
35 : 65 : 0	42	78
35 : 65 : 35	46	57
35 : 65 : 47 (silica)	50	176
35 : 65 : 70	52	127
35 : 65 : 100	56	188
50 : 50 : 0	43	107
50 : 50 : 35	57	162
50 : 50 : 70	56	250
100 : 0 : 75	56	300

Results show that if a total solids content of 55% and over is maintained it would be easier to obtain bond strengths of over 150 psi. In using field latex, it would be easier to obtain the total solids content of over 55%, if the ratio of UF resin to rubber is 1 : 1. Further, it is necessary to use an extender such as kaolin to raise the total solids percentage. Results also indicate that precipitated silica is a much better reinforcing filler than kaolin.

Use of UF resin: NR latex: Kaolin blends at 55% total solids for plywood manufacture

The results for bond strengths obtained by using field latex (total solids 35.4%) and centrifuged latex (total solids 52.5%) as the adhesive for plywood with a blend of UF resin and kaolin are given in Table 4.

TABLE 4

EFFECT OF THE USE OF UF RESIN : NR LATEX : KAOLIN BLENDS ON BOND STRENGTH (TOTAL SOLIDS 55%)

Type of latex & dry rubber content %	Ratio of Resin : Rubber: Kaolin	Additional water ml	Total volume ml	Viscosity (Bore Dia. 4mm) sec	Viscosity after 6 h sec	Failing load psi
Field (35.4)	35:65: 70	20	—	—	—	162
	35:65:100	45	—	—	—	220
Centrifuged (52.5)	35:65: 0	23	170	35	35	194
	50:50: 0	37	—	—	—	219
	35:65: 70	80	260	26	42.5	170
	35:65:100	105	285	25	39	174

No difficulty was experienced in getting adequate bond strength even without kaolin, when centrifuged latex was used. Further enhancement of bond strength is possible by mixing with kaolin. The initial viscosity of creamed latex is higher (Table 4) than when kaolin is used as the extender, but with time the acidity of kaolin causes condensation of UF resin resulting in increased viscosity. In the case of field latex blends, the use of more kaolin (100 instead of 70) has given a higher failing load, but is not recommended for commercial use because of mixing problems. These problems do not exist when the centrifuged latex blend is extended with 100% kaolin, the additional water being more than sufficient to mix the kaolin into the UF resin. However, for commercial purposes the use of kaolin as an extender at more than 70% is not normally recommended.

Replacement of UF by melamine formaldehyde

Van Alphen (1957) has found the mechanical properties of rubber containing UF resin becomes better when a small part of the urea (25%) is replaced by melamine. Table 5 confirms this reinforcement in that replacement of 25% UF resin by melamine formaldehyde (MF) gives an increased failing load, for example in the case where the wood species is *Rubber/Malaboda/Rubber* (R/M/R).

TABLE 5

EFFECT OF REPLACEMENT OF 25% UF RESIN BY MELAMINE

Type of latex & dry rubber content %	Ratio of Resin: Rubber: Kaolin	% melamine in Resin	Failing load of wood species psi		
			R/M/R	B/K/B	M/M/M
Field (35.4)	35:65: 70	0	162	112	
	35:65: 70	25	208	114	
Centrifuged (52.05)	35:65: 70	0	170	145	
	35:65: 70	25	222	152	
	35:65: 0	0	194	189	
	35:65: 0	25	250	189	
	35:65:100	0			204
	35:65:100	25 (no hardener)			·98
	35:65:100	25 (hardener)			239

Wood species R/M/R is *Rubber/Malaboda/Rubber*
Wood species B/K/B/ is *Bomie/Kokum/Bomie*
Wood species M/M/M/ is *Malaboda/Malaboda/Malaboda*

List of timber species used with their corresponding botanical names is given in Table 6.

TABLE 6

LIST OF TIMBER SPECIES USED

Local Name		Botanical Name
Aridda	—	Campnosperma zeylanica
Bomie	—	Litsea glutinosa
Hulanidda	—	Shorea stipularis
Hora	—	Dipterocarpus zeylanicus
Kokum	—	Kokoona zeylanica
Kirihembiliya	—	Palaquium petiolare
Kotta-pulung	—	Eriodendron antractuosum
Malaboda	—	Myristica dactyloides
Natau	—	Xylopia parvifolia
Rubber	—	Hevea brasiliensis
Thiniya	—	Doona congestiflora
Waldivul	—	Hydnocarpus vanenata

It must be mentioned that no hardener was used and the acidity was obtained from wood. Hence to obtain optimum results from not too acidic woods, it will be necessary to use a hardener. Van Alphen (1957) has also found that when 25% of the urea is replaced by melamine, the properties are not further enhanced and that they are at least as good as those of rubber containing pure MF resin. The most important aspect was that the resin should be formed in the latex at as high a temperature as possible without coagulating the latex. It was further observed that the entire replacement of UF with MF in the UF/NR/kaolin blend causes coagulation, indicating that MF does not stabilize kaolin as UF does.

Acidity of timber

Most timbers in Sri Lanka are acidic and it is expected that if the timber was sufficiently acidic, *i.e.* with extracts having a pH of below 4, no hardener will be required if the adhesive is UF or contains UF. If the acidity of wood is insufficient, then the rate of curing will be slow. The degree of condensation is quite important since if insufficient, the resin would be absorbed into the wood and thus be unavailable to act as an adhesive. The results of bond strength with no hardener on ten species of timbers in Sri Lanka are given in Table 7.

TABLE 7

EFFECT ON BOND STRENGTH USING DIFFERENT WOOD SPECIES

NR : UF : Kaolin is 65:35:100

Wood species	Failing load psi	Wood failure %
Aridda	241	100
Kokum	218	100
Malaboda	204	30
Waldivul	198	40
Thiniya	191	60
Hulanidda	172	0
Hora	168	0
Kirihembiliya	152	100
Kotta-pulung	134	10
Natau	93	0

The ratio of NR: UF: Kaolin was 65: 35: 100 and this formulation (Total solids 55%) can be used successfully on all species of timber used for plywood manufacture with the exception of the less acidic timbers like *Natau* and Diyathaliya. For universal application it is recommended that a hardener *e.g.* ammonium chloride be used at one fifth part per 100 parts of resin.

PF resin - NR latex blends

The PF resin obtained by condensing one molecule of phenol with two molecules of formaldehyde, is composed of linear molecules, relatively short in length and capable of being dissolved in water. The solution is alkaline in reaction, and further heating or addition of suitable catalysts *e.g.* paraformaldehyde, completes crosslinking (Buttrey, 1964).

The use of PF resin-NR latex blends should be feasible as adhesives for plywood. According to Stern (1967), phenolic resins, probably as the result of interaction between hydroxyl groups in the ortho position and the double bond of the rubber molecule to give a chromane ring, can crosslink with natural rubber. According to Scott (1962), the adhesion of rubber to textiles is improved if the latter are impregnated with a mixture of NR latex and resorcinol formaldehyde resin and the investigation of the mechanism of adhesion suggests that mechanical rather than chemical factors are more important.

One part of PF as a solution (1 part PF in 4/5 parts water) was blended with one part of NR (d.r.c. 53.7%) centrifuged formaldehyde stabilized latex. In one of the experiments, sodium hydroxide solution was added to bring the pH up to 11-12. Paraformaldehyde was used as the hardener at 5% and at 10% on the NR/PF mix. The results for bond strengths obtained are given in Table 8.

TABLE 8

EFFECT OF THE USE OF PF RESIN-NR LATEX BLENDS ON BOND STRENGTHS (TOTAL SOLIDS 55%)

Ratio of PF : Rubber : Kaolin	Paraformaldehyde %	Failing load psi
50:50 0 (NaOH solution added)	5	279.1 295.0
50:50 0	10	243.3 274.1
50:50:20	5	268.3 295.8

The bond strengths are satisfactory for commercial plywood. Samples boiled at 100 °C for 120 h withstood delamination. Hence commercial plywood of Moisture Resistant (MR), Boil Resistant (BR) and Weather and Boil Proof (WBP) could be made using PF/NR blends.

Factory trials

Sri Lanka requires 4½ million tea chests annually. Only one third of the requirement of tea chests are produced locally, the balance being imported. With the Kosgama Plywood Complex coming into full operation in the near future, Sri Lanka should be self sufficient in plywood for tea chests. Approximately 85% of plywood manufactured in Sri Lanka is for use in tea chests.

Factory scale trials were carried out with UF centrifuged formaldehyde stabilized NR latex (d.r.c. 50%) blends. Satisfactory samples were obtained with blends in the ratio 1 : 1. An average mean of 213 psi has been obtained for bond strength. Factory scale trials were also carried out with UF/NR blends (d.r.c. 55%) in the ratio of 1 : 2 but extended with 30% flour. An average mean of 190 psi has been obtained for the bond strength.

Mechanism of adhesion

Wood bonding with adhesives in the case of synthetic resin is mainly physical with only 20% of chemical adhesion. The imperfect nature of the wood surface does not permit a state of absolute contact for molecular attraction. The bonding effect should be such as to fill all the imperfections in the wood surfaces to achieve a state of perfect mechanical adhesion. Urea formaldehyde has a suitable molecular structure that would assist in this. It has either NH_2 or OH or both these groups freely dispersed in the molecule. These groups are polar and are attracted towards the OH groups of the cellulose. In the glue line the urea formaldehyde hardens by chemical reaction—polymerisation, with little loss of water. Polymerisation takes place in an acid medium pH 2-3, which is provided by:—

(1) Formaldehyde used in stabilizing the latex, reacting with the proteins in the NR latex.

(2) Mineral filler—china clay.

(3) Acidity of wood.

The evaporation of solvent water in the urea formaldehyde resin plays a relatively secondary part to achieve full glue strength.

One of the fundamental properties required of a wood glue is good wetting characteristics in order to allow intimate contact. The most successful wood glues are water based, being suitable for filling gaps of approximately 0.05 mm in between surfaces. The OH groups in cellulose have a high attraction for water and water therefore readily wets wood.

When natural rubber latex is used for wood gluing, the necessary film forming is achieved by the water of the latex evaporating. Wood assists in absorbing this water from the glue line. In rubber latices too, mechanical adhesion to other surfaces is of major importance but specific adhesion also plays a secondary role. Cohesion of film in unmodified NR latices is high, while adhesion is low. This is improved by the addition of UF resin in the form of a suspension. Rubber being thermoplastic, at plywood bonding temperature it softens and under the applied pressure grips into the interstices of wood surfaces, allowing a close contact for mechanical and specific adhesion.

The use of mineral filler (kaolin) has opposite functions in the two components of the blend. With urea formaldehyde it prevents excessive penetration of the synthetic resin into the wood. With rubber it embeds itself into the rubber latices providing an imperfect surface for mechanical adhesion.

For economical curing time of the adhesive blend it is necessary to have a minimum of 55% solid content.

Present pressing conditions are :—

Temperature	—	120°C
Pressure for tea chest panels	—	150 psi
Pressing time	—	5 to 7 min

In order to make the blend applicable on a commercial scale it is necessary to use centrifuged latex, or centrifuged-field latex blends, because the extra water needed to keep the total solid content at 55% could be made use of to disperse the urea formaldehyde powder and the kaolin filler.

UF resin is used in the unextended form in chipboard manufacture. Hence NR latex-UF resin blends, without extender, should be a promising material for investigation in its use as the binder in the manufacture of chipboard.

Economics of NR usage

The total annual consumption of urea formaldehyde resin in Sri Lanka plywood manufacture is approximately 1,400 tons. If 65% of this is to be substituted by NR, 910 tons of dry rubber are needed. At 3 lb of dry rubber per gal of field latex approximately 760,000 gal are needed. It is proposed that this latex be collected from small estates and from small holders at collecting centres. It is estimated that each collecting centre could collect approximately 200 gal per day. On the assumption that the annual number of tapping days is 250, fifteen such collecting centres will be required. Ceylon Plywoods Corporation may pay such collecting centers the RSS No. 1 outstation price less -/08 cts. (Nadarajah *et al.*, 1972). The price to be paid by collecting centres to rubber producers is suggested at RSS No. 1 outstation price less -/16 cts. The collecting centre could hence incur an expense of up to -/08 cts per lb in collecting latex. Ceylon Plywoods Corporation could arrange transport of the collected stabilized latex to the Plywood factories.

Concentration of field latex to a higher dry rubber content is advantageous. The quantity needed per annum will be only 410,000 gal, if the dry rubber content is maintained at 55%. Ceylon Plywoods Corporation could either contract with the Plantations Ministry for the supply of stabilized centrifuged latex or be a share holder in a central centrifuging factory (Nadarajah, Perera, Balasingham, & Fernando, 1972), to obtain a regular supply of centrifuged latex.

Current CIF prices of urea formaldehyde and hardener per 1,000 kilos are Rs. 1,820/- and Rs. 2,820/-, respectively. Total foreign exchange expenditure on glue components is 4 million rupees. Cost per pound of urea formaldehyde is Rs. 1.47 local. Natural rubber at RSS 1 average price for 1971 being -/80 cts per lb, the cost of the rubber would approximately be -/74 cts per lb to the Ceylon Plywoods Corporation. Centrifuging will raise the cost by 20% and will bring the price of rubber to approximately -/96 cts per lb. New uses of NR should be found and implemented to keep NR prices at attractive levels. In this context the substitution of urea formaldehyde resin in part with rubber in plywood manufacture should be deserving of implementation not only in Sri Lanka but in all natural rubber producing countries. The replacement of UF resin by rubber to the extent of 910 tons would result in a saving of about 8 lakhs to the Ceylon Plywoods Corporation and a foreign exchange involvement of approximately 1½ million rupees.

The local cost per lb of PF resin is Rs. 2.18 and the cost of NR is -/96 cts per lb of dry rubber in the form of formaldehyde stabilized centrifuged latex. The replacement of 50% of the imported PF resin which amounts to approximately 50 tons, by NR would result in a saving of approximately one lakh of rupees to the Ceylon Plywoods Corporation and of a foreign exchange involvement of approximately one lakh of rupees.

With the expansion of cashew nut production in Sri Lanka, it is expected that cashew nut shell liquor (CNSL) should be available in Sri Lanka in the near future. Cardanol is the active constituent of CNSL and is present in CNSL as anacardic acid. Cardanol is a meta substituted phenol, and is mono-hydroxy with the C_{15} H_{27} hydrocarbon chain substituted in the meta position.

Since this phenol is reactive at the ortho and para positions, and is trifunctional with respect to the reaction with formaldehyde, it is suitable for investigations regarding the condensation with formaldehyde to form PF resins. We are investigating the preparation of this type of PF resin and its properties in blends with NR latex.

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