

## Abstracts

**Recombinant DNA in woody plants**, F. SAKAI: "Structure and Function of Genes" ed. T. Komano, pp. 253–263, Gakkaishuppannsennta, Tokyo (1998) (in Japanese).

Recombinant DNA techniques for woody plant improvement were introduced.

**Efficient plantlet regeneration from protoplasts isolated from suspension cultures of poplar (*Populus alba* L.)**, J. QIAO, H. KURODA, T. HAYASHI and F. SAKAI: *Plant Cell Reports*, **17**, 201–205 (1998).

An efficient plant regeneration system from protoplasts for poplar was developed. Protoplasts were isolated from 4-day-old suspension cultures derived from seed-induced calli with a yield of  $7 \times 10^6$  cells/fresh wt cells and then cultured in  $\text{NH}_4 \text{NO}_3$ -free Murashige and Skoog (MS) medium supplemented with 2,4-dichlorophenoxyacetic acid (2,4-D), thidiazuron (TDZ) and glucose as an osmoticum. The plating efficiency of the cultured protoplasts was calculated at 31.7% at day 14. Cell colonies were observed after culturing for 4 weeks. Regenerated colonies were propagated through sub-culture in liquid MS medium containing 2,4-D. Buds were induced from regenerated calli on MS medium containing kinetin or TDZ. Regenerated shoots were rooted on half-strength MS medium, and the plantlets were transplanted in soil. Randomly amplified polymorphic DNA analysis did not detect any DNA polymorphism among the regenerated plants.

**Transient expression of goat growth hormone gene in poplar (*Populus alba* L.) protoplasts: A quick method for detection of foreign gene expression in mRNA level**, J. QIAO, Y. ISHIHARA, H. KURODA, F. SAKAI, H. SAKAI and T. KOMANO: *Biosci. Biotech. Biochem.*, **61**, 1580–1581 (1997).

We developed a sensitive, accurate, and fast method to detect foreign gene expression using reverse transcriptase-mediated polymerase chain reaction (RT-PCR) in poplar tree protoplasts. Template total RNA was purified by removing the transfected foreign gene vector completely with DNase I treatment before the RT reaction. Expression of cDNA that encodes goat growth hormone was confirmed at the mRNA level 24 h after electroporation mediated DNA transfer.

**Expression system for foreign genes using protoplasts from *Liriodendron tulipifera* L. suspension culture**, Y. ISHIHARA, H. KURODA, T. HAYASHI and F. SAKAI: *Wood Research*, **84**, 12–14 (1997).

*In vitro* culture and electroporation-mediated gene transfer systems of *Liriodendron tulipifera* (yellow-poplar) were developed as an important basic step towards researching the regulation of gene expression and producing new woody plants.

## ABSTRACTS

**Laser isolation of chromosomes demonstrates high sequence similarity between the X and Y sex chromosomes of dioecious *Silene latifolia***, C.P. SCUTT, Y. KAMISUGI, F. SAKAI and P.M. GILMARTIN: *Genome*, **40**, 705–715 (1997).

The isolation of X and Y sex chromosomes from the dioecious plant *Silene latifolia* (white campion) is reported. This is achieved by the ablation of surrounding chromosomes using an argon ion laser microbeam. Associated DNA sequences are then amplified by use of the degenerate oligo-primed polymerase chain reaction (DOP-PCR). Pools of DOP-PCR products are used to investigate the genomic organization of sex chromosomes and a novel procedure to enrich these pools in sub-sets of expressed sequences is introduced. Data complementary to the laser ablation studies is obtained by genomic *in situ* hybridisation (GISH). And, additionally, the chromosomal locations sex chromosome repeat sequences are analysed by fluorescence *in situ* hybridisation (FISH). The combined evidence derived from these studies demonstrates the X and Y sex chromosomes of *S. latifolia* to be of very similar DNA composition and also to share a significant repetitive DNA content with the autosomes. The evolution of *Silene* sex chromosomes is discussed and compared to that of sex chromosomes in another dioecious species, *Rumex acetosa*.

**Two stilbene synthase genes from Japanese red pine**, Y. YAMAUCHI, H. KURODA and F. SAKAI: *Wood Research*, **84**, 15–18 (1997).

Stilbene synthase gene (*sts*) was efficiently amplified by PCR from genomic DNA of Japanese red pine (*Pinus densiflora*). We found that the PCR product is a mixture of, at least, two *sts* genes. Both of the *sts* genes are quite similar in their sequences but are different in length of their introns. They carried respective active sites of the enzyme and expressed simultaneously in the roots but not in the hypocotyls. Together with those findings described in the text, we concluded that the two *sts* genes characterized here are isogenes, but not allogene nor pseudogene.

**Synthesis of asymmetrically labeled sucrose by a recombinant sucrose synthase**, T. NAKAI, N. TONOUCI, T. TSUCHIDA, H. MORI, F. SAKAI and T. HAYASHI: *Biosci. Biotech. Biochem.*, **61**: 1955–1956 (1997).

About eighty percents of radioactivity was recovered in asymmetrically labeled sucrose from UDP [<sup>14</sup>C]glucose or [<sup>14</sup>C]fructose with recombinant sucrose synthase expressed in *Escherichia coli* harboring pEB-01. High level of the recovery is due to the fact that enzyme conserving the activity of sucrose synthase has affinity for UDP-glucose and fructose similar to the intact enzyme from mung bean, but lower affinity for sucrose.

**Expression and characterization of sucrose synthase from mung bean seedlings in *Escherichia coli***, T. NAKAI, N. TONOUCI, T. TSUCHIDA, H. MORI, F. SAKAI and T. HAYASHI: *Biosci. Biotech. Biochem.*, **61**: 1500–1503 (1997).

The cDNA fragment coding for mung bean (*Vigna radiata* Wilczek) sucrose synthase was introduced by PCR into the expression vector pET-20b resulting in the construction plasmid pEB-01. After transformation of *Escherichia coli* strain BL21 (DE3) cells by the pEB-01 and induction with isopropyl thio- $\beta$ -galactoside, high level expression of the recombinant enzyme was obtained. The enzyme formed a tetrameric form which conserved the activity of sucrose synthase. The affinity of the recombinant enzyme for UDP-glucose was similar to that of native enzyme, whereas the affinity of the recombinant enzyme for sucrose was lower for the recombinant.

**A beta-glucosidase gene downstream of the cellulose synthase operon in cellulose-producing *Acetobacter***, N. TONOUCHI, N. TAHARA, Y. KOJIMA, T. NAKAI, F. SAKAI, T. HAYASHI, T. TSUCHIDA and F. YOSHINAGA : *Biosci. Biotech. Biochem.*, **61** : 1789–1790 (1997).

The discovery of beta-glucosidase gene downstream of the cellulose synthase operon in cellulose-producing *Acetobacter* was described.

**A xyloglucan-specific endo-1, 4- $\beta$ -glucanase isolated from auxin-treated pea stems**, T. MATSUMOTO, T. TAKEDA, F. SAKAI and T. HAYASHI : *Plant Physiol*, **114** : 661–667 (1997).

A xyloglucan-specific endo-1, 4- $\beta$ -glucanase was isolated from the apoplast fraction of auxin-treated pea stems in which both the rate of stem elongation and the amount of xyloglucan solubilized were high. The enzyme was purified to apparent homogeneity by sequential cation-exchange chromatographies, affinity chromatography and gel filtration. The purified enzyme gave a single protein band on SDS-polyacrylamide gel electrophoresis, and the molecular size was determined to be 77 kD by SDS-PAGE and 70 kD by gel filtration. The isoelectric point (pI) was about 8.1. The enzyme specifically cleaved the 1, 4- $\beta$ -glucosyl linkages of the xyloglucan backbone to yield mainly nona- and heptasaccharides but did not hydrolyze carboxymethylcellulose, swollen cellulose and (1 $\rightarrow$ 3, 1 $\rightarrow$ 4)- $\beta$ -glucan. By hydrolysis, the average molecular size of xyloglucan was decreased from 50 to 20 kD with new reducing chain ends in the lower molecular size fractions. This suggests that the enzyme has endo-1, 4- $\beta$ -glucanase activity against xyloglucan. In conclusion, a xyloglucan specific endo-1, 4- $\beta$ -glucanase with an activity that differs from the activities of cellulase and xyloglucan endotransglycosylase has been isolated from elongating pea stems.

**Cellulose as a biological sink of CO<sub>2</sub>**, T. HAYASHI, Y. IHARA, T. NAKAI, T. TAKEDA and R. TOMINAGA : *Advances in Chemical Conversions for Mitigating Carbon Dioxide*, eds. T. INUI, M. ANPO, K. IZUI, S. YANAGIDA and T. YAMAGUCHI (Elsevier, Tokyo), pp. 243–248 (1998).

$\beta$ -Glucan synthesis has been demonstrated from UDP-glucose at the interface between

## ABSTRACTS

tobacco plasma membrane and a polylysine-coated coverslip, where microtubules are exposed and  $\beta$ -glucans are formed underneath. The synthesis of  $\beta$ -glucan microfibrils was direct. This indicates that  $\beta$ -glucan synthases penetrate through the membrane to synthesize microfibrils into the interface between the membrane sheet and coverslip and move in the fluid membrane along cortical microtubules, where the force of glucose polymerization propels the movement. Random sequencing of 1,000 clones from the cDNA library of cotton fiber cells at a high rate of cellulose synthesis revealed 173 clones with sequences found in the GeneBank database. Some clones identified contained homologs of the bcs A gene encoding the catalytic subunit of bacterial cellulose.

**Xyloglucan**, T. HAYASHI: *Seikagaku*, **69**, 1392–1397 (1997).

Recent advances in the studies on xyloglucan were reviewed.

**Possible biochemical roles of oxalic acid as a low molecular weight compound involved in brown-rot and white-rot wood decays**, M. SHIMADA, Y. AKAMATSU, T. TOKIMATSU, K. MII and T. HATTORI: *J. Biotechnology*, **53**, 103–113 (1997).

Possible biochemical roles of oxalic acid are discussed in relation to brown-rot and white-rot wood decays. In the brown-rot wood decay system, oxalic acid may serve as a proton source for enzymatic and non-enzymatic hydrolysis of carbohydrates and as a metal chelator. On the other hand, in the white-rot wood decay system, oxalic acid may play multiple roles, such as inhibitor of lignin peroxidases, and an electron donor for producing NADH, which may be used for reduction of lignin derived quinones, a source of formate radicals to reduce dioxygen of ferric iron to yield superoxide anion radicals and ferrous iron, respectively, and a chelator for stabilization of manganese ions for lignin degradation. Similar roles of oxalic acid in other living organisms are also briefly described.

**Stereochemistry of Lignan Biosynthesis in *Wikstroemia sikokiana***, T. OKUNISHI, T. UMEZAWA and M. SHIMADA: *Wood Research*, **No. 84**, 25–27 (1997).

Several lignans were isolated from *Wikstroemia sikokiana*, and their enantiomeric compositions were determined by chiral HPLC. Based on the enantiomeric compositions and a possible biosynthetic pathway proposed by feeding experiments with deuterium labelled precursors, stereochemical mechanisms of lignan biosynthesis in *Wikstroemia sikokiana* were discussed.

**The degradation of  $\beta$ -O-4 type lignin carbohydrate complex (LCC) model compounds by lignin peroxidase**, S. MIYATA, T. TOKIMATSU, T. UMEZAWA, T. HATTORI and M. SHIMADA: *Wood Research*, **No. 84**, 22–24 (1997).

$\beta$ -O-4 type lignin carbohydrate complex (LCC) model compounds were submitted to oxidation by lignin peroxidase, and the reactivity of the  $\beta$ -O-4 type LCC model compounds was found to be almost equal to that of the  $\beta$ -O-4 type lignin model dimers.

**A new oxidative degradation of a bio-recalcitrant  $\alpha$ -Carbonyl  $\beta$ -O-4 lignin model compound with Mn (III)/oxalate system,** N. KONDOU, T. HATTORI and M. SHIMADA: *Wood Research*, No. 84, 19–21 (1997).

The bio-recalcitrant  $\alpha$ -Carbonyl  $\beta$ -O-4 lignin model compound was found to be degraded with Mn (III) in the presence of oxalate and DMSO, yielding the C $\alpha$ -C $\beta$  bond cleavage and the  $\beta$ -O-4 bond cleavage products. The reaction mechanisms for the degradation of the substrate was quite different from LiP system.

**The role of secondary metabolite of wood-rotting fungi and mycorrhizal fungi,** T. HATTORI: *Wood Research and Technical Notes*, No. 33, 1–12 (1997) (in Japanese).

Recent advances in the role of secondary metabolite of wood-rotting fungi and mycorrhizal fungi were reviewed.

**Stereochemical diversity in lignan biosynthesis,** T. UMEZAWA, T. OKUNISHI and M. SHIMADA: *Wood Research*, No. 84, 62–75 (1997).

Recent advances in lignan biosynthetic studies are reviewed in relation to stereochemical mechanisms. Literature survey of enantiomeric compositions of several lignans isolated from various plants indicated that these plants produce (or accumulate) different enantiomers of the lignans with various enantiomeric compositions. Some are optically pure while the other are mixtures of both enantiomers. The data as well as recent results of enantioselective lignan synthesis with *Forsythia* and *Arctium* enzymes indicated that different stereochemical mechanisms are operating to give rise to the different enantiomers in *Forsythia* spp., *Arctium lappa*, *Wikstroemia* spp., *Phyllanthus* sp., and *Zanthoxylum* spp., and that metabolic steps to produce the optically pure lignans are probably different in the plants. Thus there is a great diversity in stereochemical mechanisms for lignan biosynthesis in different plants.

**Changes in the three dimensional architecture of the cell wall during lignification of xylem cells in *Eucalyptus tereticornis*,** T. FUJINO and T. ITOH: *Holzforsch.*, 52, 111–116 (1998).

The three dimensional architecture of the cell wall during differentiation of xylem cells in *Eucalyptus tereticornis* was visualized by rapid-freezing and deep-etching electron microscopy. A highly porous structure was demonstrated in cell corner, middle lamellae and primary walls of both cambium and enlarging xylem cells, but disappeared after lignification of the xylem cells. The porosity of the structure was abruptly diminished by the encrustation of lignin as well as dense deposition of cellulose microfibrils in differentiating xylem cells. This study is the first to detected rosettes, cellulose synthesizing enzyme complexes, in the differentiating xylem cells of a woody plant, and provides the first account of the visualization of the three dimensional architecture of xylem cell walls before

## ABSTRACTS

and after lignification.

**The use of tree species for wooden artifacts excavated from the Akano-Wan Site on Lake Biwa, Shiga prefecture**, M. OHYAMA and T. ITOH: *Mokuzaigakkaishi*, **44**, 59–68 (1998).

Many wooden remains were excavated from the Akano-Wan Site (from the Jomon-to the Kamakura periods) south of Lake Biwa. In this study, tree species of wooden artifacts excavated were identified anatomically. Based on the identification, we studied the species selection characteristics for the respective purposes and judged the forest environment of this site in the past.

Of 2,152 samples, 52 taxa were identified, including 1,578 samples of conifers and 574 of broad leaved trees. Among the broad leaved trees, evergreen species were dominant. *Cryptomeria japonica* D. Don was dominant with about 60% of these species which were used in large quantities for most kinds of wooden artifacts. On the whole, the species appropriate for the respective purposes were selected in terms of mechanical properties with the only exception being many spades made of *C. japonica*. The shapes of these spades were different from those made of *Quercus* subgen. *Cyclobalanopsis*, which may indicate that they were used for another purpose.

It is known that in the past *C. japonica* also occurred with great frequency because of pollen analyses made at several points around Lake Biwa. On the basis of our results and those of pollen analyses, we presume that the natural forest, mainly composed of *C. japonica*, had flourished around the southern part of Lake Biwa in the past.

**Tree species of wood remains excavated from Uchisato-Hatcho Site**, T. ITOH: Uchisato-Hatcho Site, Excavation at the Uchisato-Hatcho Site in Yawata City, Kyoto Prefecture, Japan, Papers of the Museum of Kyoto, **No. 13**, The Museum of Kyoto, 139–142, Plates 40–41 (1998).

A large number of wooden remains were excavated from Uchisato-Hatcho Site in Yawata City, Kyoto covering the era from Yayoi to Edo period. Fifty three pieces of wood including naturally buried wood and posts were identified microscopically.

**Cellulose network of hemocoel in selected compound styloid ascidians**, S. KIMURA and T. ITOH: *J. Electron Microscopy*, **46**(4), 327–335 (1997).

The network structure of cellulose microfibrils was found in the hemocoel of selected compound styloid ascidians, *Polyandrocarpa misakiensis*, *Metandrocarpa uedai* and *Polyzoa vesiculiphora*. The networks of *P. misakiensis* and *M. uedai* were composed of fibers with 0.16  $\mu\text{m}$  in diameter which were bundles of cellulose microfibrils with 16 nm. By contrast, in *P. vesiculiphora*, the network was composed of cellulose bundles with 1  $\mu\text{m}$  in diameter. Cellulose skeletons of glomerulocytes were always observed in the cellulose networks in each

ascidian. Cellulose fibers loosened from the cellulose skeletons of glomerulocytes were often observed, and the loosened cellulose fibers were incorporated into the network in the hemocoel. These observations suggest that; (i) the glomerulocytes play a role of transporting cellulose fibers into the hemocoel for making cellulose network, (ii) some ascidians, which have glomerulocytes, utilize cellulose not only for skeletal structure of tunic but also for skeletal structure of extra-cellular matrices in the hemocoel.

**The differences of cellulose synthesizing activity between wild and mutant strains of barley**, T. ITOH and N. SAKURAI: Research for Future, the committee of "Research for Future" program News, **No. 7**, 3 (1997).

It has been demonstrated that the differences of cellulose synthesizing activity of two strains of barley, wild type and mutant, are dependent on the different distribution of cellulose synthesizing enzyme complexes in the plasma membrane.

**Tree species of wooden artifacts excavated from Shimonaizen Site**, T. ITOH: Shimonaizen Site, The Cultural Properties Research Report of Hyogo Prefecture **155**, 279–282 (1996).

The twenty four wood specimens of pillars were excavated from Shimonaizen-Iseki in Sumoto city in Hyogo prefecture which correspond to Nara era or middle of Yayoi era and were identified microscopically as follows: *Torreya*, *Pinus*, *Quercus* (*Lepidobalanus*), *Zelkova*, *Illicium*, Lauraceae, and *Cleyera* were identified. Most of the artifacts were made of *Torreya nificera* and some made of *Cleyera japonica*.

**Cellulose synthesizing enzyme complexes first found in animal kingdom (Tunicates)**, T. ITOH: *Chemistry and Biology*, **35**, 400–402 (1997).

The cellulose synthesizing enzyme complexes, so called terminal complexes (TCs), were first found in the plasma membrane of epidermal cells. TCs were linear type similar to those found in some group of algae. In general, two types of TCs, linear and rosettes were found in biological kingdom. The present study clarified that the TCs in the tunicates produced crystal, polymorph of cellulose. This paper gives the first evidence that the crystalline cellulose is synthesized by linear Tcs.

**Tree species of excavated wood**, T. ITOH: Annual Report on the Archaeological Research of Kyoto University Site in 1994, Archaeological Research Centre of Kyoto University, pp. 74–79 (1994).

The buried forest of late Jomon was excavated from archaeological site in Northern campus. The hundred and one pieces of wood were identified microscopically as follows: *Torreya*, *Abies*, *Chamaecyparis*, *Salix*, *Populus*, *Juglans*, *Castanopsis*, *Quercus* (*Cyclobalanopsis*), *Zelkova*, *Morus*, *Aphananthe*, Lauraceae, *Sikimia*, *Firmiana*, *Aesculus*, and *Acer* were identified.

## ABSTRACTS

**Anatomical description of Japanese hardwoods III**, T. ITOH: *Wood Research and Technical Notes*, **No. 33**, 83–201 (1997).

The anatomical characteristics of Japanese hardwoods classified from Rosaceae to Coriariaceae covering 93 species, among 55 genera and 8 families are described. The photomicrographs of cross, radial and tangential sections covering 93 species are also presented.

**Phylogenetic variation of native cellulose**, J. SUGIYAMA, W. HELBERT, M. KOYAMA and T. OKAMOTO: *Proc. Int'l Workshop on Green Polymers*, Bandun-Bogor, Indonesia, pp. 330–334 (1997).

Does the structure of cellulose microfibrils reflect evolution of life or is it genetically controlled? Cellulose is biosynthesized by the Terminal Complexes (TCs) which are the cellulose synthases aggregates. The microfibril width, as well as the number of cellulose chains involved in a microfibril, seems to depend closely to the number of protein units associated to form TCs. This means that, at least, the crystal width of cellulose crystallites is not the simple physicochemical phenomena but biologically regulated. Cellulose microfibrils can be characterized at various levels of structure, and their structural details are known to display varietal differences among species. However, the cause of such variations remains unanswered, for instance, whether the TCs is responsible for the generation of  $I_\alpha/I_\beta$  allmorphism, uniplanar orientation behavior of microfibrils or not. In this paper, therefore, we would like to present our preliminary survey to deduce the possible causes of structural variation by statistically analyzing the crystallographic data of celluloses from various origins.

**The enzymatic susceptibility of cellulose microfibrils of the algal-bacterial type and the cotton-ramie type**, N. HAYASHI, J. SUGIYAMA, T. OKANO and M. ISHIHARA: *Carbohydr. Res.*, **305**(2), 261–269 (1997).

Two types of substrates, the algal-bacterial type (rich in cellulose  $I_\alpha$  cellulose and the cotton-ramie type (dominant in cellulose  $I_\beta$  cellulose, were degraded comparatively by *Trichoderma viride* cellulase. The algal-bacterial type cellulose microfibril was more susceptible than the cotton-ramie type. The residual cellulose microfibrils were observed by TEM and analyzed by FTIR and electron diffraction. It becomes clear that the residual cellulose of the algal-bacterial type cellulose was getting rich in the cellulose  $I_\beta$  with the lapse time of cellulase treatment. These results indicate that the cellulose  $I_\alpha$  in the microfibril of the algal-bacterial type cellulose is hydrolyzed preferentially by the cellulase.

**Selective degradation of cellulose  $I_\alpha$  component in *Cladophora* cellulose with *Trichoderma viride* cellulase**, N. HAYASHI, J. SUGIYAMA, T. OKANO and M. ISHIHARA: *Carbohydr. Res.*, **305**(1), 109–116 (1997).

We previously reported that the algal-bacterial type cellulose microfibril was more susceptible to enzymatic attack than the cotton-ramie type cellulose. In cellulose crystallite (CC) of the algal-bacterial type cellulose, the cellulose  $I_\alpha$  crystal component was more selectively degraded than the cellulose  $I_\beta$  crystal component. The shortened CC was observed frequently in the residue of *Cladophora* CC. Fibrillation was observed in the residual *Halocynthia* CC and repeatedly hydrolyzed *Cladophora* CC that richly contained cellulose  $I_\beta$ . These results may suggest the supermolecular structure of CCs.

**Adhesion between oxygen plasma-treated polypropylene film and deposited aluminum thin film —Structure of the peeled interface—**, Y. NAKAMURA, K. NAKAMAE, J. SUGIYAMA and T. MOROHASHI: *Jpn. J. Adhes. Soc.*, **33**(4), 136–143 (1997) (in Japanese).

Adhesion between a polypropylene film and vacuum-deposited aluminum thin film (PPf/Al) is improved by oxygen plasma treatment of the PP surface under appropriate conditions. The adhesive improvement of PPf/Al, however, is greatly diminished by a higher oxygen plasma discharge power or prolonged treatment time. In order to clarify the cause of the weak strength of PPf/Al, both sides of the peeled interface obtained from the intensively-treated PPf/Al were analysed by SEM, XPS, static-SIMS and TEM. An organic layer, which was found on the Al side of the peeled interface, was determined to be derived from PP using static-SIMS. Also, this layer was directly observed by TEM. The chemical similarity of both sides of the peeled interface meant that cohesive failure of the PP took place. It is concluded that PP molecules near the surface are partially decomposed by the oxygen plasma, which is followed by the formation of a weak boundary layer (WBL) of PP. The peel strength of the untreated PPf/Al was as weak as the intensively-treated one. In this case, however, interfacial failure between PPf and the aluminum thin film was indicated because of the large differences on both sides of the peeled interface. XPS and static-SIMS suggested the existence of a small amount of low molecular weight organic materials such as contaminants, additives, and PP oligomers at the PPf/Al interface.

**Structure determination of cellulose microfibrils in the cell wall of *Cladophora***, T. IMAI, J. SUGIYAMA and T. ITOH: *Wood Res.*, No. **84**, 28–30 (1997).

Preliminary results on the nanodomain structure in algal cellulose microfibrils are presented.

**Synchrotron radiated X-ray and neutron powder diffraction study of native celluloses**, M. WADA, T. OKANO and J. SUGIYAMA: *Cellulose*, **4**, 221–232 (1997).

Precise determination of d-spacings and compositional ratio of cellulose  $I_\alpha$  and  $I_\beta$  in various native cellulose samples was successfully carried out by employing synchrotron-radiated X-ray diffraction and time-of-flight (TOF) neutron diffraction from powder specimen. X-ray diffraction peaks were separated by deconvolution method using six types

## ABSTRACTS

of profile functions : Gaussian, Lorentzian, intermediate Lorentzian, modified Lorentzian, pseudo-Voigt, and Pearson VII functions. In terms of R-factors, the pseudo-Voigt functions gave the best fit with the observation and was used for determination of d-spacings. The numerical results for *Valonia* cellulose were :  $dI_{\alpha}$  (100) = 0.613 nm ;  $dI_{\beta}$  ( $1\bar{1}0$ ) = 0.603 nm ;  $dI_{\beta}$  (110) = 0.535 nm ;  $dI_{\alpha}$  (010) = 0.529 nm ;  $I_{\alpha}$  content = 0.65. The determined differences between  $dI_{\alpha}$  (100) and  $dI_{\beta}$  ( $1\bar{1}0$ ) and between  $dI_{\beta}$  (110) and  $dI_{\alpha}$  (010) were similar to those reported earlier. Comparison between unresolved peaks for the two types of cellulose samples revealed a small but definite difference between  $dI_{\alpha}$  (110) and  $dI_{\beta}$  (200). The TOF neutron diffractometry using deuterated samples confirmed this difference.

**Characterization of native crystalline celluloses in cell wall of Oomycota, W. HELBERT, J. SUGIYAMA, M. ISHIHARA and S. YAMANAKA : *J. Biotechnol.*, **57**(1-3), 29-37 (1997).**

Cellulose samples from four Oomycetes species (*Saprolegnia parasitica*, *Pythium aphanidermatum*, *Pythium butleri* and *Phytophthora cactorum*) have been investigated. They were purified by mild hydrolysis of the cell walls, followed by extraction in diluted NaOH. The  $\beta$ -(1-3) glucan, the main component of the hyphal cell wall, was then easily extracted. The purified cellulose was characterized by X-ray diffractometry, FT-IR, and electron microscopy. Both X-ray and electron diffractograms were poorly resolved and were similar to those of cellulose IV<sub>I</sub>. In addition, the observation of their cell walls revealed microfibrillar network, the individual microfibril was, however, extremely narrow in width. Although the interpretation of their structure still remains uncertain because of the low crystalline nature, the detailed d-spacing analysis and the FT-IR inspection suggested that Oomycota cellulose could be either interpreted as cellulose IV<sub>I</sub> or low crystalline cellulose I <sub>$\beta$</sub> . The latter is favored from the taxonomic point of view.

**Parallel-up structure evidences the molecular directionality during biosynthesis of bacterial cellulose, M. KOYAMA, W. HELBERT, T. IMAI, J. SUGIYAMA and B. HENRISSAT : *Proc. Natl. Acad. Sci. USA*, **94**, 9091-9095 (1997).**

The "parallel up" packing in cellulose I <sub>$\alpha$</sub>  and I <sub>$\beta$</sub>  unit cells was experimentally demonstrated by a combination of direct staining the reducing-ends of cellulose chains, together with microdiffraction-tilting electron crystallographic analysis. Microdiffraction investigation of nascent bacterial cellulose microfibrils showed that the reducing end of the growing cellulose chains points away from the bacterium and this provides direct evidence that polymerization by the cellulose synthase takes place at the non-reducing end of the growing cellulose chains. This mechanism is likely to be valid also for a number of processive glycosyltransferases such as chitin synthases, hyaluronan synthases and proteins involved in the synthesis of nodulation factor backbones.

**High resolution atomic force microscopy of native *Valonia* cellulose I microcrystals**, A.A. BAKER, W. HELBERT, J. SUGIYAMA and M.J. MILES: *J. Struct. Biol.*, **119**, 129–138 (1997).

We have studied the surface of native *Valonia* cellulose I microcrystals under propanol and water by atomic force microscopy (AFM). Ultra-high resolution images of the surface are presented, as well as lower resolution morphological observations of whole crystals. The pitch of 0.52 nm along the molecule due to the asymmetrical glucose unit and the intermolecular spacing of 0.6 nm are clearly resolved in both imaging environments. The relationship between the crystalline bulk and the surface are discussed, with particular attention being paid to previous crystallographic studies. We also show that the glucose units along the cellulose chains are not topographically equivalent due to the two-fold screw symmetry, and accordingly present strong evidence of triclinic character by direct surface imaging, rather than by taking average measurements in reciprocal space. The crystallographic distinction between monoclinic and triclinic structure is a displacement of the cellulose chains by a quarter of the c-axis period, resulting in either a stagger or a diagonal shifting respectively of the cellobiose unit along the chain axis by 0.26 nm. This structural identification represents, as far as we are aware, the highest resolution AFM imaging of a biological specimen to date. This study opens up the future possibility of identifying the localised triclinic or monoclinic nature of the *Valonia* cellulose surface with AFM.

**Systematic survey on crystalline features of algal celluloses**, M. KOYAMA, J. SUGIYAMA and T. ITOH: *Cellulose*, **4**, 147–160 (1997).

Algal celluloses from different origins have been analyzed with special reference to the crystalline features, such as allomorphism ( $I_\alpha/I_\beta$  or triclinic/monoclinic two-phase model), dimension, uniplanar orientation behavior of the specific crystallographic plane to the cell wall surface. Three types of celluloses, namely,  $I_\alpha$  rich/broad microfibril/0.6 nm oriented type,  $I_\beta$  dominant/flat-ribbon/0.53 nm oriented type, and  $I_\beta$  dominant/small/randomly oriented type, was confirmed in algal system. The first seems to occur in more primitive organisms than the others. The variation relates remarkably to the arrangement of cellulose synthesizing complexes, where they vary from multiple-row linear type, consolidated rosette type, and isolated rosette type, respectively. In *Chara* was found two types of crystals, one is  $I_\beta$  dominant/ribbon shape/0.6 nm oriented type and the other is  $I_\beta$ /narrow/random.  $I_\beta$  dominant/ribbon shaped/0.6 nm oriented type was so far never observed in plant cellulose except for some of families in tunicates. Finally, The reducing end staining technique to analyze the polarity of the chains in a microfibril revealed parallel packing in Cladophorales, Zygnematales, which means the molecules are parallel in a microfibril being independent from the crystal forms of  $I_\alpha$  and  $I_\beta$ .

## ABSTRACTS

**The behavior of cellobiose *Phanerochaete chrysosporium* dehydrogenase on adsorption to crystalline and amorphous celluloses**, M. SAMEJIMA, T. OHKUBO, K. IGARASHI, A. ISOGAI, S. KUGA, J. SUGIYAMA and K.-R.L. ERIKSSON: *Biotech. and Appl. Biochem.*, **25**, 135–141 (1997).

The adsorption of cellobiose dehydrogenase (CDH) to cellulose has been previously reported. However, the structural type of cellulose on to which CDH is adsorbed has not been investigated. In the present study we have compared the behaviour of CDH when it adsorbs on the highly crystalline cellulose microfibrils from *Valonia macrophysa* and on the completely amorphous cellulose prepared from a solution of Avicel in the SO<sub>2</sub>/amine system. The isotherms of CDH adsorption to both *Valonia* and amorphous celluloses fit well with the Langmuir adsorption theory. However the maximum adsorption of CDH to the amorphous cellulose was much higher than that to *Valonia* cellulose. The location of CDH adsorbed on cellulose was revealed with colloidal-gold-tagged antibodies by transmission electron microscopy. By using this technique it was demonstrated that CDH adsorption to *Valonia* cellulose was limited to the amorphous regions attached to the crystalline microfibrils, whereas no CDH was adsorbed to the surface of the highly crystalline microfibrils. Furthermore, continuous monitoring of cellulase activity showed that limited amount of structures susceptible to enzymic hydrolysis exist even on the surface of *Valonia* cellulose. From these observations, we conclude that amorphous regions of cellulose seem to be the preferred sites of CDH adsorption whereas CDH is not adsorbed to the surface of highly crystalline microfibrils.

**High resolution electron microscopy of cellulose II and  $\alpha$  chitin single crystals**, W. HELBERT and J. SUGIYAMA: *Cellulose*, **5**, 113–122 (1998).

Single crystalline cellulose II and  $\alpha$  chitin regenerated from their low-molecular weight solution using phosphoric acids as a solvent have been investigated by electron diffraction together with high resolution imaging. Two types of cellulose II were regenerated by precipitation either in water (DP=7) or in ethanol (DP=15), and the latter reveal better crystalline perfection. In both cases, the structures are in good accord with the previously published 2-chain monoclinic model.  $\alpha$  chitin was regenerated by precipitation only in ethanol. The structure agreed well with the previous antiparallel model as its electron diffraction pattern of  $a^*b^*$  projection fit well with the proposed P2<sub>1</sub>2<sub>1</sub>2<sub>1</sub> symmetry. In high resolution images, the direct imaging of molecular packing of  $\alpha$  chitin is ultimately possible if the imaging condition is carefully controlled.

**Enzymatic hydrolysis of bacterial cellulose**, M. SAMEJIMA, J. SUGIYAMA, K. IGARASHI and K.-E.L. ERIKSSON: *Carbohydr. Res.*, **305**, 281–288 (1998).

Native cellulose from the bacterium *Acetobacter xylinum* as well as acid-treated bacterial cellulose prepared from partial hydrolysis of the native bacterial cellulose with 2.5N HCL

were subjected to enzymatic hydrolysis by *Trichoderma viride* cellobiohydrolase I (CBH I) and endoglucanase II (EGII). The activities of the two enzymes were continuously monitored with an oxidation-reduction potential electrode based on the cellobiose dehydrogenase-ferricyanide redox system. The individual CBH I and EG II hydrolyzed both native and acid-treated bacterial celluloses in a similar way. While CBH I rapidly hydrolyzed both cellulose samples, the ability of EG II to hydrolyze these samples was very limited. However, the hydrolytic behaviour of the two enzymes, while no synergistic increase in hydrolysis rate was observed with the acid-treated cellulose. Electron microscopy demonstrated that the synergistic action of CBH I and EG II for the native bacterial cellulose involved drastic disintegration of the twisted and bent ribbon-like structure of microfibril bundles and gave rise to the formation of linear, needle-like microcrystallites. Thus, the ribbon-like structure of microfibril bundles in the native bacterial cellulose seems to have a high susceptibility for the combined action of the two enzymes. In contrast, the microfibril aggregates of the acid-treated bacterial cellulose were not disintegrated by the combination of the two enzymes. From these observations, it seems reasonable to assume that differences in the assembling pattern of the microfibrils must be one of the major reasons for the significant differences in the synergism of the two enzymes for the two bacterial cellulose samples.

**Surface structure of native cellulose microcrystals by AFM**, A.A. BAKER, W. HELBERT, J. SUGIYAMA and M.J. MILES: *Appl. Phys* A435, **66**, S559–S563 (1998).

Atomic force microscopy (AFM) has been used to study the surface of native cellulose I microcrystals from *Valonia ventricosa*. High resolution images show clear structural details of the surface, namely the 0.52 nm repeat along the cellulose chains due to the glucose sub-unit and the inter-molecular spacing of  $\sim 0.6$  nm. Cellulose from *Valonia* exists naturally in both a triclinic ( $I_\alpha$ ) and a monoclinic ( $I_\beta$ ) crystal form within the same microfibril; the difference being a displacement of adjacent chains by 0.26 nm, a quarter of the c-axis period. The most significant finding in this work is that it has been possible to image the cellobiose repeat along the chain due to topographic differences associated with the asymmetric glucose unit, and thus identify triclinic structure on the microcrystal surface. Computer modelling has been used to construct Connolly surfaces of the facets of the two different crystal forms, and the triclinic models are in excellent agreement with the images obtained by AFM.

**Improvement on preparation of RNA from differentiating xylem tissue of *Eucalyptus camaldulensis* L.**, K. BABA and K. ITO: *Wood Res.*, **84**, 7–11 (1997).

The CTAB method for RNA isolation in differentiating xylem has improved in the treatment of tissues with methanol containing DTT and the addition of vanadyl ribonucleosides in to the extraction buffer. Vanadyl ribonucleosides were supposed to inhibit the binding of polyphenols to RNA also, not only inhibited RNase activity. The

## ABSTRACTS

yield of RNA was more than 270 g/g of tissue in average, and poly(A)<sup>+</sup> RNA was subsequently purified by using an oligo-dT cellulose column with about 0.7% recovery of total RNA.

**Molecular cloning of cDNAs of the genes expressed in differentiating xylem of tension wood formation in *Eucalyptus camaldulensis* L.**, J. TOYOTA, K. BABA, T. HIBINO and T. ITOH: *Wood Res.*, **84**, 31–33 (1997).

Molecular cloning was performed by screening of a cDNA library constructed from poly(A)<sup>+</sup> RNA of differentiating xylem in upper side of leaning stem, using subtracted probe. Northern hybridization revealed that the expression of twelve clones were increased in tension wood formation.

**Effects of lignin-carbohydrate complexes on foaming of benzylated wood without plasticizers**, T. HIRAOKA, M. UEDA, Y. TAKAMI, T. WATANABE, N. SHIRAISHI and T. KOSHIJIMA: *Holzforschung*, **51**, 273–280 (1997).

Research has been done with the aim of making a foam from benzylated wood. It has been found that it is possible to produce an expandable benzylated wood without adding any plasticizers or other polymers. We have also found that it is necessary for the benzylated wood to retain more than 73% of the LCCs in the original wood in order to accomplish ten to twenty times foaming. There was direct proportional relation between foaming extents and LCC content of the resultant resins up to twenty times foaming. These results indicate that the LCCs in benzylated wood act as a compatibilizer between lignin and polysaccharides. The occurrence of lignin in the benzylated lignocellulose contributed greatly to the enhancement of closed cell content in the foam, and also yielded desirable effects on other physical properties of the resin.

**Cloning and characterization of the gene encoding the iron-sulfur protein of succinate dehydrogenase from *Pleurotus ostreatus***, T. IRIE, Y. HONDA, T. MATSUYAMA, T. WATANABE and M. KUWAHARA: *Biochimica et Biophysica Acta*, **1396**, 27–31 (1998).

Genomic and cDNA fragments encoding the iron-sulfur protein (Ip) subunit of succinate dehydrogenase (EC 1.3.99.1) have been cloned from an edible basidiomycetous fungus, *Pleurotus ostreatus*. The gene is interrupted by five introns and is predicted to encode a polypeptide of 268 amino acid residues. Sequence comparison with Ip subunit from other species identified three conserved cysteine-rich clusters. One of these contains a critical histidine residue implicated in carboxin sensitivity in the heterobasidiomycete *Ustilago maydis*.

**Biodegradation of chemical pollutants by using white-rot fungi**, H. ITOH and I. KUWAHARA: *Bio Industry*, **15**(2), 5–13 (1998) (in Japanese).

Degradation of environmentally hazardous chemicals, including halogenated

heterocyclic, polycyclic and biphenyl compounds which have been used as pesticides, herbicides, antiseptics, explosives and other purposes by white-rot fungi was reviewed. Application of fungi to bioremediation of soil polluted by these aromatics was also mentioned.

**Molecular simulation of polysaccharides**, F. TANAKA: *Wood Research and Technical Notes*, No. 33, 13–25 (1997) (in Japanese).

Methods of molecular simulation and their application on polysaccharides were summarized. Both molecular mechanics and molecular dynamics simulation studies of glucan and galactan were described precisely. The difference of the chain properties between these molecules was discussed theoretically, in terms of their 3-dimensional structures based on the molecular simulation techniques.

**Cole-Cole plots for dielectric properties of absolutely-dried spruce wood**, M. YOKOYAMA and M. NORIMOTO: *Wood Research and Technical Notes*, No. 33, 71–82 (1997).

The dielectric properties in the longitudinal and tangential directions for absolutely dried Sitka spruce (*Picea sitchensis* Carr.) wood were measured at five frequencies (50 Hz, 110 Hz, 1 kHz, 10 kHz, 100 kHz) and over a temperature range from  $-150^{\circ}\text{C}$  to  $-10^{\circ}\text{C}$ . From the Cole-Cole plots of the results, the dielectric properties of wood and cell wall over a frequency range from  $10^{-5}$  Hz to  $10^{12}$  Hz were estimated. The anisotropy of the relaxation due to the orientational polarization of methylol groups was not recognized. The electrical conduction in the absolutely dried wood was considered to be closely related to the orientation of methylol groups.

**Thermal-softening properties of water-swollen wood IV, The effects of chemical constituents of the cell wall on the thermal-softening properties of wood**, Y. FURUTA, H. AIZAWA, H. YANO and M. NORIMOTO: *Mokuzai Gakkaishi*, 43(9), 725–730 (1997).

To investigate the effects of the chemical constituents in the non-crystalline region of the cell wall on the thermal softening properties of water-swollen wood, the temperature dependence of viscoelastic properties for water saturated and vapor-saturated udaikamba (*Betula maximowicziana* Rogel) wood specimens in the tangential direction was measured by means of the tensile forced vibrational method. The results obtained in the measurement from 5 to  $95^{\circ}\text{C}$  for the water-saturated specimens showed that a relaxation might exist below  $5^{\circ}\text{C}$  in addition to a peak of loss tangent  $\tan\delta$  around  $60^{\circ}\text{C}$  which was considered to be associated with the micro-Brownian motion of lignin. On the other hand, the results obtained in the range from  $-150$  to  $0^{\circ}\text{C}$  for vapor-saturated specimens showed a peak of loss modulus  $E''$  or loss tangent  $\tan\delta$  around  $-40^{\circ}\text{C}$  in addition to the process around  $-120^{\circ}\text{C}$  due to the motions of adsorbed water and methylol groups. The apparent activation energy of the relaxation around  $-40^{\circ}\text{C}$  was about 24 kcal/mol. To extract hemicelluloses,

## ABSTRACTS

specimens were treated with a water solution of 15% NaOH or treated by steaming at 200°C for 10 min. The relaxation around -40°C in untreated specimens almost disappeared after both treatments, while that around 80°C remained unchanged. These results suggested that the relaxation around -40°C was associated with the micro-Brownian motion of hemicelluloses and that around 80°C with that of lignin.

**Transverse shrinkage anisotropy of coniferous wood investigated by the power spectrum analysis**, U. WATANABE, M. NORIMOTO and M. FUJITA: *J. Wood Sci.*, **44**(1), 9-14 (1998).

The transverse shrinkage behavior of early wood and late wood tracheids of radiata pine (*Pinus radiata* D. Don) was investigated by the power spectrum analysis. The representative cell model shapes before and after shrinkage constructed by the analysis revealed that the early wood tracheid showed anisotropic shrinkage, although the late wood tracheid showed almost isotropic shrinkage. To link the macroscopic shrinkage of coniferous wood with the results obtained by the power spectrum analysis, a two-layer model composed of early wood and late wood was adopted, and the relation between shrinkage anisotropy and late wood fraction was predicted. The results suggested that the shrinkage anisotropy depended significantly on the mechanical interaction between early and late wood.

**Thermal-softening properties of water-swollen wood V, The effects of drying and heating histories**, Y. FURUTA, M. NORIMOTO and H. YANO: *Mokuzai Gakkaishi*, **44**(2), 82-88 (1998).

The effects of drying and heating histories on the temperature dependence of viscoelasticity in the radial direction for wet hinoki (*Chamaecyparis obtusa* Endl.) wood were investigated. Remarkable differences between green and wet specimens with drying histories were recognized in dynamic viscoelastic measurements with increasing temperatures. The dynamic modulus  $E'$  of wet specimens changed around 50°C and 80-90°C. These relaxations were considered to be due to the drying history and the micro-Brownian motion, respectively, of lignin molecules. However, the green specimens showed only one relaxation due to lignin. With increases of the time left in water, the  $E'$  at room temperature of wet specimens with a drying history increased, and their loss peaks due to their drying histories were reduced. In the second measurement, the green specimens and the wet specimens with drying histories showed similar results. The  $E'$  at room temperature for green specimens decreased remarkably. The green specimens showed the largest static Young's moduli  $E$  at 20°C. The  $E'$  in wet conditions at 20°C decreased remarkably immediately after drying or heating, but increased with time. These results suggested that drying or quenching induced strains due to the orientational changes of the molecules composed of amorphous regions of the cell walls, and long time immersions were necessary to release the strains.

**The viscoelastic behavior of Japanese lacquer film I, Mechanical relaxation processes of lacquer film**, E. OBATAYA, Y. OHNO and M. NORIMOTO : *Mokuzai Gakkaishi*, **44**(2), 89–95 (1998).

The storage modulus  $E'$  and loss tangent of three kinds of Japanese lacquer films were measured in the temperature range of  $-150^{\circ}\text{C}$  to  $400^{\circ}\text{C}$ , and the mechanical relaxation processes detected were assigned in relation to the structure of urushiol, the principal constituent of the lacquer. The  $E'$  of the films decreased remarkably in the temperature range of  $-50^{\circ}\text{C}$  to  $100^{\circ}\text{C}$ , and then turned to increase above  $150^{\circ}\text{C}$ , and remained almost unchanged above  $200^{\circ}\text{C}$ . With respect to  $\tan \delta$ , three relaxation processes labeled  $\alpha$ ,  $\beta$ , and  $\gamma$  were observed at 11 Hz and  $30^{\circ}\text{C}$  to  $100^{\circ}\text{C}$ ,  $-60^{\circ}\text{C}$ , and  $-140^{\circ}\text{C}$ , and the apparent activation energies of these processes were 65 to 75 kcal/mol, 13 kcal/mol and 8 to 9 kcal/mol, respectively. It was suggested that the  $\alpha$  process with remarkable drop in  $E'$  was due to the micro-Brownian motion of polymerized urushiol molecules, and the increase of  $E'$  in a higher temperature range was caused by the oxidative polymerization of urushiol. The  $\beta$  and  $\gamma$  processes were attributed to the molecular motion related to the absorbed water and that of methylene groups in the side chains of urushiol molecules, respectively. The polymerization of urushiol progressed during storing at a room temperature for 2 months or at  $200^{\circ}\text{C}$  for 2 hours, which caused a shift of the  $\alpha$  peak to a higher temperature range.

**A method of measuring viscoelastic properties of wood under high temperature and high-pressure steam conditions**, W. DWIANTO, T. MOROOKA and M. NORIMOTO : *Mokuzai Gakkaishi*, **44**(2), 77–81 (1998).

A method of measuring the viscoelastic properties of wood under high-temperature and high-pressure steam conditions was developed. An autoclave built-in testing machine was used for the measurements. In the inside of the autoclave, a newly developed load cell capable of resisting a steam pressure of  $16 \text{ kg/cm}^2$  and a temperature of  $200^{\circ}\text{C}$  was installed. We observed that this load cell could be used for detecting loads precisely under steaming at temperatures from  $100$  to  $200^{\circ}\text{C}$ . In addition to load-detecting problem, we need to avoid the non-uniform thermal degradation of wood in the measuring process under steaming at high temperatures. This non-uniform degradation can be minimized by minimizing the time required for wood attaining a thermal equilibrium state through specimens in the FSP state. According to this method, a stress relaxation curve for sugi (*Cryptomeria japonica* D. Don) wood in compression under steaming at  $180^{\circ}\text{C}$  was obtained. The stress was seen to decrease rapidly with time, reaching almost 0 at 3000 sec.

**Influence of thermal softening and degradation on the radial compression behavior of wet spruce**, A. UHMEIER, T. MOROOKA and M. NORIMOTO : *Holzforschung*, **52**(1), 77–81 (1998).

Thermal softening and degradation of wood are important factors in wood processing.

## ABSTRACTS

In this investigation, the influence of temperature between 0 and 200°C on the mechanical behavior of wet spruce subjected to large radial compression was studied. The yield stress of wet spruce dropped by slightly less than one tenth between 0 and 200°C. The glass transition of lignin was detected accurately by measuring the yield stress. A thermal degradation process was observed between 150 and 200°C. The shape of the normalized stress-strain curves were similar at different temperatures.

**Transverse shrinkage of coniferous wood cells examined using replica method and power spectrum analysis**, U. WATANABE, M. FUJITA and M. NORIMOTO : *Holzforshung*, **52**(2), 200–206 (1998).

The shrinkage behavior of coniferous wood cells was investigated by the power spectrum analysis as well as by the replica method. During drying, cell lumens shrank in normal wood and expanded in compression wood, depending on their cell wall structures. The tracheids of *Agathis bornensis* with no distinct growth rings also showed the anisotropic shrinkage. The representative cell models before and after shrinkage constructed by the power spectrum analysis revealed that the difference in the anisotropic shrinkage among wood species greatly depended on their transverse cell shapes.

**The effects of adsorbed water on dynamic mechanical properties of wood**, E. OBATAYA, M. NORIMOTO and J. GRIL : *Polymer*, **39**(14), 3059–3064 (1998).

The storage modulus and the loss tangent of Sitka spruce (*Picea sitchensis*) in the longitudinal direction at various moisture contents were measured at 20°C, and the effect of adsorbed water was investigated by using a uniaxial rheological model to eliminate the contribution of matrix swelling. The largest value for Young's modulus of matrix was obtained at around 8% moisture content. The rearrangement of matrix molecules accompanied by the adsorption of hydrated water increased the value of Young's modulus up to about 8% moisture content, whereas the plasticization of matrix molecules by the adsorption of dissolved water decreased it at above 8% moisture content. The loss tangent of matrix had two peaks at 1% and 20% moisture contents. It was considered that the former was due to the motion of the adsorbed water itself and the latter to the relaxation related to the micro-Brownian motion of matrix substances, especially hemicelluloses.

**Sensory and emotional characteristics of wood V, Temperature-humidity environment and wood**, T. HAISHI and M. NORIMOTO : *J. Soc. Mat. Sci.*, **46**(11), 1335–1341 (1997).

Temperature-humidity environment in wooden houses is reviewed.

**Development of simplified method of measuring humidity control index B and its application to a large wood building**, M. OZAKI, T. MOROOKA, M. NORIMOTO and N. ISODA : *House Clima Research Note*, **No. 23**, 1 (1997).

A simplified way of measuring B-value was proposed and its application to the large wood building WCH, which was built recently on the ground of Kyoto University was described. It was found that the simplified method, i.e., method (2), could be used for measuring B-value without any control of ambient temperature instead of using the conventional method in a controlled chamber. In applying the simplified method for measuring B-value, we investigated humidity environment of the the top floor room w3 of WCH. The w3 room exhibited little variation of humidity though the flooring and other interior material lined in w3 room exhibited B-value as low as  $-200$  which indicates low humidity control effect (2). It was recognized that the migration of humidity from this area to the w3 room governs humidity environment for the w3 room, resulting in unchanged humidity in the w3 room.

**Enhancement of leach and termite resistances of plywood treated with boric compounds**, W.-Y. SU, M. K. YALINKILIC, T. HATA, Y. IMAMURA and S. ISHIHARA : *Mokuzai Gakkaishi*, **43**(7), 595–601 (1997).

Fire retardant chemicals composed of trimethylol melamine (TM)-boric acid (B) or-phosphoric (P) and/or-dicyandiamide (D) were applied to the surfaces of plywood followed by hot pressing. The effectiveness of these various treatments were evaluated based on the incombustibility, leachability, and termite resistance of the treated plywoods. All treated specimens had better fire-retardant properties than the untreated ones, and similar improvement were observed even after a deteriorative pretreatment of dipping in  $50^{\circ}\text{C}$  warm water for 30 minutes prior to testing. The specimens treated with TMP combinations had better improvements in the incombustible properties, in terms of ignition time, after-flaming time, glowing time, weight loss and char length. Unleached specimens treated with boric acid had the best termite resistance, followed by TMB and TMDB combinations. In all cases, trimethylol melamine appeared to have a profound effect in keeping the damage to lower levels after leaching. Observation by ion chromatography revealed that trimethylol melamine was effective in slowing down boron and phosphorus leaching even after several cycles of a severe leaching procedure.

**$\text{NO}_x$  purification by wood charcoals and their composites with metal oxides**, T. FURUTSUKA, T. HATA, Y. IMAMURA and S. ISHIHARA : *Wood Res.*, No. 84, 46–49 (1997).

Wood powder carbonized at about  $600^{\circ}\text{C}$  indicated the best conversion or adsorption of NO even though the specific surface area was not remarkably large compared to the wood powder carbonized at  $1000^{\circ}\text{C}$  and commercial activated charcoal. On the other hand, after passing  $\text{NO}_2$  through the materials,  $\text{NO}_2$  was not detected among every sample except for raw wood powder. It was assumed that wood charcoal reduced  $\text{NO}_2$  to NO and then NO to  $\text{N}_2$ . The vanadium oxide-dispersed wood charcoal showed the highest capability to adsorb greater amount of NO, and the titanium oxide-dispersed one was effective by light

## ABSTRACTS

illumination.

**Metal distribution in the Laguna lake water system and adsorption of some metals by carbonized wood powder**, L.L. PULIDO, B.B. BISANA, T. HATA, Y. IMAMURA, S. ISHIHARA and T. KAJIMOTO: *Wood Res.*, No. 84, 54–61 (1997).

The metal distribution in the Laguna lake water system was assessed using water samples taken from the surface, middle and bottom portions of the lake at five designated sampling points. Trial purification of the waste water was conducted using raw and carbonized wood powder from wood wastes of *Acacia mangium*. Beneficial and dangerously toxic metals were present in all the water samples. Sodium (Na) was the most dominant alkali metal followed by potassium (K), magnesium (Mg) and calcium (Ca). Toxic metals such as arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), lead (Pb), iron (Fe), mercury (Hg), zinc (Zn), etc., were found but each concentration was below the water quality criteria set by the National Pollution Control Commission of the Philippines. Adsorption tests showed that wood waste from *Acacia mangium* should be a potential purification material in treating Laguna lake water samples, and especially raw and carbonized wood powder of this species could be used as material in adsorbing heavy metals like Zn and Cu.

**Detection of degradation in wooden houses**, Y. IMAMURA, "Textbook of Wood and Wood-Based Materials for Architecture", Y. Imamura, S. Kawai, M. Norimoto and T. Hirai, ed., p. 270–276, Toyo-shoten, Tokyo, 1997 (in Japanese).

The methods to detect the degradation in Wooden Houses due to fungal and termite attacks were outlined.

**Durability of wood-based materials**, Y. IMAMURA, "Textbook of Wood and Wood-Based Materials for Architecture", Y. Imamura, S. Kawai, M. Norimoto and T. Hirai, ed., p. 198–206, Toyo-shoten, Tokyo, 1997 (in Japanese).

Resistances of wood-based materials such as laminated timber, plywood, particleboard and fiberboard against biodegradation were reviewed and the methods to enhance the durabilities were also described.

**Diffusion of polyethylene glycol #4000 and sucrose into archaeological waterlogged woods**, AE K. KANG, H. SAKAI, S. IMADU, Y. IMAMURA and S.J. PARK: *Mokuzai Gakkaishi*, **43**, 504–512 (1997) (in Japanese with English summary).

Four kinds of archaeological waterlogged woods, which had been degraded to various degrees, were immersed in aqueous solutions of polyethylene glycol (PEG) #4000 or sucrose to replace the water with the chemical. The concentrations of the solutions were increased from 10 to 70% in steps of 20% per three weeks. The changes of the weights of the samples, observations of the treated samples under a scanning electron microscope, the distributions

of moisture contents and concentrations of the chemicals in the longitudinal direction in the samples were investigated to clarify why decreases of weights and shrinkage of wood sometimes happened during impregnation. When wood was immersed in the sucrose solution at 60°C, the dimensions did not change for all of the specimens, and conspicuous increases of the weights were detected for all specimens except for kuri wood (*Castanea crenata* S. et Z.) with the least degree of degradation. The treatment in the PEG solution at 60°C caused gradual increases of weights and dimensional stability for severely degraded specimens, however, the decreases of weights and the occurrences of shrinkage were recognized for kunugi (*Quercus acutissima* Carr.) and kuri wood with smaller degrees of degradation. The collapse of the cell walls and cracks in specimens were detected when treated with PEG. The deformation were assumed to be caused by the different speed of the chemical penetration, that is, sucrose replaced water in specimens rapidly, but PEG dehydrated the degraded specimens in large concentration solutions because of its slow penetration speed. This dehydration is thought to occur in the less degraded specimens more frequently than in the greater degraded ones, because archaeological degradation should make movement of chemicals easy.

**The design of durable timber bridges with the failure mode and effects analysis (FMEA)**, A. MIYATAKE, Y. IMAMURA, K. FUJITA, H. WADA, T. SASAKI and K. CHIBA: *Mokuzai Hozon (Wood Preservation)*, **23**, 289–295 (1997) (in Japanese with English summary).

The Failure Mode and Effects Analysis (FMEA), which was one of the reliability analysis methods, was applied to the design of durable timber bridges. FMEA is defined as the method to evaluate the lack of an adequate design and the latent faults of the system by analyzing the failure of each element and its influence on the total item. The findings on the durability of the timber bridges obtained through the actual inspection were introduced to the factors of FMEA to conduct the general system.

**Control of termite attack using trapping method and acoustic emission (AE) monitoring, A case study at an electric power plant**, Y. FUJII, Y. IMAMURA, E. IWATSUBO and S. YAMAMOTO: *Mokuzai Hozon (Wood Preservation)*, **23**, 111–120 (1997) (in Japanese with English summary).

In order to prevent attacks by subterranean termites (*Coptotermes formosajus* Shiraki and *Reticulitermes speratus* Kolbe) on buildings and to control their potential, artificial traps were buried around the buildings of an electric power plant. The attacking activities of the termites in and around the traps were monitored by the detection of acoustic emission (AE) generated by the feeding of the termites. The traps has a cylindrical form with 600 mm height, 300 mm in diameter, consisted of wood sticks of Japanese red pine for forage in its center and slender polystyrene foam sticks surrounding the wood sticks. In eight traps of the ten sets, termite activities were observed, especially a large number of termites were

## ABSTRACTS

found in the three of them. The traps were renewed every one or two months. The amount of termites coming into the inhabiting traps decreased drastically after the first renewal in June 1993, however, it varied slightly in the following two and a half years. The amount of termites in the traps has increased during the period when the traps were kept without exchanging since September 1995. The estimated distribution of the termite attack in the plant was shown that the termite activity was restricted significantly by the installing and renewal of the artificial traps, and any other serious additional attacks were not found in and near the buildings during the test period. The rates of AEs detected varied according to the feeding activities, which were associated with the number of termites in the trap and the temperature conditions.

**Soiling of external materials by algae and its prevention IV, Development of laboratory scale method to determine the effect of chemicals on control of algal growth**, N. OHBA, Y. TSUJIMOTO, Y. IMAMURA and S. ISHIHARA: *Mokuzai Hozon (Wood Preservation)*, **23**, 229–235 (1997) (in Japanese with English summary).

*Protococcus viridis* is the dominant species grown on the surfaces of external walls at every climatic regions in Japan. Soiling by this algae causes the severe problem of housing maintenance. For evaluation of the effect of the anti-algal chemicals on the prevention of soiling by *P. viridis*, the assay methods in the medium solutions and on the coated plates were designed, and the measuring system of the cell multiplication was developed using the light absorbance of chlorophyll. Effects of chemicals on control of the algal-cell multiplication in the medium solutions were evaluated by measuring the absorbance of transmitted light through cell suspensions of *P. viridis*. After 2 weeks of incubation, remarkable differences were observed depending on the types of the chemicals and its concentrations. Effects of coating by chemicals on control of the surface soiling by the algae were evaluated by decreasing of reflected light from the plates. Algal-cell densities on the plates coated by chemicals, which had been leached in water for 4 weeks and then inoculated and incubated for 2 weeks, showed good agreement with the ranks of the surface soiling on the boards after accelerated outdoor exposure for 5 months.

**Soiling of external materials by algae and its prevention III, Development of accelerated outdoor-exposure test method and evaluation of soiling of external materials**, N. OHBA, Y. TSUJIMOTO, Y. IMAMURA and S. ISHIHARA: *Mokuzai Gakkaishi*, **43**, 792–799 (1997) (in Japanese with English summary).

For the evaluation of algal soiling of external materials, a new accelerated test method under outdoor conditions was designed and applied to different types of sample boards. The test method consisted of exposure with a 45-degree inclination facing to the north and the mist-spraying of water with ammonium phosphate as a nutrient. The species of the algae and their growth on the specimens detected within three to five months were correlated

closely with those observed by surveys of the external surfaces of buildings in the current situation. The newly designed test method was assumed to be suitable for estimation of the algal growth on external materials within a short period of time representing natural soiling. When accelerated test method was conducted with external materials, a rapid development of algal soiling was detected on any types of samples which easily absorbed water.

**Improvement of weather resistance of film-forming type clear finishes by pre-treatment with PEG and influence of exposure test sites**, M. KIGUCHI, Y. KATAOKA, S. DOI, M. MORI, M. HASEGAWA, S. MORITA, Y. KADEGARU and Y. IMAMURA : *Mokuzai Hozon (Wood Preservation)*, **23**, 168–175 (1997) (in Japanese with English summary).

The weathering resistance of a film forming type clear finish on Douglas-fir plywood pre-treated with polyethylene glycol (PEG) solutions was assessed by exposing coated specimens for two years at six test sites (Hokkaido, Tsukuba, Toyama, Kyoto, Kagoshima and Okinawa) in Japan. Pre-treatment with a 1% solutions of DDAC did not work to prevent surface failures of the clear film.

A 10% solution of PEG as a pre-treatment showed excellent results for preventing film failure on the clear finish at all exposure test sites. This was likely to be due to properties of photo stabilization of wood surfaces by PEG. Pre-treatment with a 30% solution of PEG, however, showed delamination of the clear finishing exposed to Hokkaido, Toyama and Okinawa. Since PEG is a high moisture absorptive reagent, the treated wood absorbs much moisture during exposure test where are much snow in winter (Hokkaido and Toyama) or high temperature and humidity (Okinawa). Climatic conditions of exposure test site influenced the weathering ability of film forming type finishes on wood treated by PEG as a pre-treatment.

**Liquid penetration of precompressed wood VI. Anatomical characterization of pit fracture**, U. WATANABE, Y. IMAMURA and I. IIDA : *J. Wood Sci.*, **44**(2), 158–162 (1998).

Pit fractures of refractory coniferous heartwoods caused by precompression in the radial direction were investigated and were discussed in terms of improved liquid penetration. Small cracks appeared at the boundary between the torus and margo and along the outer margin of the margo, as well as on the torus, when specimens were compressed and deformation was fixed by drying set. The remarkable cracks were generally observed for *Cryptomeria japonica* D. Don. *Pseudotsuga menziesii* Franco showed peculiar detachment of the torus from the pit border, while *Larix leptolepis* Gordon exhibited only small cracks on the torus. These fractures patterns were more clear when the precompressed specimens were recovered by water-impregnation and then re-dried.

**Analysis of chemical structure of wood charcoal by X-ray photoelectron spectroscopy**, K. NISHIMIYA, T. HATA, Y. IMAMURA and S. ISHIHARA : *J. Wood Sci.*, **44**(1),

## ABSTRACTS

56–61 (1998).

Wood charcoal carbonized at various temperatures was analyzed by X-ray photoelectron spectroscopy (XPS), Fourier-transform infrared spectroscopy (FT-IR), and X-ray diffractometry to investigate the changes of chemical structures during the carbonization process. From the infrared spectra, the carbon double bonds and aromatic rings were seen to form at a carbonization temperature of about 600°C. From the XPS spectra, the ratio of aromatic carbons increased in the temperature range of 800–1,000°C and over 1,800°C. The condensation of aromatic rings proceeded as the carbonization progressed. The drastic reduction of electrical resistivity of charcoals was observed in almost the same temperature range. It was found that the condensation of aromatic rings had some relations to the decline in electrical resistivity. Wood charcoal carbonized at 1,800°C was partly graphitized, a finding supported by the results of X-ray diffraction and XPS. The functional groups containing oxygen diminished with the increase of carbonization temperature.

**Improvement of fire retardancy of plywood by incorporating boron or phosphate compounds in the glue**, W-Y SU, SUBYAKTO, T. HATA, K. NISHIMIYA, Y. IMAMURA and S. ISHIHARA, *J. Wood Sci.*, **44**(2), 131–136 (1998).

A practical approach to enhancing the fire retardancy of wood-based materials by adding fire retardant chemicals to the glue was developed. Plywoods were manufactured using urea melamine formaldehyde resin mixed with ammonium pentaborate or dihydrogen phosphate. Treated plywoods had better incombustibility than untreated ones. X-ray photoelectron spectroscopy (XPS) clearly demonstrated the distribution of boron and phosphorus, which had migrated from the glue to wood, contributing better fire retardant properties. The cross-sectional micrographs from scanning electron microscopy showed that untreated specimens exhibited a foamy structure near the interface in the glue layer and the deformed structure of wood cells. The cell structure and cell wall thickness retained intact in the specimens treated with urea melamine formaldehyde resin or mixed with ammonium pentaborate or dihydrogen phosphate. When observing the effect of the thickness of overlay veneers on incombustibility, a shorter glowing time was obtained from the specimens with a thicker surface layer when the fire retardant chemical was added at 2%, but the differences were smaller at the higher chemical retention of 4%. A similar tendency was observed for the char length.

**Deterioration of Wood**, M. TAKAHASHI: in “Science of Wood and Wood-Based Materials” (eds., Y. Imamura et al.), Toyo Shoten, 174–190 (1997) (in Japanese).

Deterioration of wood by surface mold, sap-stain fungi, decay fungi, wood-boring beetles, and termites are reviewed.

**Contribution of wood preservation to the conservation of global ecosystems, K. TSUNODA:** *Proc. Canada Wood Preservation Assn.*, **18**, 3–7 (1997).

Significance and importance of wood preservation has been documented, although its role is not well realized by the public. Increased concern about the environmental issues leads us to reconsider the problems from various viewpoints.

Strategy to prevent global warming through stabilization of greenhouse gases in the atmosphere and to develop a new energy source should be seriously discussed for the future generations. Because we are now sitting in front of the predictable human-inducing crisis of environmental destruction, species extinction, and other related detrimental things. Along with the concept, a couple of subjects are reviewed. Role of forests, sustainability and utilization of forest resources, reforestation and deforestation, potential of a new energy technology, and wood preservation in terms of its economy and contribution to the conservation of global ecosystems with a special emphasis on a balance of carbon in the atmosphere are discussed. Further investigations are needed to reduce environmental pollution caused by wood preservation industry, as we are supposed to establish the industry as an environmentally friendly one. Role of wood preservation should be highly appreciated in relation to retaining of our living standards in the future because it seems to make it possible to sustainably supply enough raw materials from forests and to protect the earth from warming by a reduced deforestation through an efficient use of forest resources.

**High tolerance of wood-destroying brown-rot fungi to copper-based fungicides, K. TSUNODA, K. NAGASHIMA and M. TAKAHASHI:** *Material und Organismen*, **31**(1), 31–44 (1997).

Five wood-destroying basidiomycetes were compared by agar dilution and wood block tests in relation to their copper tolerance. Among the fungi tested, *Poria cocos* proved to be the most tolerant followed by *Tyromyces palustris*.

Scanning electron microscopic observation revealed that hyphae of the two brown rot fungi were surrounded by aggregates and/or encrustations in the presence of copper. Substances surrounding the hyphae contained more copper in comparison to a adjacent structures/areas as demonstrated by energy dispersive X-ray analysis, and were considered to be composed of copper oxalate. Immobilization of copper in the form of copper oxalate appears to account for the detoxification of copper by certain brown rot fungi, although the process and mechanism still remained unsolved.

**Antisapstain formulation, K. TSUNODA:** in “Wood Preservation Textbook” (eds., M. Norimoto et al.), Japan Wood Preserving Association, 138–146 (1998) (in Japanese).

General information on the antisapstain formulations is provided in the text. Fundamental characteristics of chemicals, mode of action, uses and application methods are briefly described with a list of antisapstain chemicals and formulations.

## ABSTRACTS

**Resistance of borate-treated lumber to subterranean termites in the field, K. TSUNODA, A. ADACHI, T. YOSHIMURA, T. BRYNE, P.I. MORRIS and J.K. GRACE:** *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP 98-10255, pp. 5 (1998).

Borate-treated wood samples were tested for their resistance against subterranean termites in the field. Wood samples (10.5×10.5×40 cm) of western hemlock were pressure impregnated with sodium octaborate tetrahydrate (DOT) and didecyldimethylammonium chloride (DDAC), and assigned into two groups on the basis of boron contents: high retention (1.5–2.2% BAE) and low retention (0.7–1.3% BAE). Eight replicates were prepared for each retention level. Four untreated controls were also included in the field evaluation for comparison. Each sample was placed on a concrete block 19 cm above ground surface and covered with plastic box in Kagoshima, Japan on July 1, 1993. Four boxes were employed so that 5 samples (two each of treated groups and one untreated sample) were in each box.

After two years of exposure, three of all the treated samples exceptionally sustained very slight attacks, while in general untreated controls were moderately to severely attacked. Borate-treatment was proved to be satisfactorily effective in protecting lumber in above ground situations from subterranean termites. Further trials have been set up to determine the long-term efficacy of the treatment compared to chromated copper arsenate treated and naturally durable wood.

**Termite, T. YOSHIMURA:** in "Wood Preservation Textbook" (eds., M. Norimoto et al.), Japan Wood Preserving Association, 83–96 (1998) (in Japanese).

Ecology, physiology and economical impacts of termites are reviewed.

**Termiticidal performance of an entomogenous fungus, *Beauveria brongniartii* (Saccardo) Petch in laboratory tests, T. YOSHIMURA and M. TAKAHASHI:** *Jpn. J. Environ. Entomol. Zool.*, **9**(1), 16–22 (1998).

The termiticidal performance of an entomogenous fungus, *Beauveria brongniartii* (Saccardo) Petch was investigated using laboratory tests. Workers of *Coptotermes formosanus* Shiraki were forced to be exposed to sheet formulations of *B. brongniartii* (Formulation name: Biolisa-Kamikiri) developed against long-horned beetles with different conidial densities. All the workers exposed to the high-density formulation ( $3.3 \times 10^8$  conidia/cm<sup>2</sup>) for one minute died within 5 days, but one day's exposure to the low-density formulation ( $5.6 \times 10^6$  conidia/cm<sup>2</sup>) caused only approximately 50% death of workers in the same period. This suggested that the density of conidia seriously affect the termiticidal performance of the sheet formulation of *B. brongniartii*. When infected workers were kept with approximately the same numbers of un-infected insects in the same container, all the test individuals have died eventually, showing the contagious effect of *B. brongniartii*.

**Termite control in 21st century**, T. YOSHIMURA: *Mokuzai Kogyo (Wood Technology)*, **53**(3), 109–114 (1998) (in Japanese).

New technologies in termite control which are coming to be commercialized in Japan are summarized.

**Termite control by stainless mesh**, T. YOSHIMURA: *Shiroari (Termite)*, No. **112**, 11–15 (1998) (in Japanese).

Stainless mesh developed against subterranean termite invasion is reviewed with reference to a possible application method in Japanese houses with crawl space.

**Enhancement of the biological resistance of wood by phenylboronic acid treatment**, M.K. YALINKILIC, T. YOSHIMURA and M. TAKAHASHI: *J. Wood Sci.*, **44**(2), 152–157 (1998).

Phenylboronic acid (PBA) was tested in terms of boron leachability from treated wood. In addition, the fungal and termiticidal efficacy of PBA-impregnated sugi (*Cryptomeria japonica* D. Don) wood was tested against the decay fungi *Coriolus versicolor* (L. ex Fr.) Quél. and *Tyromyces palustris* (Berk. et Curt) Murr., representing white-rot and brown-rot fungi, respectively, and the Formosan subterranean termite *Coptotermes formosanus* Shiraki. Ion chromatography analysis of hot water extracts of treated wood before and after leaching indicated that PBA is considerably resistant to water leaching, and saturation of the treatment solution increased the fixation ratio of boron in wood, whereas boric acid could not remain in wood impregnated even with the saturated solution. Decay test results revealed the excellent bioactive performance of PBA. Wood treated with 0.34% PBA solution was found resistant to both decay fungi, even after running-water leaching for 10 days and treatment with 1.00% PBA completely inactivated the Formosan subterranean termite for the leached specimens. Weight gain levels were 0.18% w/w (0.46 kg/m<sup>3</sup>) and 0.99% w/w (2.49 kg/m<sup>3</sup>) for these concentration levels, respectively, after being leached by running water. Contrary to the general belief that boron is a slow-acting toxicant against termites and unable to prevent mass loss of treated wood, PBA acted rapidly, and the mass loss caused by termites was low.

**A new process for in situ polymerization of vinyl monomers in wood to delay boron leaching**, M.K. YALINKILIC, W. DWIANTO, Y. IMAMURA and M. TAKAHASHI: *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP 98-40110, pp. 16 (1998).

A supplementary combination treatment with vinyl monomers; styrene (ST) and methylmetacrylate (MMA) was studied in order to extend service life of boron treated wood. Sapwood specimens of Japanese cedar (*Cryptomeria japonica* D. Don) first treated with boric acid (BA) at 1.00% aqueous solution concentration. Vinyl monomers were impregnated after air-drying of BA-treated wood at ambient temperatures. Polymerization was

## ABSTRACTS

performed during compression of monomer impregnated wood to a 50 to 70% dry set of radial dimension under a hot-press heated to the polymerization temperatures of 60 and 90°C required by the selected catalysts VAZO ( $\alpha$ ,  $\alpha'$ -Azobis-isobutyronitrile) and benzoyl peroxide, respectively. Wood acquired a perfect dimensional stability and remarkably high moisture exclusion efficiency with the minimum water holding capacity with the compressed-wood polymer composite (CWPC) process that was approved by submerging of the test specimens in tap water, boiling water exposure to a 10 cycles accelerated severe weathering. As a result, boron leaching rate from CWPC pretreated with BA was considerably slower than that from ordinary WPC. Scanning electron microscope observations were found explanatory for controlled-but-continuous boron leaching determined analytically. An effective bulking was found necessary to accompany to polymerization in cell wall with an even distribution of monomer in wood. Grafting to cell wall components can be tried further to achieve an envelop polymerization of boron deposited sites in WPC for better boron immobility.

**Manufacture of Cylindrical LVL by Spiral-Winding Method I. Effect of interlocked-plie on the tensile Young's modulus**, H. YAMAUCHI, S. SHOHO, P. YANG, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood res. Soc.)*, **43**(9), 747–753 (1997) (in Japanese with English summary).

The fundamental characteristics of manufacturing cylindrical laminated veneer lumber (LVL) by a spiral winding method were studied. The material made by this method has a grain sloped to the longitudinal axis of the cylinder. To minimize the reduction of Young's modulus due to the sloped grain and to reinforce the weakness of the splitting strength along the grain, the veneer tapes are wound in the clock-wise and counter clock-wise directions alternately resulting in an interlocked grain of the cylinder wall. In the present paper, the effect of the interlocked grain structure of the LVL on Young's modulus was calculated theoretically and was verified by experiments.

In order to verify the results of calculations, the tensile Young's moduli of the veneer specimens from spruce (*Picea spp.*), then those of the laminates with interlocked grains made from the same specimens were measured.

The tensile Young's moduli of specimens with interlocked grain were greater than those of specimens without interlocked grain. When the angles between the interlocked grains were small, especially less than 10° the Young's moduli only decreased a little compared to 0°. Because the theoretical curves match the experimental values, the effect of the interlocked grain structure can be predicted from this theoretical curve.

**Manufacture of Bamboo-Cement Composites II. Effects of additives on hydration characteristics**, L. MA, Y. KUROKI, W. NAGADOMI, B. SUBIYANTO, S. KAWAI and H. SASAKI: *Mokuzai Gakkaishi (J. Jpn. Wood res. Soc.)*, **43**(9), 754–761 (1997) (in Japanese)

with English summary).

This study dealt with the hydration temperature and hardness of a mixture of bamboo (*Phyllostachys heterocycla* Mitf. var. *pubescens* Ohwi) and cement with some additives. Cement-bonded bamboo particleboards also were manufactured. The additives used were sodium hydrogen carbonate, sodium carbonate, sodium silicate, calcium chloride, and magnesium chloride. The effects of the additives on the compatibility between bamboo powder and cement were examined. The results were as follows: 1) Based on the hydration temperature, magnesium chloride and calcium chloride improved the compatibility of bamboo powder and cement. 2) The rise in hydration temperature with respect to time varied depending on the additive used. 3) Larger amounts of additives resulted in higher values of hydration temperature peaks ( $T_{max}$ ). 4) High correlations between  $T_{max}$  or the compatibility factor ( $C_A$ ) and the modulus of rupture (MOR) of cement-bonded bamboo composites were observed.

**Manufacturing Condition and Mechanical Properties of Cylindrical LVL Manufactured by Spiral-Winding Method, H. Yamauchi, I. MIURA, T. SASAKI, A. KOIZUMI, S. KAWAI and H. SASAKI: *Zairyo (J. Soc. Mat. Sci. Jpn)*, 47(4), 350–355 (1988) (in Japanese with English summary).**

The mechanical properties in bending and in compression of full size cylindrically laminated veneer lumbers (C-LVL) made by spiral winding method were tested. The C-LVLs have about 300 mm outer diameter, 25 mm wall thickness, and 3,600 mm length. The results obtained are as follows: 1) The modulus of elasticity (MOE) of C-LVL depends on the species of veneer raw materials, that is, MOE of C-LVL was the same as the MOE of solid lumber of the same species. 2) The number of plies affects the modulus of rupture (MOR) and the mode of failure of C-LVL. It has no effect on MOE. 3) The interlocked grain structure of C-LVL with  $\pm 10$  degree in alternate layers effectively prevented decrease in MOE of C-LVL compared to that of solid lumber. 4) There was little effect on MOE or MOR by the addition of radial filler in C-LVL with 10 plies or more. 5) The properties in compression is about equal to those in bending. In the compression test, buckling failure was observed. These results show that C-LVL is suitable for structural uses, especially as building and construction posts.

**Towards the Sustainable Utilization of Ligno-Cellulosic Resources (Key Note Address), S. KAWAI: IUMRS-ICA-97, p. 752, Chiba, 16–18, Sept. (1997).**

This presentation deals with the research and development for more effective utilization of wood and non-wood ligno-cellulosic materials. More reliable and higher performance wood composite products are being developed by reducing the element sizes and aligning the elements in the fiber direction. The new processing technology to convert forest thinnings, wood wastes, agricultural wastes, and recycled wood into new types of lumber and panel

## ABSTRACTS

composite products is highly required to ensure the sustainable utilization of the existing forest resources. In such utilization, a relatively small-scale and simple production system, such as movable milling system, is necessary because the resources are usually diffused in time and space.

**Durability of Wood Based Panels—In-door exposure test—**, S. KAWAI: Seminar Textbook of the Wood Composite Board Section in Wood Technological Association of Japan, p. 1–13, Nov., Tokyo (1997) (in Japanese).

Results in 5-years in-door exposure test of various wood based panels are shown and the properties of those panels before and after in-door exposure for 0–5 years are compared and discussed.

**Classification, Properties and Manufacture of Wood Composite Products**, S. KAWAI: “Wood and Wood Composites for Housing”, ed. by Y. IMAMURA, S. KAWAI, M. NORIMOTO and T. HIRAI, p. 37–48, Toyo Shoten (1997) (in Japanese).

Newly developed wood composite products are classified by the orientation and the size of elements composed. The fundamental properties and manufacturing processes of those products are reviewed.

**Today and Future—R & D on New Lignocellulosic Composite Products**, S. KAWAI: *Wood Res. and Tech. Notes*, **33**, 26–32 (1997) (in Japanese).

Recent development of lignocellulosic composite products is reviewed and the future research works, especially on non-wood lignocellulosics including agricultural wastes are discussed.

**Engineered Wood Products**, S. KAWAI: “Introduction to the Wood Preservation”, Jpn. Wood Preserving Association, p. 30–35 (1998) (in Japanese).

The classification and properties of engineered wood products are introduced.

**Recycling of Wood Based Materials**, S. KAWAI: *Kenchiku Chisiki*, 176–178, March (1998) (in Japanese).

Recycled wood from houses is reviewed and recent progress of recycling technology for wood resources is introduced.

**PSL & I Beam, Wood Composite Boards**, S. KAWAI: “Wood Utilization Handbook” ed. by Editorial Board for Textbook of Forest Products in Akita Pref., p. 70–73 (1998) (in Japanese).

Parallel strand lumber and I-beam of LVL frange with plywood/OSB web are reviewed. Wood composite boards such as OSB, particleboard, fiberboard and cement bonded particleboard are also outlined.