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United Nations Industrial Development Organization

Workshop on Adhesives used in the
Wood Processing Industries

Vienna, Austria, 31 October - 4 November 1977

REPORT OF THE WORKSHOP *

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CONTENTS

Introduction

The Workshop on Adhesives Used in the Wood Processing Industries, organized by the United Nations Industrial Development Organization (UNIDO), met at Vienna from 31 October to 4 November 1977. Its main purpose was to analyse the various factors involved in the use and manufacture of the adhesives which are a prerequisite for the production of wood based panels, viz.: plywood, laminated boards, block-boards, particle boards, ply moulds, high density plywood, plymetals and other wooden laminated products and all others used in modern wood processing industries (timber engineering, gluelam, furniture, joinery, etc.); namely by:

- determining the minimum requirements for adhesives production;
- determining whether natural products occuring in developing countries could be used for the production of binding agents to replace a certain amount of high priced imported synthetic resins; and recommend by future research needed in this field;
- assessing the various glue spreading systems for application in developing countries;
- recommending the quality control and standards for these products.

The Workshop brought together participants from both developed and developing countries to compile appropriate data and guidelines on the above topics that UNIDO might disseminate in the developing countries to potential investors and industrialists on the one hand, and financiers, government agencies and other regulatory bodies on the other hand, to ensure the development of economically viable wood-processing industries in the developing countries.

The Workshop was a follow-up of an Expert Working Group Meeting on Production of Panels from Agricultural Residues which UNIDO convened at Vienna in December 1970, the purpose of which was to assist those countries that, though not self-sufficient in wood and wood products, had great quantities of unutilized agricultural residues and non-wood ligno cellulosic material.

Adhesives often play a cruoial role in the development of wood based panel industries in the developing countries, since they are a major cost factor in this industry. It was felt at that meeting, and at the World Consultation on Wood Based Panels which FAO convened in New Delhi, India,

in February 1975, that information should be compiled, discussed and diffused to allow developing countries make fuller use of naturally occuring products as binders or extenders for this industry, and to study optimum ways of utilizing these or even producing them as well as synthetic adhesives locally. The convening of the Workshop reflects the awareness of UNIDO that developing countries lack knowledge of what technologies are available and are thus unable to decide which technology is best for them.

Recommendations

Recommendation addressed to industry

1. Complete feasibility studies should be done before any investment decision is taken on the establishment of adhesive production facilities in developing countries.

Recommendations addressed to research institutes

1. The work on the development of tannin-formaldehyde resins, based on wattle, chestnut, mangrove, quebracho, coconut and other extracts in the present and potential tannin producing countries should be carried out by the tannin, resin adhesive plywood and particle board industries, so that maximum technical know-how is available for the project.

2. Greater attention should be paid by specialized research institutes in the field of developing suitable preservative treatment processes for plywood.

3. Standard methods of measuring formaldehyde, both in the air and in ligno-cellulosic based panels, should be developed and steps taken to make them generally accepted.

Recommendations addressed to governments

1. To reduce the cost influence of the resin adhesive used in the ligno cellulosic panels and consequently increase their potential use in low cost housing and furniture, it is recommended that:
   a) If no local resin manufacture exists, import duties for resin adhesives, tannins and hardness should be reduced;
   b) Maximum investment incentives, envisaged by the local legislation, should be given to promote establishment of adhesive manufacturing plants in developing countries, because although the production of adhesives is capital intensive, their local production will help develop the plywood industry which is labour intensive.

2. National standard bodies and ISO should take steps to ensure that standards for adhesives bonded wood products do not exclude the use of adhesives based on tannin formaldehyde resins and other natural products on grounds other than performance.

Recommendations addressed to UNIDO

1. If requested to do so, technical assistance should be given by UNIDO to present and potential tannin producing countries to investigate and obtain efficient tannin-formaldehyde resins based on wattle, chestnut, mangrove, quebracho, coconut and other extracts.

2. UNIDO should sponsor a workshop exclusively on adhesives from natural products within the next five years. In the mean time UNIDO should act as a co-ordinator of this research effort. The laboratories involved in this research should submit a report on progress to UNIDO at the end of each calendar year. It is requested that UNIDO diffuse this information to interested parties.

3. The workshop identified the need for a study to cover the subject of extenders and fillers and recommended to UNIDO to commission such a study.

4. Attempts by developing countries having scarce wood and wood wastes to utilize alternative raw materials, hitherto unutilized, such as rice husks, coconut husks and straw involving appropriate research and development work, should be encouraged and supported by UNIDO.

5. UNIDO should compile a list of specifications and test methods issued by various countries; and publish it as a follow-up to the workshop's report. This list should include a glossary (in English) of terms used in the wood glueing industry.

I. Organization of the Workshop

M. M. Aref, Head of the Agro-Industries Section of UNIDO opened the Workshop with an address of welcome in whioh he referred to the Lima Declaration and Plan of Action on Industrial Development and Co-operation[1/] as it pertained to development, particularly in the wood-processing industry.

[1/] A/10112, annex, chapter V.

The Workshop was attended by 23 participants from the following countries: Argentina, Australia, Federal Republic of Germany, Ghana, India, Kenya, Malaysia, Mexico, New Zealand, Norway, Paraguay, the Philippines, Switzerland, Turkey, the United Kingdom of Great Britain and Northern Ireland and Yugoslavia. They comprised individuals occupying managerial or policy-making positions in the wood based panel industries in their countries, adhesives manufacturers, specialists from adhesive equipment manufacturers, and scientists from wood research institutes working in the field of adhesives, attending in their own capacity and not as representatives of their governments.

Thirteen observers attended whose background was similar to that of the participants and took part actively in the Workshop. They came from the following countries: Austria, Federal Republic of Germany, Finland, Indonesia, Malaysia, Norway, Switzerland, the United Kingdom of Great Britain and Northern Ireland, and the United States of America.

J. George was elected Chairman and J. C. Scharenberg Vice Chairman cum Rapporteur while A. V. Bassili and H. Eldag of the UNIDO Secretariat served as secretaries to the Workshop. The following participants served as discussion leaders:

Discussion leader	Agenda item
J. C. Sharenberg	4. Economics of adhesives production for: a) synthetic resins b) resins based on naturally occuring products
K. F. Plomley	5. Utilization of naturally occuring organic products: a) past research b) industrial application
J. Reinhardt	6. Industrial application of synthetic adhesives for: a) ligno-cellulosic based panels b) gluelam and tibmer eingineering products c) joinery and furniture products
S. Senn	7. Equipment for application of: a) ready-to-use adhesives b) adhesive-particle blending c) adhesive spreading
J. George	8. Testing procedures and equipment for adhesive testing

The Agenda given in Annex I was adopted unanimously. Twelve documents were specially commissioned for the Workshop (See Annex II). English was the working language of the Workshop.

II. Economics of production of resin adhesives

The two papers prepared for this topic were presented by their authors. These were "Economics of Production of Synthetic Resin Adhesives" by J. George (Document ID/WG.248/3) and "Economic Aspects of Tannin Extracts as Wood Adhesive Binders" by J. C. Soharenberg (Document ID/WG.248/7).[1/]

In the ensuing discussion the following points emerged:

1. The economic feasibility of manufacturing resin adhesives for the ligno cellulosic based panel industry in developing countries will depend on the availability of raw material technology, domestic and export markets for the finished products, and investment costs related to the existing market.

2. Technical considerations

   The principal resins needed by the wood processing industries are the following:

   (a) Urea-formaldehyde (UF)
   (b) Phenol-formadehyde (PF)
   (c) Urea-melamine-formaldehyde resins (MUF)
   (d) Resorcinol-formaldehyde (RF)
   (e) Phenol-resorcinol-formaldehyde (PRF)

   These products can be made in the same reaction vessels with approximately the same manufacturing conditions.
   Polyvinylacetate (PVA), hot melts, epoxies, acrylics, isocyamide, rubber based adhesives, etc., were not considered in the discussions because of the small volumes involved.

3. Urea-formaldehyde resins are used in the manufacture of particle board and plywood for internal use (furniture, doors, etc.); phenol-formaldehyde resins are for exterior use (sidings, concrete forms, etc.) and urea-melamine formaldehyde resins are for semi-exterior uses, where a full waterproof bond is not required. Resorcinol based formaldehyde resins are cold-setting fully water-proof adhesives for woodworking.

1/ Another UNIDO document that deals with this topic is: Synthetic resin adhesives. A survey of production techniques and world trade (Document ID/WG.83/8) by A.G.Seljestad, Norsk Spraengstofindustrij A/S, Oslo, Norway

4. The main raw materials involved are the following:

   (a) Urea;

   (b) Phenol;

   (c) Melamine;

   (d) Resorcinol;

   (e) Formaldehyde.

   Urea, phenol, melamine and resorcinol are obtained by petrochemical processes, while formaldehyde can be obtained by the oxidation and/or dehydrogenation of methanol, in itself another petrochemical product.

5. Products listed under (a), (b), (c) and (d) can be considered as 100 per cent solids for resin manufacturing purposes while formaldehyde can be obtained as a solid containing up to 98 per cent active ingredient or as a solution containing up to 55 per cent active ingredient, or as a urea formaldehyde concentrate with up to 85 per cent active ingredient.

6. Other rawmaterials may be:

   (a) Natural products that react with formaldehyde; (tannins, etc.):

   (b) Non-active extenders and fillers (wheat flours, walnut- and cocoonut shell flour, sander dust, etc.);

   (c) Chemical hardeners and retarders.

   When considering the feasibility of a resin manufacturing plant, only UF and PF need to be disoussed as they constitute more than 95 per cent of the resins used for ligno cellulosio based panel manufacture.

7. Marketing considerations

   The developing countries considering local resin manufacture should take into account the market available for the produot, either domestic or export. The resin to be manufactured will, for obvious reasons, be sold almost exclusively in the domestic market and the partiole board and/or plywood produced can then be sold locally or exported.

8. It is oonsidered that one ton of particle board, trimmed and sanded, will consume about 60 - 100 kg of UF resin at 100 per oent solids, or 60 - 120 kg of PF resin at 100 per oent solids.

   The oorresponding quantity of phenolio resin used for waferboard and strand board is about half that mentioned above, but its unit oost is muoh higher.

9. The average consumption of resin by plywood is rather more difficult to generalize as it will vary according to the number of glue lines per board, thickness of each ply, quantity of extender used and type of wood being processed. Perhaps for UF bonded plywood, sheets about 4 mm thick (3-ply construction) can be said to be average, and for PF bonded plywood boards, 12 mm (5-ply construction) may be typical.

10. Taking this into account for UF resins with 100 per cent extender added, the average consumption per cubic metre would be about 20 - 25 kg of 100 per cent resin solids for the 3-ply construction while for PF resins with 20 per cent extender added the average consumption may be estimated at 25-30 kg of 100 per cent resin solids for the 5-ply construction.

A market survey for particle board and plywood in each country, with these factors in mind could determine the potential market for resin manufacturing.

11. Raw material considerations

The local availability of raw materials for resin manufacture will probably be very low or non-existent in small-market countries and therefore these have to be imported from more developed countries.

12. Typical prices (November 1977) for these products would be: paraformaldehyde US$700/ton F.O.B.; formalin, 37 per cent solution US$120/ton F.O.B. (equivalent to US$300 at similar concentration to 92 per cent paraformaldehyde) UF concentrate (80 per cent) US$160/ton F.O.B.

13. The other raw materials show the following approximate prices:

Urea	130 $/ton
Phenol	500 $/ton
Tannin (quebracho and wattle)	450 - 500 $/ton

The powdered UF and PF resins can be approximately quoted at US$400 and US$ 700 per metric ton, respectively.

14. Any resin manufacturing project must take into account:

(a) import duty differences on resin adhesives and on the raw materials for their production;

(b) freight rates on anhydrous raw materials and the resin adhesive in powder form;

(c) the required technological degree of the resin producing facility in relation to its installation cost;

(d) the availability of relevant technology and skilled manpower to establish the resin plant, promote the product amongst users and service them technically;

(e) complications arising from the transport of hazardous chemicals such as formaldehyde and phenol;

(f) complications in the pruchase of the different raw materials involved;

(g) economies of scale.

15. Regarding the replacement of synthetic urea and phenol by natural tannins, or all the synthetic raw materials, these may replace part materials if a careful study of comparative costs and availability under locally prevailing conditions prove it to be economic. Tannins may be used as cure accelerators for phenolic resins in plywood production.

16. Investment considerations

A plant for the production of resin adhesives can vary in size in accordance with the available market for the finished product. Its size will also have to be regulated by the costs of the raw materials available plus labour and fixed capital costs compared to the cost of imported resin adhesive. The cost of the latter would include taxes and duties that could be increased in order to protect local industry and/or the raw materials be granted preferantial treatment.

17. The cost of the plant will vary considerably and no figures can be given. Each case should be evaluated in the light of local conditions and requirements.

The smaller resin plant can operate successfully on paraformaldehyde or UF concentrate if imported from overseas and/or 37 per cent formalin is imported overland from neighbouring countries. The economics of transporting larger amounts of these products for larger sized resin plants would not allow them to operate successfully, so a formaldehyde plant would have to be installed to compete with imported finished resin at relatively lower cost levels. A formaldehyde plant can be engineered for 300 to 10.000 tons annual capacity and its cost would vary aooording to the process to be used.

Recommendations

18. In concluding its discussions on this topic, the Workshop made the following recommendations.

19. The effects of economies of scale vary greatly from country to country, and no minimum capacities can be suggested. Complete feasibility studies should be done before any investment decision is taken.

20. Among the major outlets for ligno cellulosic based panels are low cost housing and furniture. To reduce the cost influence of the resin adhesives it is recommended that:

(a) if no local resin manufacture exists, import duties for resin adhesives, tannins and hardeners should be reduced;

(b) maximum investment incentives, envisaged by the local legislation, should be given to promote the establishment of adhesives manufacturing plants in developing countries, because although the production of adhesives is capital intensive, their local production will help develop the plywood industry, which is labour intensive.

III. Utilization of naturally occurring organic products

Two papers and an annotated bibliography were submitted dealing with the utilization of naturally occurring organic products as wood adhesives.

A. In his "Review of past research on utilization of naturally occurring organic products as replacement of synthetic phenolic adhesives", E. Kulvik made the following points:

1. Adequate supplies of methanol may be available in the near future. However, the long term supply of phenol and resorcinol is considered to be less assured because benzene is increasingly in demand for other uses.

2. The availability of phenols for wood adhesives over a long term can be better assured by modifying the synthetic resins with naturally occurring products. Intermittent and world wide shortages and price increases of synthetic phenol and resorcinol have intensified the search for alternative lower cost materials based on natural, non-petrochemical resources as replacement in adhesives for the wood-working industries.

3. Reserach into the development of phenolic adhesives from naturally occurring sources has been reported from time to time. Such natural sources include:

   - the polyphenols of commercial vegetable tannins;
   - the polyphenols of other wood and bark extracts;
   - lignin such as in spent sulphite liquor.

   All these have been suggested for partial or full replacement of phenol in phenol-formaldehyde adhesives for the manufacture of plywood and particle board. The use of some of these natural products for replacement of resorcinol in resorcinol-based adhesives and for acceleration of cure of PF adhesives has also been considered.

4. The substitution of natural phenolics for synthetic phenols, especially from various tannin extracts, is reported to be an established commercial practice in a number of countries and significant economic advantages are reported to have been obtained by their use. Of particular interest are resources available within the adhesive consuming country, thus benefitting both the domestic product and balance of payments of the country. There are useful natural sources of phenols available in many developing countries and particular attention should be given to identify these sources and determine whether they could be used to replace a certain amount of synthetic phenolics.

5. Spent sulphite liquor adhesive formulations comply with certain standards for plywood and particle board but it was suggested that tannins had greater potential for replacement of synthetic phenol and resorcinol than lignin products.

6. Although not having the high replacement potential of some condensed tannins, chestnut tannin has been shown to have value as a substitute for phenol. Replacement in the amount of 50 per cent for synthetic phenol in an ordinary, alcaline phenolformaldehyde resin for plywood seems to be the maximum to meet the requirements according to BS 1455 (1972) for WBP gluing. The chestnut wood tannin modified adhesive resin is industrially in Malaysia under the same conditions of plywood manufacture as the unmodified resin. It is also an inexpensive and effective accelerator for the cure of phenol-formaldehyde resins.

7. In discussion, interest was shown in mangrove tannin as a potential adhesive base. Past work has shown that an efficient plywood adhesive can be prepared although, because of a higher proportion for fortifying resin is required, the cost of formulations is likely to be higher than for wattle tannin. Furthermore, variability in viscosity was a problem in commercial extracts.

8. The industrial use of quebracho tannin as a replacement of up to 80 per cent of synthetic phenol in phenolic resins was reported from Argentina, although further work on this extract is warranted. Quebracho tannin is used industrially in Finland as a cure accelerator for phenolic resin plywood adhesives.

B. K.F.Plomley presented a paper entitled "The formulation and industrial application of naturally occurring polyphenol (tannin) adhesives in the wood based panel industry". (Document ID/WG.248/6) In it he drew attention to the fact that:

9. The possibility of using the condensed tannins as substitutes for phenol and resorcinol in wood adhesives has been recognized for many years and over the last 25 years a considerable fund of information on the properties of tannins and the formulation and properties of tannin adhesives has been built up. This research has resulted in the commercial use of wood adhesives based on wattle bark extract and on quebracho wood extract.

10. Adhesives based on commercial wattle tannin have first been used in Australia for the manufacture of exterior grado plywood since 1960 and for particleboard since 1969. Formulations have been developed for timber laminating under laboratory conditions either cold, warm setting and using radiofrequency heating to cure the adhesive. Warm setting formulations have been used commercially in South Africa. Wattle tannin is now used industrially as a replacement for resorcinol in water resistant staroh adhesives for corrugated board in these two countries. Particle board adhesives based on quebracho extract have been used commercially in Argentina.

11. A pilot plant has been installed in New Zealand for the manufacture of pinus radiata bark extract, specifically for adhesives. Condensed tannins are also used to accelerate the cure of phenolic resin adhesives, replacing resorcinol.

12. Wattle tannin adhesives are used as substitutes for phenol- and resorcinolformaldehyde adhesives. As such they show high durability in exterior exposure and accelerated weathering tests and comply with relevant standards, which are based on the performance of the synthetic resin adhesives. Plywood and particle board bonded with wattle tannin adhesives pass the relevant specifications involving immersion in boiling water for 72 hours.[2/]

13. Weathering tests on plywood panels bonded with wattle tannin adhesives have been in progress for 15 years without bond failure. Accelerated ageing tests have been carried out on commercial particleboard bonded with wattle tannin-formaldehyde in comparison with phenol- and urea-formaldehyde bonded boards. In a test consisting of immersion in water at 40°C for 24 hours and redrying for six days, the cycle being repeated up to 15 times, the performance of tannin formaldehyde (TF) and PF bonded boards was similar and much superior to UF bonded boards. Three years of humidity at 38°C have shown a similar performance by tannin-formaldehyde and phenol-formaldehyde adhesives.

14. Unmodified tannin based adhesives differ from the PF resin adhesives in the wood-glue moisture relationship. An understanding of this characteristic is considered to be highly important for the successful use of tannin adhesives. Rate of loss of moisture when in contact with wood is more rapid for tannin adhesives than for PF resins and the minimum amount of moisture in the adhesive for flow in the hot press is higher. This can have important effects at all stages of the glueing process, as it influences glue transfer, prepress adhesion and bond quality. The situation is ameliorated by relatively small changes in formulation and by control of gluing, assembly and pressing conditions.

15. At the present time it is primarily cost rather than lack of technology and supply of suitable extracts which limits the use of tannin adhesives. This situation is likely to change, especially with decrease in petroleum resources. It is recommended that research should be continued and directed towards the improvement of adhesive formulations

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2/ Standards Association of Australia (1963) - AS 087 Plywood for Exterior Use.
Standards Association of Australia (1976) - AS 1859 Flat Pressed Particleboard.

based on available tannins and towards the discovery of new tannins with valuable properties. At the same time information should be exchanged, especially with the developing countries and countries where an additional extraction industry could be set up and where the economics may be more favourable for the use of tannin adhesives.

16. The Workshop took note of the "Annotated Bibliography on the Research done on the Use of Naturally Occuring Adhesives for Wood Processing Industries" compiled by J. George (Document ID/WG.248/5)[3/]. It requested the particpants to communicate to the UNIDO Secretariat any recent work so that they may be incorporated in an addendum, to the document and that UNIDO publishes an up-dated bibliography on similar lines.

17. In conclusion the workshop recommended that:

(a) If requested to do so, Technical Assistance should be given by UNIDO to present and potential tannin producing countries to investigate and obtain efficient tannin-formaldehyde resins based on wattle, chestnut, mangrove, quebracho, coconut and other extracts;

(b) The investigation work in the selected countries should be carried out jointly by the tannin, resin adhesive, plywood and particleboard industries so that maximum technical know-how is available for the project.

(c) UNIDO should sponsor a workshop exclusively on adhesives from natural products within the next five years. In the interim UNIDO should act as a co-ordinator of this research effort. The laboratories involved in this research should submit a report on progress to UNIDO at the end of each calendar year. It is requested to diffuse this information to interested parties.

(d) National Standards Bodies and ISO should take steps to ensure that standards for adhesive bonded wood products based on tannin formaldehyde resins and other natural products do not exclude the use of adhesives on grounds other than performance.

[3/] Another annotated bibliography on a related subject was published by UNIDO some time ago. It is the "Annotated bibliography on the utilization of agricultural residues and non-wood fibrous material for the production of panels". by H. Augustin, Institute for Wood Chemistry and Chemical Technology of Wood, Federal Research Institute for Forest and Wood Economy, Hamburg, Federal Republic of Germany (Document ID/WG.83/16).

IV. Synthetic resin adhesives

Three papers were prepared and discussed under this topic. These were "Industrial Application and Formulation of Synthetic Resin Adhesives in the Wood Based Panel Industry" by J. Reinhardt (Document ID/WG.248/3); "Formulation and Industrial Application of Synthetic Resin Adhesives in the Glulam Beam and Timber Engineering Industry" by H.C. Volb (Document ID/WG.248/1) and "Formulation and Industrial Application of Synthetic Resin and Special Adhesives Used in the Joinery and Furniture Industries and other Specialized Wood Products" by E. J. van der Straeten and T. I. Mynott (Document ID/WG.248/4).[4/]

1. Particle board and plywood manufacturing plants account for most of the current consumption of synthetic, formaldehyde based adhesives. These synthetic adhesives use raw materials that are derived from the petrochemical industry, except for urea and melamine. Figures 1 to 4 show the various routes from the raw material to fomaldehyde resins. These flowsheets illustrate that there should be few, if any, restrictions to the availability of the raw materials, particularly in regions where natural gas or crude oil is readily available. However, with the dwindling availability of crude oil and, to a lesser extent, coal there arises the possibility of raw material shortages. World prices for the raw materials are dependent on petroleum feed stock prices. The demand for crude oil is increasing and may exceed the supply. It is estimated that less than five per cent of the world's crude oil is currently used in the chemical industry. Availability and price of the raw materials are closely related and provided realistic resin prices can be achieved, it is anticipated that manufacturers of synthetic resin will be able to bid competitively for their raw materials. If realistic prices for resin cannot be achieved, the heavy chemical industry will divert its raw materials to outlets with a better return on capital and problems may arise on the supply and price of formaldehyde-based resins. Consequently, it is necessary to find alternative supplementary raw materials for the manufacture of wood adhesives.

4/ Other UNIDO documents dealing with this topic are:

(a) "The use of glues and other adhesives in furniture and joinery" by J. Meriluoto, Lahti Technical Institute, Lahti, Finland (Document ID/WG.105/26/Rev.1)

(b) "Adhesives for Wood" by J. Reinhardt, CIBA-GEIGY (UK) Ltd., Duxford, Great Britain.

Figure 1 SOME RAW MATERIALS FROM COAL

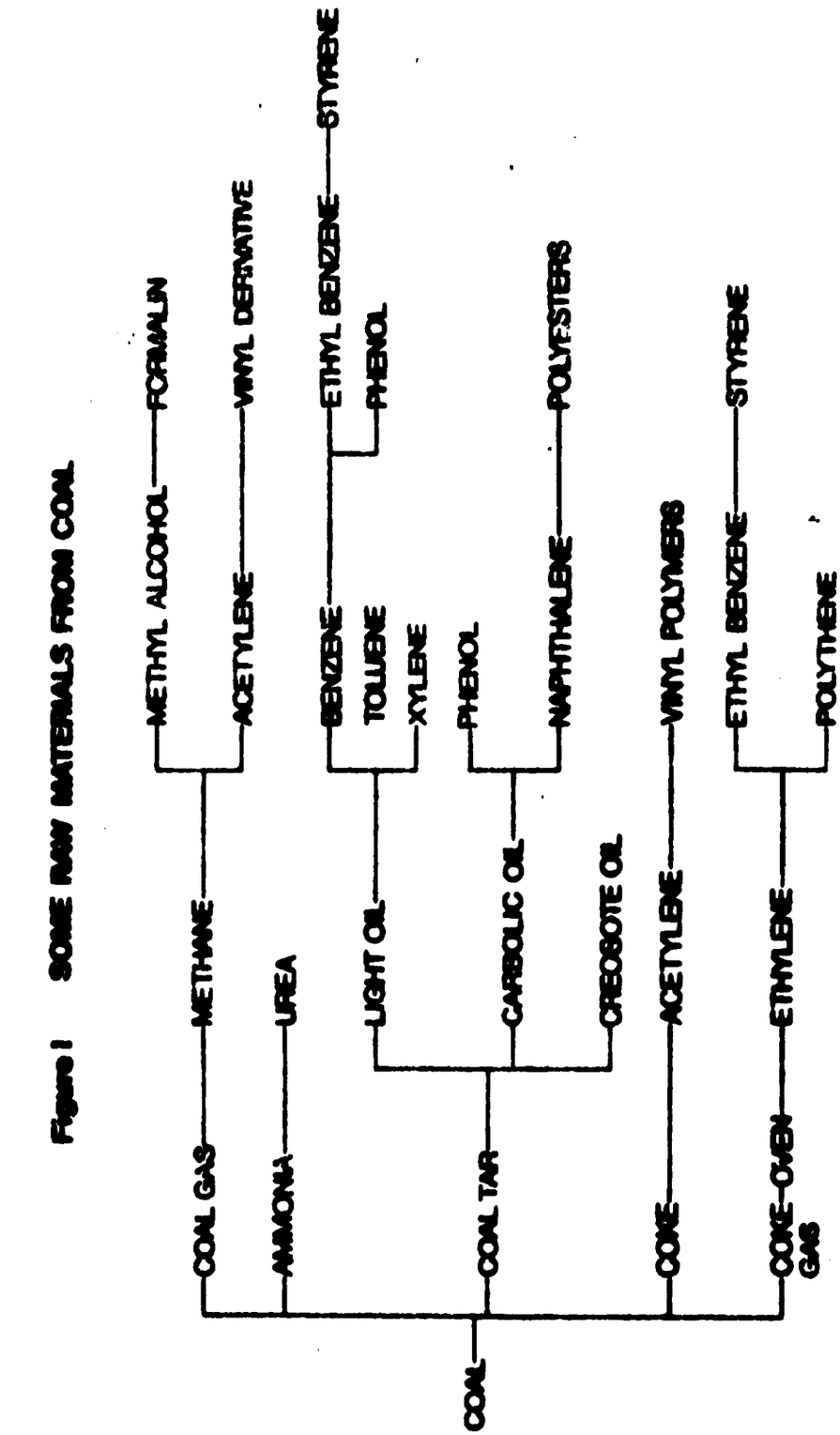


Figure II

SOME RAW MATERIALS FROM CRUDE PETROLEUM

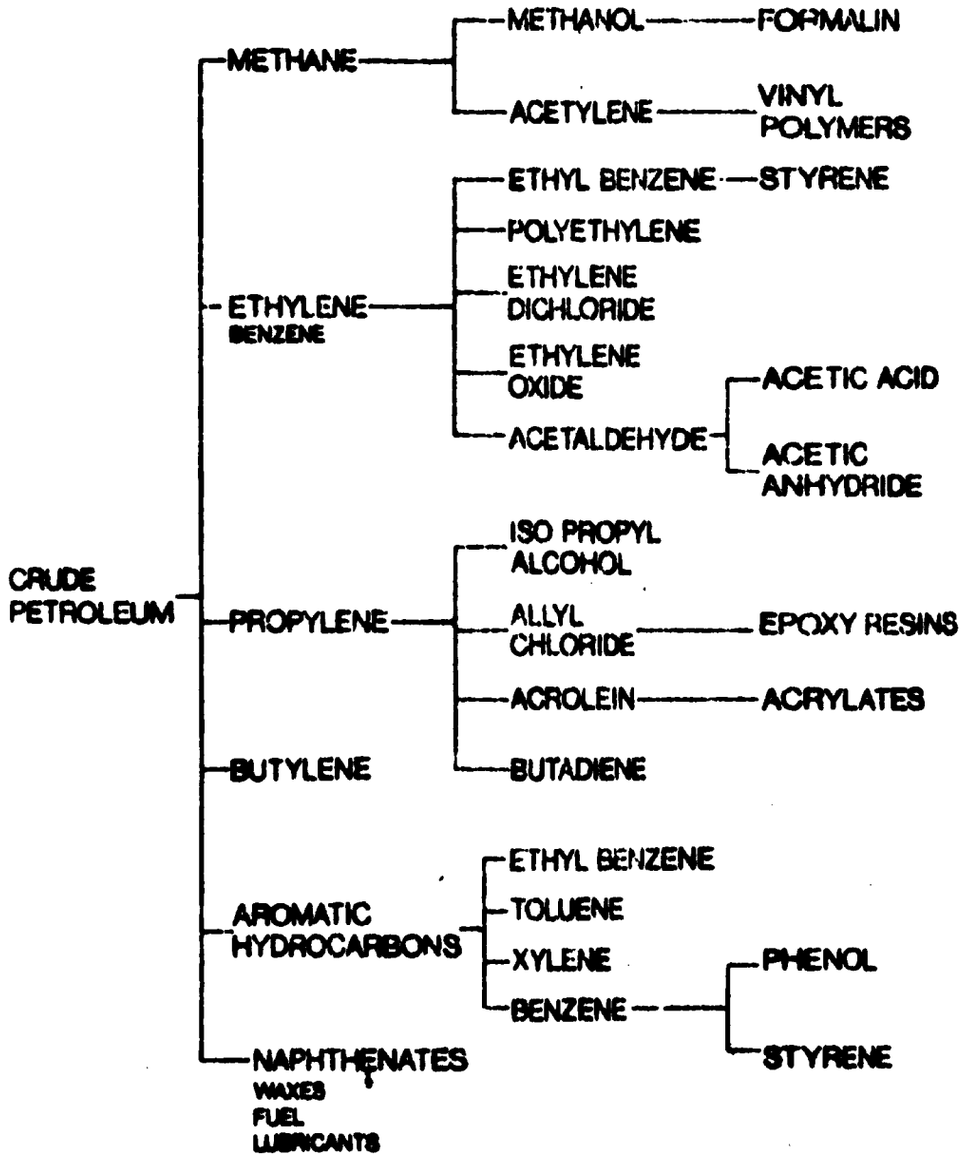


Figure III

FLOW SHEET FOR MANUFACTURE OF UREA & MELAMINE

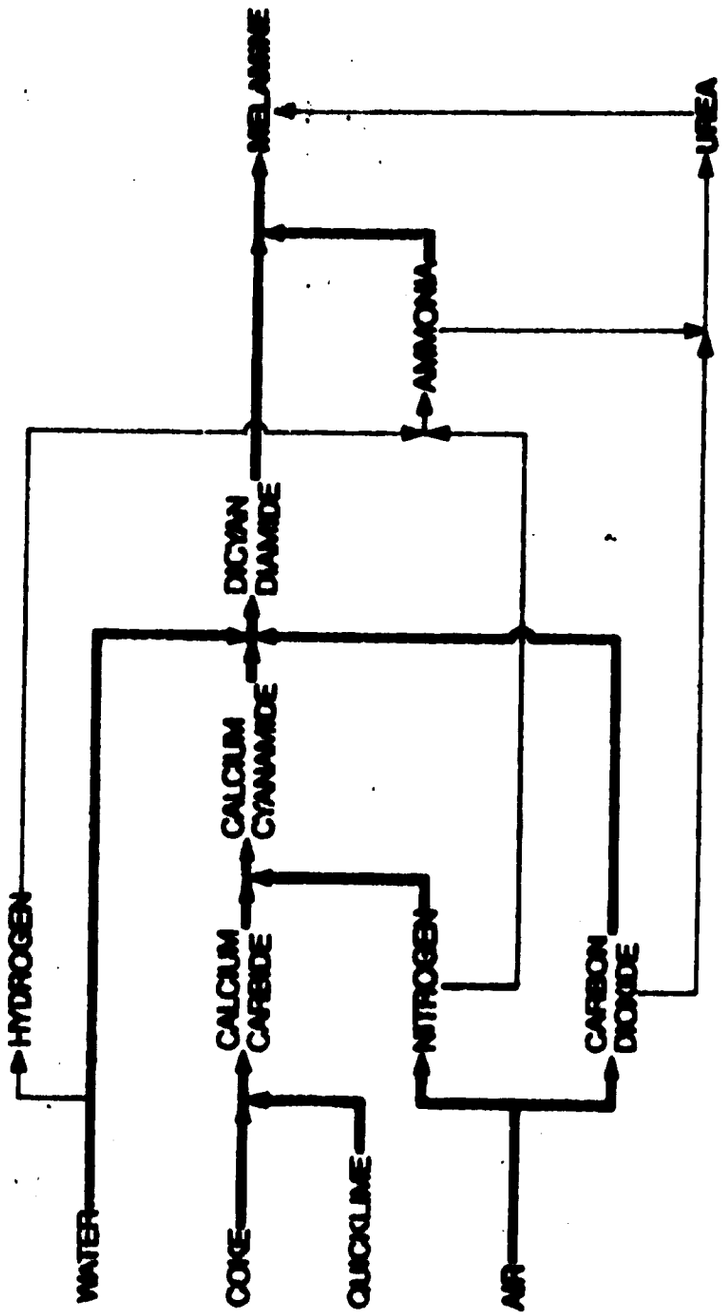
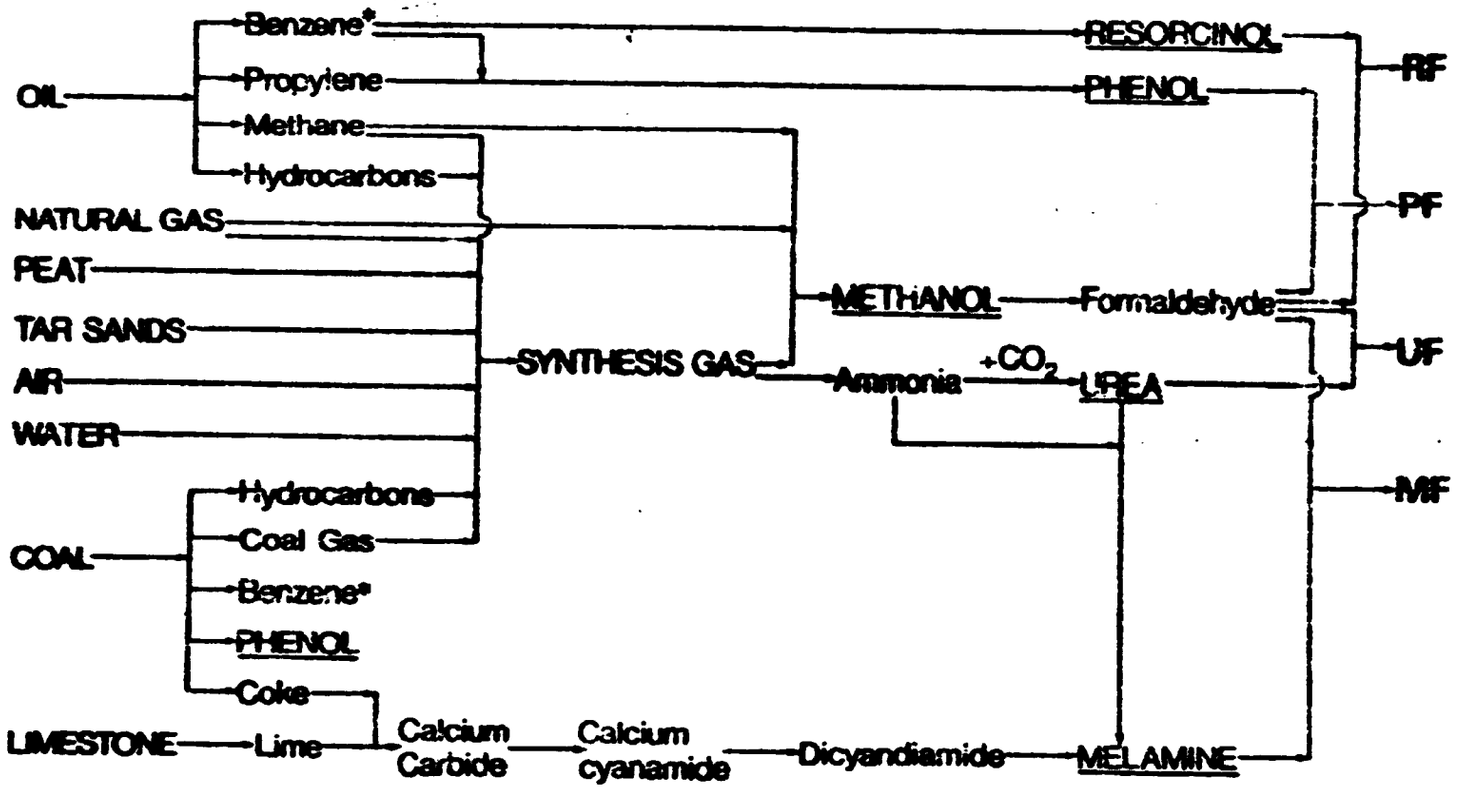


Figure IV SYNTHESIS ROUTES TO FORMALDEHYDE RESINS



Benzene* from either source can be used to produce phenol & resorcinol

2. The custom of using wax (as an emulsion or molten) in the manufacture of particle board was questioned. It was agreed that the addition of wax increased the rate of liquid water repellency of particle board. It was suggested that molten wax also helps to fix resin particles on to the flakes in the production of flake board, and wax emulsion in general confers certain "slip" properties in resin blenders and on conveyors, forming stations and cauls.

3. Preservative treatment of panel products may be divided into two groups:

   (a) Treatment against attack by insects;

   (b) Treatment against attack by fungi.

   Protection can be achieved by:

   (a) Treating the veneer or particles prior to adhesive application;

   (b) The incorporation of preservatives into the adhesives;

   (c) Post treatment of the glued, finished and panel product.

   There is no universal solution to the preservative treatment of plywood and particle board.

   Additives for improving the insect and fungi resistance of particle board are used. For example in the Federal Republic of Germany there are five approved preservatives for the protection of particle board against fungi that meet the requirements of the Federal Institute of Materials Testing in Berlin.

   The treatment of plywood is more difficult. A considerable amount of work has been carried out by CSIRO in Australia, the Forest Products Laboratory in the United Kingdom and preservative manufacturers. There is no universal solution to this problem as yet and the ideal preservative fulfilling all requirements (adhesive compatibility, protection against all hazards and universally acceptable for all legislation on human toxicity of the preservative) has not yet been developed. Therefore, the workshop felt that greater attention should be placed on this work in future.

4. The Workshop's attention was drawn to the increasing publicity being given to the emission of formaldehyde from ligno cellulosic based panels. Statements have been made that formaldehyde is a serious health hazard, even carcinogenic. Speakers stressed that no evidence

existed to support such claims and pointed out that such statements could bring unjustified discredit on wood-based panel products. In consequence, world trade in these materials could be affected.

5. The speakers recognized that formaldehyde gas in air - even at levels as low as 1 ppm - produces temporary unpleasant physiological reactions.

6. Some countries are already introducing standards to limit the emission of formaldehyde from ligno cellulosic based panels, especially particle boards. The intention of these standards is to reduce the emission to amounts that in general, would not cause discomfort in rooms containing even large amounts of ligno cellulosic based panel products.

7. The workshop stressed that:

- there is no evidence that formaldehyde at low concentration is carcinogen, or even produces permanent disorders;

It recommended that:

- standard methods of measuring formaldehyde, both in air and ligno cellulosic based panels, should be developed and steps taken to make them generally accepted;
- the problem is an international one, and maximum exchange of information should occur between all national manufacturers' associations;
- greater attention should be paid by specialized research institutes in the field of developing suitable preservative treatment processes for plywood.
- due to the scarcity of wood and wood waste in some of the developing countries alternative raw materials hitherto utilized such as rice husks, coconut husks, and straw should be considered if they are available in suitable quantities. Some of these raw materials have natural resistance to termites, fire attack and decay. Attempts to bond these materials have been encouraging but appropriate research should be carried out. Attempts to utilize these materials should be sympathetically supported by UNIDO.
- the Workshop identified the need for a study to cover the subject of extenders and fillers and recommended to UNIDO to commission such a study.

V. Equipment for application of adhesives

Three papers prepared for this topic were presented and discussed. These were: "Equipment for Preparing Ready-to-Use Adhesives" by S. Senn (Document ID/WG.248/12), "Mixing Equipment for Glue Coating of Wooden Chips or Irregular Particles of Similar Shape" by F. Engels (Document ID/WG.248/13) and "Equipment for Glue Coating" by H. Funke (Document ID/WG.248/11).[5/]

1. The ensuing discussion dealt mainly with glue mixing equipment and adhesive application equipment for the particle board industry. With regard to the glue mixing equipment it was recommended to use mechanical methods and avoid the costly electronic control units while ensuring that the human element does not become a risk when blending the glue. The ready to use glue mix should contain all components and for safety and economic reasons no in-line mixing or seperate application of the components on to the furnish is recommended. However, the separate application of wax could be an acceptable procedure.

2. The addition of starch, waxes, fungicides and other special additives are optional and depend on board requirements. Excessive mixing of the glue components should be avoided to prevent excessive foaming and minimize the risk of insufficient glue solids application. The blending equipment for glue application on to the particles which was described, reflected mainly the requirements of the developed countries. For developing countries where plants usually have smaller capacities, investment and maintenance could be minimized by the use of only one blender for alternatively gluing face and core material. This is possible because of the shorter retention time offered by the modern blenders. Glue viscosity variations do not present a problem for the modern equipment. Simple accurate proportioning of glue to particles will require the presence of a reliable operator. The use of belt conveyors for transporting resin coated particles will in most cases meet the needs of developing countries. Experience has shown that certain non-essential glue deck items such as metering devices, fall into disuse shortly after plants beoome operational. This indicates the need for a careful determination of the items considered to be essential. Additional control systems can be inoorporated at a later stage provided that during the planning stages this had been borne in mind.

5/ Another UNIDO document that deals with the subject is: "Selection of Equipment for Joining" by E. van der Straeten and J. Reinhardt, CIBA-GEIGY (Uk) Ltd., Plastics Division, Duxford, Great Britain (Document ID/WG 151/18).

3. Experience has shown that other ligno cellulosic raw material e.g. bagasse, rice husks, coconut coir, etc. can be coated with glue using existing equipment. Further development work is needed, however. Attempts to use these and other ligno cellulosic raw materials should be encouraged by UNIDO.

4. The following paper - item 14 of the agenda - dealt with glue application equipment for the plywood, gluelam and furniture industry. The various applicators are designed for specific products. Hence selection of equipment will be limited by the products manufactured. For plywood and veneering in developing countries roller coating equipment is generally the most suitable because it tolerates a wide glue viscosity range and can apply a wide range of spread. The machine is also not sensitive to glue fillers with a certain grit content. The use of roller coaters makes it necessary that veneer thickness be controlled to ensure even spreads. Thin veneers may require a reduction in glue viscosity to ensure correct passage through the rollers. With spray coating applicators inefficient glue application occurs and up to 50 per cent glue losses can be experienced. Problems may be encountered when spraying filled resins. For furniture and joinery glue gun application may be used but it is important to clean these guns regularly. In gluelam production where high throughput is required, coaters were recommended.

VI. Adhesive testing procedures and standards

The paper prepared by A. Frühwald entitled "Adhesive Testing Procedures and Bonding Strength Testing Equipment" (Document ID/WG.248/8) was presented. In the ensuing discussion the following points emerged:

1. Tests on uncured adhesives comprise evaluation of viscosity, reactivity, pot-life, pH and solids, plus other minor tests. It was noted that the temperature of 140 - 150°C was too high for solids determination as weight loss from the condensation reaction and by pyrolysis is observed. Generally lower temperatures are used within different time lapses.

2. The group debated the validity of measuring the quality of plywood by wood failure versus sheer tests, but no consensus could be reached.

3. In countries where wood species vary widely, tests are made on wood of two species of different densities. For hardwood species the shear values are taken generally as a measure of quality, while for softwoods the wood failure values are taken. Some countries take both values as necessary for plywood quality evaluation. The values of 100 per cent wood failure really give the value for the shear strength of the wood but not for the glue-line. The only relationship between these values would be that the shear strength of the glue line is greater than that of the wood; no other relationship is possible. In particleboard a strong correlation exists between shear strength and internal bond. It was recommended that for particle board standards, a shear strength tests be considered for adoption as it is easier to carry out than an internal bond test.

4. Tests made on the same types of plywood, following standards set by Turkey, the Federal Republic of Germany and the United Kingdom, gave different results. This was also noted by different Asian nations which have to export to different countries, each with different standards, so an Asian plywood standard[6/] has been adopted in October 1977. by the Asian plywood manufacturers, in which the use of wood failure and shear strenth determinations was adopted. Japan uses only shear strength as quality measurement while in the USA it is evaluated on wood failure values.

5. It was felt that international standards should be prepared and adopted for testing glue-lines of plywood, although it was reported that ISO has such a standard in preparation.

6. The need for non-destructive testing of panels was mentioned as many boards are lost by destructive testing. In the U.S.A. ultrasonic test methods are being used for plywood, particlebaord and glue lam, they being an effective continuous production quality control tool,

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6/ **Asian Plywood Standards, adopted October 6, 1977 Conference of Asian Plywood Manufacturers.**

although physical tests are also being carried out. The correlation between ultrasonic values and physical strength test values is being studied. It was felt that ultrasonic devices would be too advanced for many developing nations.

7. It was recommended that UNIDO should compile a list of specifications and test methods issued by the various countries and issue it as an addendum to this report. This list should also include a glossary (in English) of terms used in the wood glueing industry.

ANNEX I

Agenda

Agenda Item	
1	Election of officers and adoption of agenda
2.	Economics of production of synthetic resin adhesives
3	Utilization of naturally occurring organic products:
	a) past research;
	b) industrial application.
4.	Industrial application of synthetic adhesives for:
	a) wood based panels;
	b) gluelam and timber engineering products;
	c) joinery and furniture products.
5	Equipment for application of:
	a) ready-to-use adhesives;
	b) adhesive-particle blending;
	c) adhesive spreading.
6.	Testing procedures and equipment for adhesives
7	Quality control procedures and standards for glued assemblies
8	Adoption of the report

Annex II

List of Documents[a/]

Documents prepared for the Workshop

Symbol	Title and author	Agenda item
ID/WG.248/2	Review of past research on utilization of naturally occuring organic products as replacement of synthetic phenolics in wood adhesives. by E. Kulvik, Manag by E. Kulvik, Manager, A/S Jontungruppen, Sandefjordt, Norway	3
ID/WG.248/3	Economics of production of synthetic resin adhesives by J. George, Director Indian Plywood Industries Research Institute, Bangalore, India	2
ID/WG.248/4	Formulation and industrial application of synthetic resin and special adhesives used in the joinery and furniture industries and other specialized wooden products. by E.J. van der Straeten and T.I. Mynot, Plastic Division, CIBA-GEIGY, Duxford, Cambridge, Great Britain	4
ID/WG.248/5	Annotated Bibliography on the research done on the use of naturally occurring adhesives for wood processing industries. by J. George, Director, Indian Plywood Industries Research Institute, Bangalore, India	3
ID/WG.248/6	The formulation and industrial application of naturally occurring polyphenol (tannin) adhesives in the wood panel industry by K. F. Plomley, Principal Research Scientist, Wood based panels group, CSIRO, Highelt, Victoria, Australia	3
ID/WG.248/7	Economic aspects of tannin extracts as wood adhesive binders by J. C. Scharenberg, Development Manager, Compania Casco S.A.I.C., Buenos Aires, Aregentina	2

[a/] A limited number of copies of these documents are available upon request in the language in which they were issued (mainly English).

Symbol	Title and author	Agenda items
ID/WG.248/8	Adhesive testing procedures and bonding strength testing equipment by A. Frühwald, Division Leader, Institut für Holzphysik, Bundesforschungsanstalt für Holzwirtschaft, Hamburg, Federal Republic of Germany	6
ID/WG.248/9	Industrial application and formulation of synthetic resin adhesives in the wood based panel industry by J. Reinhardt, Export Sales Manager, Plastics Division, CIBA-GEIGY, Duxford, Cambridge, Great Britain	4
ID/WG.248/10	Formulation and industrial application of synthetic resin adhesives in the glued-laminated beam and timber engineering industry by H. C. Kolb, Head Timber and Timber Connection Department, Otto Graf Institute, Stuttgart, Federal Republic of Germany	4
ID/WG.248/11	Equipment for glue coating by H. Hunke, Professor Fachhochschule Rosenheim, Federal Republic of Germany	5
ID/WG.248/12	Equipment for preparing ready-to-use adhesives by S. Senn, Chief Technologist, Fehrni Institute Ltd., Zurich, Switzerland	5
ID/WG.248/13	Mixing equipment for glue coating of wooden chips or irregular particles of similar shape by W. Engels, Director Draiswerke GmbH, Mannheim, Federal Republic of Germany	

Documents issued after the Workshop on the recommendation of the participants

ID/WG.248/17	Report of the Workshop on Adhesives used in the Wood Processing Industries	8

Miscellaneous documents

ID/WG.248/1	Provisional Agenda	1
ID/WG.248/14	Agenda and Programme of Work	1
ID/WG.248/15	List of Participants	
ID/WG.248/16	List of Documents	

The following studies on uses of wood have been published by the United Nations Industrial Development Organization.

ID/10 Production Techniques for the Use of Wood in Housing under Conditions Prevailing in Developing Countries
Report of Study Group, Vienna, 17-21 November 1969
United Nations publication, Sales No. 70.II.B.32

ID/61 Production of Prefabricated Wooden Houses
Veijo M. E. Tiusanen
United Nations publication, Sales No. 71.II.B.13

ID/72 Wood as a Packaging Material in the Developing Countries
B. Hoehert
United Nations publication, Sales No. 72.II.B.12

ID/79 Production of Panels from Agricultural Residues
Report of Expert Group Meeting, Vienna, 14-1 December 1970
United Nations publication, Sales No. 72.II.B.4

ID/108/Rev.1 Furniture and Joinery Industries for Developing Countries
I: Raw Material Inputs
II: Processing Technology
III: Management Considerations

ID/133 Selection of Woodworking Machinery
Report of a Technical Meeting, Vienna, 19-23 November 1973

ID/154 Low-cost Automation for the Furniture and Joinery Industry

ID/180 Wood Processing for Developing Countries
Report of a Workshop, Vienna, 3-7 November 1975

UNIDO/LIB/SER.D/4 UNDIO Guides to Information Sources No.4: Information Sources on the Furniture and Joinery Industry

UNIDO/LIB/SER.D/9 UNIDO Guides to Information Sources No. 9: Information Sources on Building Board from Wood and other Fibrous Materials

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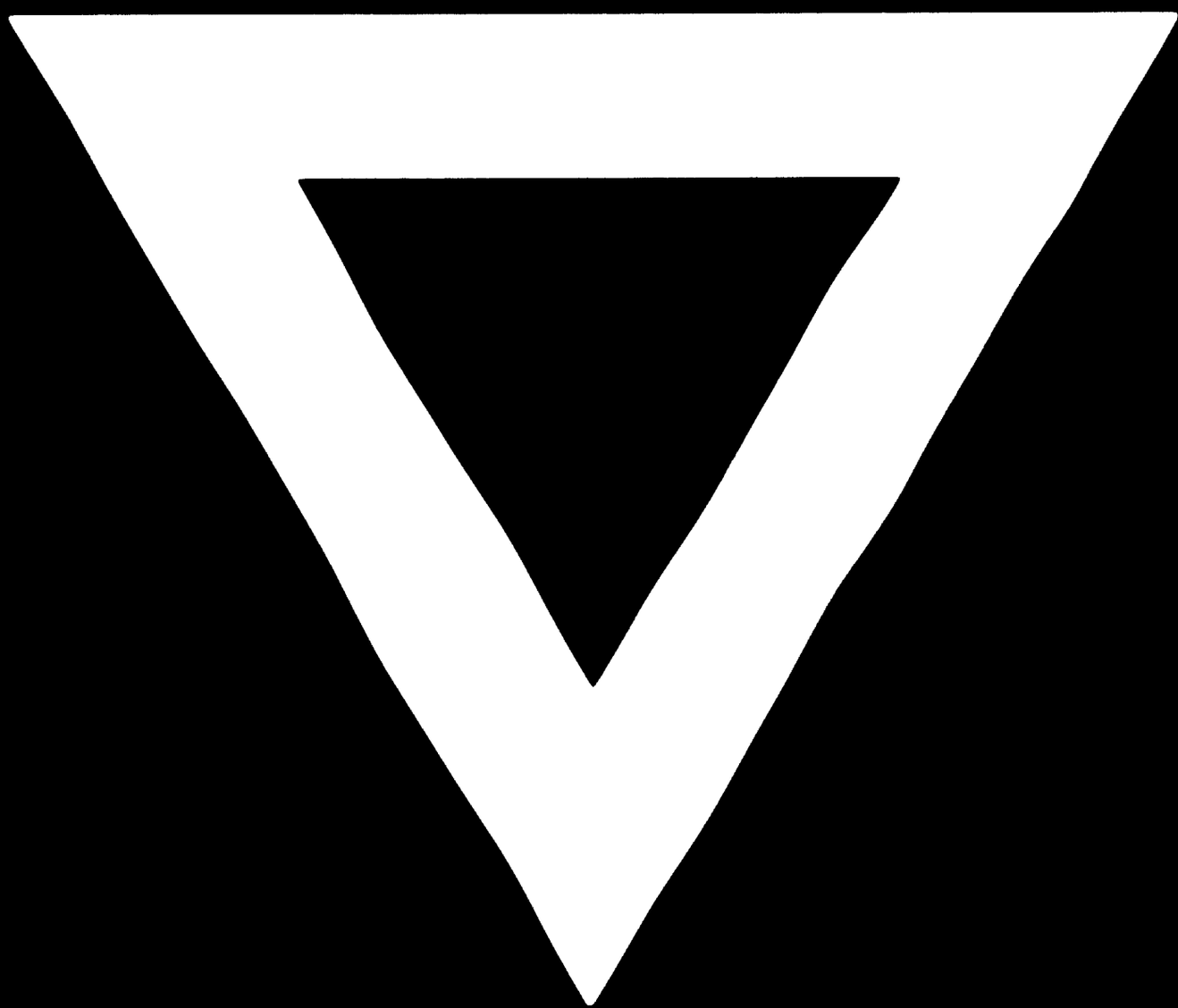

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