

## 2.5 Wood Products

### Overview

Aim of present research in the field of wood, its constituents and wood products is to utilize every bit of woody and lignocellulosic raw material available. Current research is focused towards using plantation timber; use of FT-NIR and ultrasonics for wood quality assessment; modification of wood surfaces for enhancing its stability, durability and surface qualities; development of new methods of timber drying; testing of exotics and imported species for their durability and treatability; developing surface coating systems, use of plant extract as preservative and lignin in various by products.

The testing facilities were developed for evaluating the performance/suitability of musical instruments made out of plantation timbers. Studies were carried out on tree-ring analysis (dendrochronology) of teak from Karnataka and Maharashtra which is an innovative research work which showed good potential to know drought years, flood years, insect attack, fire scars and adaptation of species with changes in climate.

The method of laboratory testing for the assessment of the durability of timbers against powder post beetles is standardized. Twenty different imported timber species evaluated for their durability against fungi and termites at Nallal, Palode, Hyderabad, Vishakapatnam, Jodhpur, Jabalpur and Dehradun. All species in the yard tests of different place of origin at Dehradun were moderately to badly attacked by fungi and termite except Australian teak.

Eight species of plantation timber were evaluated for their durability against decay by fungi and termites. *A. mangium* of 10, 15 & 20 years timber can be classified under Class I whereas 5 years comes under Class II. *Eucalyptus tereticornis* showed good resistance against decay

by fungi (Class I) *Grewia robusta* belongs to class III and *M. dubia* falls under non-resistance class (IV).

Treatability evaluation is also being carried out of few imported wood species. Seven (*Tectona grandis*, *Shorea robusta*, *Shorea marcoptera*, *Shorea* sp., *Pterocarpus soyauxii*, *Dryobalanops* sp. and *Xylia dolabriformis*) timbers tested using accelerated tests were found more durable. Different treatment regimes were developed for the treatment of difficult to treat species to give appropriate retention of preservatives. Studies on Eco-friendly preservatives from natural products for durability improvement is also being carried out.

A two step temperature-vacuum schedule has been evolved for the range of 70 % to below FSP for poplar at FRI, Dehradun. The energy and cost saving is very high as for a four-run drying, one needs to run the kiln for just 29 hours. The reduction in moisture contents observed below FSP was of the order of 29 % of the initial value at the best temperature vacuum combination. In another experiment a three-step temperature vacuum schedule has been evolved for the range of 50 % to below FSP for Teak. The energy and cost saving is very high as for drying by this method, one needs to run the kiln for very short time compared to conventional steam heated kilns. The reduction in moisture contents observed below FSP was of the order of 33 % of the initial value at the best temperature vacuum combination.

A conveyor belt Micro Wave (MW) dryer system fabricated, installed at IWST, Bangalore was standardized. MW technique proved to be relatively faster method for drying wood upto fibre saturation point. It has no negative effect on mechanical properties and preservative treatment



of timber. A high quality of drying of bamboo species (*D. stocksii* and *D. strictus*) could be achieved using microwave dryer. The time of drying for bamboo is drastically reduced from several days in conventional kiln drying to few hours in MW drying.

#### Projects under the theme

Project	Projects Completed During the Year	Ongoing Projects	New Projects Initiated During the Year
Plan	6	13	8
Externally Aided	3	2	3
<b>Total</b>	<b>09</b>	<b>15</b>	<b>11</b>

#### 2.5.2 Wood and other lignocellulosic Composites

Particle boards using lops and tops of poplar, eucalyptus and in combination (three different ratios) were prepared and tested. Experiments were performed at two pressure level, three resin content levels, three sizing agents (wax) %. Particle boards of poplar and eucalyptus were also prepared using 2% of thermally conductive filler with two pressure level and three resin content levels and tested for their various physical and mechanical properties.

Phenol Urea Formaldehyde (PUF) adhesive prepared with five different ratios of phenol: urea: formaldehyde and analyzed for their properties. Using these combinations plywood prepared and tested for glue shear strength.

Jute-Polypropylene and Bamboo-Polypropylene composites prepared and evaluated for mechanical properties and rheological properties. Coupling agent was synthesized by melt phase functionalization of polypropylene (PP) with m-Isopropenyl-dimethylbenzyl-isocyanate (m-TMI) using twin screw extruder. Polypropylene, m-TMI-grafted-PP and nanoclay (in the ratio of 1:1:2) were

compounded on torque rheometer. The masterbatch, thus, prepared was compounded with pure PP so as to get PP composites filled with 2.5, 5, 7.5 and 10% of nanoclay. The samples were evaluated for their mechanical behaviour. Rheological properties of the blends were also studied.

Co-polymerization kinetics studies using filler supported catalyst system are undertaken. Design of reactor system including laying of gas feed lines and gas metering system, reactor automation and data acquisition using computers completed at IWST, Bangalore. Preliminary experiments on synthesis of composites using polymerization filling technique completed. Work on studying effect of various parameters like temperature, pressure and catalyst concentration on co-polymerization is in progress.

#### 2.5.3 Wood Processing

An indigenously designed convection heating type vacuum kiln has been installed in the Wood Seasoning Discipline, FRI, Dehradun. Drying behaviour of chir pine timber was studied in this kiln. The drying time of chir pine timber reduced remarkably in the vacuum kiln compared to the conventional steam-heated kiln. The vacuum kiln is going to be a very useful tool for the wood processing industry for their need of seasoned timber.

#### 2.5.4 Value Addition and Utilization

Studies on moisture blocking capacity of different traditional wood finishes with progressive layers of coating on wood surfaces are being undertaken at FRI, Dehradun.

Studies on finger jointing on Indian timbers are being undertaken at FRI, Dehradun with a view to reducing wastage of precious wood material and also to look at the possibility of adopting finger jointing for structural and semi structural uses.



Red, yellow and white meranti were evaluated for treatability. White meranti was easily treatable and classified in class 'a' while red in class 'c' and yellow in class 'd'. Douglas fir is easily treatable.

Different preservative treatment schedules were developed by varying treatment conditions like pressure, hot water dipping and diffusion etc., for the treatment of difficult to treat species. The methods of pressure treatment followed by diffusion gave adequate retention with different preservatives (four combinations).

Methanol and hot water extractives isolated from neem leaves gave maximum complexation i.e. 34.24%. Methanolic extractive exhibited 34.24% Copper (II) complexation while hot water exhibited 22% complexation of Copper (II) at 48 h. Malt agar bioassay results revealed efficacy of both the complexes at very low concentration i.e. at 0.002% against brown rot and white rot. Metal Hot Water Complex (CHWC) and Metal Methanolic Complex (MMC) were found very effective against wood decaying fungi i.e. brown rot and white rot in laboratory.

The effect of moisture content; grain orientation; defects (hollowness) on ultrasonic velocity in wood of *Acacia mangium*, *Grevillea robusta*, *Shorea robusta*, *Dalbergia sissoo* and *Tectona grandis* were studied and *Mangifera indica* and developed a relationship which will be helpful in future to detect defects were developed. The strength properties (MOE, MOR, FS at LP) of *Acacia mangium*, *Grevillea robusta*, *Shorea robusta*, *Dalbergia sissoo*, *Tectona grandis* and *Mangifera indica* were studied by conventional test method and were correlated with the values obtained by ultrasonic method. The ultrasonic technique was tried on standing trees for defect detection.

In another study for evaluation of wood and wood products in use by ultrasonic, three field visits were conducted and detailed survey was made for finding used wood and wood products, wooden logs and wooden structure fixed in market of Karnataka. (Timber Yard



Ultrasonic Technique on Standing Trees for Defect Detection

Survey – 6, Saw mill Survey - 6, *in-situ* structures survey - 6). Purchased the used wood and wood products. Identified *in-situ* structures/wood products (10). Samples prepared as per IS 1708 – 1986 for specific gravity (30) and static bending (30) tests.

Studies carried out on *Acacia mangium* procured from Orissa indicate the timber is dimensionally steady and grouped along with *D. sissoo* and *Adina cordifolia*. The timber was dried in dehumidifier kiln for 47 days to attain 18% moisture content from initial moisture content of 80%.



Studies on anatomical Chair Made Out of *Acacia* properties for all the trees completed. Mechanical properties like Compression, Static bending, Hardness, Shear, Tension, Nail and Screw holding were evaluated in green and dry condition. Installation of preservative samples at





Nallal for durability study completed. Periodic inspection was carried out to study the extent of damage. The timber was subjected to various handicrafts working quality and found suitable for carving, turning etc.

Sound absorption coefficient and effect of different wood parameters (grain orientation and thickness) in *Azadirachta indica*, *Eucalyptus tereticornis*, *Grevillea robusta*, *Melia composite* and *Tectona grandis* on sound absorption coefficient was determined. Also determined anatomical and strength properties of all species. Data generated on acoustical properties will help in selection of non-conventional timber species for utilizing as sound insulation material for paneling in the buildings. Generated data on commercially available 3 musical instruments (veena, violin and dholak). Studied the effect of anatomical parameters and strength properties on frequency spectrum generated by the commercially available musical instruments. Got fabricated veena and dholak from plantation species. Analysed the data obtained on frequency spectrum generated by musical instruments and found the suitability of species for musical instruments based on frequency spectrum and damping coefficients. Project completion report submitted to funding agency (CSIR).



Setup for Testing Musical Instruments

A Microwave dryer system was fabricated, installed and standardized at IWST Bangalore. Treatment of silver oak, eucalyptus, teak, rubber wood and *Gmelina arborea* with varying thickness and time was studied. Comparison of drying behaviour of microwave

treated and untreated wood was analysed. Ray cell of silver oak and eucalyptus were found to rupture by MW treatment for 20 minutes. Dehumidification drying characteristics of MW treated and untreated wood was carried out for all the five species. Effect of microwave treatment on treatability of rubber wood, silver oak, teak wood and *Gmelina arborea* was evaluated. It is observed that rubber wood lost more moisture. Effect of microwave treatment on drying of wood has been studied on 2 inch thick planks. Mechanical and physical properties of MW treated samples have been evaluated. The technology of microwave drying was demonstrated and explained to wood exporter and importer at Mangalore and at VVK Bangalore.

The method of laboratory testing for the assessment of the durability of timbers against powder post beetles was standardized to include in the BIS standards. Adults and larvae of *Lyctus africanus* and *Sinoxylon conigerum* were employed as the test insects and studying the durability of plantation timbers against borers. Natural durability of *Mesopsis eminii*, *Hevea brasiliensis*, *Grewilia robusta*, *Acacia mangium*, *Melia dubia* and *Acacia auriculaeformis* against the beetles were tested. Wood treated with neem products, CNSL, extractives from *Dysoxylum malabaricum*, *Cleistanthus collinus*, insecticides, Chlorpyrifos and Imidachloprid and tree seed oils were tested by exposure of adults and larvae of *L. africanus* and *S. conigerum*.

Indian Wood Insect Database (IWID), a web based database for Indian wood insects was developed in collaboration with FRI, Dehradun. The insect museums in different research institutions, universities, national collections at ZSIs and BSI were visited and wood insects documented. The data pertaining to about 1000 wood species and 2500 wood insects have been entered into the database. The database is an open



ended one and it is accessible worldwide and facilities for registration and contribution are inbuilt in the database. The database was launched by Director General, ICFRE at IWS, Bangalore on 10<sup>th</sup> December 2009. The database has been uploaded on ICFRE server on 22<sup>nd</sup> December 2009.

An anatomical approach was applied to evaluate treatability of timbers. Specific gravity of *Acacia mangium* and *Hevea brasiliensis* was determined. Samples were treated with 5% silver nitrate followed by 2% hydrazine hydrochloride and exposed to bright sunlight. Observed penetration of preservative to carry out qualitative analysis of absorption. Photomicrographs of the same were taken under stereo microscope. Specific gravity of the treated wood samples was determined and quantitative analysis of absorption was carried out. Sections were cut to see the impregnation of chemicals under microscope. Totally 5 species (*A. mangium*, *A. auriculiformis*, *H. brasiliensis*, *G. arborea* and *G. robusta*) were completed. Completed qualitative and quantitative analysis of wood samples treated with silver nitrate. Treatment of samples with red oil was started. Sections of the samples of all the 5 species were taken to find out the stains.

Effect of moisture content and diameter on the treatability using vacuum impregnation method was undertaken on *Calamus thwaitesii* (cane). Prophylactic treatment was given with 2% Boric acid. Green and dried cane specimens were treated with two different preservatives, (CCB and boric acid) by vacuum pressure impregnation method following three different treatment schedules. Absorption of preservative is calculated on weight gain basis. Qualitative analysis by spot test and quantitative analysis of 10 specimens for each set by chemical assay method was completed. Further work is under progress.

Under the study on tree ring analysis of certain species in Western Ghats to monitor climate changes and its relevance to wood quality, teak discs were collected from Madikeri, Mundagod of Karnataka and Thane, Chandrapur from Maharashtra. Collected meteorological data and information on sites from Karnataka and Maharashtra. Teak samples were prepared by using special technique to expose growth rings. Training provided to JRFs at IITM, Pune for handling COFECHA and ARSTAN programmes in tree ring analysis. Specific gravity, ring width and age of 36 discs completed from Karnataka and Maharashtra. Study on vessel morphology completed for all 36 discs. Cross dating and standardization of discs carried out using COFECHA and ARSTAN programme, respectively. Specific gravity, ring width and age by ring counting. Collection and sending to expose growth rings completed for 6 core samples of *Myristica* spp. Correlation and data analysis for chronology development and wood quality completed for all teak discs from Karnataka and Maharashtra. Determination of age of 6 cores of *Myristica* spp. completed. Among vessel morphology, only vessel density of *Myristica* spp. from Sirsi (Karnataka) is completed.

In the study on the permeability of selected imported timbers marketed in Karnataka, five species of imported timbers viz., *Xylia dolabriformis* (Pyinkado), *Instia bijuga* (Merabau), *Dipterocarpus* spp. (Gurjan) and two *Shorea* spp. (Red meranti and Balau) marketed in Karnataka were procured. One hundred fifty experimental samples from each species (size: 22mm x 22mm x 22mm) were made. After conditioning of these samples, flow measurements were being recorded. On the other hand, test stakes of all five species (size: 19mm x 19mm x 450 mm) were exposed under field



condition. Periodical observation was in progress to evaluate their service life under field condition.

In an effort to study the performance of coatings on modified wood surfaces work on reaction conditions of acetylation and benzylation were standardized. Stands for natural weathering were designed and fabricated. The chemically modified wood panels (benzoylated and acetylated) of Rubber wood and *Pinus radiata* with average weight gains of 10-15% were prepared. Modified and unmodified wood panels were coated with a transparent and opaque polyurethane exterior paint. The coated and uncoated panels have been exposed to outdoor weathering and samples are being examined for weathering deteriorations. Screening and procurement of UV absorbers were completed.

In another study, chemical modification of wood using octanoyl and lauryl chloride carried out and reaction parameters are being optimized. Basic experiments on chemical modification of wood using alkylene epoxides viz., propylene oxide and butylene oxide carried out. Esterified/etherified wood was characterized using FTIR and NMR spectroscopy.

For improvement of weathering properties of wood surfaces by chemical modification, basic experiments using phenyl isothiocyanate were carried out. Study of dimensional stability, decay resistance and light stability of phenyl isothiocyanate modified rubberwood was carried out. Modified wood samples exhibited good dimensional stability and fungal resistance but not effective in decreasing photo yellowing.

### 2.5.5 Pulp and Paper

Modified lignin product from mill I and mill II prepared by passing  $\text{SO}_2$  gas at optimized conditions were analyzed for their chemical composition and tested for their performance as solvent for isolated lignin, as dispersing agent/emulsifiers and possible use as an oil well drilling additives. It was found that lignin as well as modified lignin products made from soda spent black liquor of both the mills are more stable at higher temperature upto  $900^\circ\text{C}$  as compared to lignin from both the mills as the IPDT values are higher in case of modified lignin's of both the mills which shows slow decomposition at high temperature and can find application where the higher operating temperature is required. As far as their application as solvent for isolated lignin are concerned, lignin modified from soda spent black liquor from both the mills can find application as an additive for organosolv pulping particularly to overcome precipitation of lignin onto pulp fibres during washing but from mill II the results are better under the optimized conditions under which the product were prepared. Testing of modified lignin samples prepared from both the mills for application as dispersing agent/emulsifier in terms of reduction in Standard Dispersion Number (SDN) indicates that these can find application as binder in rubber industry. Modified lignin from soda spent black liquor of both the mills passed the physical characteristics viz. Physical state, moisture content & water solubility as per the specification for oil well field chemicals. Although rheological properties in terms of apparent viscosity (cp) & yield point (lbs./100 sq.ft.) lowered in modified products prepared from liquor of both the mills but could not exactly match the required specification.