

Abstracts

YAZAKI, K.: **ABC transporter**, *Plant Cell Technology Series Vol. 18, The Plant Membrane Transport System* (eds. Kato, K., Shimazaki, K., Maeshima, M., Mimura, T.), Shujunsha (Tokyo), pp.119–128 (2003) (Review in Japanese).

TERASAKA, K., N. SHITAN, F. SATO, F. MANIWA, K. UEDA and K. YAZAKI: **Application of vanadate-induced nucleotide trapping to plant cells for detection of ABC proteins**, *Plant Cell Physiol.*, **44**, 198–200 (2003).

The vanadate-induced nucleotide trapping technique, which has been conventionally used to characterize mammalian ABC proteins, was applied to berberine-producing plant cell cultures, *Thalictrum minus* and *Coptis japonica*. One membrane protein at ca. 180 kDa was photoaffinity-labeled with 8-azido- $[\alpha\text{-}^{32}\text{P}]$ ATP in the *T. minus* cells in the presence of vanadate, which was specifically induced by the addition of benzyladenine in a similar manner as the induction of berberine biosynthesis in these cell cultures, whereas three bands were observed in the *C. japonica* cells in the size region between 120 and 150 kDa corresponding to full-sized ABC protein. The benzyladenine-induced band in *T. minus* showed properties similar to those of human MDR1, including the recognition of berberine, which suggests that the ABC protein detected in *T. minus* takes this endogenous alkaloid as a putative substrate for transport. This is the first application of this technique to plant cells.

SHITAN, N., I. BAZIN, K. DAN, K. OBATA, K. KIGAWA, K. UEDA, F. SATO, C. FORESTIER and K. YAZAKI: **Involvement of CjMDR1, a plant MDR-type ABC protein, in alkaloid transport in *Coptis japonica***, *Proc. Natl. Acad. Sci. USA*, **100**, 751–756 (2003).

Alkaloids comprise one of the largest groups of plant secondary metabolites. Berberine, a benzylisoquinoline alkaloid, is preferentially accumulated in the rhizome of *Coptis japonica*, a ranunculaceous plant, whereas gene expression for berberine biosynthetic enzymes has been specifically observed in root tissues, which suggests that berberine synthesized in the root is transported to the rhizome to be highly accumulated. We recently isolated a cDNA encoding an MDR (multidrug-resistance protein)-type ABC transporter (*Cjmdr1*) from berberine-producing cultured *C. japonica* cells, which is highly expressed in the rhizome [Yazaki, K., Shitan, N., Takamatsu, H., Ueda, K. & Sato, F. (2001) *J. Exp. Bot.*, **52**, 877–879]. Functional analysis of *Cjmdr1* using a *Xenopus* oocyte expression system showed that CjMDR1 transported berberine in an inward direction, resulting in a higher accumulation of berberine in *Cjmdr1*-injected oocytes than in the control. Typical inhibitors of ABC proteins, such as vanadate, nifedipine, and glibenclamide, as well as ATP depletion clearly inhibited this CjMDR1-dependent berberine uptake, suggesting that CjMDR1 functioned as an ABC transporter. Conventional membrane separation methods showed that CjMDR1 was localized in the plasma membrane of *C. japonica* cells. *In situ* hybridization

indicated that *Cjmdr1* mRNA was expressed preferentially in xylem tissues of the rhizome. These findings strongly suggest that CjMDR1 is involved in the translocation of berberine from the root to the rhizome.

MORISHIGE, T., E. DUBOUZET, K.-B. CHOI, K. YAZAKI and F. SATO: **Molecular cloning of columbamine O-methyltransferase from cultured *Coptis japonica* cells**, *Eur. J. Biochem.*, **269**, 5659–5667 (2002).

To identify all of the O-methyltransferase genes involved in isoquinoline alkaloid biosynthesis in *Coptis japonica* cells, we sequenced 1,014 cDNA clones isolated from high-alkaloid-producing cultured cells of *C. japonica*. Among them, we found all three reported O-methyltransferases and an O-methyltransferase-like cDNA clone (CJEST64). This cDNA was quite similar to S-adenosyl-L-methionine: coclaurine 6-O-methyltransferase and S-adenosyl-L-methionine: isoflavone 7-O-methyltransferase. Since S-adenosyl-L-methionine: columbamine O-methyltransferase, which catalyzes the conversion of columbamine to palmatine, is one of the remaining unelucidated components in isoquinoline alkaloid biosynthesis in *C. japonica*, we heterologously expressed the protein in *E. coli* and examined the activity of columbamine O-methyltransferase. The recombinant protein clearly showed O-methylation activity using columbamine, as well as (S)-tetrahydrocolumbamine, (S)-, (R,S)-scoulerine and (R,S)-2,3,9,10-tetrahydroxyprotoberberine as substrates. This result clearly indicated that EST analysis was useful for isolating the candidate gene in a relatively well-characterized biosynthetic pathway. The relationship between the structure and substrate recognition of the O-methyltransferases involved in isoquinoline alkaloid biosynthesis, and a reconsideration of the biosynthetic pathway to palmatine are discussed.

TERASAKA, K., K. SAKAI, F. SATO, H. YAMAMOTO and K. YAZAKI: ***Thalictrum minus* cell cultures and ABC-transporter**, *Phytochemistry*, **62**, 483–489 (2003).

Cultured *Thalictrum minus* cells produce a benzylisoquinoline alkaloid, berberine, in the presence of benzyladenine, and excrete it into the culture medium. *T. minus* cells excluded berberine, even if berberine was exogenously added to the medium, without benzyladenine treatment. Similarly, *T. minus* cells excluded a heterocyclic dye (neutral red) and calcein AM, which is used as a fluorescent probe to detect the drug efflux pump activity by ABC transporters. The addition of several inhibitors of P-glycoprotein, a representative ABC transporter, induced the accumulation in of both berberine and calcein AM ATP-dependent manner. Expression of P-glycoprotein-like ABC transporter genes was also demonstrated. Involvement of ABC transporter in the secretion of berberine in *T. minus* cells is discussed.

TANIGUCHI, S., Y. IMAYOSHI, T. HATANO, K. YAZAKI and T. YOSHIDA: **Hydrolysable tannin production in *Oenothera tetraaptera* shoot tissue culture**, *Plant Biotech.*,

19, 357–363 (2002).

Shoot generating tissue cultures of *Oenothera tetralopha* were established. The tissues, which were subcultured on the LS agar medium containing 10 μ M IAA and 10 μ M kinetin, produced galloylglucoses and monomeric and dimeric ellagitannins. Plants were regenerated from the tissues upon the transfer from the regulator-containing medium to the medium which lack the regulator hormones. Regeneration of the plants from the *Oenothera* shoots were accompanied by the change in composition of hydrolysable tannins.

SAKAI, K., N. SHITAN, F. SATO, K. UEDA and K. YAZAKI: **Characterization of berberine transport into *Coptis japonica* cells and the involvement of ABC protein**, *J. Exp. Bot.*, **53**, 1879–1886 (2002).

Cultured *Coptis japonica* cells had a high activity to take up berberine from the medium, a benzyloquinoline alkaloid, and exclusively transport it into the vacuoles. This uptake activity depended on the growth phase of the cultured cells but the culture medium did not show a direct effect on the uptake. The treatments with several inhibitors suggested that berberine uptake depended on the ATP level. Some inhibitors of P-glycoprotein, an ABC transporter involved in multiple drug resistance in cancer cells, strongly inhibited berberine uptake, whereas specific inhibitors for glutathione biosynthesis and vacuolar ATPase, bafilomycin A1, had little effect. Vanadate-induced ATP trap experiments done to detect ABC proteins expressed in *C. japonica* cells showed that three membrane proteins between 120 and 150 kDa were photolabeled with 8-azido- $[\alpha\text{-}^{32}\text{P}]$ ATP. Two of them revealed the same photoaffinity-labeling pattern as P-glycoprotein, and the interaction of these proteins with berberine was also demonstrated. These results suggested that the ABC proteins of MDR-type are involved in the uptake of berberine from the medium.

KOEHLER, A., S. SOMMER, K. YAZAKI, A. FERRER, A. BORONAT, S.-M. LI and L. HEIDE: **High level expression of chorismate pyruvate-lyase (*UbiC*) and HMG-CoA reductase in hairy root cultures of *Lithospermum erythrorhizon***, *Plant Cell Physiol.*, **43**, 894–902 (2002).

Shikonin, a red naphthoquinone pigment, is produced by cell cultures of *Lithospermum erythrorhizon* (Boraginaceae). It is biosynthetically derived from two key precursors, i.e. 4-hydroxybenzoate (4HB) and geranyldiphosphate (GPP). The bacterial *ubiC* gene, encoding chorismate pyruvate-lyase (CPL) which converts chorismate to 4-hydroxybenzoate, was expressed in *Lithospermum erythrorhizon* under the control of the strong (ocs)₃mas-promotor. This introduced an efficient biosynthetic pathway to 4HB, i.e. a one-step reaction from chorismate, in addition to the endogenous multi-step phenylpropanoid pathway. Feeding experiments with $[1, 7\text{-}^{13}\text{C}_2]$ shikimic acid showed that in the most active transgenic line, 73% of 4HB was synthesized via the genetically introduced pathway. However, there was no correlation between CPL activity and 4HB glucoside or shikonin accumulation in the transgenes. HMG-CoA reductase (HMGR) is involved in the biosynthesis of GPP in *Lithospermum erythrorhizon*. Two forms of HMGR1 of *Arabidopsis thaliana* were

expressed in *Lithospermum* under control of the (ocs)₃mas promotor. Only moderate enzyme activities were obtained with the complete membrane protein, but high activity was achieved using the soluble cytosolic domain of HMGR1. Shikonin accumulation remained unchanged even upon high expression of soluble HMGR.

YAMAMOTO, H., P. ZHAO, K. YAZAKI and K. INOUE: **Regulation of lithospermic acid B and shikonin production in *Lithospermum erythrorhizon* cell suspension cultures**, *Chem. Pharm. Bull.*, **50**, 1086–1090 (2002).

Cell suspension cultures of *Lithospermum erythrorhizon* produced a large amount of lithospermic acid B, a caffeic acid tetramer, as well as shikonin derivatives (each ca. 10% of dry wt.) when cultured in shikonin production medium M-9. Various culture factors for increasing the production of lithospermic acid B were investigated. Lithospermic acid B production was inhibited by 2, 4-D or NH_4^+ , whereas it was stimulated by Cu^{2+} . These regulatory patterns were similar to those for the production of shikonin derivatives in these cell cultures, suggestive of close relations and similar metabolic regulation between the production of these compounds. Cultivation under light illumination, however, showed that these metabolisms were independently regulated. In particular, blue light showed a stimulatory effect on lithospermic acid B production, while shikonin production was strongly inhibited, indicative of an effective condition for lithospermic acid B production.

TANIGUCHI, S., K. UEGHI, R. KATO, H. ITOH, T. HATANO, K. YAZAKI and T. YOSHIDA: **Accumulation of hydrolyzable tannins by *Aleurites fordii* callus culture**, *Planta Med.*, **68**, 1145–1146 (2002).

A callus culture of *Aleurites fordii* Hemsley (Euphorbiaceae) producing five galloylglucoses and an ellagitannin, geraniin, was established. The production of pentagalloylglucose was remarkably enhanced under light irradiation compared with that in the dark. Cell growth and tannin production were also greatly affected by changing the concentrations and composition of nitrogen sources.

PARK, Y.W., R. TOMINAGA, J. SUGIYAMA, Y. FURUTA, E. TANIMOTO, M. SAMEJIMA, F. SAKAI and T. HAYASHI: **Enhancement of growth by expression of poplar cellulase in *Arabidopsis thaliana***, *Plant J.*, **33**, 1099–1106 (2003).

To study the role of cellulose and cellulase in plant growth, we expressed poplar cellulase (*PaPopCell1*) constitutively in *Arabidopsis thaliana*. Expression increased the size of the rosettes due to increased cell size. The change in growth was accompanied by changes in biomechanical properties due to cell wall structure indicative of decrease in xyloglucan cross-linked with cellulose microfibrils by chemical analysis and NMR spectra. The result supports the concept that the paracrystalline sites of cellulose microfibrils are attacked by poplar cellulase to loosen xyloglucan intercalation and this irreversible wall modification promotes the enlargement of plant cells.

OHMIYA, Y., T. NAKAI, Y.W. PARK, T. AOYAMA, A. OKA, F. SAKAI and T. HAYASHI: **The role of PopCell and PopCel2 in poplar leaf growth and cellulose biosynthesis**, *Plant J.*, **33**, 1087–1097 (2003).

Poplar calli transcribed two cellulase (endo-1,4- β -glucanase) genes, *PopCell1* and *PopCel2*, whose mRNAs were differentially located in the growing leaves of poplar during cell wall synthesis. Histochemical and RT-PCR analyses of promoter-GUS fusion gene activities in transgenic poplar demonstrated that *PopCell1* promoter derived GUS activity was localized in the petiole and leaf veins, whereas *PopCel2* was confined to mesophyll cells and disappeared from the tip during the development of leaves. Autoradiography of the leaf showed that the radioactivity of [14 C] sucrose incorporated into cellulose corresponded to the combination of the sucrose-induced tissue specific patterns of *PopCell1* and *PopCel2*. Interestingly, 2,6-dichlorobenzonitrile not only inhibited the incorporation of the radioactivity into cellulose but also repressed the induction of both cellulase genes. Suppression of cellulases by expression of *PopCell1* antisense cDNA or co-suppression of *PopCell1* mRNA by overexpression of *PopCell1* sense cDNA reduced leaf growth. Therefore, we came to the conclusion that *PopCell1* and *PopCel2* probably function to promote leaf growth in poplar by the endohydrolysis of 1,4- β -glucan.

IHARA, Y., F. SAKAI and T. HAYASHI: **Transferase activity of GhCesA2 (putative cotton cellulose 4- β -glucosyltransferase) expressed in *Pichia pastoris***, *J. Wood Sci.*, **48**, 425–428, (2002).

GhCesA2 is a cotton homologue of AxCesAs, which encode cellulose 4- β -glucosyltransferase. The central catalytic region of GhCesA2 was expressed as a soluble protein in *Pichia pastoris* after its N and C terminal regions containing transmembrane helix were deleted from its cDNA sequences. Western blot analysis showed that recombinant protein was a 100 kDa signal, which decreased to 85 kDa after the treatment with Endoglycosidase H. Although the protein is a putative 4- β -glucosyltransferase, we did not detect the synthesis of β -1,4-glucan.

TAKEDA, T., Y. FURUTA, T. AWANO, K. MIZUNO, Y. MITSUISHI and T. HAYASHI: **Suppression and acceleration of cell elongation by integration of xyloglucans in pea stem segments**, *Proc. Natl. Acad. Sci. USA*, **99**, 9055–9060 (2002).

Xyloglucan is a key polymer in the walls of growing plant cells. Using split segments and epidermis-peeled segments of pea stem, we demonstrate that the integration of xyloglucan caused by the action of wall-bound xyloglucan endotransglycosylase suppressed cell elongation, while that of its fragment oligosaccharide accelerated it. The integration of xyloglucan prevented cell elongation by incorporation of xyloglucan and further inducing a rearrangement of cortical microtubules to a longitudinal orientation, while that of its oligosaccharide allowed cell elongation by solubilization of xyloglucan and maintaining the microtubules in a transverse orientation. This paper proposes that xyloglucan metabolism controls the elongation of plant cells.

HAYASHI, T.: **Plant cell growth is controlled by the integration of xyloglucans**, *Nippon-Nogeikagaku Kaishi*, **76**, 957–961 (2002).

Effect of xyloglucans on plant cell elongation was reviewed.

HAYASHI, T.: **Is cellulase required for plant growth?** *Plant Cell Tech.*, **17**, 204–207 (2002).

Role of cellulase on plant growth was reviewed.

HAYASHI, T.: **Promotion of plant growth by cell wall engineering**, in the Proceedings of 4th International Wood Science Symposium, 1–4 (2002).

Cell wall engineering on plant growth was reviewed.

TAKEDA, T., Y. FURUTA, T. AWANO, K. MIZUNO, Y. MITSUISHI and T. HAYASHI: **Xyloglucan metabolism controls the elongation of plant cells**, in the Proceedings of First Spanish Congress on Physiology, Biochemistry and Molecular Biology of Carbohydrates, 27–28 (2002).

Xyloglucan metabolism on plant cell elongation was reviewed.

SHIMOMURA, F., F. SAKAI and H. KURODA: **O-methyltransferase (OMT) cDNA clones from *Pinus densiflora* seedlings**, *Wood Research*, **89**, 11–12 (2002).

Five O-methyltransferase (OMT) cDNA clones isolated have sequenced.

KURODA, H.: **Towards molecular mechanism in stilbenoid biosynthesis**, in the Proceedings of 4th International Wood Science Symposium, 343 (2002).

Stilbenoid biosynthesis was reviewed.

YOON, J.J., E. MUNIR, H. MIYASOU, T. HATTORI, T. TERASHITA and M. SHIMADA: **A possible role of the key enzymes of the glyoxylate and gluconeogenesis pathways for fruit-body formation of the wood-rotting basidiomycete *Flammulina velutipes***, *Mycoscience*, **43**, 327–332 (2002).

Biochemical role of the representative enzymes involved in carbon metabolism of glucose were investigated in relation to the fruit-body formation of the basidiomycete *Flammulina velutipes*. Changes in specific activities of the enzymes of the tricarboxylic acid (TCA) cycle and glyoxylate (GLOX) and gluconeogenesis pathways were measured at different stages of development of the fungus. The enzyme activities of malate synthase (MS) and fructose biphosphatase (FBP) as the key enzymes for the GLOX-gluconeogenesis pathways increased in mycelia during the fruit-body formation. The activities of isocitrate dehydrogenase (IDH) for the TCA cycle and NADP-linked glutamate dehydrogenase (GLTDH (NADP)) for glutamate synthesis increased more markedly. Moreover, the mycelial mat of the cultures producing fruit bodies yielded greater enzyme activities of isocitrate lyase (ICL), MS, FBP, and IDH than that of the cultures that did not produce fruit bodies. These results suggest that the GLOX-gluconeogenesis pathways as well as the glutamate synthesis have a strong correlation with the fruit-body formation of *F. velutipes*.

YOON, J.J., T. HATTORI and M. SHIMADA: **A metabolic role of the glyoxylate and tricarboxylic acid cycles for development of the copper-tolerant brown-rot fungus *Fomitopsis palustris***, *FEMS Microbiology Letters*, **217**, 9–14 (2002).

Fruit bodies of the copper-tolerant brown-rot fungus *Fomitopsis palustris* were produced in liquid medium for the first time. To induce fruit body formation of this fungus, it was important to inoculate the liquid medium with mycelia grown on potato dextrose agar plates and also to adjust the initial pH of the medium to 5.0. The metabolic role of the glyoxylate and tricarboxylic acid cycles during fungal development in the liquid culture was investigated in relation to oxalate biosynthesis. The enzymes for the glyoxylate cycle and oxalate biosynthesis in mycelium showed greater activities at the vegetative growth stage than at the fruiting stage. The ratios of isocitrate dehydrogenase activity to isocitrate lyase activity in mycelium were 0.3 and 4.0 at the vegetative and fruiting stage, respectively. Thus, isocitrate lyase for the glyoxylate cycle played a more important role in oxalate synthesis at the earlier stage of the cultivation, whereas isocitrate dehydrogenase played a major role in glutamate synthesis during fruit body formation.

YOON, J.J., T. HATTORI and M. SHIMADA: **Purification and characterization of NADP-linked isocitrate dehydrogenase from the copper-tolerant wood-rotting basidiomycete *Fomitopsis palustris***, *Biosci. Biotechnol. Biochem.*, **67**, 114–120 (2003).

NADP-linked isocitrate dehydrogenase (EC 1.1.1.42), a key enzyme of the tricarboxylic acid cycle, was purified 672-fold as a nearly homogeneous protein from the copper-tolerant wood-rotting basidiomycete *Fomitopsis palustris*. The purified enzyme, with a molecular mass of 115 kDa, consisted of two 55-kDa subunits, and had the K_m of 12.7, 2.9, and 23.9 μ M for isocitrate, NADP, and Mg^{2+} , respectively, at the optimal pH of 9.0. The enzyme had maximum activity in the presence of Mg^{2+} , which also helped to prevent enzyme inactivation during the purification procedures and storage. The enzyme activity was competitively inhibited by 2-oxoglutarate (K_i , 127.0 μ M). Although adenine nucleotides and other compounds, including some of the metabolic intermediates of glyoxylate and tricarboxylic acid cycles, had no or only slight inhibition, a mixture of oxaloacetate and glyoxylate potently inhibited the enzyme activity and the inhibition pattern was a mixed type.

MAEDA, M. H. KAKU, M. SHIMADA and T. NISHIOKA: **Cloning and sequence analysis of D-erythrulose reductase from chicken: its close structural relation to tetrameric carbonyl reductases**, *Protein Engineering*, **15**, 611–617 (2002).

Sequence analysis of cDNA for d-erythrulose reductase from chicken liver showed that the deduced pen reading from encodes the protein with a molecular mass of 26 kDa consisting of 246 amino acids. Although the reductase shares more than 60% identity in the amino acid sequence with the mouse tetrameric carbonyl reductase, these two enzymes have many biochemical differences: their substrate specificity, subcellular localization, organ

distribution, etc.

MIKAME, K., N. SAKAKIBARA, T. UMEZAWA and M. SHIMADA: **Lignans of *Linum flavum* var. *compactum***, *J. Wood Sci.*, **48**, 440–445 (2002).

A new dibenzylbutyrolactone lignan 7,6'-dihydroxy-bursehernin, together with six known lignans, pinoresinol, lariciresinol, secoisolariciresinol, α -peltatin, β -peltatin, 5-methoxypodophyllotoxin, were isolated from the methanol extracts of *Linum flavum* var. *compactum*. The enantiomeric analysis of pinoresinol and lariciresinol isolated from the species, which are upstream lignans in the lignan biosynthetic pathway, indicated that they are not optically pure, which is in accordance with our recent findings on lignans occurring in other plant species.

SUZUKI, S., N. SAKAKIBARA, T. UMEZAWA and M. SHIMADA: **Survey and enzymatic formation of lignans of *Anthriscus sylvestris***, *J. Wood Sci.*, **48**, 536–541 (2002).

Gas chromatography - mass spectrometry analysis of the β -glucosidase-treated MeOH extracts of *Anthriscus sylvestris* showed, based on comparison of the mass spectra and retention times with those of authentic samples, the presence of lignans, yatein, secoisolariciresinol, lariciresinol, matairesinol, hinokinin, and pluviatolide. The existence of small amounts of bursehernin was suggested by mass chromatography. In addition, nemerosin and deoxypodophyllotoxin were tentatively identified by comparing the mass spectra with those reported in the literature. Enzyme preparations from *A. sylvestris* catalyzed the formation of secoisolariciresinol and lariciresinol from coniferyl alcohol. Furthermore, the enzyme preparation catalyzed the formation of lariciresinol from (\pm)-pinoresinols and the formation of secoisolariciresinol from (\pm)-lariciresinols. Thus, pinoresinol/lariciresinol reductase (PLR) activity was detected. Chiral high performance liquid chromatography analysis showed selective formation of (+)-lariciresinol and (–)-secoisolariciresinol from (\pm)-pinoresinols with the *A. sylvestris* PLR preparation, indicating that the stereochemical property of *A. sylvestris* PLR-catalyzed reduction was similar to those of *Forsythia* PLR and *Arctium lappa* ripening seed PLR.

SHIMADA, M. and T. HATTORI: **Unique energy acquiring strategy of wood-rotting fungi (in Japanese)**, *Chemistry and Living Organisms*, **40**, 491–558 (2002).

The unique energy acquiring strategy of wood-rotting fungi was reviewed.

SHIMADA, M., J.J. YOON, E. MUNIR and T. HATTORI: **Physiology and metabolism of wood destroying fungi (in Japanese)**, *Wood Preservation*, **28**, 86–97 (2002).

We reviewed physiology and metabolism of wood-destroying fungi in relation to oxalic acid metabolism of the fungi.

FUKUSHIMA, K., R. FUNADA, J. SUGIYAMA, K. TAKABE, T. UMEZAWA and H. YAMAMOTO (eds.): **Secondary Xylem Formation, Introduction to Biomass Science**, Kaiseisha (2003).

Recent advances in wood bioscience are outlined

especially in relation to secondary xylem formation.

UMEZAWA, T.: **Chemistry of Lignans and Neolignans, In "Secondary Xylem Formation", Introduction to Biomass Science**, (Ed. Umezawa T. *et al.*) Kaiseisha, pp. 264–268 (2003) (in Japanese).

Chemistry of lignans and neolignans is outlined especially in relation to secondary xylem formation.

UMEZAWA, T.: **Chemistry of Norlignans, In "Secondary Xylem Formation", Introduction to Biomass Science**, (Ed. Umezawa T. *et al.*) Kaiseisha, pp. 268–269 (2003) (in Japanese).

Chemistry of norlignans is outlined especially in relation to secondary xylem formation.

UMEZAWA, T.: **Biosynthesis of Lignans, In "Secondary Xylem Formation", Introduction to Biomass Science**, (Ed. Umezawa T. *et al.*) Kaiseisha, pp. 286–287 (2003) (in Japanese).

Biosynthesis of lignans is outlined especially in relation to secondary xylem formation.

UMEZAWA, T.: **Biosynthesis of Neolignans, In "Secondary Xylem Formation", Introduction to Biomass Science**, (Ed. Umezawa T. *et al.*) Kaiseisha, pp. 288 (2003) (in Japanese).

Biosynthesis of neolignans is outlined especially in relation to secondary xylem formation.

UMEZAWA, T.: **Biosynthesis of Norlignans, In "Secondary Xylem Formation", Introduction to Biomass Science**, (Ed. Umezawa T. *et al.*) Kaiseisha, pp. 289–290 (2003) (in Japanese).

Biosynthesis of norlignans is outlined especially in relation to secondary xylem formation.

YOON, J.J. T. HATTORI and M. SHIMADA: **Enzymatic studies on roles of the glyoxylate and TCA cycles during fruit body formation of the copper-tolerant brown-rot fungus *Fomitopsis palustris***, Proceeding of the IAWPS 2003 (International Conference on Forest Products) Eds. Lee, H.H. and Jang, S.S., Daejeon, Korea, April 21–24, Vol. 1., pp. 530–535 (2003).

Fruit bodies of the copper-tolerant brown-rot basidiomycete *Fomitopsis palustris* were produced in the liquid medium for the first time. Biochemical roles of NADP-linked isocitrate dehydrogenase, glutamate dehydrogenase, and isocitrate dehydrogenase during the cultivation of this fungus were investigated. During the vegetative growth isocitrate dehydrogenase and glyoxylate dehydrogenase, involved in the TCA cycle and the oxalate biosynthesis, respectively, played a more important role, whereas glutamate dehydrogenase and isocitrate dehydrogenase played a major role during the fruit body formation. The characteristics of the purified isocitrate dehydrogenase were also reported.

MUNIR, E., T. HATTORI and M. SHIMADA: **A possible role of unique TCA cycles in wood-rotting basidiomycetes**, The 34th International Research Group on Wood Preservation (Brisbane, Australia, May 18–23)

(2003).

We have reported that the copper tolerant brown-rot fungus, *Fomitopsis palustris*, acquires metabolic energy by use of the constitutively-occurring Kornberg's glyoxylate cycle coordinating with oxalate biosynthesis and glucose oxidation (Erman Munir *et al.* *Proc. Natl. Acad. Sci. USA*, **98**, 11126–11130 (2001)). Furthermore, this fungus does not have the normal TCA cycle, lacking 2-oxoglutarate dehydrogenase which is a key enzyme of the TCA cycle of most living things. This paper reports that most wood decay fungi tested lack 2-oxoglutarate dehydrogenase (ODH) and that much greater activities of glutamate dehydrogenase compensating the absence of ODH were detected from both white- and brown-rot fungi.

OKUNISHI, T., N. TAKAKU, P. WATTANAWIKKIT, N. SAKAKIBARA, S. SUZUKI, F. SAKAI, T. UMEZAWA and M. SHIMADA: **Establishment of *Daphne odora* cell culture producing stereochemically unique lignans**, Proc. 4th Intern. Wood Science Symp., p. 319 (2002).

A suspension culture of *D. odora* producing lignans was established. The cell suspension culture produced pinoresinol, lariciresinol, secoisolariciresinol, matairesinol, and wickstromol. The production of matairesinol in the cell suspension culture was much higher than that in *Daphne odora* stem tissues.

SUZUKI, S., T. NAKATSUBO, T. UMEZAWA and M. SHIMADA: **Biosynthesis of heartwood substances in a model plant —First *in vitro* norlignan formation—**, Proc. 4th Intern. Wood Science Symp., p. 341 (2002).

Enzymatic norlignan formation was reported for the first time. Thus, the authors found out that an enzyme preparation from fungal-elicited *A. officinalis* cultured cells catalyses the formation of a norlignan, (Z)-hinokiresinol, from two non-identical phenylpropanoid monomers, 4-coumaryl alcohol and 4-coumaroyl CoA, and from a dimer, 4-coumaryl 4-coumarate, without any additional cofactors.

SAKAKIBARA, N., S. SUZUKI, T. UMEZAWA and M. SHIMADA: **Biosynthetic pathway for heartwood syringyl lignans and antitumor podophyllotoxin**, Proc. 4th Intern. Wood Science Symp., p. 342 (2002).

Little is known about the biosynthesis of a syringyl (3,5-dimethoxyphenyl) lignan yatein, in spite of its importance as a typical heartwood lignan and a key intermediate of the antitumor lignan podophyllotoxin. The present study, based on individual administration of [¹³C]phenylalanine and deuterium labeled lignans and simultaneous administration of two distinct lignans labeled with deuterium atoms to *Anthriscus sylvestris*, established the two independent biosynthetic pathways from matairesinol; one to afford yatein via thujaplicatin, 5-methylthujaplicatin, and 4,5-dimethylthujaplicatin and the other to bursehernin via pluviatolide. The latter pathway did not lead to yatein, eliminating the presence of a metabolic grid from matairesinol to yatein.

NAKATSUBO, T., S. SUZUKI, CHIANG V.L., T. UMEZAWA and M. SHIMADA: **Regeneration system for *Robinia pseudoacacia***, Proc. 4th Intern. Wood Science Symp., p. 334 (2002).

Preliminary results of regeneration of *R. pseudoacacia* shoots derived from mature trees were reported.

HATTORI, T., A. OHTA, M. ITAYA and M. SHIMADA: **Utilization of lipid and fatty acids as a carbon source by ectomycorrhizal fungi**, Proc. 4th Intern. Wood Science Symp., p. 348 (2002).

The growth of ectomycorrhizal (ECM) fungi, 59 strains of 34 species in 17 genera, on fatty acids and lipid were compared. Several ECM fungi were found to utilize either saturated (palmitate), monounsaturated (oleate) fatty acids or triolein as a carbon source. The results were discussed in relation to family-, genus-, and species-specific features on utilization of them as a carbon source.

ITO, T.: **The impact of wood identification for the understanding of wood culture and its exchange between Korea and Japan**, Proc. of International Conference on Forest Products, April 21–24, Daejeon, Korea (2003).

The wood identification is a strong tool to understand the uses of trees for the wooden cultural properties, such as excavated wood from historic sites, wooden Buddha sculptures, buried wood, traditional wooden building and national treasures. The author has been engaged in the identification of these cultural properties, especially excavated wood in Japan for past 20 years or more. When we surveyed the papers dealing with the identification of excavated wood, the first paper was traced back to 1936 that appeared in the Journal of Japanese Society of Forestry, 18(8), 588–602, reporting that the wood species of coffins excavated in both Japan and Korea. Since then, a great number of papers dealing wood identification has been reported in our country. The author has input the data of tree species and uses by computer along with the name of wood artifacts, era, historic site and references. By arranging these data, we are able to learn the tree species and uses from the statistical point.

ITO, T.: **Artisan and their works in traditional wood works**, *Kino Kokoro*, No. 23, 60–63 (2003).

The paper deals with the introduction of traditional wood works with three major discussions; natural environment that support traditional wood works, traditional wood works and wooden national treasure in Shoso-in temple.

ITO, T.: **Silk roads and wood culture**, *Sanrin*, Vol. 1428, 35–43 (2003).

Niya historic site that is located along silk road is rich in wooden artifacts. The author pointed out that wood culture developed in Niya historic site.

ITO, T.: **Identification of tree species and its utilization**, In, "Manual of Environmental Archaeology", ed. By Akira Matsui, Douseisha press (2003).

The author contributed a chapter, "identification of tree species and its utilization".

ITO, T.: **Tree species and dating of building materials in Niya historic sites**, In, "The mystery of Niya historic site", Ed. By M. Nakai and Y. Kojima (2002).

The author contributed one chapter in this book.

ITO, T.: **Short visit to an illusive ancient city, "Niya Historic Site"**, *Wood Research and Technical Notes*, No. 38, 1–12 (2002).

The paper deals with a record of travel to Niya historic site.

ITO, T.: **Tree species and uses of wooden remains excavated from the relics in Japan III**, *Wood Research and Technical Notes*, No. 38, 39–217 (2002).

This paper deals with a database of excavated wood from historic sites.

ITO, T.: **Wood identification of wooden tablet excavated from Kannon-ji historic site**, "Kannonji Historic Site I" Tokushimaken Kyouiku Iinkai, Tokushimaken Maizou Bunkazai Center, 167–170 (2002).

A number of wooden tablet excavated from Kannon-ji historic site was identified microscopically.

ITO, T.: **Wood species of wooden artifacts excavated from Chikaoka historic site**, "Chikaoka Historic Site II", Kanazawasi Maizou Bunkazai Center, p. 24, plate 1 (2002).

Wood species of wooden artifacts excavated from Chikaoka historic site was identified microscopically.

ITO, T.: **Wood species of wooden artifacts excavated from Tsukuda historic site**, Hyougoken Bunkazai Chyousa Houkokusho, No. 176, 79–83 (1998).

Wood species of wooden artifacts excavated from Tsukuda historic site were identified microscopically.

ITO, T., M. KUWAHARA and H. SASAKI: **Physical and Chemical analysis of wood pieces and air, Solar boat (I)**, Waseda University Rikougaku Sougou Center, 43–47 (2002).

Wood pieces and air of Solar boat were analysed physically and chemically.

ITO, T.: **Cellulose-synthases localize in terminal complexes-prove by using freeze-fracture combined with immunogold labeling**, *Growth Control in Plants*, 37, 44–50 (2002).

Visualization of cellulose synthases using freeze fracture replica labeling is reviewed.

ITO, T., Y. TABATA, E. WIDJAJA, T. MULYANINGSIH, IR., PARMAN, H. WIRIADINATA and Y.I. MANDANG: **Structure and artificial induction of aloeswood**, Proc. of 6th Pacific Regional IAWA meeting, Sept., 9–13 (2003) (Yogyakarta, Indonesia).

Aloeswood, which is called "Gaharu" in Indonesia and Malaysia, is known to produce a fragrant wood in the xylem. It covers *Aquilaria* and some other genera. It is not known yet how the fragrant wood is formed in the living tree. Many report suggest that the fragrant wood is induced by the Pathological infection of some fungi. We analyzed the Aloewood tissue by microscopy. We also tried to inoculate some fungi into living trees in order to induce fragrant wood artificially. We have got the

following conclusions: (1) the crystals of calcium are localized mainly in included phloem; (2) aromatic resin deposition may start at ray and included phloem; (3) aromatic resin is produced vertically at 1–2 cm apart from the holes.

ITO, T. and S. KIMURA: **Cellular and developmental events of cellulose biosynthesis in animal kingdom, Tunicates**, *Proc. 21st International Carbohydrate Symposium*, July 7–12 (2002) (Cairns, Australia).

Cellulose is a major component of the cell wall in land plants, and its presence has been recorded in various other organisms such as algae, fungi, bacteria, and animals. Many experiments of cellulose synthesis have been made in plants. It has been demonstrated that cellulose microfibrils are synthesized and assembled by transmembrane enzyme particles in the plasma membrane called terminal complexes (TCs). It has been shown that land plants produce cellulose microfibrils with 3.5 nm in diameter by the function of rosette TCs. It has also been shown that marine algae produce cellulose microfibrils with ca 20 nm in diameter by the function of linear TCs. Tunicates (urochordates) are the only animals known to produce highly crystalline cellulose. However, the details of the mechanism for the synthesis of cellulose in the tunicates are not yet known. Cellular and developmental events of cellulose biosynthesis in tunicates have been investigated by our group for the last several years. We would like to present the major achievements so far obtained from this project. Our major approaches are based on the structural analysis by using different techniques for electron microscopy including freeze fracture replication and electron diffraction. The findings are as follows: (1) specific linear terminal complexes are found in the cell membrane of epidermis, (2) vacuole in the glomerulocyte is a new cellulose-biosynthetic site. Therefore, two different sites of cellulose biosynthesis, that is, cell membrane and vacuole membrane; are found; (3) new cellulosic structures, network structure and tunic cords, other than tunic are found; (4) the common ancestor of tunicates (ascidians, thaliaceans, and appendicularians) already possess cellulose biosynthetic ability, supported by the finding that appendicularians produce cellulose in the house.

T. ITO: **Localization of cellulose synthases and related enzymes using freeze-fracture replica labelling**, *Proc. of Plant Polysaccharide Workshop*, July 4–6 (2002) (Palm Cove, Australia).

Localization of cellulose synthases using freeze-fracture replica labeling was reviewed.

NISHIYAMA, Y., H. CHANZY, M. WADA, J. SUGIYAMA, K. MAZEAU, T. FORSYTH, C. RIEKEL, M. MUELLER, B. RASMUSSEN and P. LANGAN: **Synchrotron x-ray and neutron fiber diffraction studies of cellulose polymorphs**, *Advances in X-Ray Analysis*, **45**, 385–390 (2002).

Recent advances in elucidation of cellulose polymorphic structures are reviewed.

WATANABE, T., Y. ARIGA, U. SATO, T. MATSUMOTO, N. NIKAIKIDOU, T. NONAKA and J. SUGIYAMA: **Crystalline chitin hydrolysis by chitinase A1 from *Bacillus circulans* WL-12: effect of mutations of Tyr56 and Trp53**, *Advances in Chitin Science*, **6**, 289–290 (2002).

Chitinase A1/chitin interaction was investigated with particular interest on the role of aromatic residues along the catalytic site of the enzyme.

HULT, E.-L., S. YAMANAKA, M. ISHIHARA and J. SUGIYAMA: **Aggregation of microfibrils in bacterial cellulose induced by high pressure incubation**, *Carbohydr. Polym.*, **53**, 9–14 (2003).

The nascent morphology of cellulose produced by *Acetobacter aceti* (AJ12868) incubated at 30 atmospheres pressures was investigated using AFM, TEM, X-ray and optical microscopy. The bacteria survived the elevated pressure and produced cellulose. The ribbons produced at 30 atm had similar crystalline features as the ribbons produced in the control medium but exhibited larger microfibril aggregates.

HORI, R. and J. SUGIYAMA: **A combined FT-IR microscopy and principal component analysis on softwood cell walls**, *Carbohydr. Polym.*, **52**, 449–453 (2003).

A combined FT-IR microscopy and principle component analysis was used to investigate chemical variations between softwood species as well as types of wood cell walls; latewood tracheids, earlywood tracheids and earlywood ray parenchyma cells. The method allowed us to detect small spectral differences between cell types rather than species and to predict characteristic chemical components of each cell type. The method enabled information to be obtained which allowed an evaluation of the polysaccharide composition even in lignified woody plant cell walls.

LEHTIÖ, J., J. SUGIYAMA, M. GUSTAVSSON, L. FRANSSON and T.T. TEERI: **The binding specificity and affinity determinants of the family 1 cellulose-binding domains from *Trichoderma reesei* Cel6A and Cel7A.**, *Proc. Natl. Acad. Sci. USA*, **100**(2), 484–489 (2003).

Cellulose binding modules (CBMs) potentiate the action of cellulolytic enzymes on insoluble substrates. Numerous studies have established that three aromatic residues on a CBM surface are needed for binding onto cellulose crystals and that tryptophans contribute to higher binding affinity than tyrosines. However, studies addressing the nature of CBM-cellulose interactions have so far failed to establish the binding site on cellulose crystals targeted by CBMs. In this study, the binding sites of CBMs on *Valonia* cellulose crystals have been visualized by transmission electron microscopy. Fusion of the CBMs with a modified staphylococcal protein A (ZZ-domain) allowed direct immuno-gold label-ing at close proximity of the actual CBM binding site. The transmission electron microscopy images provide unequivocal evidence that the fungal family 1 CBMs as well as the family 3 CBM from *Clostridium thermocellum* CipA have defined binding sites on two opposite corners of *Valonia* cellulose crystals. In most samples these corners

are worn to display significant area of the hydrophobic (110) plane, which thus constitutes the binding site for these CBMs.

IMAI, T., J.-L. PUTAUX and J. SUGIYAMA: **Geometric phase analysis of lattice images of crystalline allomorphs of *Cladophora* microcrystals**, *Polymer*, **44**, 1871–1879 (2003).

A geometric phase analysis has been applied to high-resolution transmission electron microscopy images from algal cellulose microcrystals. The pictures were decomposed into images containing selectively the amplitude or phase information associated to selected Bragg reflections. Compared with I_α (monoclinic)-rich cellulose microfibrils, I_β (triclinic)-rich microfibrils were found to be more heterogeneous when viewed along the H-bonding sheets. As a microfibril twist and radiation damage could not be totally ruled out as having an effect on the lattice image, this result has to be considered with care when used in order to survey the distribution of different allomorphs in a cellulose microfibril. However, the geometric phase analysis of noisy low dose high-resolution images appears as a promising new method to investigate polymer crystals and the distribution of domains having different structures or containing lattice distortions.

TOKOH, C., K. TAKABE, J. SUGIYAMA and M. FUJITA: **CP/MAS ^{13}C NMR and electron diffraction study of bacterial cellulose structure affected by cell wall polysaccharides**, *Cellulose*, **9**, 351–360 (2002).

Acetobacter xylinum was cultured in Schramm-Hestrin medium containing pectin (pectin medium), xylan (xylan medium), or glucomannan (mannan medium). X-ray diffractometry revealed that xylan and glucomannan affected the size of the cellulose crystals and their d-spacing values. Solid-state cross polarization magic angle spinning carbon-13 nuclear magnetic resonance spectroscopy indicated that the ratio of cellulose Ia was reduced by the addition of polysaccharides. These effects were more remarkable on the cellulose in the mannan medium than that in the xylan medium, and were scarcely observed in the pectin medium. Electron diffraction analysis revealed that these effects on hemicelluloses along cellulose microfibrils are continuous in the mannan medium and discontinuous in the xylan medium. These findings suggest that the uronic acid in the polysaccharides prevents interactions with cellulose leading to alterations of the structure of the cellulose crystal.

TOKOH, C., K. TAKABE, J. SUGIYAMA and M. FUJITA: **Cellulose synthesized by *Acetobacter xylinum* in the presence of plant cell wall polysaccharides**, *Cellulose*, **9**, 65–74 (2002).

Acetobacter xylinum was cultured in Schramm-Hestrin (SH) medium containing glucuronoxylan (xylan medium) or pectin (pectin medium). Loose bundles of cellulose microfibrils were formed in the xylan medium. In contrast, the cellulose ribbons formed in the pectin medium were the same as those normally formed in SH medium. The periodic acid-thiocarbohydrazide-silver proteinate method indicated that positive reacted substances located

along cellulose microfibrils formed in both mediums. Freeze-fracture and deep-etching electron microscopy also revealed that polysaccharides exist around cellulose microfibrils. X-ray diffractometry and Fourier Transform Infrared spectroscopy demonstrated that the addition of xylan induced a change in the ratio of cellulose I_α and I_β . Electron diffraction analysis revealed that xylan discontinuously affected the crystalline structure of cellulose microfibrils. Pectin did not have this effect. Glucuronoxylan in the medium prevented the assembly of cellulose microfibrils and changed the crystal structure of cellulose, whereas pectin in the medium scarcely had an effect.

HORI, R., M. MUELLER, U. WATANABE, H. LICHTENEGGER, P. FRATZL and J. SUGIYAMA: **The importance of seasonal differences in the cellulose microfibril angle in softwoods in determining acoustic properties**, *J. Mater. Sci.*, **37**, 4279–4284 (2002).

The influence of the micro- and mesoscopic structure of wood cell walls on the acoustic properties of softwood was investigated in a synchrotron X-ray microbeam diffraction experiment with particular attention to the seasonal differences of crystallographic features. A multiple regression analysis was performed for data from 12 different softwood species in order to determine the dependence of longitudinal relative Young's modulus (E/σ) and loss tangent ($\tan \delta$) on seasonal cellulose microfibril angles (MFAs), crystal width of cellulose microfibrils etc. We conclude that a low MFA in both latewood and earlywood yields high E/σ and low $\tan \delta$, which is the condition for use of wood as violin or piano soundboards. Among the softwood species we characterized Sitka spruce best fits this criterion.

SUGIYAMA, J.: **Cellulose: Introduction, New horizon between structure and biogenesis**, (Eds. Fukushima, K., Funada, R., Sugiyama, J., Takabe, K., Umezawa, T., Yamamoto, H.: Secondary xylem formation) Kaiseisha Press, 89–90, 121–125 (2003) (in Japanese).

Recent advances in structural biology of cellulose and its biogenesis was outlined.

BABA, K.: **Molecular biology of xylem differentiation**, (Eds. Fukushima, K., Funada, R., Sugiyama, J., Takabe, K., Umezawa, T., Yamamoto, H.: Secondary xylem formation) Kaiseisha Press, 39–41 (2003) (in Japanese).

Recent study of molecular biology for xylem formation was reviewed.

BABA, K.: **Structure and formation of reaction wood**, (Eds. Fukushima, K., Funada, R., Sugiyama, J., Takabe, K., Umezawa, T., Yamamoto, H.: Secondary xylem formation) Kaiseisha Press, 76–80 (2003) (in Japanese).

The structural properties and mechanism of reaction wood formation were reviewed.

SATO, S., Y. HONDA, M. KUWAHARA and T. WATANABE: **Degradation of vulcanized and nonvulcanized polyisoprene rubbers by lipid peroxidation catalyzed by oxidative enzymes and transition metals**,

Biomacromolecules, **4**, 321–329 (2003).

In spite of numerous reports concerning the biodegradation of rubber materials, there has been no report of rubber degradation by fully characterized enzymes. In the present paper, we presented a new method to decompose non-vulcanized and vulcanized polyisoprene rubbers by controlling the free radical chain reactions of lipids using oxidative enzymes, manganese peroxidase (MnP), laccase (Lac) and horseradish peroxidase (HRP). Non-vulcanized synthetic polyisoprene (IR) was degraded by the free radicals from unsaturated fatty acids produced by MnP, HRP and a combination of Lac/1-hydroxybenzotriazole (1-HBT). In contrast, lipoxygenase caused no apparent degradation. Degradation of IR was also observed in lipid peroxidation initiated by the Fenton reaction (FR) and Mn(III), an oxidation product produced by MnP. Vulcanized polyisoprene rubber sheets were degraded by the lipid peroxidation initiated by HRP, MnP, Mn(III) and FR. Pyrolysis GC-MS analysis demonstrated that the lipid peroxidation liberated isoprenoid fragments from the vulcanized rubbers.

WATANABE, T., H. TERANISHI, Y. HONDA and M. KUWAHARA: **A selective lignin-degrading fungus, *Ceriporiopsis subvermispora* produces alkylitaconates that inhibit the production of a cellulolytic active oxygen species, hydroxyl radical in the presence of iron and H₂O₂**, *Biochem. Biophys. Res. Commun.*, **297**, 918–923 (2002).

A cellulolytic active oxygen species, hydroxyl radicals ($\cdot\text{OH}$), play a leading role in the erosion of wood cell walls by brown rot and non-selective white rot fungi. In contrast, selective white rot fungi have been considered to possess unknown systems for the suppression of $\cdot\text{OH}$ production due to their wood decay pattern with a minimum loss of cellulose. In the present paper we first report that 1-nonadecene-2, 3-dicarboxylic acid, an alkylitaconic acid (ceriporic acid B) produced by the selective white rot fungus *Ceriporiopsis subvermispora* intensively inhibited $\cdot\text{OH}$ production by the Fenton reaction by direct interaction with Fe ions, while non-substituted itaconic acid promoted the Fenton reaction. Suppression of the Fenton reaction by the alkylitaconic acid was observed even in the presence of the Fe³⁺ reductants, cysteine and hydroquinone. The inhibition of $\cdot\text{OH}$ production by the diffusible fungal metabolite accounts for the extracellular system of the fungus that attenuates the formation of $\cdot\text{OH}$ in the presence of iron, molecular oxygen and free radicals produced during lignin biodegradation.

ENOKI, M., Y. HONDA, M. KUWAHARA and T. WATANABE: **Chemical synthesis, iron redox interactions and charge transfer complex (CTC) formation of ceriporic acids from the selective lignin-degrading basidiomycete, *Ceriporiopsis subvermispora***, *Chem. Phys. Lipid*, **120**, 9–20 (2002).

We synthesized a metabolite from *Ceriporiopsis subvermispora*, 1-nonadecene-2, 3-dicarboxylic acid (ceriporic acid B) by Grignard reaction to analyze chemical properties of the alkylitaconates. MS and NMR spectra of the

synthetic compound was identical to those of the fungal metabolite isolated. The dicarboxylic acid inhibited autoxidation of Fe²⁺ to Fe³⁺ as well as reduction of Fe³⁺ to Fe²⁺ by the strong natural reductants, cysteine, glutathione, and ascorbic acid. The formation of charge transfer complexes (CTCs) between 1-heptadecene-2, 3-dicarboxylic acid and oxidized intermediates from phenolic substrates were also observed. Thus, we herein report that the new class of lipid-related metabolites produced by *C. subvermispora* are potential metabolites participating in the control of iron redox reactions and CTCs formation from oxidized lignin fragments.

KOSHIJIMA, T. and T. WATANABE: **Association between lignin and carbohydrates in wood and other plant tissues**, Springer Series in Wood Science, eds. by T. Koshijima and T. Watanabe, Springer Verlag, Berlin, 1–329 (2003).

Throughout the world 10 million tons of wood are used every year for paper-making, cellulose preparations, cloth and dietary supplements. Wood is mainly composed of polysaccharides and lignin which are hydrophilic and hydrophobic respectively. This book describes the academic approaches to chemical structure, biosynthesis, and physicochemical properties of native bonds between lignin and carbohydrates in wood and other plant tissues. Microbial degradation of lignin-carbohydrate complexes is also reviewed.

FACKLER, K., E. SREBOTNIK, T. WATANABE, P. LAMAIPIIS, M. HUMAR, C. TAVZES, M. SENTJURC, F. POHLEVEN and K. MESSNER: **Biomimetic pulp bleaching with copper complexes and hydroperoxides**, *Biotechnology in the Pulp and Paper Industry, Progress in Biotechnology*, Vol 21, eds. by L. Viikari and R. Lantto, Elsevier, Amsterdam, 223–230 (2002).

A low molecular weight delignification system consisting of hydroperoxides and Cu(II) coordinated by pyridine derivatives was applied to pulp bleaching. Selectivity of the oxidation system in lignin degradation were examined using ¹⁴C-labelled lignin and cellulose. Free radicals and active oxygen species involved in the system were analyzed by ESR.

WATANABE, T.: **Lignin biodegradation by white rot fungi**, In *Biomass Handbook*, ed by S. Yokoyama, Ohmura, Tokyo, 176–183 (2002) (in Japanese).

Biochemistry and applications of lignin biodegradation by white rot fungi are reviewed.

WATANABE, T.: **Carbohydrate Industry - Biotechnology for industrial application**, In *Biotechnology Mokuzaikagaku-Kouza 11*, eds by Y. Katayama, T. Hayashi and M. Kuwahara, Kaisei-sha, Otsu, 129–136 (2002) (in Japanese).

Biotechnology and industrial applications of oligosaccharides from wood biomass are reviewed.

SATO, S. and T. WATANABE: **Degradation of vulcanized and non-vulcanized rubbers by white rot fungi and biomimetic radical reactions**, In *Environmental Restoration and Useful Substance Production*, 126–132, CMC-

Shuppan, Tokyo (2003) (in Japanese).

Degradation of vulcanized and non-vulcanized rubbers by white rot fungi and biomimetic free radical reactions are reviewed.

WATANABE, T.: **Extracellular free radical process of white rot fungi and wood biomass conversion**, *APAST*, **45**, 10–14 (2002) (in Japanese).

Biodegradation of lignin is an extracellular free radical event that proceeds in concert with the activation of molecular oxygen and redox cycling of transition metals. In this article the extracellular free radical process of white rot fungi is reviewed. Application of selective white rot fungi to wood biomass conversion is also discussed.

SATO, S. and T. WATANABE: **Degradation of vulcanized and non-vulcanized rubbers by white rot fungi and biomimetic radical reactions**, *Eco-Industry*, **7**, 25–31 (2002) (in Japanese).

Degradation of vulcanized and non-vulcanized rubbers by white rot fungi and biomimetic radical reactions are reviewed.

KUWAHARA, M. and T. WATANABE: **Degradation of lignin in wood by mushrooms**, *Bioscience and Industry*, **60**, 9–10 (2002) (in Japanese).

Wood decay patterns by selective and non-selective white rot fungi are explained using color photographs and illustrations.

SYAFWINA, Y. HONDA, T. WATANABE and M. KUWAHARA: **Pre-treatment of oil palm empty fruit bunch by white-rot fungi for enzymatic saccharification**, *Wood Res.*, **89**, 19–20 (2002).

Empty fruit bunch (EFB) or oil palm (*Elaeis guineensis*) is a residue of palm oil production in Indonesia, Malaysia and the rest of Southeast Asian countries. EFB is a potential resource that can be used for the production of useful materials, but its industrial applications are still limited. In this research, production of fermentable sugars from EFB using pre-treatments with white rot fungi. Effects of fungal treatments on enzymatic saccharification of EFB were evaluated, together with those of beech wood.

WATANABE, T., H. YANO, H. TERANISHI, M. ENOKI, Y. HONDA, N. SHIRAI, M. KUWAHARA and K. MESSNER: **Lignin-degrading basidiomycetes: Biocatalysts for the conversion of wood biomass into eco-materials and chemical products**, *Proc. Kyoto Univ. Intern. Symp. on Post-Petrofuels in the 21st Century—Prospects in the Future of Biomass Energy*, p. 132–143, Sep 3, 4, Montreal, Canada (2002).

Lignin degradation is a key process for biological and biochemical conversion of wood biomass, because cell wall polysaccharides in wood are protected by lignin from enzymatic hydrolysis. In the pretreatments for enzymatic saccharification and microbial fermentation, network of lignin must be degraded with minimum loss of cell wall polysaccharides. We report wood decay mechanism of *C. subvermispora* and its applications to the production of ethanol and auto-bonding wood moldings.

WADA, M., H. ITO, Y. HONDA, M. KUWAHARA and T. WATANABE: **Ethanol fermentation of wood pretreated by white rot fungi and alcoholysis**, *Proc. Kyoto Univ. Intern. Symp. on Post-Petrofuels in the 21st Century—Prospects in the Future of Biomass Energy*, p. 241–242, Sep 3, 4, Montreal, Canada (2002).

Ethanol was produced by simultaneous saccharification and fermentation (SSF) of beech wood chips after pretreatment with white rot fungi and ethanolysis. Beech wood chips treated with *Ceriporiopsis subvermispora*, *Dichomitus squalens*, *Pleurotus ostreatus*, and *Coriolus versicolor* were subjected to ethanolysis to separate into soluble and insoluble pulp fractions. In the present study, ethanol was produced from the pulp fraction by SSF using cellulase and *Saccharomyces cerevisiae*. The fungal pretreatments with white rot fungi increased the ethanol yield by SSF depending on their wood decay pattern. Maximum yield was obtained when beech wood chips were treated with *C. subvermispora* for 8 weeks. The yield was 1.6 times higher than that obtained without the fungal treatments.

NAKAJIMA, M., T. TSUMIYA, T. KOSHIIJIMA, K. OKUMA, K. MAMOTO and T. WATANABE: **Production of cellobiose and its derivatives as industrial bulk chemicals from lignocellulosics**, *Proc. Kyoto Univ. Intern. Symp. on Post-Petrofuels in the 21st Century—Prospects in the Future of Biomass Energy*, p. 247–252, Sep 3, 4, Montreal, Canada (2002).

Cellobiose was continuously produced from cellulose in an ultrafiltration membrane bioreactor designed for the enzymatic hydrolysis of water-insoluble polysaccharides. By using the test plant, 50–100 kg of cellobiose crystalline with over 95% purity was produced per month. To evaluate cellobiose as a functional food additive, sugar tolerance test was carried out. Cellobiose functioned as an indigestible sugar in healthy humans. Cecal fermentation of cellobiose predominately produced butyric acid that is known as an important fuel and powerful differentiating agent for the colon epithelial cells. Long-term feeding of high sucrose diet to rats with or without cellobiose supplement demonstrated that the oligosaccharide supplement decreased fructosamine, total cholesterol, and triglyceride levels in serum. We also found that body fat of the rats decreased by the cellobiose supplement. These results suggest that cellobiose is beneficial to prevent diabetes and obesity.

SATO, H., Y. HONDA, T. WATANABE and M. KUWAHARA: **DNA-mediated transformation of lignin-degrading fungus, *Ceriporiopsis subvermispora***, *Proc. Kyoto Univ. Intern. Symp. on Post-Petrofuels in the 21st Century—Prospects in the Future of Biomass Energy*, 243–246, Sep. 3, 4, Montreal, Canada (2002).

A selective lignin-degrading fungus *Ceriporiopsis subvermispora* was examined to be transformed by a plasmid, pPHT1 which contains *Escherichia coli* hygromycin B phosphotransferase gene under the control of *Coprinus cinereus* β -tubulin gene promoter and terminator sequences. Although most drug resistant colonies did not continue to grow, two isolates showed mitotically stable drug-resistance on sequential subcultivations. Southern hybridization analysis of the stable isolates suggested

integration of the marker sequence in their chromosomes. These results indicated that *C. subvermispora* was transformed to hygromycin B resistance by introduction of the marker gene. This is the first report on DNA-mediated transformation of the fungus.

LAMAIPIS, P., K. FACKLER, T. WATANABE, K., F. POHLEVEN, M. SENTJURG and K. MESSNER: **Methyl radical derived from non-enzymatic coordinated-copper system and its potential relation to the selective delignification by white-rot fungi**, *Abst. The 7th International Mycological Congress*, p. 344, Aug 11–17, Oslo, Norway (2002).

Free radicals produced by a low molecular weight delignification system consisting of hydroperoxides and Cu(II) coordinated by pyridine derivatives were analyzed by spin trapping with DEMPO. The ESR spectra demonstrated that methyl was produced as a major radical species, in addition to smaller amounts of hydroxyl, methoxyl and acyl radicals. In combination with delignification experiments of wood cell walls by the radical reactions, we proposed that methyl radical is a key radical species responsible for the selective delignification.

TERANISHI, H., Y. HONDA, M. KUWAHARA and T. WATANABE: **Ceriporic acid, a metabolite of white rot fungus, *Ceriporiopsis subvermispora* inhibits the production of a cellulolytic active oxygen species, hydroxyl radical**, *Abst. of 1st Intern. Cellulose Conf.*, p. 57, Nov. 6–8, Kyoto, Japan (2002).

Suppression of hydroxyl radical ($\cdot\text{OH}$) production by ceriporic acids from a selective lignin-degrading fungus, *Ceriporiopsis subvermispora* are analyzed.

WATANABE, T., H. TERANISHI, M. ENOKI, Y. HONDA, M. KUWAHARA and K. MESSNER: **Free radical process controlled by lipid-related metabolites produced by the biopulping fungus, *Ceriporiopsis subvermispora***, *Proc. 2nd International Cellulose Symp. on Emerging Technol Pulping and Papermaking*, p. 31–37, Oct. 9–11, Guanzou, China (2002).

The best biopulping fungus, *Ceriporiopsis subvermispora* degrades lignin at a site far from enzymes. In the present paper, extracellular free radical chemistry of this fungus is discussed in relation to the application to biopulping and biobleaching.

SATO, S., C. KHANONGNUCH, K. YAMAMOTO, N. YAGI, H. KISHIMOTO, K. MURAOKA, Y. HONDA and T. WATANABE: **Degradation of vulcanized and nonvulcanized polyisoprene rubbers by ligninolytic systems of white rot fungi**, *Abst. of 9th Intern. Seminar on Elastomers*, p. 49–50, Apr. 2–4, Kyoto, Japan (2002).

Vulcanized and nonvulcanized polyisoprene rubbers were degraded by white rot fungi and their biomimetic free radical reactions.

SATO, S., C. KHANONGNUCH, K. YAMAMOTO, N. YAGI, H. KISHIMOTO, K. MURAOKA, Y. HONDA and T. WATANABE: **Microbial degradation of vulcanized polyisoprene rubbers by lignin-degrading basidiomycetes**, *Abst. of The 3rd JSPS-NRCT Joint Seminar on Development of*

Thermotolerant Microbial Resources and Their Applications, p. 154, Chaing Mai, Thailand, Nov. 17–21 (2002).

Vulcanized rubbers were decomposed by several wood rot fungi including thermotolerant isolates from northern Thailand, such as *Lenzeites* sp. NP14 and *Coriolus versicolor* RC3. Sulfide bonds in the rubbers degraded by white rot fungi were analyzed by the measurement of total sulfur content, ^{13}C -DD/MAS solid state NMR, double shot pyrolysis GCMS and ESCA. These analyses demonstrated that preferential cleavage of mono-sulfide bonds linking to *cis*-1,4-polyisoprene main chains was achieved by the fungal treatment.

KHANONGNUCH, C., N. CHAWACHART, S. LUMYONG, Y. HONDA and T. WATANABE: **Laccase producing thermotolerant fungus *Coriolus versicolor* RC3 and the potential uses in azo dye decolorization**, *Abst. of The 3rd JSPS-NRCT Joint Seminar on Development of Thermotolerant Microbial Resources and Their Applications*, p. 114, Chaing Mai, Thailand, Nov. 17–21 (2002).

Laccase producing thermotolerant fungus *Coriolus versicolor* RC3 was isolated from northern Thailand. The laccase decolorized azo dyes at 60°C in the presence of mediator compounds.

PUNNAPAYAK, H., C. NORASING, K. CHA-AIM and T. WATANABE: **Evidence of prebleaching of a eucalyptus paper pulp with a thermotolerant *Schizophyllum commune***, *Abst. of The 3rd JSPS-NRCT Joint Seminar on Development of Thermotolerant Microbial Resources and Their Applications*, p. 113, Chaing Mai, Thailand, Nov. 17–21 (2002).

Schizophyllum commune PT was isolated from Pattani province in south Thailand. The fungus able to grow at 42°C and able to survive at 45°C. The fungus was applied to pulp bleaching.

IDYANTI, T., SYAFWINA, B. PRASETYA, T. WATANABE and M. KUWAHARA: **Utilization of oil palm empty fruit bunch to produce lignin degrading enzyme by white rot fungi**, *Proc. The Forth Intern. Wood Sci. Symp.*, p. 359–362, Serpong, Indonesia, Sep 2–5 (2002).

Laccase, manganese peroxidase, manganese-independent peroxidase, were produced by cultivation of PSM 01 and *Coriolus versicolor* IFO 30388 on oil palm empty fruit bunch fibers. Cellulose and xylanase were also produced using a filtrates of oil palm empty fruit bunch fibers.

SURYANEGARA, L., Y. KUSNADI, T. IDYANTI, B. PRASETYA, T. WATANABE and M. KUWAHARA: **Production of laccase and manganese peroxidase by white-rot fungi using extracts from oil palm empty fruit bunch fibers as inducer**, *Proc. The Forth Intern. Wood Sci. Symp.*, p. 357, Serpong, Indonesia, Sep. 2–5 (2002).

Laccase and manganese peroxidase were produced on oil palm empty fruit bunch fibers using a new isolate, PSM 01 and *Coriolus versicolor* IFO 30388. In a liquid shaking fermentation system, addition of hot water extracts from empty fruit bunch increased laccase and manganese peroxidase activities of the two strains by 4–13 times.

PRASETYA, B., T. IDIYANTI, L. SURYANEGARA, T. WATANABE and M. KUWAHARA: **Biobleaching of *Acacia mangium* kraft pulp using laccase secreted by local isolate PSM 01**, *Proc. The Forth Intern. Wood Sci. Symp.*, p. 350, Serpong, Indonesia, Sep. 2-5 (2002).

In the presence of a mediator compound, HBT, *Acacia mangium* kraft pulp was bleached with a laccase produced from a basidiomycete PSM 01 isolated from Indonesia.

SYAFWINA, E., D. WONG, Y. HONDA, T. WATANABE and M. KUWAHARA: **Pre-treatment of empty fruit bunch of oil palm by white-rot fungi for the utilization of its components**, *Proc. The Forth Intern. Wood Sci. Symp.*, Serpong, p. 351-356, Indonesia, Sep. 2-5 (2002).

Empty fruit bunch (EFB) of oil palm (*Elaeis guineensis*) was treated from white rot fungi to produce fermentable sugars from EFB. Effects of fungal treatments on enzymatic saccharification of EFB were evaluated.

MOUE, M., Y. HONDA, T. WATANABE and M. KUWAHARA: **Genetic transformation of white rot fungus *Pleurotus ostreatus* to carboxin resistance using electroporation**, *Wood Res.*, **89**, 17-18 (2002).

Expression of genes encoding fungal ligninolytic enzymes has been studied using various host organisms, including *Escherichia coli*, yeast, *Aspergillus* spp, and Baculo virus system, but recombinant enzymes obtained with these heterologous systems had unusual properties such as elevated molecular weights, requirements of re-folding and low specific activities. A homologous gene expression system can provide an enzyme in both active and native form, which makes it possible to characterize the enzyme properties and to elucidate its physiological role in the biological functions. Recently, we have developed a DNA-mediated transformation system which employs PEG/CaCl₂ treatment of *Pleurotus ostreatus* protoplasts with a drug resistant marker gene to a systemic fungicide, carboxin. And a homologous gene expression of *P. ostreatus* MnP3 isozyme was achieved using the transformation system. In this paper, we have described that electroporation was successfully employed as an alternative gene transfer procedure for *P. ostreatus*.

HONDA, Y.: **Biotechnology for conversion of wood components, molecular breeding of basidiomycetes using genetic transformation**, in "Wood Science series 11: Biotechnology" ed. Y. Katayama, M. Kuwahara and T. Hayashi, Kaiseisha Press, Ohtsu, 112-117 and 161-171 (2002) (in Japanese).

Research trends in molecular breeding of basidiomycetous fungi were reviewed. Potential applications of genetically modified wood rot fungi were discussed in respect of biocatalysts for conversion of wood materials to useful substances, including pulp, ethanol, fuels, biodegradative plastics, films, feed and so on.

HONDA, Y.: **Structure and function in *B* mating locus, expression vectors, molecular breeding in oyster mushroom**, in "Basic science and biotechnology in filamentous fungi" ed. K. Shishido, IPC, Tokyo, 59-62, 293-296 and 324-326 (2002) (in Japanese).

Recent progress in studies on molecular biology of white

rot fungus, *Pleurotus ostreatus*, was reviewed. Topics include structure and function of *B* mating type locus, gene transfer technology, expression systems for recombinant gene and isolation of genetically modified strains.

HONDA, Y., M. MOUE, T. WATANABE and M. KUWAHARA: **Degradation of bisphenol A by recombinant *Pleurotus ostreatus***, *Proc. Xth International congress of bacteriology and applied microbiology*, p. 211, 27 Jul.-1st Aug., Paris, France (2002).

Pleurotus ostreatus is a white-rot basidiomycete fungus, which is a good model for understanding biodegradation of plant cell wall lignin and also various environmental pollutants, such as PCB or dioxins. We have developed a homologous gene expression system in this fungus using a drug resistant marker gene, *Cbx^R*, and the promoter and terminator sequences of *P. ostreatus sdi1* which encodes iron-sulfur protein (Ip) subunit of succinate dehydrogenase. With the expression system, strains expressing one of its manganese peroxidase genes (*mnp3*) were isolated. In this paper, we describe estimation of degradation activity of the recombinant and wild-type strains, using bisphenol A as a model compound. When the recombinant *P. ostreatus* strain was inoculated on 0.5% glucose-0.2% pepton medium containing 0.4 M of bisphenol A, degradation of the substrate was observed in accord with the activity of manganese peroxidase in the culture filtrate. However, neither of the manganese peroxidase activity nor degradation of bisphenol A was observed, when wild-type control strain was used in the same condition. This result suggested that molecular breeding of ligninolytic fungi has much impact on actual application of them in bioremediation.

HONDA, Y., C. IMAMURA, H. TAKAHASHI, T. WATANABE and M. KUWAHARA: **Heterologous expression of *Phanerochaete* manganese peroxidase in *Pleurotus ostreatus***, *Abst. the 7th International mycological congress*, 11-17 Aug., Oslo, Norway (2002).

Manganese peroxidases catalyze oxidation of Mn(II) to Mn(III) in the presence of hydrogen peroxide and form a class of extracellular peroxidases of white rot basidiomycetes. The enzymes have been focus of research interests because of their importance in lignin biodegradation and potential for utilization in many industrial processes. Genomic and cDNA sequences encoding manganese peroxidase have been cloned and characterized from variety of white rot basidiomycetes, including *Ceriporiopsis subvermispura*, *Phanerochaete chrysosporium*, *Pleurotus ostreatus* and *Pleurotus eringii*. However, overexpression of active ligninolytic peroxidases is difficult with non-basidiomycetous host systems such as *Escherichia coli*, *Saccharomyces cerevisiae* and *Aspergillus* spp. We have developed a recombinant gene expression system in *P. ostreatus*, using promoter and terminator sequences of *sdi1* which encodes iron-sulfur subunit of succinate dehydrogenase. The system was successfully used to overexpress one of its manganese peroxidase genes, *mnp3* under the control of homologous *sdi1* expression signals. Here we report heterologous expression of wild-type and artificially mutagenized manganese peroxidases from *P. chrysosporium* using the gene expression system in *P.*

ostreatus.

KURIMOTO, Y., K. KANO, Y. KOHDZUMA and M. NORIMOTO: **Performance of charcoals for humidity control**, *Wood Industry*, **57**(9), 392–397 (2002) (in Japanese).

Charcoals from different sizes and wood species were prepared at carbonization temperatures of 500–900°C for 3 h to investigate their humidity control capacity. Humidity control tests were carried out in a sealed batch system at temperature levels of 15–25°C for 3–24 h cycles. At the 24 hour-cycle, there was no difference in the humidity control capacity of the charcoals with any carbonization temperature, size and wood species. Three milligrams of charcoal per unit air volume (1 cm³) kept the change in relative humidity (RH) within 3%. When the cycle was shortened to 3 h, the humidity control capacity of these decreased. Controlling the carbonization temperature and size of charcoal was the way to minimize the decrease in humidity control capacity. The humidity control ability of charcoal (22–30 mesh) carbonized at 600°C for 3 to 24 hour-cycle temperature changes was equivalent to 1–3/5 of that of a commercial silica gel commonly used in museums.

HWANG, K., I. JUNG, W. LEE, J. JANG, H. BAE and M. NORIMOTO: **Bending quality of main Korean wood species**, *Wood Res.*, No. **89**, 6–10 (2002).

The aim of this study was to evaluate the bending quality for ten kinds of main Korean wood species and to investigate the effect of the metal strap thickness on bending quality of Korean red pine. Bitter wood, horn beam, birch, painted maple and cork oak showed excellent quality. Sargent cherry, Korean red pine and pitch pine showed intermediate quality. Basswood and royal paulownia showed worse quality. The density of wood species was main factor to determine the bending quality. As for the relationships between annual ring orientation and metal strap thickness, the bending quality of specimens with intermediate annual ring orientation was better than that of flat-grained specimens in the strap thickness of 1.0 mm and 0.8 mm, while the reverse result was obtained in the strap thickness of 0.6 mm and 0.4 mm. These findings suggested that it was important to determine the appropriate strap thickness in relation to wood species, thickness of specimens, form radii and annual ring orientations in specimens.

MURAKAMI, R., F. TANAKA and M. NORIMOTO: **Relationship between bending quality and wood species**, *Wood Res.*, No. **89**, 21–22 (2002).

The bending quality (BQ) of wood varies widely not only among the different species but also within the same species. This paper investigates factors concerning the BQ of sixteen kinds of wood species including softwood, temperate and tropical hardwood. A jig made of an iron strap with wood handles at both ends was used in the bending operation. After the specimen (33.8 cm (*L*) by 2 cm (*T*) by 1 cm (*R*)) were conditioned 20°C in oven-dry state, at 20°C in wet state and at 100°C in wet state, they were subjected to the bending operation. The BQ was evaluated by the ratio of the radius of the form to the

thickness of the specimen. In the group of good quality, Japanese zelkova, oak, elm, beech, white oak had a large ray content, a high density and a small microfibrillar angle (MMA). Yellow poplar had a middle ray content, a middle density and a relatively large MMA. Compression wood of igem had a large MMA. In the group of inferior quality, igem radiata pine Japanese cedar, sawara cypress, ginkgo, Japanese red pine and cypress had a low or middle density, a small ray content and a high softening temperature. Malas had a middle ray content and a small MMA. Balsa had a small ray content, an extremely low density and a small MMA. Poplar had a low ray content, a low density and a relatively large MMA.

SUGIMOTO, H. and M. NORIMOTO: **Changes in dielectric relaxation of wood by heat treatment**, *Wood Res.*, No. **89**, 23–24 (2002).

This paper investigated changes in the dielectric relaxation due to methylol groups of sugi wood in absolutely dry condition by heat treatment. Heat treatment temperatures were 200, 250, 270, 300, 400, 500, 600 and 700°C. The powders passed a 100-mesh screen were used for the samples of dielectric measurements. Dielectric loss of the samples in the absolutely dry condition were measured at 31 frequencies between 1 kHz and 1 MHz in the temperature range from –150 to 0°C. The relaxation magnitude of the relaxation due to methylol groups was calculated by applying the sech law to the dielectric loss-log frequency curve. The relaxation magnitude decreased abruptly from 200°C and reached 0 at 300°C.

CHENG, W., T. MOROOKA and M. NORIMOTO: **Shrinkage stresses occurring in the drying process of wood using superheated steam**, *Wood Res.*, No. **89**, 25–26 (2002).

In the present paper, an attempt was made to clarify characteristic features of shrinkage stress appearing in the drying process using superheated steam above 100°C. Drying of wet sugi specimens (5 cm (*T*) by 6.5 cm (*R*) by 1 cm (*L*)) was carried out in an autoclave using humidity- and temperature controlled superheated steam above 100°C. The shrinkage stress during drying was measured by restraining the shrinkage of the specimen with newly developed equipment. The maximum shrinkage stress decreased with increasing relative humidity. The shrinkage stress due to the decomposition of wood constituents at high temperature was observed not only under superheated condition but also under saturated condition. Such stress was larger in the *T*-direction than in the *R*-direction. By subtracting shrinkage stress due to the decomposition from the measured shrinkage stress, the shrinkage stress due to drying was estimated to be below 1 kg/cm².

OHSHIMA, K., T. MOROOKA and M. NORIMOTO: **Some mechanical properties of wood under superheated steam**, *Wood Res.*, No. **89**, 27–28 (2002).

Two methods of heating at temperatures above 100°C, high pressure saturated steam heating for wet wood and dry heating for oven dried wood, have been attempted to keep radially compressed permanently. To enable

practical application, however, the fixation of deformation of wood should be made in the air-dried condition. The purpose of this study is to provide basic information on the fixation of compressive deformation of wood in an air-dried condition above 100°C. After sugi specimens were equilibrated with ambient temperature between 120 and 180°C and relative humidity between 0 and 100% by the use of superheated steam, they were radially compressed to 50%, followed by boiling of the specimens for 30min to determine their strain recovery. Although plots of the strain recovery versus steaming time depended markedly on the temperature and relative humidity of the steam, they could be superimposed by shifting them along the time axis.

KAWAI, Y., Y. KOBAYASHI and M. NORIMOTO: **Hybrid drying with high-frequency heating and hot air under atmospheric pressure IV: water movement in *Cryptomeria japonica* wood during high-frequency heating**, *J. Wood Sci.*, **49**(1), 18–21 (2003).

The relations among internal temperature, internal pressure, and moisture content distribution in sugi square lumber during high-frequency (HF) heating were determined to clarify the mechanism of water movement during the combination of HF heating and hot air exposure. Green sugi square lumbers were subjected to HF heating under atmospheric pressure. The water movement and pathways in the lumber during HF heating were also investigated. Results showed that internal pressure is the driving force of water movement. HF heating causes a rise in the internal temperature and internal pressure in sugi square lumber. Ordinarily, water in lumber evaporates from the surfaces of lumber during hot air drying. However, with HF heating the internal pressure is generated by the increased temperature, and liquid water is driven not only parallel to grain but also perpendicular to the grain of the lumber. The ratio of the amount of liquid flow in the parallel and perpendicular directions ranged from 2 : 3 to 1 : 3. When the movement of water in the lumber was traced with a 0.5% aqueous solution of acid fuchsin, water was found to move through the lumber in the longitudinal direction and then flow in a direction perpendicular to the grain or in the radial and tangential direction.

SUGIMOTO, H. and M. NORIMOTO: **Dielectric relaxation of heat-treated wood**, *J. Soc. Mats. Sci.*, **52**(4), 362–367 (2003) (in Japanese).

Changes in the dielectric relaxation of sugi specimens by heat treatment were investigated. Dielectric properties in the longitudinal direction for the oven-dried specimens were measured in the range from 20 Hz to 1 MHz and from –150 to 20°C. The relaxation due to the orientation of methylol groups was observed for the specimens treated at the temperature up to 300°C. The relaxation magnitude obtained from the Cole-Cole plots did not change by the heat treatment up to 200°C, but it decreased remarkably above 200°C and became 0 at 300°C, showing the disappearance of methylol groups. Any relaxation was not detected within the range measured for the specimens treated at the temperature between 300°C and 450°C. However, one relaxation was recognized for the specimens

treated at the temperature between 500°C and 600°C. Regarding the specimen treated at 500°C as a system in which a small amount of ellipsoids of graphite disperses in the medium of an insulator, the applicability of the Maxwell-Wagner's theory to the $\tan \delta$ versus logarithmic frequency curve at 20°C was examined. A good agreement between the experimental and calculated results was obtained in the case that long narrow ellipsoids orient to the direction of the electrical field. These results suggested that the relaxation was due to the interfacial polarization.

SUGIMOTO, H. and M. NORIMOTO: **Dielectric relaxation of heat-treated wood**, *Proceedings of the Fourth International Wood Science Symposium, LIPI-JSPS Core University Program in The Field of Wood Science*, Serpong, Indonesia, Sep. 2–5, 35 (2002).

Changes in the dielectric relaxation of sugi wood by heat treatment were investigated. The relaxation due to the orientation of methylol groups was observed for the specimens treated at the temperature up to 300°C. The relaxation magnitude obtained from the Cole-Cole plots did not change by the heat treatment up to 200°C, but it decreased remarkably above 200°C and became 0 at 300°C. No relaxation was detected for the specimens treated at the temperature between 300°C and 450°C. However, one relaxation was recognized for the specimens treated at the temperature between 500°C and 600°C. It was considered that the relaxation was due to the interfacial polarization.

Higashihara, T., T. Morooka, M. Inoue and M. NORIMOTO: **Mechanism of permanent fixation of radially compressed wood by steaming or heating**, *Proceedings of the Fourth International Wood Science Symposium, LIPI-JSPS Core University Program in The Field of Wood Science*, Serpong, Indonesia, Sep. 2–5, 58–63 (2002).

Large transverse deformation of wood is fixed permanently by dry heating and steaming at elevated temperatures. To clarify the dominant mechanisms of the permanent fixation, stress relaxation of wood in the radial compression and recovery of deformation after relaxation experiment were examined. In the recovery measurements, the compressed samples were treated with boiling water as well as dimethyl sulfoxide (DMSO). Heating for glycerin-saturated wood were also examined. In each treatment, the relationship between the residual stress at the end of the relaxation measurements and the strain recovery in boiling water could be expressed by a single curve regardless of heating time and temperature. The findings that the recovery of deformation in swelling liquids was large suggested that the fixation of deformation by steaming was not the result of structural changes of the cell wall polymers such as crosslinking or crystallization, but the formation of some cohesive structure that can be easily disintegrated with organic liquid.

MOROOKA, T., K. OHSHIMA and M. NORIMOTO: **On a master curve for strain recovery vs. steaming time obtained under superheated steam**, *Proceedings of the Fourth International Wood Science Symposium, LIPI-JSPS Core University Program in The Field of Wood Science*, Serpong,

Indonesia, Sep. 2-5, 64-65 (2002).

Two methods of heating at temperatures above 100°C, high pressure saturated steam heating for wet wood and dry heating for oven dried wood, have been attempted to keep radially compressed permanently. To enable practical application, however, the fixation of deformation of wood should be made in the air-dried condition. The purpose of this study is provide basic information on the fixation of compressive deformation of wood in an air-dried condition above 100°C. After sugi specimens were equilibrated with ambient temperature between 120 and 180°C and relative humidity between 0 and 100% by the use of superheated steam, they were radially compressed to 50%, followed by boiling of the specimens for 30min to determine their strain recovery. Although plots of the strain recovery versus steaming time depended markedly on the temperature and relative humidity of the steam, they could be superimposed by shifting them along the time axis.

KOBAYASHI, Y., Y. KAWAI, M. NORIMOTO and O.R. PULIDO: **Industrial application of hybrid drying of wood using HF heating and hot-air**, *Proceedings of the Fourth International Wood Science Symposium, LIPI-JSPS Core University Program in The Field of Wood Science*, Serpong, Indonesia, Sep. 2-5, 81-86 (2002).

A new drying method using a combination of high frequency (HF) heating and hot air drying under atmospheric pressure was applied to sugi thick lumbers. We introduced HF heating into a conventional hot air drying to raise the internal temperature of the lumbers. The lumbers were heated under atmospheric pressure by HF heating to 101°C at the center of lumbers during hot-air (80°C) drying. Internal pressure at the center of the lumbers increased following the rise in temperatures. The moisture gradients underwent changes during drying such that the moisture content near the center and in the surface zones were lower than in the middle zones in the early stages of drying. Finally, the moisture distribution became flat. The hybrid drying was tried on sugi square lumbers, drying time and running costs were reduced to 1/5 and 1/2 compared to conventional hot air drying. The moisture gradients were uniform after drying. More than 80% of the lumbers were dried to less than 20% moisture content in a short drying time.

KAWAI, Y., Y. KOBAYASHI and M. NORIMOTO: **Moisture movement in large size lumber during HF heating and hot-air drying**, *Proceedings of the Fourth International Wood Science Symposium, LIPI-JSPS Core University Program in The Field of Wood Science*, Serpong, Indonesia, Sep. 2-5, 94-99 (2002).

The relationships among the internal temperature, internal pressure and water movement in sugi under HF heating were investigated. HF heating causes rise in the internal pressure in sugi solid wood. Results showed that this internal pressure is the driving force of water movement that improves the drying of refractory species. Ordinarily, water in vapor phase moves towards the surfaces by diffusion. However, in HF heating, internal pressure is generated and liquid water is driven not only parallel to the grain, but also perpendicular to the grain of

the lumber. The ratio of the amount of liquid flow in the parallel and perpendicular directions ranged from 2 : 3 to 1 : 3.

SUGIMOTO, H. and M. NORIMOTO: **Changes in dielectric properties of wood by heat treatment**, *Proceedings of the IAWPS2003 International Conference on Forest Products, better Utilization of wood for Human, Earth and future*, Daejeon, Korea, April 21-24, 430-435 (2003).

This paper deals with changes of dielectric properties along the grain for sugi wood specimens treated at various temperatures between 200°C and 800°C. Dielectric measurements were carried out in the frequency range from 20 Hz to 1 MHz over the temperature range from -150°C to 20°C. The relaxation due to the motions of methylol groups was observed for the absolutely dried specimens treated at temperatures up to 270°C. The relaxation magnitude rapidly decreased with increasing treatment temperature. No relaxation was observed for the absolutely dried specimens treated at 500-600°C. Dielectric measurements of the absolutely dried specimens treated at 700°C and 800°C were impossible for extremely high conductivity of the specimens. On the other hand, the relaxation due to the motions of water molecules adsorbed on hydroxyl groups was observed for the specimens treated at Temperatures up to 300°C. The relaxation moved to a higher temperature and its magnitude decreased with increasing treatment temperature. Another relaxation related to the adsorbed water was detected for the specimens treated at temperatures above 300°C. The relaxation moved to a lower temperature and its magnitude increased with increasing treatment temperature.

TANAKA F. and N. FUKUI: **Molecular dynamics simulation of cellulose surrounded by water molecule**, *2002 Cellulose R & D*, 82-83 (2002).

Morphological features of cellulose molecule in aqueous conditions were investigated through Molecular Dynamics Simulation Method. The molecule was remained in extended form and was not fallen into folded-chain form and/or random coil form throughout the simulation. In aqueous condition, the hydroxyl groups on cellulose chain were fully solvated and separated from each other. And then, the chain could not form the intra-molecular hydrogen-bonding directly. This was the reason why cellulose chain in aqueous condition was not able to be assembled into the folded-chain and/or the random coil structures. This simulation result also shows that the existence of polar solvents, such as water molecules, has very important role on the morphological features and the characteristics of cellulose molecule.

NAKATA, K., H. SUGIMOTO, S. UESUGI, T. HARADA, M. INOUE and S. KAWAI: **Development of compressed wood fasteners for timber construction VII. Fire endurance of timber joints with compressed LVL plate and drift pin**, *Mokuzai Gakkaishi (J. Jpn. Wood Research Soc.)*, 48 (4), 249-256 (2002).

Fire endurance of joints with a compressed LVL plate and a compressed LVL pin (LVL/LVL joint) was evaluated by using a cone calorimeter and a full-scale fire

test under loading in accordance with the standard ISO 834-1. In the fire tests, the temperature rise at the inside of the LVL/LVL joint was very slow, and no char layer was observed around the compressed LVL plates and pins. The increase in deflection of the LVL/LVL joint was less than that of the joint with steel plate and steel pin, and the fire endurance time was longer. Therefore, the LVL/LVL joint gives good fire endurance performance.

YAMAUCHI, H., I. MIURA, Y. OKAZAKI, S. KAWAI and H. SASAKI: **Manufacture of cylindrical LVL by spiral-winding method III. Relationships between tensile strength, veneer grain angle, and butt joints interval in LVL**, *Mokuzai Gakkaishi (J. Jpn. Wood Research Soc.)*, **48** (5), 363–370 (2002).

The relationships between veneer grain angles, distance between end butt joints in the adjacent veneer layers (butt joint interval) and tensile strengths of LVL were investigated for the design of the cylindrical LVL (C-LVL). The results are as follows; 1) When the butt joint interval was more than 12 times veneer thickness, the tensile strength of 4-ply LVL was not affected by the butt joints of veneer. 2) The interlocked grain structure in the alternated layers of LVL also prevented decrease in the tensile strength, which is almost the same effect as in the tensile Young's modulus. 3) The relationships between butt joint interval and tensile strength of LVL are determined by the ratio of the tensile strength and shear strength of the veneer laminae. 4) Intersecting portions of adjacent layers of the wall of a C-LVL shell will be reinforced in its peripheral region and are therefore not critical to the strength of C-LVL.

HERMAWAN, D., T. HATA, S. KAWAI, W. NAGADOMI and Y. KUROKI: **Effect of carbon dioxide-air concentration in the rapid curing process on the properties of cement-bonded particleboard**, *J. Wood Science*, **48**(3), 179–184 (2002).

This study deals with the effects of carbon dioxide (CO₂)-air concentration in the rapid curing method on the properties of cement-bonded particleboard manufactured using conventional cold pressing as the setting method. The hydration of cement was examined using X-ray diffractometry, thermal gravimetry, and scanning electron microscopy. The results are as follows: 1) The properties of CO₂-cured boards improved with increasing CO₂ concentration. When 10% or 20% CO₂ was applied for 10 min of curing time, the properties of the CO₂-cured boards were comparable to those obtained by conventional 2-weeks curing. 2) The hydration process of cement could be accelerated within several minutes using CO₂ curing, even with a low concentration of 10–20% CO₂; a reduction in calcium hydroxide was observed followed by rapid formation of calcium carbonate.

UMEMURA K. and S. KAWAI: **Durability of isocyanate resin adhesives for wood IV. Degradation under constant steam heating**, *J. Wood Science*, **48**(5), 387–393 (2002).

The durability of isocyanate resins consisting of emulsion type polymeric diphenylmethane diisocyanate (EMDI) was investigated under constant steam heating.

Two kinds of resin, water only-added resin and polyol/water added were used in this study. The degradation of the resins under steam heating was observed using Fourier transform infrared spectroscopy (FT-IR), weight changes, and thermogravimetric analysis (TGA). FT-IR analysis showed the degradation reaction of the resins scarcely proceeded for a few hours and then increased significantly. The weights of the resins decreased linearly during steam heating. The thermal stability of steam treated resins was made clear by TGA. The bond strength reductions of the specimens bonded with the resins were also observed. The adhesion durability using polyol/water added resin was superior to that of water only-added resin. It was clarified that the durability of the isocyanate resins under steam heating was markedly inferior to that under dry heating.

UMEMURA K., T. TAKAHASHI and S. KAWAI: **Durability of isocyanate resin adhesives for wood III. Degradation under constant dry heating**, *J. Wood Science*, **48**(5), 380–386 (2002).

The durability of isocyanate resins consisting of emulsion type polymeric diphenylmethane diisocyanate (EMDI) was investigated under constant dry heating. Two kinds of resin, water only-added and polyol/water added resin were used in this study. The values of apparent activation energy of the resins increased with increasing weight loss. The adhesion durability of polyol/water added resin was superior to that of water only-added resin.

KAWAI, S., Y. OKUDAIRA, M. ZHANG, J. XU and R. WIDYORINI: **Manufacture and properties of kenaf composite panels**, *Proc. 4th International Wood Science*, p. 253–256, 2–5 Sept. (2002) (Serpong, Indonesia).

This paper deals with the development of kenaf bast oriented fiberboard and the core binderless particleboard. The oriented medium density fiberboard (MDF) from kenaf bast fibers was manufactured with newly developed pilot-scale equipment and the MDF with a density of 800 kg/m³ provides 2–3 times higher in mechanical performance than plywood. Using a steam-injection press the binderless particleboards from kenaf core with a density range from 150 to 650 kg/m³ was successfully developed. The bonding performance of the binderless boards was excellent while the board density were relatively low.

WIDYORINI, R., J. XU, T. WATANABE and S. KAWAI: **The bonding mechanism of kenaf core binderless particleboard**, *Proc. 4th International Wood Science*, p. 281, 2–5 Sept. (2002) (Serpong, Indonesia).

In order to discuss the bonding mechanism of kenaf core binderless particleboard, kenaf core themselves and their boards were analyzed by chemical and spectrochemical methods. The results showed that chemical compositions of boards were changed due to steam treatment. Extractives of board increased with increasing pressing time and steam pressure. After steam treatment, the degradation of hemicellulose, lignin, and alpha-cellulose were clearly appeared. Analysis of neutral sugar composition by alditol-acetate procedure showed that the

xylose content of hot water extractives became dominant due to steam treatment.

SUBIYANTO, B., SUBYAKTO and S. KAWAI: **Zero-emission processes of oil-palm utilization, case study of oil palm in PT. Kertajaaya Lebak Banten Province**, *Proc. 4th International Wood Science*, p. 305–311, 2–5 Sept. (2002) (Serpong, Indonesia).

The objective of this paper is to discuss the economic aspect of comparison of empty fruit bunches (EFB) utilization for building materials such as MDF and compost as replacing fertilizer. The value of EFB for compost is lower than that of wood chips for MDF or pulp and paper. Thus, EFB fibers have potentials to utilize for raw materials of panel products or pulp and paper by further development of its conversion technology. Further research and development on processing technology of EFB fibers as a raw material for panel products is necessary. At the present conditions the utilization of composting could have a certain advantage for local sustainable recycling system of small amount of EFB residues.

SUBYAKTO, T. HATA, I. IDE, T. YAMANE and S. KAWAI: **Fire protection of a laminated veneer lumber joint by carbon phenolic spheres sheeting**, *Proceedings of the forth International Wood Science Symposium, Serpong, Indonesia*, p. 43 (2002).

Fire resistant of timber joints has been attracted main interest because the joint is considered as a weak point in a structure when exposed to fire. In our previous experiment, improvement of fire resistant performance of a laminated veneer lumber (LVL) joint with metal plate connectors protected with graphite phenolic spheres (GPS) sheet was obtained. In addition, carbon phenolic spheres (CPS) have been developed and the anisotropy in thermal properties was found clearly. A high ratio in thermal properties between horizontal and vertical direction was observed. These properties may be taken as an advantage to apply CPS for developing a new, fire-retardant material for wood composites. The objective of the present experiment is to improve the fire resistant performance of a LVL joint covered with CPS sheeting subjected to creep test under fire. In particular, effects of carbonizing temperature of charcoal as raw material of CPS (800, 1600°C), thickness of CPS sheet (1, 2, 3 mm), and location of CPS sheet overlaid at the joint (bottom, 2 sides, 3 sides) on the fire resistant performance of LVL joint were evaluated. The results show that the time to rupture of the joint covered with CPS800 sheet was slightly prolonged compared to uncovered joint, on the other hand, that of CPS 1600 was prolonged very remarkably. The changes of the charcoal properties due to increasing carbonizing temperature might be the main reason for CPS 1600 has higher fire performance, and locations of CPS 1600 sheet have a significant effect on the fire performance of the joint. The CPS 1600 sheet with thickness of 3 mm covered at 3 sides of the joint prolonged the time to rupture more than 16 times (756 min) compared to unprotected joint (47 min).

KAWAI, S. M. ZHANG, Y. OKUDAIRA, J. XU, R. WIDYORINI and G. HAN: **Development of kenaf bast fiberboard and core binderless particleboard**, *Proc. 6th Pacific Rim Bio-based Composites Symposium*, p. 129–134 (2002) (Portland).

This paper deals with manufacturing the kenaf bast oriented fiberboard and the core binderless particleboard. The oriented medium density fiberboard (MDF) from kenaf bast fibers was manufactured with newly developed pilot-scale equipment and the oriented MDF with a density of 800 kg/m³ provides 2–3 times higher in mechanical performance than plywood. The binderless particleboards from kenaf core with a density range from 350 to 650 kg/m³ was successfully developed by using a steam-injection press. The bonding performance of the binderless boards was excellent while the board densities were relatively low. The mechanical performance of binderless boards was improved with increasing the steam pressure and the longer pressing time contributed to the better dimensional stability.

ADACHI, K., M. INOUE and S. KAWAI: **Compression behavior of wood by a roll-press**, *Proc. 6th Pacific Rim Bio-based Composites Symposium*, p. 232–239, 10–13 Nov. (2002) (Portland).

Wood was pressed by using a platen press and a roller press to investigate the mechanism of compressed wood. The results showed that the bending properties were greatly different between the two pressing methods. The bending strength by roll-pressing decreased with the increase of the contact angle calculated from compression rates, thickness of wood and the diameter of roller. Several fractures in wood inherent to the roll-pressing were observed. The reasons why these phenomena occurred in using roll-press were considered that the large strain was concentrated in outer surface layer of specimen, and that the shear strain occurred by tension and compression strain in the fiber direction. These findings suggest that the roll-pressing is a prospective method of compressing wood.

UMEMURA, K. and S. KAWAI: **Effects of heat and moisture on durability of isocyanate resin adhesives for wood**, *Proc. 6th Pacific Rim Bio-based Composites Symposium*, p. 355, 10–13 Nov. (2002) (Portland).

Durability of emulsion type isocyanate resin (EMDI) was investigated under dry and steam heating. The degradation of the resins under both heating was observed by transform infrared spectroscopy (FT-IR) and changes in weight. In dry heating, the after-cure based on the reaction of untreated isocyanate groups was much more remarkable than degradation. The weight loss of the resin was only a small percentage, with 66 hr required to reach 2% weight loss. In steam heating, the resin began to degrade significantly after a few hours. The absorption peaks regarded as the formation of amine due to the hydrolysis reaction of urea linkages were observed. The weight of the resin decreased remarkably during steam heating. The weight loss at 15 hr was 55%. Therefore, the isocyanate resin under steam heating was much less durable than that of under dry heating. The bond strength reduction of the specimens bonded with the resin

was also observed. Wood failure exhibited relatively high values, showing greater degradation took place in wood than in the adhesive in both heating. The calculated half-lives under dry and steam heating were 1.97 day and 0.71 hr, respectively. This indicated that the adhesion durability under wet conditions was much lower excessively than under dry conditions.

OGAWA, S., C.M.E. SUSANTI and H. YANO: **Direct Utilization of Acacia mangium bark as water proof wood adhesives**, *Proc. 4th International Wood Science*, p. 182–187, 2–5 Sept. (2002) (Serpong, Indonesia).

The direct conversion of acacia mangium bark into waterproof wood adhesives was studied. The outer bark of acacia mangium was found to have a significant amount of extractive. The extractive yields were affected by bark powder particle sizes regardless of solvent ratio and extracting time. At fractions under 45 μm , more than 50% extractive yields was obtained. The average adjusted Stiasny value for the extractives was 94.5%, indicating that tannin rich portion in a bark is ground down easily, and gathers with the small particle fraction. The gelation time of the mixture of extractive, formaldehyde and water reduced with the increases of pH from 4 to 8. On this basis, plywood was produced using lauan (*Shorea* spp.) rotary lathe veneers and adhesive prepared from bark powder with a particle size of less than 63 μm , paraformaldehyde and water. The shearing strength of 11.7 kgf/cm² after 72 hrs of boiling, which complies with the requirement of the JIS K6802 for exterior-grade plywood, was attained.

NAKAGAITO, A.N., H. YANO and S. KAWAI: **Production of high strength composites using microfibrillated kraft pulp**, *Proc. 6th Pacific Rim Bio-based Composites Symposium*, p. 171–176, 10–13 Nov. (2002) (Portland).

Among refined materials such as wood pulp, there is a new form of expanded high-volume cellulose obtained by a homogenization process known as microfibrillated cellulose (MFC), which structure presents as a web of interconnected fibrils and microfibrils greatly expanded in surface area. This expansion in area increases the chemical reactivity as well as the binding between fibers in composites. All of these characteristics denote the potential to reconstitute materials from high strength elementary fibers to composites possessing high mechanical properties. PF resin bonded composites were produced impregnating sheets of MFC from soft wood kraft pulp fibers with a high molecular weight phenol-formaldehyde resin (Gun Ei Chemical Industry Co., Ltd.; PL-2340; MW=3351) followed by hot pressing at 160°C for 30 minutes under pressures from 40 to 100 MPa. The MOR value achieved 370 MPa with a density of 1.39 g/cm³, a strength comparable to soft steel with a density of 7.8 g/cm³. Strength tends to decrease at weight gains above 45% while MOE does not change. Composites made using wood pulp without microfibrillation achieved values of about 2/3 of MOR for MFC, nevertheless MOE of both are very similar. The higher MOR in the case of MFC is due to the higher yield strain, indicating the possibility to produce high strength composites based on MFC obtained from wood and non-wood plant fibers.

YANO, H., S. NAKAHARA and A.N. NAKAGAITO: **The potential of microfibrillated plant pulp fiber-based materials**, *Proc. 6th Pacific Rim Bio-based Composites Symposium*, p. 188–192, 10–13 Nov. (2002) (Portland).

By using plant microfibre bundles as a raw material, a moulded product with a bending strength of 250 MPa was obtained without any binders. When oxidized starch, 2% by weight, was added, the yield strain doubled and the bending strength reached 320 MPa. A combination of plant microfibre bundles and biodegradable plastic (Polylacticacid) in a ratio of 7 to 3 resulted in a thermoplastic material with a bending strength of 270 MPa. These newly developed advanced materials have resulted in a combination of environmentally-friendly and high strength properties.

NAKAHARA, S., H. YANO and S. KAWAI: **Development of environmentally-friendly and high strength kraft pulp fiber based materials**, *Wood Research*, No. 89, p. 35–36 (2002).

To produce high-strength, environmentally-friendly products based on KP fiber, KP was mechanically treated and was reconstituted without using any additives other than starch to ensure the bio-degradability and recyclability of paper. The results showed that the mechanical properties of KP molded products increased due to mechanical fibrillation. In addition, adding a small amount of starch as a binder was effective not only in improving mechanical property but also in reducing molding pressure.

YANO, H.: **Production of high strength wood based composites by PF resin impregnation and compression**, *Wood Industry*, 58(4), 150–156 (2003) (in Japanese).

How to produce high strength wood based composites by a combination of low molecular PF resin and compression under high pressure were reviewed.

YANO, H.: **High strength wood based materials**, *Cellulose Communications*, 10(1), 22–27 (2003) (in Japanese).

The potential strength of wood based materials was described.

YANO, H.: **Effects of extractives on the physical properties of wood**, "Secondary Xylem Formation", Edited by K. Fukushima, *et al.*, Kaiseisya, Ootsu, p. 311–315 (2003) (in Japanese).

Effects of extractives on the physical properties, especially acoustic properties such as Young's modulus and loss tangent were described.

HATA, T., P. BRONSVELD, T. VYSTAVEL, J. DEHOSSON, H. KIKUCHI, K. NISHIMIYA and Y. IMAMURA: **Electron microscopic study on catalytic carbonization of biomass carbon**, *Proceedings 15th international congress on electron microscopy (ICEM15)*, Volume 1, Physics and materials, Durban, p. 231–232 (2002).

Wood charcoal transforms into graphite at temperatures around 2500 K rather easily. Many attempts have been made to accelerate the process or to lower the process temperature by addition of catalytic particles, e.g. the

process of hydrocarbon decomposition and CO disproportionation on Fe-, Co- and Ni-containing catalysts at 1773 K. In this study results are reported on the carbonization of biomass carbon either suspended in a solution of Al-triisopropoxide or mixed with Al₂O₃ particles at temperatures from 1000 K onwards. The well-known structure of merging and interlinking of graphitic fibrils was observed preferentially at the higher heat treatment temperatures.

HATA, T.: **How to treat wood charcoal containing heavy metals**, *Development of Comprehensive Technologies for Environmental Conversion including Prevention of Global Warming by Carbonization of Wood, etc, in the fiscal 2001*, p. 57–60 (2002) (in Japanese).

How to treat wood charcoal containing heavy metals was briefly explained.

HATA, T. and Y. IMAMURA: **Research and development of selective carbonization technology for demolished wood from houses**, *Protect Report of Wood Research Institute, in the fiscal 2001*, RITE, 81-90/90 (2002) (in Japanese).

The possible utilization of wood wastes from demolished houses was explained.

KAKITANI, T., T. HATA, Y. IMAMURA and T. KAJIMOTO: **Behaviour of arsenic in the beginning of pyrolysis of chromium-copper-arsenate (CCA) treated wood**, *Twelfth European Biomass Conference, Biomass for Energy, Industry and Climate Protection*, Amsterdam, p. 651–653 (2002).

Pyrolysis of CCA (copper, chromium and arsenic) treated wood was considered as a possible technique for disposing or recycling instead of combustion. The volatility of arsenic prior to and during pyrolysis of CCA treated wood was studied. Two types of volatilization models of arsenic were proposed as follows; (1) Unreacted arsenic compound, arsenic pentoxide, was released around 150–200°C as a form of arsenic trioxide. (2) Reacted arsenic compound, chromium arsenate, was initially decomposed to arsenic pentoxide, which was released around 350–400°C as a form of arsenic trioxide. Heat treatment effectively retarded the release of arsenic prior to and during pyrolysis and it was indicated that little arsenic was released during pyrolysis under 300°C. The behaviour of metal compounds in CCA treated wood could be controlled by applying heat treatment and a low-temperature pyrolysis.

KAKITANI, T., T. HATA, Y. IMAMURA and T. KAJIMOTO: **Possibility of disposal of chromium-copper-arsenate (CCA) treated wood by pyrolysis, Fate of arsenic during pyrolysis**, *Proceedings of the 21st Annual Meeting of Japan Society of Energy and Resources*, Osaka, p. 411–416 (2002) (in Japanese).

We tried to make a mode of As behaviour during the pyrolysis of CCA (copper, chromium and arsenic) treated wood. The volatility of arsenic prior to and during pyrolysis of CCA treated wood was studied.

HATA, T., K. NISHIMIYA, P. BRONSVELD, T. VYSTAVEL, J. DEHOSSON, H. KIKUCHI and Y. IMAMURA: **Electron microscopic study on catalytic carbonization of biomass carbon: I. Carbonization of wood charcoal at high temperature by Al-Triisopropoxide**, *Molecular Crystals and Liquid Crystals*, **386**, 33–38 (2002).

Currently, carbonized materials from wood or waste wood have been focused upon as raw materials for carbons. These carbons are important for the production of artificial graphite. First hand observation was done on the growth of long parallel graphite structures in wood charcoal. A comparison is made between graphitization in pure biomass carbon and catalytic graphitization in biomass carbon suspended in Al-triisopropoxide. Both types of samples were carbonized during 5 min under an argon pressure of 50 MPa at temperatures up to 2500 Kelvin. Catalytic graphitization was developed by formation and dissociation of plate like Al₄C₃, but only at temperatures higher than 2000 K.

OTONO A., T. KAKITANI, T. HATA and Y. IMAMURA: **Fractional determination of arsenic after pyrolysis of chromated copper arsenate (CCA) treated wood, For recycling wood waste containing heavy metals**, *Wood Research*, **90**, 29–30 (2002).

Chromated copper arsenate (CCA) is known as one of the most widely used wood preservatives. Generally, wood for outdoor use is treated with wood preservatives to prevent insect attack and decay. CCA is used for many applications because of its high performance against weathering by rain and sunshine. In this research, to investigate the behaviour of arsenic during pyrolysis, gasified arsenic compounds were collected in sequent traps (two quenching traps to liquidify smoke and one TBAH trap to catch arsenic compounds) and chemically analyzed.

ISHIMARU K., T. HATA and Y. IMAMURA: **Surface characterization of wood charcoal under different carbonization conditions**, *Wood Research*, **90**, 31–32 (2002).

In this paper, the effects of carbonization conditions such as carbonized temperature, heating rate and reaction time on the surface chemical structure of wood charcoal were studied by XPS.

NAKAI T., T. HATA and Y. IMAMURA: **Chemical components of pyrolyzed liquid of wood-based materials and their bioactive efficiency**, *Wood Research*, **90**, 33–34 (2002).

In this study, the chemical components of pyrolyzed liquid obtained from commercial wood-based materials were analyzed and evaluated. In addition, the effectiveness of this liquid in controlling wood-destroying fungi was examined with consideration of the bio-active components included in the liquid product.

HATA, T. and Y. IMAMURA: **Development of selective carbonization technology for demolished wood from houses**, *Project Report of Wood Research Institute, in the fiscal 2001*, 83-92/120 (2003) (in Japanese).

The mechanism of heavy metals during thermal

conversion of wood wastes from demolished houses was explained.

KAKITANI, T., T. HATA and Y. IMAMURA: **Purification of chromium-copper-arsenate (CCA) treated wood and approaches to collection and recycling of the elements**, *Proceedings of the 19th Conference on Energy, Economy, and Environment*, Tokyo, p. 849–852 (2003) (in Japanese).

Some possible approaches to the purification of CCA (copper, chromium and arsenic) treated wood were considered. Our strategy to solve the problem of green house effect and the control of deterioration of wood is shown.

KUROSAKI, F., K. ISHIMARU, T. HATA and Y. IMAMURA: **PY-GC-MS and XPS analysis of wood charcoal prepared by fast pyrolysis**, *Proceedings of the IAWPS2003, International conference on forest products*, Volume 1, Daejeon, p. 555–557 (2003).

The microstructure of carbon materials plays an important role in their applications. Since the microstructure is greatly influenced by the chemical compounds bonded to the edge of hexagonal carbon layer and by the chemical bonding conditions, the present study was conducted in order to investigate the factors influencing such compounds and conditions by fast pyrolysis. As previous studies indicated that the microstructure of wood charcoal made from Japanese cedar was drastically changed under HTT ranging from 400°C to 800°C, the heat treatment at the same range of temperature was conducted followed by fast pyrolysis at 800°C where the powder sample was carbonized during free fall in the pyrolyzer at 800°C. The gas generated during the pyrolysis and the unstable chemical compounds bonded to the edge of hexagonal carbon layer were analyzed and identified by GC-MS. The change of the microstructure of wood charcoal residue during the fast pyrolysis was investigated by XPS. CC-MS analysis demonstrated that the volume and kinds of gas during carbonization at low temperature were greater than at high temperature. The results of XPS analysis showed that the fast pyrolysis of wood charcoals treated at lower temperature resulted in smaller O/C ratio and more progress in carbonization than at high temperature. The results also showed that oxygen-containing and other functional groups initially bonded to the edge of hexagonal carbon layer became free by fast pyrolysis. Therefore, fast pyrolysis in combination with carbonization of wood charcoal could be used to control chemical compounds bonded to the edge of hexagonal carbon layer.

FUJISAWA, M., T. HATA, V. CASTRO, F. TANAKA, Y. IMAMURA, H. KIKUCHI and T. FURUNO: **Characterization of SiC/C composite materials from wood charcoal by a pulse current sintering method**, *Proceedings of 52nd Academic Lecture Meeting of Materials Research*, Tokyo, p. 271–272 (2003) (in Japanese).

SiC/C composite materials from the powder of wood charcoal and SiO₂ were developed using a pulse current sintering method. We studied the microstructure, electrical resistivity and thermal constants of the specimens

with the aim of developing highly functional SiC/C composite materials with great electrical and thermal conductivity by changing the heat treatment temperature concentrations of SiO₂.

KUROSAKI, F., K. ISHIMARU, T. HATA and Y. IMAMURA: **Microstructural investigation of carbonized wood prepared by fast pyrolysis**, *Proceedings of 52nd Academic Lecture Meeting of Materials Research*, Tokyo, p. 269–270 (2003) (in Japanese).

The present study showed that carbonized wood prepared at 800°C had a different microstructure and surface chemical structure when prepared by fast pyrolysis than by slow pyrolysis. The use of fast pyrolysis to prepare wood for carbonization may allow the microstructure and surface chemical properties of the charcoal to be tailored.

HATA, T., P. BRONSVELD, T. VYSTAVEL, B. KOOI, J. DEHOSSON, T. KAKITANI, A. OTONO and Y. IMAMURA: **Electronmicroscopic study on chromium-copper-arsenate (CCA) treated wood during pyrolysis**, *Proceedings of the 19th Conference on Energy, Economy, and Environment*, 847–848 (2003) (in Japanese).

The effectiveness of pyrolysis as a possible technique for disposing of CCA (chromium, copper and arsenic oxide)-treated wood was studied with electronmicroscopy.

HATA, T., P. BRONSVELD, T. VYSTAVEL, J. DEHOSSON, H. KIKUCHI, K. NISHIMIYA and Y. IMAMURA: **Study on improvement of graphitization of biomass carbon**, *Proceedings of IUFRO -All Division 5 Conference, Forest Products Research, Providing for Sustainable Choices*, Rotorua, p. 241 (2003).

Japanese cedar was preheated at 773 K, and subsequently prepared in two different ways, one by suspension mixing with Al-triisopropoxide and one by powder mixing with 40 µm Al₂O₃ particles. A direct pulse heating apparatus was used for a 5 min carbonization step at temperatures between 1000 and 2500 K. The samples were analyzed in an analytical transmission electron microscope with Gatan Imaging Filter, in a high-resolution transmission electron microscope and in a scanning electron microscope. The well-known conglomerate of randomly twisted and highly anisotropic graphite-like fibrils whose width gradually increases due to high temperature annealing was observed preferentially at the higher heat treatment temperatures. The 'rigidity' which results in its poor ability of transformation into well-ordered graphite during heat treatment could be surpassed by the intermediate reaction of Al₂O₃ and carbon to flake-like Al₄C₃ which dissociates under the proper CO pressure into Al vapour and solid graphite. Around 2500 K disintegration reactions in the Al₂O₃ powder sample were observed readily, but below 2000 K wetting of carbon with aluminum is problematic even in the triisopropoxide sample. Reactions could be seen only in the immediate surroundings of nano particles of Al₂O₃ being formed during the heat treatment. The carbon flakes could be imaged in greater detail both in top view and in cross view. They seem to be composed of carbonized microfibrils, transformed into well-aligned graphite. The powder

results do not look inferior to the triisopropoxide ones.

KAMIJIMA, M., Y. HASEMI, N. YASUI, T. KIMURA, A. Umayahara, A. HOUGO, T. HATA, Y. TAMURA, S. OHNISHI, K. SAKAI, M. SHIMIZU, K. HIYAMA, K. ONO, M. YOSHIDA and K. YAMAMOTO: **Reestimation of fire resistance of code-acceptable traditional wooden constructions wood/soil walls (4) Fire resistance tests of real size wood/soil walls under load**, *Proceedings of Meeting of AIJ Kanto Chapter in Architectural Institute of Japan*, 419-422 (2002) (in Japanese).

Fire resistance tests are conducted on real-size specimens of wood/soil wall assembly with different construction details as a basis for developing code-acceptable traditional wooden constructions.

HIYAMA, K., H. MURAKAMI, Y. HASEMI, A. Umayahara, N. YASUI, M. KAMIJIMA, T. KIMURA, M. SHIMIZU, T. HATA and Y. TAMURA: **Reestimation of fire resistance of code-acceptable traditional wooden constructions wood/soil walls (6) Effect of Parts Specifications on Fire resistance of wood/soil walls under load**, *Proceedings of Meeting of AIJ Kanto Chapter in Architectural Institute of Japan*, 427-430 (2002) (in Japanese).

Fire resistance tests are conducted on small-scale specimens of wood/soil wall assembly with different construction details as a basis for developing code-acceptable traditional wooden constructions. The influence of both-side plastering of soil wall, thickness and water content of the soil layer and various reinforcements of timber/soil layer interface on the prevention of the heat and flame penetration through a wood/soil wall was revealed.

YASUI, N., Y. HASEMI, M. AKIZUKI, A. Umayahara, S. OHNISHI, M. KAMIJIMA, T. HATA, T. KIMURA, Y. TAMURA and H. MURAKAMI: **Influences of construction details on the fire resistance of traditional wood/soil walls**, *J. Environ. Eng., AIJ*, No. 567, 7-13 (2003) (in Japanese).

Fire resistance tests are conducted on small-scale specimens of wood/soil wall assembly with different construction details as a basis for developing code-acceptable traditional wooden constructions. The tests have revealed significant influence of both-side plastering of soil wall, thickness and water content of the soil layer and various reinforcements of timber/soil layer interface on the prevention of the heat and flame penetration through a wood/soil wall. It has been also clarified that charring of the timber element, a major cause of the collapse of the wall due to fire, can be reduced by the protection of the load-bearing timber elements by soil or wood or by design considerations reducing fire exposure of the timber element.

IMAMURA, Y: **Durability of Wood**, In "The Control Measures against Variation of Wood Properties and Efficient Utilization", *The Working Party Report of The Japan Wood Research Society*, II, 57-66 (2002) (in Japanese).

The variation of the durability against decay and insect attacks was described.

IMAMURA, Y: **Effective Recycling and Safety Disposal of Preservative-treated Wood Wastes**, In "The Chemical Treatment of Wood with Ecological Compatibility", *The Working Party Report of The Japan Wood Research Society*, III, 71-82 (2002) (in Japanese).

Effective recycling and safety disposal of preservative-treated wood wastes was described.

SUDIYANI, Y., S. HORISAWA, K. CHEN, Y. IMAMURA and S. DOI: **Changes in surface properties of tropical wood species exposed to the Indonesian climate in relation to mold colonies**, *J. Wood Sci.*, 48, 542-547 (2002).

Changes in mold populations and genera on the exposed surfaces of tropical hardwood - albizia (*Paraserianthes falcate*), kapur (*Dryobalanop lanceolata*), mahoni (*Swietenia macrophylla*), nangka (*Artocarpus heterophyllus*), pusp (*Schima wallchii*) - were investigated. The wood specimens were exposed to the Indonesian climate for 32 weeks. Properties including mass loss, wettability, mold growth (colony-forming units), and mold genera were evaluated. The change in properties after exposure was significantly affected by the wood species, but there was no clear relation between mass loss and the initial chemical components or between wettability and wood density. The number of mold populations was different by exposure period and wood species, but there was no significant effect of climate conditions, such as rainfall and ultraviolet radiation. Of the genera identified, *Aureobasidium*, *Cladosporium*, and *Penicillium* were dominant molds on the exposed wood surfaces.

SUDIYANI, Y., Y. IMAMURA, S. DOI and S. YAMAUCHI: **Infrared spectroscopic investigations of weathering effects on the surfaces of tropical wood**, *J. Wood Sci.*, 49, 86-92 (2003).

Two Fourier transform infrared spectroscopic techniques, photoacoustic and diffuse reflectance spectroscopy, were utilized to explore the physical and chemical changes in wood caused by weathering. Five tropical wood species (albizia, kapur, mahoni, nangka, pusp) were exposed to natural weathering for various periods. The contents of extracts, phenolics, and Klason lignin in unexposed samples of these wood species were determined by chemical analysis. Infrared spectra of the weathered surfaces were recorded by the two techniques. The photoacoustic spectra exhibited rapid decomposition and elution of wood constituents containing benzene rings in the region closest to the exposed surface. Line maps of infrared spectra in the vertical direction obtained by diffuse reflectance infrared microspectroscopy were consistent with the view that the additive effects of water and ultraviolet irradiation play an important role in destroying the lignin-hemicellulose matrix of the cell wall. The infrared spectroscopy techniques are available for the analysis of weathered wood.

SUDIYANI, Y., Y. IMAMURA and S. DOI: **Weathering performance of wood impregnated with phenolic-resin**, *Proceedings of the fourth International Wood Science Symposium*, Serpong, Indonesia, Sept. 2-5, 176-181 (2002).

Thin wood blocks from the tropical hardwood species of albizia (*Paraserianthes falcate*) and Japanese softwood

species of sugi (*Cryptomeria japonica*) were impregnated with a low molecular-weight phenol formaldehyde resin. The specimens were weathered to outdoor conditions for 1 year at an angle 5 degree from the horizontal facing east, at Serpong, Tangerang, Indonesia. Weathered performances of untreated and treated woods were evaluated in weight loss, discolorations, surface erosion by visual observations and identification of mold genera. The results indicated that PF-resin treatment improved the surface resistances of wood such as color stability and physical performance in cracking and hangnail against weathering. Weight losses of treated wood of two wood species were smaller than that of the untreated wood. PF-resin impregnation also contributed to the suppression of mold contamination of the surfaces of both wood species. After 1 year exposure, as much as 10 fungal genera were isolated, among them *Aureobasidium* was the dominant mold.

FEBRIANTO, F., M.D. PUTRI, A.H. ISWANTO, B. TAMBUNAN and Y. IMAMURA: **Composite of Woodflour—Recycle Polypropylene II, The role of maleic anhydride and dicumyl peroxide in the strengthening of the composites**, *Proceedings of the fourth International Wood Science Symposium*, Serpong, Indonesia, Sept. 2–5, 235–239 (2002).

The physical and mechanical properties of recycle polypropylene (RPP) composites with wood flour (WF) were investigated under various maleic anhydride (MAH) and dicumyl peroxide (DCP) concentrations. The physical and mechanical properties of the obtained composites were greatly affected by MAH and DCP concentrations. It was found that addition of MAH and DCP in the amount of 6% (based on RPP) and 15% (based on MAH weight), respectively, gave the best results. The values of moisture content, density, water adsorption, thickness swelling, modulus of elasticity, internal bond, and screw holding power of the composites were 0.82%, 0.72 g/cm³, 8.34%, 0.69%, 126 kg/cm³, 15,362 kg/cm³, 3.47 kg/cm³, and 67.6 kg/cm³, respectively.

SHIBATA, A, Y. ENOMOTO and Y. IMAMURA: **Behavior of arsenic in pyrolytic liquid produced by pyrolysis of CCA-treated wood and its removal by rectification**, *Mokuzai Hozon (Wood Preservation)*, **28**, 236–241 (2003) (in Japanese with English summary).

It is important to recycle CCA-treated wood wastes safely from the viewpoint of efficient utilization of resources and environmental protection. For obtaining of the safe wood vinegar, we conducted the purification system to remove arsenic from pyrolytic liquid produced by pyrolysis of CCA-treated wood. Almost 99% of the arsenic could be removed from the pyrolytic liquid containing 80 ppm arsenic, resulting in 1 ppm of arsenic in the refined wood vinegar. The rectification system was shown to be very effective in removing arsenic from the pyrolytic liquid produced by pyrolysis of CCA-treated wood wastes.

TAKAHASHI, M. and T. YOSHIMURA: **Recent development in the control of Japanese subterranean termites**, *Sociobiology*, **40**, 13–23 (2002).

Two species of subterranean termites, *Coptotermes formosanus* Shiraki and *Reticulitermes speratus* (Kolbe), cause great economic losses in wooden constructions in Japan. Because most Japanese houses have a crawl space under the first floor, the control of subterranean termites has been commonly achieved by treating soil and floor woodwork with termiticides. In the crawl space, termiticidal water emulsion is usually applied to soil, but use of termiticidal granules is starting as a way of reducing the atmospheric concentration of chemicals during operation. Several improved methods have been devised using micro-encapsulated formulations, foaming formulations, termiticide-treated sheets, and easy-hardening pastes containing termiticides. Formulations for woodwork treatment should contain termiticides and fungicides, and be applied to timbers by pressure and/or surface treatments. On-ground concrete slabs are becoming popular in Japan to control the humidity in the crawl space. Humidity-regulating materials are also used to produce unfavorable conditions for termites and fungi. Increased public criticism of man-made chemical products supports the development of alternative termite control methods. Physical barriers using stainless steel mesh are being introduced from Australia, and anti-termite cups for floor posts have been devised and marketed. The idea of IPM (Integrated Pest Management) for termite control has long been considered in Japan. A bait system using an inhibitor of chitin synthesis as the toxicant was introduced a few years ago from the U.S. Biological control using entomogenous fungi appears to be promising when combined with baiting techniques.

YOSHIMURA, T., N. KAGEMORI, S. KAWAI, K. SERA and S. FUTATSUGAWA: **Trace elements in termites by PIXE analysis**, *NIM B*, **189**, 450–453 (2002).

Trace elements in a Japanese subterranean xylophagous termite, *Coptotermes formosanus* Shiraki were analyzed by the PIXE method. The total amount of fourteen major elements out of twenty-seven detected in an intact termite was higher in a soldier termite (23,000 µg/g) than in a worker termite (10,000 µg/g). A block of wood (*Pinus densiflora* Sieb. et Zucc.) for termite feed had a much lower concentration (3,600 µg/g) compared with that in an intact termite. This probably relates the functional bio-condensation and/or bio-recycling of trace elements in *C. formosanus*. When a termite was separated into three anatomical parts: head, degutted-body and gut, the worker gut contained the highest total amount of fourteen major measured elements (31,000 µg/g). This might be correlated with the higher activity of food digestion and energy production in the worker gut. Moreover, the mandible of soldier head with an exoskeleton that is intensely hardened, showed a preferential distribution of Mn and Fe. These results suggest that the characteristic localization of elements will be closely related to the functional role of the individual anatomical part of *C. formosanus*.

YOSHIMURA, T. and T. HIGUCHI: **Termite control strategies with fungi (I) Historical background and the present status of research**, *Shoroari (Termite)*, No. 128, 3–10 (2002) (in Japanese).

Biological control of termites is one of the promising options as a non-chemical remedial treatment. Historical background and the present status of research activities on termite controlling strategies with entomopathogenic fungi are reviewed in this paper.

YOSHIMURA, T. and T. HIGUCHI: **Termite control strategies with fungi (2) The sheet formulation with *Beauveria brongniartii*, *Shoroari* (Termite), No. 129, 3–12 (2002) (in Japanese).**

In this paper, we described the fundamental termiticidal activity of the sheet formulation of a entomopathogenic fungus, *Beauveria brongniartii*. Four field trials, 3 for *Coptotermes formosanus* and 1 for *Reticulitermes speratus*, by baiting methods are also briefly outlined.

YOSHIMURA, T.: **The 14th International Congress of the International Union for the Study of Social Insects—"Gene and Social Insects"—, *Mokuzai Hozon* (Wood Preservation), 28, 194–197 (2002) (in Japanese).**

The 14th International Congress of the International Union for the Study of Social Insects (IUSI) was held at Hokkaido University from 27th July to 3rd August, 2002 with the main theme "Gene and Social Insects". Approximately 500 participants presented about 400 papers on social insects consisting of ants, wasps, bees, termites, and aphids etc. Total 48 presentations on termites are briefly reviewed in this paper with special references on the future missions in termite researches.

YOSHIMURA, T., N. KAGEMORI, J. SUGIYAMA, S. KAWAI, K. SERA, S. FUTATSUGAWA, M. YUKAWA and H. IMAZEKI: **Trace elements in mandibles of *Coptotermes formosanus*, The 14th International Congress of IUSI Proceedings, Sapporo, July 27–August 3, 43 (2002).**

Quantitative analyses of the trace elements in the mandibles of workers and soldiers of *C. formosanus* with the normal-PIXE method showed that Mn (300–450 ppm) and Fe (100–300 ppm) deposited more than 10 times higher in soldiers and 4–5 times higher in workers when comparing with concentrations in intact termites. On the other hand, concentrations of the major trace elements such as K, P, and S in the mandibles were similar or lower than those in intact termites. Visualization of the distribution of the elements on the surface of the mandibles by the micro-PIXE method indicated that Mn and Fe preferentially distributed in whole soldier mandibles and the cutting edges (teeth) of worker mandibles along with the pigmentation. These results clearly suggest that Mn and Fe deposition contribute to the hardening of the exoskeleton, and that the deposition is closely related to the pigmentation. Detailed structural analyses are required to reveal the true nature of matrices consisting of biological polymers (chitin) and metals in the termite mandibles.

YOSHIMURA, T.: **New technologies of termite control in Japan, Proceedings of the 14th FAOPMA 2002 Convention and Exhibition, Yokohama, Nov. 10–12, 72–76 (2002).**

Among 21 termite species known in Japan, two subterranean rhinotermitids, *Coptotermes formosanus* Shiraki and *Reticulitermes speratus* (Kolbe) have been causing the great economic losses against not only wooden

constructions but also other exterior wooden materials in Japan. Many alternative termite controlling methods with less-use or non-use of chemicals are being investigated as a major part of the environmentally-sound wood preserving system in Japan. New technologies such as baiting, physical barriers, biological control, positive regulation of the crawl space environment, and novel termite detection system are reviewed in this paper.

YOSHIMURA, T.: **Termite symbiosis—What we can learn from the gut micro-ecosystem—, Proceedings of the fourth International Wood Science Symposium, Serpong, Indonesia, Sept. 2–5, 312–318 (2002).**

Termite guts are axially and radially structured habitats with multi-environmental micro-niches created by microorganisms. Recent studies have clarified the functional interactions among tripartite, hosts, microorganisms and wood. Termites degrade cellulose and hemicellulose to pyruvate in midguts, and this is supplied to the hindgut bacterial flora. Among diverse bacterial groups spirochetes are likely to be responsible for the large activities of acetogenesis in most wood-feeding termites. Hindgut protists degrade cellulose and hemicellulose but not lignin, and produce acetate as an energy source for hosts together with acetate of bacterial origin.

NAKAYAMA, T., Y. YANASE, T. YOSHIMURA, Y. FUJII and Y. IMAMURA: **Effects of humidity changes on the feeding activity of a pest termite, *Reticulitermes speratus* (Kolbe), *Jpn. J. Environ. Entomol. Zool.*, 13, 125–131 (2002).**

The effect of the environmental relative humidity (RH) on the feeding activity of *Reticulitermes speratus* (Kolbe), which is one of the major pest species and is distributed throughout almost the whole country, was investigated by acoustic emission (AE) monitoring. Two trials of fixed and variable RH tests were conducted. In the fixed RH test, although no significant difference was observed, higher AE events were observed at 70% and 80% RH than at other RH levels. The AE event rates generated by the feeding activities of workers under stepwisely-changed RH gradient (50–90–50% RH) increased with environmental RH rising, and decreased rapidly when RH lowered. The highest feeding activities were detected at 80% and 90% RHs in the variable test. From these results, it seems that the feeding activity of *R. speratus* workers is restrained by lowering environmental RHs.

NAKAYAMA, T., T. YOSHIMURA and Y. IMAMURA: **Water dependence of Japanese subterranean termites, Proceedings of the fourth International Wood Science Symposium, Serpong, Indonesia, Sept. 2–5, 175 (2002).**

In order to clarify the water dependence of these subterranean species, survival rates, mass changes and moisture content changes of workers were measured when cultured without a water supply (dry conditions). The survival rates of *C. formosanus* and *R. speratus* workers kept at 25°C and 70% RH in dry conditions decreased to almost 0% after 4 and 2 days, respectively, regardless of the colony, although more than 90% survived at least 1 day. The masses of both species decreased to approximately

50–60% of the original value after 3 days (*C. formosanus*) and 42 hours (*R. speratus*), just before all the workers died. When the workers were kept at 25°C and 70 % RH in dry conditions for not more than 24 hours in *C. formosanus* and 12 hours in *R. speratus*, no detrimental effects were observed in the transferred individuals. Our results suggest that 30–40% water loss causes unrecoverable physiological effects on workers of *C. formosanus* and *R. speratus*.

NAKAYAMA, T., Y. TANIGUCHI and Y. IMAMURA: **Effect of moisture content on electric resistivity of wood charcoal**, *Bull. Nara Univ. Educ.*, **51**(2) (Nat), 55–59 (2002) (in Japanese with English summary).

Sugi (Japanese cedar, *Cryptomeria japonica* D. Don) wood block was carbonized at 500–1,000°C to investigate the relationship between treatment temperatures and the electric resistivity, and its effect on the moisture content of wood charcoal. The electric resistivity of wood charcoal was measured in the room condition after conditions at 50% and 90% RHs and 25°C for one week. The electric resistivity of wood charcoal rapidly decreased in the range of temperatures from 600 to 800°C. The correlation between electric resistivity and moisture content of wood charcoal was higher at lower carbonization temperatures. Therefore, it can be assumed that the wood charcoal carbonized at lower temperatures has a possibility to use as a humidity sensor by measurement of the electrical resistivity.

OKAHISA, Y., T. YOSHIMURA and Y. IMAMURA: **Potential of termite attack on Moso bamboo under different seasons with a special reference to starch content**, *Proceedings of the IAWPS 2003 Intl Conference on Forest Products 30th Anniversary of the Korean Society of Wood Science and Technology*, Daejeon, South Korea, April 21–24, Volume 2, 1090–1094 (2003).

The decrease of the use of domestic bamboo in various architectural styles has been causing a significant effect on bamboo plantations. However, bamboo is the interesting material for buildings not only because of its sustainability as natural resource but also due to its excellent and dynamic performance. For architectural applications, the durability of bamboo should be highly considered when it is used under the conditions conducive to biological degradation. There have been some reports on the biological degradation of bamboo material, which is mainly related to its starch content. However, previous investigations mainly focused on the damage of bamboo by *Dinoderus minutus* Fabricius attack, which is a serious pest insect to bamboo. Since termites have caused serious damages to building or construction materials in Japan, this study was conducted to evaluate the potential termites attacks against Moso bamboo (*Phyllostachys pubescens*) in correlation with the change of seasonal starch contents. Bamboo culm (3–5 years) was cut into three sections based on the distance from the bottom of the culm (top, middle and bottom). Specimens (20×20 mm×thickness) were prepared from each section for termite test. The termite test was conducted according to the Japan Wood Preserving Association (JWPA) standard against *Coptotermes formosanus* and *Reticulitermes speratus*. In addition, a chemical analysis was conducted using HPLC

to determine the starch content of each section. Results of this study indicated that the pattern of termite attacks was significantly different from *D. minutus*. The termite attacks were higher at the bamboo with lower starch content.

KARTAL, S.N. and Y. IMAMURA: **Leaching characteristics, decay and termite resistance of treated wood with boron compounds, N'-N-(1,8-Naphthalyl) hydroxylamine (NHA-Na), and hydroxynaphthalimide (NHA-H)**, *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP 03-30307 (2003).

Despite many advantages of boron wood preservatives, boron itself does not adequately protect wood in ground contact and exterior applications because its natural diffusibility and susceptibility to leaching. As a result of previous studies to limit or decrease boron leaching, several fixation systems have been developed. In this study, we evaluated the effects of N'-N-(1,8-Naphthalyl) hydroxylamine (NHA-Na) and hydroxynaphthalimide (NHA-H) on boron leaching and decay and termite resistance via boron precipitation in wood after NHA treatments at varying concentrations. Wood blocks were treated with disodium octaborate tetrahydrate (DOT), boric acid (BA) NHA-Na or NHA-H solutions. Preliminary results showed treatment of wood blocks with DOT, boric acid, and calcium borate and 1% or 0.1% NHA-Na solutions in sequential processes appears to somewhat reduce the susceptibility of boron to leaching. Blocks treated sequentially with boron compounds and then 1% NHA-Na solutions showed about 30% less boron leaching. In addition, the existence of boron and NHA in wood together showed a synergetic effect against wood degrading organisms and termites. We conclude that precipitation of NHA at higher concentrations decreases or limits boron leaching. On the other hand, the relationship between boron and NHA concentration in wood as regards precipitation possibilities appears to be predictive for reducing boron leachability.

KARTAL, S.N. and Y. IMAMURA: **Removal of copper, chromium, and arsenic from CCA-C treated wood: *Aspergillus niger* fermentation and acid extraction**, *Proceedings of the IAWPS 2003 Intl Conference on Forest Products 30th Anniversary of the Korean Society of Wood Science and Technology*, Daejeon, South Korea, April 21–24, Volume 1, 480–485 (2003).

The release of copper, chromium, and arsenic elements into the environment from chromated copper arsenate (CCA)-treated waste wood become an increasing concern due to their accumulation in forms leading to toxic effects on the environment. Remediation of CCA-treated waste wood will decrease concerns about environmental pollution from such waste. Certain isolates of fungi and bacteria can readily remediate waste wood that has been treated with CCA. This study evaluates the potential of the fungus *Aspergillus niger* to remove copper, chromium, and arsenic from wood treated with CCA wood preservative. In the study, *A. niger* was first cultivated in carbohydrates media in order to produce large quantities of oxalic acid. Bioremediation of CCA-treated wood was then performed through both leaching of heavy metals with

oxalic acid occurred during the first stage and possible biosorption of metals onto the binding sites in the cellular structure of *A. niger*. Oxalic acid production by *A. niger* was 13.4 kg/m³ at pH 6 and in an enriched nitrogen and phosphorus medium. *A. niger* exposed to CCA-treated chips for 10 days showed a decrease in arsenic of 97%. In addition, *A. niger* fermentation removed 49% copper and 55% chromium from CCA-C treated chips. Ethylenediaminetetracetic acid (EDTA) extraction was applied to bioremediated chips as a dual remediation process to increase removal of elements. Dual remediation of CCA-C treated wood resulted in a total reduction of 100% copper and arsenic, and 79% chromium. This study showed that fungal fermentation and passive metal removal by *A. niger* had a potential in arsenic release from CCA-C treated waste wood.

YANASE, Y., Y. FUJII, S. OKUMURA, T. YOSHIMURA and Y. IMAMURA: **Detection of acoustic emission (AE) generated by the feeding activity of dry-wood termite**, *Proceedings of the fourth International Wood Science Symposium*, Serpong, Indonesia, Sept. 2-5, 114-120 (2002).

Acoustic emission (AE) monitoring of termite attack on wood was applied for dry-wood termite *Incisitermes minor* (Hagen) in a laboratory and a wooden house. In the laboratory testing, four AE transducers were mounted on the side surface of a wood specimen of 55 mm in square and 600 mm long at regular intervals of 150 mm. After AE measurement, the wood specimen was cut into four pieces, and the numbers of termites inhabiting each piece were counted. The wood piece inhabited the most by termites generated the largest number of AEs. In another test, AE generation from wood specimen inoculated with termites was continuously measured with four AE transducers for 132 days. In the beginning, the AE events was the highest at an AE transducer mounted near the inoculated hole, but the AE events of each transducer changed with the time, probably due to the movement of the termite attacking area progressed. In AE monitoring for a wooden house attacked by termites, significant numbers of AEs generated by termite attack were detected from the columns, joists, window frames, rain doors, and doors. By boring and disassembling near the AE detection points apart, termites were found and the positions where significant numbers of AEs were detected almost corresponded to the positions where termites were attacking. No AEs were detected about one month after the treatment of AE detection areas by termiticide.

YANASE, Y., Y. FUJII, S. OKUMURA, T. YOSHIMURA, Y. IMAMURA, T. MAEKAWA and K. SUZUKI: **Detection of termite attack to wood stakes in a monitoring station using ceramic gas sensors and acoustic emission (AE) sensor**, *The Int. Res. Group on Wood Preserv., Document*, No. IRG/WP 03-20271 (2003).

To evaluate termite activity in monitoring stations non-destructively, metabolic gas from termites and acoustic emission from feeding activity of termites were measured. Ten stations with small wood stakes of Japanese red pine (*Pinus densiflora*) were buried around a house attacked by *Coptotermes formosanus* Shiraki. The air in the station was collected by sucking through a drilled hole of the station lid

and analyzed using two types of ceramic gas sensors (odour- and hydrogen-selective sensors). Acoustic emissions (AEs) were detected by a PZT sensor attached on the cross section of one of the small stakes in the station. The concentrations of two components of the gas, odour and hydrogen, and AE event rate per 2 minutes were measured periodically from December 2001 to December 2002. The infestation activity was also evaluated by visual inspection. In the early stage of the experiment, from the first to the third measurements, neither AEs nor significant concentration level of the gas components were detected, and no termites was observed in all the stations. After then termites were observed in the stations, and higher gas concentration of odour and hydrogen and larger numbers of AE events were detected. These findings suggest that termite attack in the monitoring station can be evaluated by using two types of the gas sensors and AE sensor.

YANASE, Y., Y. FUJII, S. OKUMURA, T. YOSHIMURA and Y. IMAMURA: **A long-term observation of termite activity in the nest by continuous acoustic emission (AE) monitoring**, *The Int. Res. Group on Wood Preserv., Document*, No. IRG/WP 03-20280 (2003).

The temperature in the environment or in termite nests affects the termite activities. In order to evaluate the effects of temperature on the termite activity, acoustic emission (AE) monitoring was applied to two nests of *Coptotermes formosanus* Shiraki, a nest in a standing tree and an underground nest under a wooden house. Temperatures were continuously measured for about one year using thermocouples at four points, the centre of the nest, the periphery of the nest, the environment around the nest, and the underground. AEs were detected at the centre of nest and underneath the nest sphere by using wave-guides inserted into the nest of the standing tree, and at the centre of nest and at the wooden construction member near the nest in the wooden house, respectively. The nests were periodically stimulated by rotating the wave-guide. The temperatures in the two nests varied from 5 to 35°C during the experiment. The highest and the lowest temperatures were recorded in August and February, respectively. The highest AEs were recorded when the temperature of the nest in the tree was between 30 and 35°C and when the temperature of the nest under the house was above 25°C. In winter, when the nest temperature was below 10°C, no significant numbers of AE were detected. These findings clearly show that AE generation has close relation to the termite activities, which are regulated by the temperature in the nest.

TAKEMATSU, Y., H. YUZAWA, M. OHKUMA, T. YOSHIMURA and T. KUDO: **The molecular phylogenetic analysis of the genus *Coptotermes* in Asia based on the DNA sequences of mitochondrial COII and 12S rRNA genes with reference to their morphology**, *Proceedings of the Japan Science and Technology Corporation International Symposium "Bio-recycle Research on Termites and Their Symbiotic Microorganisms"*, Wako, Feb. 26-27, 2P3 (2002).

Molecular phylogenetic analyses based on the partial sequences of mitochondrial COII and 12S rRNA genes were made for a large variety of *Coptotermes* termites

collected in Japan, Thailand and Indonesia. The samples were classified into 11 groups according to the morphology of the soldier caste. The present molecular phylogenetic analyses indicated that these samples were categorized into 3 major groups relating to *C. formosanus*, *C. curvignathus* and *C. gestroi*. Comparing the results with morphological observations, it was found that the chaetotaxy and density of hairs of head and pronotum were the most important characters for identification of *Coptotermes* species.

TAKEMATSU, Y., H. YUZAWA, M. OHKUMA, T. YOSHIMURA and T. KUDO: **Taxonomy of the genus *Coptotermes* of urban area in Asia based on the DNA sequences of mitochondrial COII and 12S rRNA genes with reference to their morphology**, *Proceedings of the fourth International Wood Science Symposium*, Serpong, Indonesia, Sept. 2–5, 335 (2002).

Molecular phylogenetic analyses based on the partial sequences of mitochondrial COII and 12S rRNA genes were conducted for 11 *Coptotermes* morphospecies. The present molecular analyses indicated that the genus *Coptotermes* were divided into 3 major groups relating to *C. formosanus*, *C. curvignathus* and *C. gestroi*, and the homology of each group was more than 98%. It was also found that the chaetotaxy and density of hairs of head and pronotum were the most important characters for identification of *Coptotermes* species.

YUSIASIH, R., T. YOSHIMURA, T. UMEZAWA and Y. IMAMURA: **Evaluation of biological activities of tropical wood extractives responsible for durability against termite and fungi**, *Proceedings of the fourth International Wood Science Symposium*, Serpong, Indonesia, Sept. 2–5, 491–497 (2002).

Wood meals of Nangka (*Artocarpus heterophyllus* Lamk), Puspa (*Schima walichi* Kort) and Kisampang (*Evodia latifolia* DC) heartwoods were extracted with hot methanol. Crude extracts from these species showed concentrations of 10.36, 1.54 and 1.24%, respectively. The extracts were then evaluated for biological activity against termites and fungi. The crude extract from Nangka heartwood showed the greatest effect on both of the organisms in laboratory tests and was separated using Cellulose Thin Layer Chromatography (Cell-TLC) plate with 2-butanol-acetic acid-water (14:1:5, v/v). Two broad bands with R_f values of 0.46 and 0.96 were found, and those bands showed completely different effects against a termite, *Coptotermes formosanus* and a decay fungus, *Fomitopsis palustris*. Chemical analysis of the bands with R_f values of 0.46 and 0.96 are now being conducted.

INDRAYANI, Y., T. YOSHIMURA, Y. IMAMURA, Y. YANASE and Y. FUJII: **Acoustic emission (AE) monitoring of dry-wood termite feeding activities under various relative humidity and temperature conditions**, *The 14th International Congress of IUSSI Proceedings*, Sapporo, July 27–August 3, 101 (2002).

Acoustic emission (AE) monitoring of dry-wood termite feeding activity in wood was investigated. Workers of *Cryptotermes domesticus* Haviland collected from Iriomote Island, Japan, were loaded in the holed specimen of Indonesian pine (*Pinus merkusii* Jungh et de Vriese.) and

kept in the test chamber under various relative humidity (RH) and temperature conditions. The effect of gradual change in RH and temperature was also observed. The propagation of AE due to feeding activity of termites in the specimen was monitored. The result of this study indicated that feeding activity varied with RH and temperature changes. The highest feeding activity was observed at 70% RH, meanwhile the lowest activity was at 90% RH. When the temperature changed from 15°C to 45°C, the numbers of AE decreased at the temperatures of over 35°C and under 25°C. At the temperatures of 15°C and 45°C significant numbers of AE was not detected except electric noises. The highest feeding activity was observed at 35°C.

INDRAYANI, Y., Y. YANASE, Y. FUJII, T. YOSHIMURA and Y. IMAMURA: **Acoustic emission (AE) monitoring of dry-wood termite feeding activities under various relative humidity (RH) conditions**, *Proceedings of the fourth International Wood Science Symposium*, Serpong, Indonesia, Sept. 2–5, 107–113 (2002).

Acoustic emission (AE) monitoring of dry-wood termite feeding activity in wood was investigated with workers of *Cryptotermes domesticus* Haviland collected from Iriomote Island, Japan. The insects were loaded in the holed specimen of Indonesian pine (*Pinus merkusii* Jungh et de Vriese.) and kept in the test chamber under various relative humidity (RH) conditions. The effect of gradual change in RH was also observed. The propagation of AE due to feeding activity of termites in the specimen was monitored. The result of this study indicated that feeding activity of workers of *C. domesticus* varied with RH changes. The optimal RH condition for feeding activity was observed at 70% and 80%.

PENG, X., M. SATO, T. KAWASE, K. IKENO, H. SAWADA, N. HONDA, K. WADA, Y. TAKAHASHI and T. YOSHIMURA: **Synthesis and soil repellent, antibacterial and antifungal properties of blocked isocyanate co-oligomers having cation segments**, *Sen'i Gakkaishi*, **58**, 163–169 (2002) (in Japanese).

New type blocked isocyanate co-oligomers having cation segments were synthesized. Soil repellent, antibacterial and antifungal modifications of glass and cellulose by these co-oligomers were studied. Through measuring the contact angles and XPS spectra, it was shown that the glass and cellulose surfaces modified with co-oligomers containing ammonium and phosphonium segments change to water- and oil-repellent. The surface modified by the co-oligomers containing phosphonium segments was also found to exhibit a high antibacterial activity against *Staphylococcus aureus*. Moreover, the co-oligomers containing phosphonium segments were found to retard the multiplication of *Aureobasidium pullulans* and *Cladosporium cladosporioides* even when the concentration of co-oligomer solution was 0.01 wt%. They also showed antifungal activity against *Fomitopsis palustris* and *Trametes versicolor*.

NGEE, P.-S., A. TASHIRO, C.-Y. LEE and T. YOSHIMURA: **Comparative susceptibility of Malaysian and Japanese wood species against termite attack**, *Proceedings of the*

fourth International Wood Science Symposium, Serpong, Indonesia, Sept. 2–5, 113 (2002).

Fifteen Malaysian and 15 Japanese wood species are tested for their susceptibility against Malaysian and Japanese termites. In Malaysia, a choice-feeding test on *Coptotermes havilandi* Holmgren was conducted, and in Japan forced-feeding tests on *C. formosanus* and *Reticulitermes speratus* and a choice-test on *C. formosanus* were done. Some wood species showed completely different susceptibility against Malaysian and Japanese termites. Japanese Hiba heartwood had a high durability against Japanese termites but very susceptible against Malaysian termites. On the contrary, Malaysian Teak heartwood was highly durable against Malaysian termite but consumed well by Japanese termites. These results suggest that the susceptibility of timbers against termites should be tested with target termite species.

LENZ, M., T. YOSHIMURA and K. TSUNODA: **Response of laboratory groups of *Reticulitermes speratus* (Kolbe) to different quantities of food**, *The Int. Res. Group on Wood Preserv., Document*, No. IRG/WP 03-10489 (2003).

As part of a project aimed at improving understanding of the foraging biology of Japan's most widespread wood-destroying termite, different sized groups of *Reticulitermes speratus* (0.5; 1 and 2 g) from two colonies were kept on 16 or 64 cm³ of sapwood of *Cryptomeria japonica* for 12 weeks in the laboratory. Patterns of wood consumption, wood consumption rates and survival are discussed.

Sung-Min KWON, Won-Joong HWANG and Nam-Hun KIM: **Annual ring formation of major wood species in Korea**, *Proceedings of the IAWPS 2003 Intl Conference on Forest Products 30th Anniversary of the Korean Society of Wood Science and Technology*, Daejeon, South Korea, April 21–24, Volume 2, 1022–1030 (2003).

The process of annual ring formation of two softwoods (*Pinus densiflora* S. et Z. and *Pinus koraiensis* S. et Z.) and four hardwoods (*Quercus mongolica* FIHCHER, *Robinia pseudoacacia* LINNE, *Cornus controversa* HEMSLEY and *Prunus sargentii* REHDER) grown in Chunchon was investigated with an optical microscopy. In *P. densiflora* and *P. koraiensis*, the cell division of cambial zone early in April, and proceeded more actively at the beginning of May. The formation of latewood cells started at the end of August in *P. densiflora*, and in the middle of October in *P. koraiensis*. Resin canal in *P. densiflora* and *P. koraiensis* was formed at the end of July and at the beginning of May, respectively. In *Q. mongolica*, which is a ring-porous wood, the formation of vessels began in the end of March, and vessel formation was finished in earlywood at the beginning of April, and then latewood cells appeared. In *R. pseudo-acacia*, the first row of vessel in earlywood was formed in the middle of April, and the third row of vessel at the beginning of June, and then latewood cells. The tyloses in *Q. mongolica* and *R. pseudo-acacia* were observed in the middle of May and at the beginning of June, respectively. In *C. controversa*, the diffuse porous wood, the formation of cells was observed in beginning of May, and the pore multiple in the early of May. In *P. sargentii*, the formation of cells was observed in the middle of April, and the pore multiple in the early of May. In all species,

the cambium activity was ceased in the middle of November. When comparing cambium divisions, the following order was observed; ring-porous wood > softwood > diffuse-porous wood. Consequently, it is revealed that the cell division in cambial zone and the pattern of annual ring formation showed significant differences among the species.

OKABE, K., K. TSUNODA and T. YOSHIMURA: **Estimate of foraging populations of transferred colonies of *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae)**, *Wood Research*, No. 89, 37–38 (2002).

Foraging populations of three transferred colonies of *Coptotermes formosanus* Shiraki were estimated by a conventional triple-mark-recapture program and fast-marking technique. No remarkable differences in populations were found between two estimates. Foraging populations of the transferred colonies were unexpectedly small and ranged from 14,000 to 84,000.

MUIN, M. and K. TSUNODA: **Profile and effect of process parameters in the preservative treatment of wood-based composites using supercritical carbon dioxide**, *Proceedings of the fourth International Wood Science Symposium*, Serpong, Indonesia, Sept. 2–5, 145 (2002).

The profile of process parameters (temperature and pressure) in the preservative treatment of five types of wood-based composites and effects of the parameters on the mechanical strength and biological resistance of the treated materials were evaluated when supercritical carbon dioxide was used as a carrier solvent. During the introduction of liquid carbon dioxide into the treatment vessel to attain a target pressure level, pressurization rates and orders of magnitude differed with temperature levels. Although mechanical strength and biological resistance against decay fungi and subterranean termites varied among treatment conditions and composite types, the treatment at 35°C–7.85 MPa seemed promising.

MUIN, M. and K. TSUNODA: **IPBC treatment of wood-based composites using supercritical carbon dioxide**, *Proceedings of the sixth Pacific Rim Bio-Based Composites Symposium*, Portland, Oregon, USA, Nov. 10–13, 333–338 (2002).

Five kinds of structural-use wood-based composites [medium density fiberboard (MDF), hardwood plywood, softwood plywood, particleboard and oriented strand board (OSB)] were treated with 3-iodo-2-propynyl butylcarbamate (IPBC) using supercritical carbon dioxide (SC-CO₂) as a carrier solvent under 9 treatment conditions. The treated samples were tested for their decay resistance in the laboratory according to the modified Japanese standard method in which samples were exposed to a monoculture of two decay fungi for 12 weeks. IPBC/SC-CO₂ treatment could increase the decay resistance of any wood-based composite based on the relative efficacy of treatment against decay (RED) $\{[(\% \text{ mass of the untreated samples}) - (\% \text{ mass loss of the treated samples})] / (\% \text{ mass loss of the untreated samples}) \times 100\}$. Although decay resistance varied with treatment conditions, the maximum RED values of MDF, hardwood plywood, softwood plywood, particleboard and

OSB were 92, 99, 45, 43 and 21 against the white-rot fungus, *Trametes versicolor* (L.: Fr. Pilat, respectively, and 54, 100, 93, 67 and 15 against the brown-rot fungus, *Fomitopsis palustris* (Berk. et Curt.) Gilbn. and Ryv., respectively. The best performance was obtained at 55°C/11.77 MPa for MDF, hardwood plywood and particleboard, and 35°C/9.81 MPa for softwood plywood and OSB. However, most of the treatments did not succeed in depressing both decay fungi to the satisfactory level (<3% mass loss). It was possibly due to the insufficient amount of IPBC introduced under the current treatment conditions. Therefore, a further study is planned to determine the required amount of IPBC to be incorporated under some selected treatment conditions.

MUIN, M., A. ADACHI, M. INOUE, T. YOSHIMURA and K. TSUNODA: **Feasibility of supercritical carbon dioxide as a carrier solvent for preservative treatment of wood-based composites**, *J. Wood Sci.*, **49**, 65–72 (2003).

Supercritical carbon dioxide (SC-CO₂) was tested for its potential as a carrier solvent for preservative treatment of solid wood and wood-based composites. A preliminary trial showed that the treatability of solid wood varied with its original permeability and that the SC-CO₂ treatment was not promising for refractory timber species such as a *Larix leptolepis* Gordon. In contrast, 3-iodo-2-propynyl butylcarbamate (IPBC)/SC-CO₂ treatment resulted in enhanced decay resistance without any detrimental physical or cosmetic damage in all structural-use wood-based composites tested: medium density fiberboard, hardwood plywood, softwood plywood, particleboard and oriented strand board (OSB). Further trials under various treatment conditions [25°C/7.85 MPa (80 kgf/cm²), 35°C/7.85 MPa, 45°C/7.85 MPa, 35°C/11.77 MPa (120 kgf/cm²), and 45°C/11.75 MPa] indicated that although small changes in the weight and thickness of the treated materials were noted for a few cases of softwood plywood and oriented strand board. The results of this study clearly indicated that the treatment condition allowed SC-CO₂ to transfer IPB into wood-based composites, and the optimum treatment condition seemed to vary with the type of wood-based composite.

TSUNODA, K.: **System of European wood preservation standards**, *Mokuzai Hozon (Wood Preservation)*, **28**, 189–193 (2002) (in Japanese).

System of European standards regarding wood preservation is mentioned together with a brief history and necessity of standardization in Europe. Durability of solid wood and treated wood was discussed in relation to hazard classes with an emphasis on harmonization among the relevant standards.

TSUNODA, K.: **Biological resistance of wood-based composites in a protected, above-ground test in southern Japan**, *Proc. IUFRO-All division 5 conference*, Rotorua, New Zealand, Mar. 11–15 (2003).

Five kinds of commercially available wood-based composites were tested for their resistance against decay fungi and subterranean termite attack according to the above-ground test method originally developed to evaluate performance of sill plates of the Japanese houses. Ten

replicates (10 cm square x board thickness) were prepared from medium density fiberboard (MDF), hardwood plywood (HP), softwood plywood (SP), particleboard (PB) and oriented strand board (OSB). Each specimen was placed on a 19 cm high concrete block with pine sapwood feeder stakes in the hollows of the concrete block. Specimens were allocated into five groups, two each of the five wood-based composites and each group was covered with a PVC box to protect the specimens from weather. Annual visual inspection was conducted and the degree of decay and termite attack was rated according to AWPA standards [10: sound, 9: trace to slight, 7: moderate, 4: heavy, and 0: failure] since installation of the specimens on June 22, 1999. During the first year, no decay sign was observed on most of the specimens except for a single specimen each of SP and OSB. Both MDF and PB performed better than the other materials against subterranean termite attack [*Coptotermes formosanus* Shiraki and *Reticulitermes speratus* (Kolbe)]. Mean termite rating of the five wood-based composites were 9.9, 9.1, 9.0, 9.8 and 8.5 for MDF, HP, SP, PB and OSB, respectively. As expected, progress in biological attacks on the specimens was noticed in the second year. Decay sign became more prominent on some specimens, especially on the OSB specimens. Termites attacked most of the specimens to some extent in the same period. These results suggest that preservative treatment is needed to protect wood-based composites from decay and termite attack even in above-ground use.

TSUNODA, K., H. WATANABE, K. FUKUDA and K. HAGIO: **Effects of zinc borate on the properties of medium density fiberboard**, *Forest Prod. J.*, **52**(11/12), 62–65 (2002).

Since wood composites are increasingly used under conditions conducive to biodeterioration, more attention should be paid to their preservative treatment. We examined the resistance of medium-density fiberboards treated with zinc borate to fungal and termite attack. Medium-density fiberboards (300×300×2.7 mm) made of radiata pine (*Pinus radiata* D. Don) were treated with zinc borate to target retentions of 0.25, 0.50, 1.00 and 1.50% BAE (Boric Acid Equivalent). Zinc borate was incorporated into the fiberboards by introducing the chemical into the blender. Standard laboratory tests (JIS A 5905) demonstrated that there was no significant loss in mechanical or physical properties [modulus of rupture, modulus of elasticity, internal bond, water absorption and thickness swelling] of the boards. A laboratory decay test using a monoculture of *Trametes versicolor* (L.: Fr.) Pilat and *Fomitopsis palustris* (Berk. et Curt.) Gilbn. & Ryv. showed that treated boards were well protected from both fungi at 1.00% BAE with a mean mass loss of less than 3%, whereas values of 4.7% and 28.0% were recorded with untreated boards, respectively, with *T. versicolor* and *F. palustris* after the same exposure period (8 weeks). Below 0.50% BAE, the treated board specimens were attacked by subterranean termites, *Coptotermes formosanus* Shiraki, to some extent (40% of the untreated boards), and an increase in the zinc borate content (1.00 and 1.50% BAE) gave good termite protection in the laboratory. Field trials should be planned to determine the performance of

zinc borate-treated medium-density fiberboards under conditions simulating practical applications.

TSUNODA, K. : Economic importance of Formosan termite and control practices in Japan, *Sociobiology*, 41(1), 27-36 (2003).

The Formosan subterranean termite, *Coptotermes formosanus* Shiraki, has threatened Japanese wooden construction for more than 300 years. The distribution of *C. formosanus* is generally limited to the warmer coastal regions, although this distribution has also been reported to extend to areas with a monthly mean temperature in January of $>4^{\circ}\text{C}$ and to inland areas. It is estimated that the cost of preventing and controlling termite infestations is at least \$US 800 million a year based on the amount of termiticidal formulations consumed in 1996. In addition to the conventional chemical soil and wood treatments, considerable attention has recently been paid to improving the environmental conditions in the crawlspace to reduce the risk of decay and termite attack in Japanese homes.

TSUNODA, K. and M. MUIN : Preservative treatment of wood-based composites with a mixture formulation of IPBC-silafluofen using supercritical carbon dioxide as a carrier gas, *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP03-40251 (2003).

Wood-based composites treated with a mixture formulation of a fungicide, 3-iodo-2-propynyl butylcarbamate (IPBC) and a termiticide, silafluofen using supercritical carbon dioxide (SC-CO_2) as a carrier solvent were tested for their resistance to decay and termite attack in the laboratory. The treatment solution was prepared by mixing both biocides (IPBC 10 + silafluofen 1) with a co-solvent, ethanol to have an identical ratio of each constituent in the commercial formulation for superficial treatment of wood. SC-CO_2 treatments were conducted at $35^{\circ}\text{C}/7.85\text{ MPa}$, $35^{\circ}\text{C}/9.81\text{ MPa}$ and $55^{\circ}\text{C}/11.77\text{ MPa}$ with a direct introduction of the biocidal solution into the treatment vessel where specimens ($210 \times 30\text{ mm} \times$ thickness) of medium density fiberboard, hardwood plywood, softwood plywood, particleboard and oriented strand board were placed. Laboratory tests were conducted with the treated materials according to Japanese standard methods. Results of laboratory tests indicated that the current treatment conditions significantly enhanced the resistance of the treated wood-based composites against fungal and termite attacks. Comparison with the results obtained for wood-based composites treated with an individual biocide showed that treatment with a mixture would not cause any negative effect to the efficacy of each biocide, although the amount of each constituent in a mixture formulation must be carefully decided to provide wood-based composites with a satisfactory performance against any biological degradation when SC-CO_2 is used as a carrier solvent.

MORRIS, P.I., J.K. GRACE, K. TSUNODA and A. BYRNE : Performance of borate-treated wood against *Reticulitermes flavipes* in above ground protected conditions, *The Int. Res. Group on Wood Preserv.*, Document No. IRG/WP 03-30309 (2003).

Termites cause economically significant damage in

Canada only in a few localized areas. However, one of those is Canada's largest city, Toronto, Ontario. In 1996, a test was set up of borate-treated lumber above ground, protected from rain but exposed to subterranean termites (*Reticulitermes flavipes*) in Kincardine, Ontario. The material included western hemlock and ambilis fir lumber treated with borate and chromated copper arsenate (CCA). After 6 years exposure, the treated material was generally performing well, with some pieces showing residual signs of earlier superficial feeding or cosmetic damage. Performances of borate-treated and CCA-treated samples were equivalent. Attack was moderate on untreated controls.

KOMATSU, K., S. TAKINO, M. NAKATANI and H. TATEISHI : Lateral shear performance of multiple lag screwed timber joints with timber side members, *Proceedings of World Conference of Timber Engineering 2002*, Shah Alam, Malaysia, August (2002).

Lag screw timber joints have an advantage that enables to connect members from one-sided surface while bolted joints require double surfaces for completing connection. Due to this convenience, in the field of Japanese wooden residential houses, requirements for the structural use of lag screws even for timber-to-timber connections are getting increased recently. However in Japan, uses of lag screws for timber to timber structural joints are being prohibited, thus we intended to execute a series of experimental jobs for presenting scientific information by which uses of lag screws for timber to timber structural joints can be realized. We prepared basically five different combinations of test specimens composed of single main member and double sided members connected by a several lag screws located along one line. As a total, more than 70 test specimens were fabricated and destructive tests were done by monotonous tensile loading for one specimen and cyclic loading with ultimate tensile loading for another two replications. Clear tendency that as the number of lag screw increased the maximum joint strength per fastener decreased. This tendency could be predicted well by applying the Lantos's classical theory which has been used in the US National Design Specification for explaining the effect of multiple fasteners joint. On the basis of experimental results, we proposed a tentative permissible strength value of lag screw for the use of timber to timber structural joints subjected to loading parallel to the grain.

KOMATSU, K., S. TAKINO, M. NAKATANI and H. TATEISHI : Analysis on multiple lag screwed timber joints with timber side members, *Proceedings of International Council for Research and Innovation in Building and Construction, Working Commission W18, Timber Structures*, CIBW18/35-7-2, Kyoto, September (2002).

Non-linear load-slip relationships of multiple lag screwed timber joints with timber side members were analyzed by making use of the classical Lantos's theory which dealt with load distribution in the members of general multiple timber joints under axial force. Load-slip relationships obtained from single lag screwed joints were fitted by the three parameters exponential function. Then step-wise load incremental calculation method was

applied on a series of the finite deferent equations, which were obtained by applying Lantos theory to the multiple lag screwed timber joints under axial force. A series of experimental study was also conducted on the double sided timber to timber joints fastened by single raw lag screws. We prepared basically five different combinations of test specimens composed of single main member and double sided members connected by a several lag screws located along one line. From the comparisons between calculations and experimental result, it was recognized that the non-linear calculations could predict the non-linear load-slip behavior at least up to the yielding point of each multiple lag screwed joint. So far as using the 'load incremental method', it was difficult to predict precisely on the ultimate stage of each multiple joint specimens.

KOMATSU, K., S. TAKINO, T. MORI, Y. KATO, M. NAKATANI, A. KITAMORI and Y. KATAOKA: **Development of wooden semi-rigid column-beam joints by utilizing wedges and bolts**, *Proceedings of 4th International Wood Science Seminar*, Serpong, Indonesia, 205–211, August (2002).

This research was started intending to make utilizing Japanese domestic softwood timber Sugi for the structural materials of wooden residential houses. As the first step in this large scale research project, a new type of column-beams jointing method was developed by using wedges and single bolt. Moment-rotation relationship of the 'L-shaped' column-beams joint specimens were evaluated by the static push-pull cyclic loading tests, and their moment-rotation relationships were best-fitted by the three parameters exponential function (3P-exp) for the calculation of the semi-rigid portal frames which were constructed using the same column-beams joints. Three portal frames were estimated by the static push-pull cyclic loading tests. Comparisons between observed load-deformation relationship and calculated one showed very good agreement. From these experimental results, a new type column-beams joint developed here seemed to be usable for wooden residential houses.

HWANG, K.H. and K. KOMATSU: **Bearing properties of engineered wood products I: effects of dowel diameter and loading direction**, *Journal of Wood Science*, 48(4), 295–301 (2002).

The embedment tests of laminated veneer lumber (LVL) with two different moduli of elasticity (MOE), 7.8 GPa and 9.8 GPa, parallel strand lumber (PSL), and laminated strand lumber (LSL), were conducted in accordance with ASTM-D 5764. The load-embedment relationship for each of these engineered wood products (EWP) was established. The directional characteristics of bearing strength (σ_e), initial stiffness (k_e), and effective elastic foundation depth were obtained from the tested results. The effective elastic foundation depth ($\alpha = E/k_e$, $E = \text{MOE}$), based on the theory of a beam on elastic foundation, was obtained from the k_e and MOE. The α of 90 degree (perpendicular to the grain) was calculated by dividing into E_{90} (MOE of 90 degree from compression test, but MOE of zero degree (E_0), parallel to the grain, obtained from bending test) by k_{e90} , initial stiffness of 90 degree. This paper aims to obtain the bearing

characteristics of each EWP, taken into consideration of their anisotropic structure, for estimating fastening strength of dowel type fastener. The relations between the bearing coefficients (σ_e , k_e , α) on loading direction and dowel diameter were established from the load-embedment curves. From the results of embedment test, tested EWP showed different tendencies in all directions from wood and glued laminated timber (GLT).

Hwang, K.H., K. Komatsu and W. LEE: **Effect of nail pitch on the shear performance of nailed GLT-plywood specimens**, *Wood Research*, No. 89, 1–5 (2002).

Nails, used without predrilling holes in the wood, prevent the decrease of slip modulus by their clearance at the predrilled hole as like bolt fastening. For the purpose of investigating the effect of nail pitch on the shear properties of nailed plywood-sheathed glued laminated timber (GLT) specimens. Double sided single shear tests were conducted by varying nail pitch from 50 mm, 75 mm, 100 mm, and to 150 mm. The slip displacements measured at three different place, i.e. upper, bottom and center, were almost same. It was concluded from this experiment that the slip modulus were not affected by the nail pitch and showed that there were big dispersions on the observed values. The yield strength showed constant values despite of nail pitch. The maximum strength increased slightly as the nail pitch increased. Judging from these experimental results, it might be concluded that the effect of nail pitch on the shear performance of nailed plywood sheathed GLT specimen could be ignored, thus from the practical point of view, nail pitch has no significant effect on the design calculation.

KOMATSU, K.: **Joint**, in *Recommendations for Limit State Design of Buildings*, p. 206–224, Architectural Institute of Japan, Maruzen (2002) (in Japanese).

The chapter for timber joints were revised to suite with the format of limit state design method which was adopted in Recommendations for Limit State Design of Buildings edited by AIJ committee.

HAYASHI, T., M. KARUBE, K. HRARADA, T. MORI, T. OHNO, K. KOMATSU and Y. IJIMA: **Shear tests of timber joints composed of sugi composite glulam beams using newly developed steel connectors**, *Journal of Wood Science*, 48(6), 484–490 (2002).

A research project supported by the Japan Wood Working Machinery Association has been conducted since 1999 to examine the feasibility of sugi (*Cryptomeria japonica* D. Don) composite glulam beams reinforced with Douglas fir (*Pseudotsuga menziesii* Franco) lamination. This study, part of the project, was concerned with the strength properties of timber joints composed of composite glulams using newly developed structural steel connectors. Two types of beam were prepared: 10 plies (inner 6 plies sugi, outer 4 plies Douglas fir) and 8 plies (inner 4 plies sugi, outer 4 plies Douglas fir). Two types of structural steel connector, "Haratec" and "Standard," were used for joining the beam with a post or a girder. The relation between load and deformation of the joints was represented as a typical non-linear curve. Initial stiffness and maximum load of the joint composed of the composite

glulam were in the range between those of sugi and Douglas fir. Strength properties of the joints varied with three variables: type of connector, depth of the glulams, and the type of joint. Thus, the allowable loads for the connectors should be determined for each combination of these variables.

KOMATSU, K., R. AOYAGI, K.-H. HWANG and M. NAKATANI: **Lateral shear performance of wooden diagonal braces structures using small lagscrewbolts**, *Wood Research and Technical Notes*, No. 38, 218–238 (2002) (in Japanese).

In order to develop a wooden diagonal brace structure that can perform same strength in both push and pull lateral shear force, we designed a truss structure whose members were connected with each other by the small lagscrewbolts at the geometrical nodal point without eccentricity. Experimental results showed that this type of new diagonal brace system could performed almost same strength value both in push and pull loading cases.

KOMATSU, K.: **Basic properties of law material named as timber**, *Kenchiku to Machizukuri*, No. 302, 6–11 2002 (in Japanese).

Basic properties of timber as a law material of timber structures were explained mainly for architectural designers.

KOMATSU, K.: **The State of the arts of recent semi-rigid timber frame structures**, *Perfect Manual for Timber Houses Which are Strong Against Earthquake*, p.182–187, Exknowledge-Muk (2002) (in Japanese).

States of the arts for recent development of timber semi-rigid portal frame structures were reviewed.

KATO, Y., K. KOMATSU and A. KITAMORI: **Effect of wedges on the stiffness and strength of column-“Nuki” (Narrow beam) joints in traditional timber frame structures**, *Mokuzai Ggakaishi*, 49(2), 84–91 (2003) (in Japanese).

In this study, we intended to clarify the role of wedges in column-beam (“Nuki”) joints and to propose a method for calculating the optimum depth of insertion of wedges. As a first step, embedment tests of wedge specimens were done. Next, the optimum depth of insertion was calculated assuming that it was optimum when the average compressive stress on the wedges was equal to the proportional limit stress. Third, push-pull static cyclic loading tests for column-beam (“Nuki”) cross specimens were done to verify our assumption proposed in the second step. Test results on column-beam (“Nuki”) joints showed that the highest ultimate moment capacity was obtained when relatively low-rise wedges at optimum depth of insertion were used. Higher initial stiffness was observed in joints when depth of insertion was doubled to its optimum, and also when hardwood wedges were used. High-rise wedges tend to rotate as the rotation angle of the framing becomes large. Relatively low-rise wedges (5 to 10 degrees) were therefore thought to be suitable for achieving higher moment capacity and sufficient ductility, because such a combination can ensure more stable contact among wedges, column and beam (“Nuki”).

From the above discussion, it can be concluded that when relatively low-rise wedges were used, the optimum depth of insertion given by the theoretical formula based on the hypothesis proposed in this study and the strength of the joint are roughly in conformity.

NOGUCHI, M. and K. KOMATSU: **New proposal for a method to estimate stiffness and strength of bolted timber-to-timber joints and its verification by experiments**, *Mokuzai Ggakaishi*, 49(2), 92–1103 (2003) (in Japanese).

Up to now, we have been using the so-called ‘theory of a beam on an elastic foundation’ (TBEF) for estimating stiffness (slip modulus), and European yield theory (EYT) for estimating yield load of single dowel joints with timber side members. TBEF, however, requires very complicated calculations for double-sided timber-to-timber joints. Thus we proposed a new estimating method by defining ‘Semi Slip Condition’ as the new boundary condition at the interface between side member and main member. There the moment was set to zero and shear force equal to the applied load in order to make the main and side members independent, and to consider them as independent serial springs. We could get relatively simple equations for estimating stiffness. As it is not good to use different theory for estimating stiffness and yield load, we also used the TBEF to estimate yield stress in timber and bolts. Subsequently, the hypothesis we proposed was confirmed by a series of experiments.

KOMATSU, K., S. TAKKINO, T.MORI, M. NAKATANI, A. KITAMORI and K.-H. HWANG: **Development of wooden semi-rigid column-beam joints by utilizing wedges and bolts**, *Proceedings of the International Association of Wood Products Society 2003*, Vol. 1, 166–172, Daejeon, Korea (2003).

A new type of column-beam joint was developed by making use of hardwood wedges and a single bolt. Moment-rotation relationship of the ‘L-shaped’ column-beam joint was evaluated by static push-pull cyclic loading tests. Moment-rotation relationships were fitted by 3P-exp function for calculating nonlinear deformation of semi-rigid portal frames which were constructed using the same column-beam joints. Three portal frames were evaluated by static push-pull cyclic loading tests. Comparisons between observed load-deformation relationship and calculated one showed very good agreement. From these comparisons, it was concluded that performance of semi-rigid portal frame could be predicted precisely by knowing rotational rigidity of column-beam joint properly.

HWANG, K.-H. and K. KOMATSU: **Shear strength of drift-pin fastening on structural composite lumber (SCL) with inserted steel plate in air and wet condition**, *Proceedings of the International Association of Wood Products Society 2003*, Vol. 1, 55–62, Daejeon, Korea (2003).

The purpose of this paper is to supply information essential to the proper designs of dowel type fastening joints in engineered wood products (EWP) constructions. From embedment test of dowel and four types of structural composite lumber (SCL), there was distinct result that, in

each loading direction, bearing properties with dowel diameter were different with glued laminated lumber (GLT) and wood. SCL should be considered into anisotropic characteristics to design dowel type fastening from its embedment test results. It is available to estimate the yield load (P_y) by European yield theory (EYT), the slip modulus (K_s) by elastic foundation theory, and the non-linear finite element method analysis (FEMA) by using the results of embedment test and drift pin four point bending test. But, these theoretical analyses are acceptable on design step, especially in air condition. Therefore, it is necessary to get hold of the differences of shear properties in deteriorated condition, wet condition as extreme case. Wet specimens were conditioned by the test method of Building Letter (1998). The two kinds of shear tests, on air condition (control) and wet condition, were performed on the four directions of SCL and drift pin fastening with diameter 12 mm. The parallel types (LT and LR specimens) by tensile loading to the inserted steel plate and the perpendicular types (TR and RT specimens) by compressive loading to it were conducted. The yield load (P_y) and slip modulus (K_s) were obtained from tested load-slip relations. Shear strengths of all wet-conditioned specimens were lower than control specimens. Shear properties of LT specimens in all SCL, especially, were recorded remarkable declines compared to rest direction's specimens.

KITAMORI, A., Y. KATO, Y. KATAOKA and K. KOMATSU : **Proposal of mechanical model for beam-column 'Nuki' joint in traditional timber structures**, *Mokuzai Ggakaishi*, **49**(3), 179–186 (2003) (in Japanese).

In this paper, moment-resisting properties of 'Nuki' joints were studied. *Nuki* is the narrow beam member which penetrate the column. On *Nuki* joint, wedges are driven into between column and beam when a *Nuki* structure is assembled. When the wedges driven into the joint, the joint members are tightly stiffened each other. However, the mechanism of pre-stress inflicted by wedge has not been cleared up to now. In this study, we proposed a mechanical model of *Nuki* joint in which moment resistance is assumed to be induced from both friction and embedment between contacting members, and according to this assumption we derived simplified estimation method on rotational behavior by taking the magnitude of initial bearing force into consideration. In the next step, we prepared specimens that various initial bearing force was set as the experimental parameters. From the experimental strain results measured in the joint part, the suitability of the mechanical model was confirmed. The calculated and experimental moment-deformation angle relationships were well agreed with each initial bearing force level. In the case of small deformation angle region, the higher the initial bearing force is applied, the higher the rigidity and yielding moment was observed compared with those who were not applied such high initial stress. But once deformation angle become larger, the amount of initial bearing force did not affect on the moment capacity. This is because in the case of high initial stress, frictional resistance worked remarkably as well as beam tended to yield rapidly due to the effect of initial damage. From this it was concluded

that the theoretical equations derived in this report are appropriate.

MORI, T., K. KOMATSU, S. TAKINO, Y. NODA, K. HARADA and K. WATANABE : **Experimental study on the tensile strength of Sugi and Douglas fir mixed Glulam**, *The fourth International Wood Science Symposium, Indonesia*, 213–218 (2002).

The first purpose of this research was to use Japanese domestic softwood timber 'Sugi' (*Cryptomeria japonica* D. Don) mixed with Douglas fir (*Pseudotsuga menziesii* Franco) timber as Glulam. These Sugi timbers are obtained from small diameter logs having low Young's modulus. This report is a result of tensile tests with Sugi and Douglas fir mixed Glulams. These specimens were mixed Glulams which outer part was Douglas fir and the inner part was Sugi and of two heights (150 mm, 300 mm). The results showed increased strength and Young's modulus when compared to Sugi only Glulams. A model for estimating the tensile strength was the second purpose of this paper. The model is based on the assumption that a lamina of Glulam is divided into minute elements in the direction along the length and each minute element having the strength dependent on knots, finger-joints or clear wood. The calculation was accomplished by means of Monte Carlo simulation based on this model. The results showed good accordance with the experimental measurements making it a good model to estimate the strength of Glulams.

MORI, T. : **The history of glulam and recent researches on structural glulam properties**, *Wood Res. and Technical Notes*, **38**, 13–21 (2002) (in Japanese).

This paper shows the history of Glulam and recent researches on structural Glulam properties. At first the history of the Glulam was shown in this paper. The Glulam was made by the German Company in 1901. The several properties of the Glulam have researched on the some of countries. One of them is Japan. So this paper shows the recent researches on structural Glulam in Japan. The estimating technique of Glulam properties is getting better. Some of results were shown in this paper.

MORI, T., T. KITAMURA, H. ISODA, S. TAKAHASHI and A. SASAGAWA : **The bending creep behavior of glulam beam under different temperature and humidity conditions**, *J. of Structural Engineering*, Vol. 49B, 593–598 (2003) (in Japanese).

This report describes the bending creep behavior of Glulam under three different environments. These three conditions were: constant-environment (constant temperature and humidity), natural-environment, and high humidity-environment. This study compared the bending creep behavior under the three environments and showed the relationship between the temperature and the bending creep. As a result of the comparison the following conclusions were found. 1) Creep under high humidity environment was 2 times higher than the creep under the constant environment. 2) Estimated value of the bending relative creep was more than 200% after 50 years. This deformation was higher than the deformation defined by the "Standard for Structural Design of Timber

Structures". Consequently we realized that we must be cautious about the bending creep deformation of high humidity-environment. 3) Although the averages of temperature and humidity for the natural-environment were the same as for the constant-environment, the bending creep deformation under natural-environment was 10% higher than under constant-environment. Therefore the variations of temperature and humidity were the cause of an increase in the bending creep deformation. Hereafter we need to investigate the bending creep under changing temperature and humidity. Using a method of dividing first creep and second creep parts proposed by us in a previous paper we obtained a good estimated value of the creep effect, which confirmed the validity of the method.

MORI, T., K. KOMATSU, S. TAKINO, Y. NODA, K. HARADA and K. WATANABE: **Experimental study on the tensile strength of Sugi and Douglas fir mixed glulam**, *International Conference on Forest Products, Daejeon, Korea*, 226-231 (2003).

The first purpose of this research was to use Japanese domestic softwood timber 'Sugi' (*Cryptomeria*

japonica D. Don) mixed with Douglas fir (*Pseudotsuga menziesii* Franco) timber as Glulam. These Sugi timbers are obtained from small diameter logs having low Young's modulus. This report is a result of tensile tests with Sugi and Douglas fir mixed Glulams. These specimens were mixed Glulams which outer part was Douglas fir and the inner part was Sugi or all part was only Sugi. And the height was increased from 150 mm to 300 mm with a step of 30 mm. The comparison of tensile strength and Young's modulus between Sugi Glulam and mixed Glulam is shown in this paper. The results showed increased strength and Young's modulus. A new model for estimating the tensile strength was the second purpose of this paper. The model is based on the assumption that a lamina of Glulam is divided into minute elements in the direction along the length and each minute element having the limited strain dependent on knots, finger-joints or clear wood. The calculation was accomplished by means of Monte Carlo simulation based on this model. The results showed good accordance with the experimental measurements making it a good model to estimate the strength of Glulams.