Identification of *Dalbergia odorifera* with Burl Using GC-MS Technique

Zhu Tao[1,2.]

(1 Furniture Products Quality Supervision and Testing Center of Putian, Xianyou 351256, Fujian, China; 2 Wood Carving and Antique Funiture Products Quality Supervision and Testing Center of Fujian Province, Xianyou 351256, Fujian, China)

Abstract: *Dalbergia odorifera* (youli) with burl have been identified using headspace sampling method based on gas chromatography mass spectrometry technique, and its main characteristic peaks and the chemical compositions were explored aimed at providing the theoretical foundation for identification rapidly and accurately. Results showed that six main characteristic peaks existed in *Dalbergia odorifera* (youli), and the peak time concentrated between 20 ~ 25 min. Meanwhile its main chemical compositions were alkene and acetylene chemicals. Also, the fingerprint has been built according to its main characteristic peaks.

Keywords: Gaschromatographic mass spectrometry, *Dalbergia odorifera* with burl, Wood identification

Evolution of wood cell wall nanopore size distribution in the hygroscopic range

Jingbo Shi[1], Stavros Avramidis[2]

(1 Nanjing Forestry University, Department of Wood Science and Engineering, 159 Longpan, Nanjing, Jiangsu, 210037, China; 2 University of British Columbia, Department of Wood Science, 2424 Main Mall, Vancouver, BC, V6T 1Z4, Canada)

Abstract: More and more effort is being devoted to better understand cell wall architecture at the nanoscale, largely due to the growing need for biofuels, bioproducts and stronger wood products with better in-service performance. Since the pore structure is part of the cell wall nanostructure, the cell wall pore study also becomes a hot topic. Pores can be defined as spaces in cell walls that are not filled by cellulose, hemicelluloses, lignin and extractives. The origin of these pores is unknown. It is possible that these pores are caused by the partial space filling between cellulose microfibrils by lignin, hemicelluloses and extractives. It is also possible that they exist inside the wall polymer chains or in- between interfaces due to their less-packed orientation. The cell wall pore configuration which includes the pore size distribution, geometry and accessibility, is part of the wall architecture, but it is poorly understood. The main challenges are: 1) the average pore size of cell walls is less than 2nm and there are few methods to explore the pores in this range; 2) the cell wall pores are usually filled by water and their sizes change in the hygroscopic range, that is, PSD is changed in the sorption process. Thus, it is challenging to maintain the cell wall pore structure at a specified moisture contents in the experimental exploration.

Here, a “trial-and-error” approach was proposed to calculate such distribution through bridging experimental and simulated sorption isotherms presented by the authors in the past. Two main assumptions were made in the calculations, namely, the generation of new and the swelling of existing cell wall pores during water sorption. The nanopore size distribution of dried cell wall derived from the experimental CO_2 gas sorption isotherms was used as the initial boundary condition. Predicted pore size distributions were assessed to be fairly reasonable by comparing them at 95% relative humidity with the PSD of fully saturated cell walls derived from the solute exclusion method. The predicted distribution was relatively wide with several major peaks evolving in the hygroscopic range.

The present work also showed that confounded by a wide PSD that includes mostly micropores, the shape of the experimental sorption isotherms was not reliable in assessing the sorption mechanism. The simulations suggested an alternative water sorption mechanism for wood, i.e., micropore filling of cell wall nanopores.

Keywords: cell wall pores, trial-and-error, wide pore size distribution, wood, water sorption**3**

Comparative Analysis of Bacterial Community Structure and Diversity during Agarwood and Mountain-agarwood Formation

Juan Liu[1*], Xingyun Chai[2], Luqi Huang[1*]

(1 National Resource Center for Chinese Materia Medica, China Academy of Chinese Medical Sciences, Beijing 100700, China; 2 Modern Research Center for Traditional Chinese Medicine, Beijing University of Chinese Medicine, Beijing 100029, China)

Abstract: Agarwood is the resinous wood portion of Aquilaria sinensis in China, which is used as one of the famous southern medicinal plants. As an important substitute for agarwood, mountain-agarwood, belonging to the family Oleaceae, comes from the root, stem and thick branch of *Syringa pinnatifolia* Hemsl., which has a wide range of application in Inner Mongolia, China. They have good clinical efficacy in the use of the nervous system and cardiovascular diseases, respectively. However, the formation speed is extremely slow, and their cultivated seedlings have low resin content. Therefore, how to speed up the formation of agarwood and mountain agarwood, and increase the resin content is a hot research topic in this field. In this work, 16S rDNA amplicon sequencing method was used to systematically analyze the bacterial communities of different sections of agarwood and mountain-agarwood. Our data showed that both of the resin parts had more obvious species diversity than the non-resin ones. Healthy white wood of A. sinensis had the largest difference in bacterial community compared with the resin part of agarwood. Compared with agarwood, the resin and non-resin mountain-agarwood samples had small differences of bacterial community. In addition, there are two similar genus of dominant bacteria, namely *Sphingomonas* and *Microbacterium*, which might play a role during the agarwood and mountain-agarwood formation. The comparative study was firstly used to investigate the bacterial population structure and diversity during the agarwood and mountain-agarwood formation. Our work could provide basic data for exploring the common mechanism of the agarwood and mountain-agarwood formation.

Keywords: Agarwood, Mountain-agarwood, bacterium, population structure, population diversity

Radial variation studies on wood properties of populus and their hybrid progenies

Hao Shen, Jun Rao, Ying Guan, Liping Zhang, Hui Gao, Shengquan Liu

(Anhui Agricultural University, School of Forestry and Landscape Architecture, Hefei 230036, Anhui, China)

Abstract: ［Objective］Taking the *Populus deltoides* CL 50 , the *Populus nigra* CL N179 and their three hybrid progeny（zhonglin46、guariento populus、sangju populus）as the research object, the radial variation of wood properties between parents and offspring was analyzed. The purpose of this study is to provide a certain theoretical basis for cultivating high-quality poplar germplasm resources. [Methods] The chemical, physical and anatomical properties were determined by national standard. [Results] The results of wood properties showed that the mass fractions of benzene alcohol extractives of parents and their three offspring were varied from 1.36%~2.15%, and the mass fractions of holocelluloses were 79.23%~83.19%, respectively. The mass fractions of hemicelluloses were 35.09%~35.94%, and α-celluloses were 43.34%~47.25%. The lignin content of Lin 46 was 20.70%~24.73%, which was lower than that of its parents. However, the chemical content of other offspring was between their male parent and female parent. The basic densities of the five poplar species were varied from 0.33 to 0.39 g·cm-3, the fiber length was 971.06~1145.65 μm, the fiber width was 16.19~19.36 μm, and the ratio of fiber length to width was 57.07~67.28. The ratio of wall to cavity was 0.26~0.31, and the ratio of cavity to diameter was 0.76~0.80. With the increase of age of the trees, the mass fraction of benzene alcohol extractive was increased at first and then decreased, the holocellulose increased rapidly at first 5 years, and then tended to be stable. The mass fraction of α-cellulose was increased gradually with the increment of tree age, the wood mass fraction was decreased gradually, and the basic density was increased gradually of Zhonglin46 and the female parent, but decreased gradually in the male parent and another two offsprings. The fiber length was increased gradually with the increment of tree age, and the increasing rate decreased obviously at the tree age of 7 to 8 years old. The fiber width increased gradually, and the fiber length-width ratio was increased gradually, and the increasing rate became slower after 7 years old. The wall-cavity ratio was decreased at first and then increased, reaching the lowest at 6 to 7 years old, while the cavity-diameter ratio increased at first and then decreased, reaching the highest at 6 to 7 years old. [Conclusion] According to the results of the analysis of wood properties, the female parent poplar No. 50 and the offspring Zhonglin 46 were much more suitable for used as the raw material of pulp. Rotation can be chosen in the 8th year.

Keywords: *Populus deltoids*, *populus nigra*, hybrid progeny, chemical composition, fiber morphology, radial variation

Variation of cell wall structure and composition during the growth of *Calamus simplicifolius*

Kun Wang, Genlin Tian, Jianfeng Ma, Xinge Liu*

(International Center of Bamboo and Rattan)

Abstract: Rattan is an important interlayer plant in tropical and subtropical forests. Cane is an important lignified fiber raw material second to wood and bamboo, which has high economic and potential utilization value. The cell wall is the load bearing structure of the stem, and its ultrastructure and composition deposition are the basal causes of the stem properties. The study systematic investigated the anatomical structure and cell wall ultrastructure and composition of the *Calamus simplicifolius* during the growth stages by confocal Raman microscopy techniques, confocal fluorescence microscopy, transmission electron microscopy, liquid crystal polarized light microscopy and atomic force microscopy. The fluorescence imagings showed that cell differentiation and the lignin deposition of the protoxylem vessel were firstly surveyed. The degree of lignification of the whole vascular bundle increased with the cell growth. The lignin in vascular bundles was mainly concentrated in the cell corners and compound middle lamella of all kinds of cells. Lignin in fiber cell was mainly deposited in the cell corners and compound middle lamella, while carbohydrates were mainly distributed in the secondary wall. Raman images further illustrated that the carbohydrates concentration of broad-layer was slightly higher than that of the narrow layer, but the concentration of lignin was lower than that of the narrow layer in the secondary wall. The analysis of Raman spectral intensity showed that The deposition rate of carbohydrate and lignin in the early stage of cell growth was higher than that of the middle and late stages. Lignin and carbohydrate concentration of different types of cells in the secondary wall were also shown some differences. The systematic study on the anatomical structure and cell wall ultrastructure and composition of the *Calamus simplicifolius* during the growth stages not only facilitates an in-depth understanding of the formation mechanism of the rattan, but also provides theoretical guidance of the high-value utilization, genetic improvement and orientation cultivation of the *Calamus simplicifolius*.

Keywords: *Calamus simplicifolius*, anatomical characteristics, component deposition, variation.

Study on the anatomical structural characteristics of *Chionanthus retusus*

Maoya Ran,Yougui Li, Xian Wang, Jian Qiu*

(College of Materials Science and Engineering, Southwest Forestry University, Kunming, 650224, China)

Abstract: *Chionanthus retusus* is a tree from the Chionanthus of the Oleaceae family,being native to Gansu,Shaanxi,Shanxi,Hebei,the south of Henan to Yunnan,Sichuan,Guangdong, Fujian,Taiwan, and growing in sparse mixed forests,thickets,hillsides or rivers below the elevation of 3000m. It is cultivated everywhere,Korea and Japan also have cultivation. It is a kind of the better species of ornamental and practical capabilities. At present,the anatomical structure of *Chionanthus retusus* were not recorded in related literature,the identification of *Chionanthus retusus* was not reference. *Chionanthus retusus* wood as the object of study,three sections were made and molecular segregation was performed. The microstructure and segregation structure were analysed using Leica DM2000 LED microscope and Nikon ECLIPSE 80i biological digital microscope. The results showed that: The type of vessels of *Chionanthus retusus* was ring-porous wood, the shape of vessels in the cross section was round or ovoid,the arrangement of vessels was dendritic or flame-like. Vessels groupings were exclusively solitary,in radial multiples of 2-5 or more common and clusters common. The length of vessels was 134-361μm and the average value was 233μm. Tyloses was not found in vessels,and the perforation plates was simple. Helical thickenings were existed in narrower vessels elements. The arrangement of intervessel pits was alternate and the shape was ovoid. The vessel-ray pits with much borders to apparently simple were rounded or angular. The arrangement of axial parenchyma were vasicentric,marginal bands and diffuse. The vasicentric tracheids were located around the vessels with helical thickenings and intermixed with parenchyma,they were easily seen in segregation materials and slightly longer than vessels,the length was 143-393μm and the average value was 277μm. The length of fibers were 505-1181μm,the average value was 867μm,the cell wall was thin to thick and had bordered pits. The rays were not storied. The exclusively uniseriate rays were rare,their length were 1-11(20-126μm) or more cells,most of them were 2-5 cells. The multi-row rays' width were 2-4 cells(12-31μm),most were 3 cells,the 2 rows portion was often as wide as the single-row portion,the length of multi-row rays were 4-15 cells(56-168μm). The multi-row portion sometimes appeared twice in a ray. The cellular compositions of rays were procumbent,body ray cells procumbent with one row of upright and/or square marginal cells and body ray cells procumbent with mostly 2-4 rows of upright and/or square marginal cells. According to the anatomical structure of *Chionanthus retusus*,and referring to the microscopic characteristic index of IAWA

hardwood identification system,the corresponding characteristic codes of *Chionanthus retusus* were obtained:1,3,8,11,12,13,22,31,39,52,60,61,66,69,71,76,79,89,92,97,104,106,107. It can provide reference for the identification in the future.

Keywords: *Chionanthus retusus*, anatomical structure, wood segregation

Study on the Microstructure and Pore Structure Characteristics during the Development Process of *Camellia oleifera* shell

Shanshan Chang, Yunlai Bo, Qianqian Wang

(College of Materials Science and Engineering, Central South University of Forestry and Technology, Changsha Hunan, 410004, P.R.China)

Abstract： *Camellia oleifera* is a woody plant. *Camellia oleifera* seed oil has high oil content and is also an important oil crop in China. *Camellia oleifera* is abundant in the southern provinces of China, such as Hunan, Guangxi, and Guangdong. In the process of processing *Camellia oleifera* seeds into tea oil, 1 ton of *Camellia oleifera* will produce 0.54 tons of shells, which account for about 50% to 60% of the total fruit weight. Although the reserves are large, most of the *Camellia oleifera* shells are often being discarded, landfill or incinerated without being properly utilized, which not only causes a certain pollution to the environment but also causes waste of resources. At present, the research on the shell of *Camellia oleifera* mainly focus on the extraction of its chemical components into the culture medium, pharmaceuticals and cosmetics, etc. Because of the high content of lignin in the fruit shell, it can also be used to make activated carbon, but few studies have explored its biological characteristics. In order to use the shells more efficiently, the study on its microstructure and pore structure characteristics has a certain positive significance. In this study, paraffin-embedded technology was used to embed the *Camellia oleifera* shell at different growth stages (March-October) to ensure that the cell structure was relatively complete, and the paraffin-embedded slices were observed by light microscopy. At the same time, the specific surface area and pore structure of *Camellia oleifera* shells were characterized by nitrogen adsorption-desorption method, and the pore shape was explored by analyzing the adsorption-desorption isotherm. The results showed that the main cell types of *Camellia oleifera* shell include vessels, vascular tissue, parenchyma and stone cells. During the beginning developing process, the changes of stone cells are the most obvious, which is formed by the increasing and thickening of parenchyma cells near the exocarp. Tissue ratio of stone cells increased from 0% to 12.1%. In July, stone cells basically matured, followed by parenchyma, vessels and vascular tissue gradually growing to maturity during fruit maturation. The cell walls of the above four cell types have pits structure, and the number of pits on the wall of the stone cell is the largest and obvious. From March to August, the nitrogen adsorption-desorption isotherms of *Camellia oleifera* shell are basically type II and the hysteresis loop belongs to H2(b) and H3 type, and there are mainly layered slit pores. From August to September, the adsorption isotherm of the fruit shell belongs to type IV, the hysteresis loop belongs to the combination of H2(b) and H3, and the pore type is slit type and conical combination. In October, the adsorption isotherm of *Camellia oleifera* shell belongs to type IV adsorption isotherm, and the hysteresis is a combination of H3 and H5, and the pore type is a conical type combined with an ink bottle. The pore size distribution is mainly mesopores, mainly concentrated between 2 and 20 nm, and there are a small number of micropores and macropores. At the different developmental stages, the BET of *Camellia oleifera*

shell was 129.39m2/g at the initial development stage, and then increased to a peak of 100.18m2/g after decreasing. The change of pore volume shows the similar trend as BET, which may be related to the development of cells in the shell, especially stone cells. Compared with other woody materials, the mature *Camellia oleifera* shell's BET is much larger than that of common softwood and hardwood, and is smaller than that of bamboo. *Camellia oleifera* shell is a kind of nature biomass material with abundant pore structure, which has a certain development prospect in the preparation and application of biomass templates or other high-performance biomimetic materials.

Keywords: *Camellia oleifera* shell, Paraffin embedding, Microstructure, Nitrogen adsorption, Pore structure

Construction and Drawing of 3D Model of Microstructure of Wood-based Materials

Tianshu Yang[1], Shanshan Chang[2*], Qianqian Wang[3], Yujing Tan[4], Jinbo Hu[5]

(School of Materials Science and Engineering, Central South University of Forestry and Technology, Changsha, Hunan, 410004)

Abstract: As an important renewable resource, wood resource materials have the characteristics of ecological materials such as recyclability, pollution-free environment and low economic cost. They are the main source of synthetic-related biomass-based composite materials. The observation and study of the microstructure of wood materials is the basis for understanding and utilizing wood materials. However, due to the complex structure and rich content of the basic anatomical structure of wood materials, the traditional learning methods are mostly limited to the two-dimensional plane understanding of tissue cell structure,lack of comprehensive recognition and understanding of three-dimensional. In this paper, using Pro/Engineer modeling technology, based on the optical microscope observation and analysis results of three sections of transverse, radial and chord, the basic cell structural unit morphology and cell wall of three typical wood materials (*Pinus massoniana*, poplar and *Camellia oleifera*) are firstly studied. The upper structural features are constructed in three-dimensional models, such as tracheids, resin channels, ducts, fibers, axial parenchyma cells, ray cells, vascular bundles, and the like. Then, according to the arrangement and combination of each cell tissue in the wood material and the specific amount of each tissue, the basic cell tissue units are assembled to construct a 3D model of the overall tissue structure distribution of three typical wood materials. This study builds and maps the three-dimensional model of the microstructure of three typical wood materials, which can fully understand and understand the three-dimensional distribution, morphological characteristics, cell wall structure characteristics and connection characteristics of each cell tissue of various cellular materials. Cellular tissue rises from a preliminary understanding of the two-dimensional plane to a comprehensive understanding of three-dimensional. The 3D model can be observed from three dimensions and further analysis of the specific structure, which has important scientific and practical significance for the development of wood science. At the same time, this study can provide a basic reference for the in-depth study of wood structure and the development and utilization of wood aesthetic value, as well as provide a certain biological theoretical basis for the preparation of biomass template and high performance biomimetic materials. The anatomical study on the coniferous and hardwood has been relatively mature, but the research on the biomass and the remaining material of the biomass, *Camellia oleifera*, is still in its infancy. Although the cell composition can be understood from the three aspects, the causal shell morphology With the particularity of the function, it is still impossible to accurately determine the accurate arrangement of the internal organization structures and the orientation of the main cell tissues such as catheters and vascular bundles, and further research is needed.

Keywords: wood-based materials, Camellia husk, microstructure, Pro/Engineer modeling, 3D model

Wood informatics：deploying machine learning approaches (MLAs) in wood identification research

Tuo He[1,2], Lichao Jiao[1,2], Maomao Zhang[1,2], Yang Lu[1,2], Xiaomei Jiang[1,2], Yafang Yin[1,2*]

(1 Research Institute of Wood Industry, Chinese Academy of Forestry; 2 Wood Collection of Chinese Academe of Forestry)

Abstract： In this study, the data of wood anatomical images, DNA sequences and chemical profiles were analyzed by machine learning approaches to find the specific anatomical characteristics, DNA barcodes and characteristic compounds of similar wood at the species level, and then accurately identify similar wood species. On this basis, a scientific and technical system of wood identification with wood informatics as the core was formed to reveal the variation patterns of wood anatomical, genetic and chemical characteristics to realize the accurate and rapid identification of wood at the species level.

Keywords: Wood informatics, Machine learning approaches (MLAs), Wood anatomy, DNA barcoding, Chemical profile

Species Identification of Ancient Wood relic from YangZhou Museum

Qiao Lin, Jiayan Luo

(College of Materials Science and Engineering, Nanjing Forestry University)

Abstract: Archaeological wood, it is an important carrier of human civilization. In order to cooperate with the work of yangzhou museum, the cultural relics no: 2017AMM2:9 (no. 2), 2017AMM2 (no. 6), YHM14 (no. 8), yangmiao ear cup (no. 13) were identified. it is difficult to slice them directly, because most of the unearthed ancient trees are in a state of full water and serious decay. After the embedding and strengthening of polyethylene glycol (PEG) with a molecular weight of 4000, three sections with a thickness of about 15 microns were cut by the combination of freehand slicing and slide slicing machine, and the slices were sealed with glycerin. Observation and photography were performed with OLYMPUS BX51 microscope and compared with the standard section. The results showed that the identification result of sample no. 2 was the wood in *Cunninghamia lanceolate*. The identification result of no. 6 sample is the wood in *Phoebe*. The identification result of sample no. 8 was the wood in *Salix*. The identification result of sample no.13 was the wood in *Alnus*. The appraisal results provide the scientific basis for the restoration and protection of these wooden relics.

Keywords: Archaeological wood, Wood identification, Wooden preservation

Studies on the structure and chemical compositions of cell wall in P. zhennan and C. camphora after degradation by brown-rot and white-rot fungi

Yujin Bi, Biao Pan

(Nanjing Forestry University, China)

Abstract: In order to explore the chemical components of decayed *Phoebe zhennan* and *Cinnamomum camphora* , samples of these two species were exposed to white-rot fungi(*Trametes versicolor*) and brown-rot fungi(*Fomitopsis palustris*) for different durations up to 12 weeks. The degree of decay was evaluated via microscope , FTIR and XRD. Under fluorescent light microscope, secondary wall's fluorescent intensity were weaker than cell wall clearance in white rotten wood, and the fluorescent intensity of brown rotten wood were stronger than white rotten wood. Under the polarizing microscope, white rotten wood retained strong birefringence characteristic while brown rotten wood had weak birefringence. For samples decayed by white-rot, there was a decrease in the intensities of lignin associated peaks(at 1236cm-1, 1510cm-1 and 1599cm-1 in P. zhennan and at 1236cm-1 and 1599cm-1 in C. camphora), indicating that lignin was degraded by white-rot. For those decayed by brown-rot, there was a corresponding decrease in the intensities of carbohydrate peaks(at 2915cm-1and 1740cm-1), indicating that cellulose and hemicellulose was degraded by white-rot. The crystallinity of white rotten wood decreased gradually after different exposure periods. The crystallinity decreased from 57.84% and 50.78% to 54.85% and 46.92% after 6 weeks of white-rot decay for P. zhennan and C. camphora, respectively, and further decreased to 49.70% and 46.95% after 12 weeks. On the other side, the crystallinity basically remained unchanged after 6 weeks of brown rotten wood for P. zhennan and C. camphora, and decreased from 57.84% and 50.78% to 49.78% and 41.30% after 9 weeks, finally increased to 52.36% and 51.24% after 12 weeks. The decrease of crystallinity indicated that the ordered structure of cellulose crystallization area was destroyed white-rot fungi and by brown-rot. Results showed that white-rot fungi mainly degraded lignin, which could destroy the benzene ring and carbon skeleton structure of lignin, while brown-rot fungi mainly degrades the side chains of cellulose and hemicellulose, and gradually degraded the crystalline area of cellulose.

Keywords: white rot, brown rot, cell wall structure, chemical compositions

Study on cell structure and chemical composition of reaction wood in *Pinus Sylvestris*

Junyi Peng, Rui He, Xin-xin Zhang, Jiangtao Shi*

(College of Materials Science and Engineering, Nanjing Forestry University, Nanjing 210037, Jiangsu)

Abstract: The anatomical characteristics of compression wood in different areas were observed and measured by optical microscope and scanning electron microscope. NERL method, FTIR and XRD were used to study the effects of growth stress on the chemical characteristics of *Pinus sylvestris*. The results showed that the average thickness of tracheid of the compression wood was 10.62 microns, the average thickness of tracheid of the transition wood was 7.18 microns, and the average thickness of tracheid of the opposite wood was 6.07 microns. The tracheid in the three areas of the wood were affected by different degrees of growth stress, which caused the tracheid to become short and wider. Growth stress in *Pinus sylvestris* composition wood may induced the formation of traumatic resin channel. The density of samples in the composition wood of *Pinus sylvestris* was 0.66kg/m3, the content of extract was 7.37%, lignin was 35.34%, cellulose was 29.68%, and hemicellulose was 26.84%. The sample density in the opposite wood was 0.40 kg/m3, the extract content was 2.24%, the lignin content was 28.08%, the cellulose content was 39.12%, and the hemicellulose content was 24.15%. NERL and FTIR data showed that the proportion of lignin in the composition wood was much higher than that in the opposite wood, and the proportion of acid-insoluble lignin was the highest. The growth stress in composition wood has no effect on lattice structure in crystal area. The crystallinity of composition wood, transition wood and opposite wood were 27.85%, 39.37% and 42.98%.

Keywords: *Pinus sylvestris*, compression wood, wood anatomy, FTIR, XRD

The study on the *Dalbergia Odorifera* found in tomb of Song Dynasty unearthed in Nanjing

Xiran Li, Xinxin Zheng, Biao Pan

(College of Materials Science and Engineering, Nanjing Forestry University, Nanjing 210037)

Abstract: A piece of wood was found in the ancient tombs of the Song Dynasty，which was discovered in Shimenkan, Qinhuai District, Nanjing. The tree species between the lid of the coffin and tenon was identified. Through slicing and staining, the microscopic structure of the wood is observed by the optical microscope. The components of benzene alcohol extraction from wood were identified by GC-MS. The identification shows that the wood used for tenon is *Dalbergia Odorifera* .This archaeological discovery is the earliest example of the use of *Dalbergia odorifera* in Chinese woodware.

1. Observation of timber structure characteristics.

(1) The macroscopic characterization of wood: the wood is purple brown and dense. The growth ring is slightly obvious, from porous to semi porous material. It has abundant types of axial parenchyma, such as banded parenchyma, axial parenchyma winged-aliform, axial parenchyma vasicentric and tangent shape. The ray of wood is very thin. The ripple marks on the chord surface are obvious. The wood has a light aroma.

(2) The microstructure of wood (Figure 1): the cross-section of wood duct is oval, solitary pore, a few 2-3 short diameter multiple pipe holes. There is some gum in the vessels. Simple perforation plates, intervessel pits alternate and vestured pits are its characteristics. The types of axial parenchyma are affluent. There are 8 or more rhombic crystals in the parenchyma cells. There are 8 or more rhombic crystals in the parenchyma cells. The wood rays are storied structure. Rays exclusively uniseriate are few. Multiple row rays are 2-3 cells wide, mainly 2-row rays, and 5-9 cells high. Vessel–ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell.

2. Determination of chemical composition of wood extracts.

The spectrum of GC-MS (Figure 2) shows that: consistent with the spectrum in the literature, The Identification of *Dalbergia Odorrifera* and *Dalbergia Benthami Prain* on the Basis of GC-MS Analysis(Liu Yang,2016) and The Identification of *Dalbergia Odorrifera* and *Dalbergia Benthami Prain* on the Basis of PY-GC-MS Analysis (Ruoke Ma 2018),the wood has substances such as cis-Nerolidol and6,7-epoxide-humulene.

3. Conclusion: Compared with the main *Dalbergia Linn. f.* in China, it is concluded that the wood is *Dalbergia odorifera*. This research is the earliest example of the application of *Dalbergia odorifera* in wood products. It shows that *Dalbergia odorifera* has been used in Nanjing as early as Song Dynasty, and its special properties such as smell, wood color, strength and density have been recognized to some extent.

Keywords: *Dalbergia Odorifera*, Ancient wood, Identification of species, Anatomical structure, GC-MS

Study on the wood anatomic Characteristics of *Michelia fujianensis* Q. F. Zheng

Jiabao Chen, Bowen Chen, Cai Liu, Jiale Sheng, Xiaolian Wu, Xin Guan, Jinguo Lin*

(College of Material Engineering, Fujian Agriculture and Forestry University, Fuzhou, Fujian, 350002)

Abstract: *Michelia fujianensis* Q. F. Zheng was a precious broad-leaved tree species in Fujian Province. The macroscopic and microscopic structure of *M. fujianensis* wood by means of novel zoom stereomicroscope, biological digital microscope and electron microscope. Calculation of roundness of pore in cross Section by MATLAB. Comparative microstructure structure of wood with four other tree species of the same genus (*Michelia macclurei* Dandy, *Michelia chapensis* Dandy, *Michelia maudiae* Dunn, *Michelia skinneriana* Dunn). The results showed that the main macroscopic characteristics of *Michelia fujianensis* were gray bark, thick 3-4mm, small lenticel and side-to-side setup. The heartwood was light-green-brown, the sapwood was buff, the distinction was obvious between the heartwood and sapwood, with no special smell and no taste, with gloss, and growth ring was obvious. Under the magnifying glass, the pore was not clear and the terminal parenchyma was clear, the wood ray was visible under the naked eye, there was neither wavemark nor intercellular canal. The main microscopic features of wood: diffuse-porous wood, the number of pore was very large (268.93/mm^2), the pores were extremely small (average 39 μm), and pore shape was polygonal, consisting of solitary pore, multiple pore and pore cluster, with spiral thickening and even sediments, the perforation plates were commonly scalariform and simple were rarely seen; terminal parenchyma and less paratracheal parenchyma, and oil cells are occasionally found in parenchyma cells; the wood ray were not storied and more type II and less type III, wide 1-4 cells (mainly 2-3 cells), high 4-54 cells (most 12-20 cells), the ray cells were widened at the boundary of the growth wheel; ray-vessel pitting was scalariform pitting and transiens, and unilaterally compound pitting. Compared with *M. fujianensis*, the other four kinds had fewer pores, oil cells of *M. macclurei* and starch grains in parenchyma were more; the number of bars of scalariform perforation in *M. maudiae* was more and some perforation plates were located in the middle of vessel; some of pore cluster in *M. chapensis* earlywood were often filled with two wood rays and parenchyma contained starch grains; The longitudinal parenchyma of M. skinneriana has a small number of scanty paratracheal and diffuse parenchyma, and the parenchyma contain starch grains. The evolution degree of the circularity of the five kinds of wood pore was sorted as follows: *M. maudiae* >*M. skinneriana* >*M. chapensis* > *M. fujianensis* >*M. macclurei*. The research results can provide the basis for the identification and rational utilization of *M. fujianensis*.

Keywords: *Michelia fujianensis* Q. F. Zheng, Wood anatomy, *Michelia L.*, MATLAB, Circularity

Anatomical structure and properties of xylem of knee root of Taxodium distichum

Xinxin Zheng

(College of Materials Science and Engineering, Nanjing Forestry University, Nanjing 210037, Jiangsu)

Abstract: Taking the 21-year-old knee root of Taxodiaceae as the research object, the anatomical structure and wood properties of knee root of Taxodiaceae were studied to provide theoretical basis for the comprehensive utilization of knee root wood. The relative contents of lignin, cellulose and hemicellulose in different parts (edge and center) of the root were measured by FTIR and NREL(National Renewable Energy Laboratory). The microfibril angle of the root was measured by iodine staining. The crystallinity of the root was measured by X-Ray Diffraction.

Anatomical structure of the root of Taxodiaceae: Transverse section: obvious growth ring, transition from early wood to late wood was gradual, tracheids outline angular, except for the standard radial wall, other walls all have marginal pits, axial parenchyma diffuse, rays exclusively uniseriate; Radial section: ray width 1 to 2 cells, marginal pits on the tracheid radial wall, with one or two rows, cross field pitting Cupressiod. Each bundle of axial parenchyma 2 to 8 cells, most of which were 8 cells. Tangential section: the ray height was about 2 to 22 cells, most of which are in single row, occasionally two rows, without transverse resin channel, and the cell arrangement is relatively twisted;

The mearsured results of tracheid morphology were as follows: the changes of the length and width of the tracheid were from 820 to 2392 μm and 35.61 to 56.35μm respectively. According to the rules of wood anatomical molecular classification, it belongs to medium thickness tracheid. The radial variation of the knee root tracheid morphology was as follows: the tracheid length ranged from 1765.09 to 3631.84μm, and the tracheid width was from 33.81 to 53.12μm. The length of tracheid increased along the radial direction, while the width of tracheid without obvious regularity. Compared with the related parameters of wood in Taxodiaceae, the length of root tracheid of root was less than that of xylem tracheid, and the difference of tracheid width was not significant between them, maybe the tested root was still in juvenile stage;

The results were as follows: there was no significant difference in the relative content of the chemical composition between the middle part of the root and the outer part. Compared with the relative parts (center, edge; the number of rings was the same as that of the root), it was found that the lignin content of the root was slightly higher, and the cellulose and hemicellulose content are lower than that of the wood;

The average value of root microfibril angle of was 35.9°, which was larger than that of S2 layer of normal wood (10-30°), this might be caused by the compression and distortion of the cell structure at the sampling site. The crystallinity of root wood was measured by XRD (34.56%), which was lower than that of normal wood. The basic density of knee root was 0.3669/cm3, and the air dry density was 0.3735/cm3.

Keywords: knee root, anatomical structure, tracheid morphology, chemical composition, microfibril angle, crystallinity

Influence of Cambial Age and Axial Height on the Spatial Patterns of Xylem Traits in *Catalpa bungei*, a Ring-Porous Tree Species Native to China

Shan Li, Xin Li, Roman Link, Ren Li, Liping Deng, Bernhard Schuldt, Xiaomei Jiang, Rongjun Zhao, Jingming Zheng, Shuang Li and Yafang Yin*

(Department of Wood Anatomy and Utilization, Research Institute of Wood Industry, Chinese Academy of Forestry; Wood Collections (WOODPEDIA), Chinese Academy of Forestry; College of Forestry, Beijing Forestry University; Ecophysiology and Vegetation Ecology, Julius-von-Sachs-Institute of Biological Sciences, University of Würzburg; Beijing Center for Physical and Chemical Analysis)

Abstract: Studying how cambial age and axial height affects wood anatomical traits may improve our understanding of xylem hydraulics, heartwood formation and axial growth. Radial strips were collected from six different heights (0–11.3 m) along the main trunk of three Manchurian catalpa (Catalpa bungei) trees, a precious ring-porous tree species native to China, yielding 88 samples including sapwood, transitional zone and heartwood. In total, thirteen vessel and fiber related wood anatomical traits were observed using light microscopy (LM) and scanning electron microscopy (SEM), and linear models were used to analyse the combined effect of axial height, cambial age and their interaction on investigated wood anatomical traits. Our results showed that vessel diameter differed by about one order of magnitude between early- and latewood, and increased significantly with both cambial age and axial height in latewood, while it was positively affected by cambial age and independent of height in earlywood. Vertical position further had a positive effect on earlywood vessel density, and negative effects on fibre wall thickness, wall thickness to diameter ratio and length. Cambial age had positive effects on the pit membrane diameter and vessel element length, while the annual diameter growth decreased with both cambial age and axial position. In contrast, early- and latewood fiber diameter were unaffected by both cambial age and axial height. We further observed an increasing amount of tyloses from sapwood to heartwood, accompanied by an increase of warty layers and amorphous deposits on cell walls, bordered pit membranes and pit apertures. This study highlights the significant effects of cambial age and vertical position on xylem anatomical traits, and confirms earlier work that cautions to take into account xylem spatial position when interpreting wood anatomical structures, and thus, xylem hydraulic functioning. In addition, the influence of cambial age and vertical position on wood anatomical traits strongly linked with wood utilization such as fibre properties provides possible guidance in wood manufacture.

Keywords: wood anatomy; vertical and radial variation; earlywood; latewood; growth ring width; tyloses; pit membrane diameter; vessel lumen diameter; fibre length

Fluorescence visualization about the regular of delignification with alkali concentration in the internode of *A. donax*

Bingwei Chen, Shengcheng Zhai*, Changtong Mei, Xinzhou Wang

(College of Materials Science and Engineering, Nanjing Forestry University, Nanjing 210037)

Abstract: *Arundo donax*, as an indigenous species in China, offers attractive attention for biofuels production due to the high biomass yield. However, the diversity of tissues, the complexity of cell wall structure and the heterogeneity of chemical composition constitute the intrinsic recalcitrance of giant reed, which reduces the efficiency, increases the cost and impairs the practicability of bioconversion. Thus, an effective pretreatment is the key to break the tight structure of cell wall. The study on the topochemical changes during pretreatment can provide theoretical support for the maximum utilization of compositions in the cell wall. In this study, *A. donax* was pretreated by 2.5g/L, 5g/L, 10g/L NaOH-ethanol solution at 90°C water-bath for 2h, respectively. The autofluorescence of lignin showed that lignin in parenchyma could be removed more easily than that in sclerenchyma fibers. With the increase of alkali concentration, the intensity of fluorescence gradually decreased indicating more lignin had been removed. Mäule color reaction made syringyl(S) or guaiacyl (G) lignin present red or yellow under blue excitation light respectively, which could provide more detailed information on type and distribution of lignin at the cellular level. The red color in the secondary wall decreased with the increase of alkali concentration, while the yellow color in the compound middle lamellar was still obvious after pretreatment. When alkali concentration was 10g/L, the lignin content of *A. donax* was decrease from 24.37% to 17.97% and the lignin removal rate was 47.11%. Correspondingly, the enzymatic hydrolysis glucose yield and xylose yield were both at the maximum value of 49.41% and 77.61%, respectively. These results showed that the increase of alkali concentration promoted the removal of lignin and the efficiency of enzymatic hydrolysis. Fluorescence visualization can provide an insight understanding of delignification, which gives basic support in establishing a structure-activity relationship for better bioconversion.

Keywords: *Arundo donax*, vascular bundle, pretreatment, autofluorescence, lignin

Distribution of suberin in bark determined by different dying methods

Bao Zhang, Cheng Yuan, Biao Pan, Shengcheng Zhai

(Nanjing forestry university Materials Science and Engineering)

Abstract: Suberin usually exists in the periderm or root of plants, which regulates water and elements, prevents microorganisms from attacking and reduces the influence of the external environment during plant growth. Determining the distribution of suberin can provide a deeper understanding of physiological functions of suberin in plants. The traditional method of locating suberin is mainly stained by Sudan dye to make suberin colored.In this paper, the bark of *Cerasus serrulata* was used as experimental material. After resin embedding, the sections were stained with toluidine blue, hydrochloric acid-resorcinol, Sudan III, Sudan red 7B, Berberine hemisulfate salt -aniline blue to study the distribution of suberin in phellem.Sudan III and Sudan Red 7B could dye suberin red and pink, and lignin was colorless; toluidine blue could dye lignin blue, suberin was colorless or light blue, and only the fluorescence of suberin could be observed under blue excitation light after toluidine blue dyeing; berberine sulfate-aniline blue dyed area was easier to be observed. Fluorescence of cork and lignin was separated. Hydrochloric acid-resorcinol staining could stain the lignin of LR-white resin-embedded sections with cherry red, while epoxy resin-embedded sections could not be stained with resorcinol.The results showed that all the five staining methods could distribute suberin in the cell wall far from the cell lumen of cork cells. The staining effect of Sudan III under an ordinary microscope was the best. It can specifically recognize and dye suberin red. Under fluorescence microscopy, the distribution of lignin and suberin can be observed after dyeing with berberine bisulfate. After dyeing with toluidine blue, the autofluorescence of lignin can be inhibited and the distribution of phellolipid can be better observed. Hydrochloric acid-resorcinol staining can stain lignin red-brown on sections embedded with LR-white resin. In future research, researchers can try to locate and even quantitatively analyze the chemical substances in plants only by dying.

Keywords: *Cerasus serrulata*, Suberin, Dying method, Fluorescence

Effect of Deterioration in Cell Wall on Nanomechanics of Waterlogged Archaeological Wood from a 170-Year-Old Wooden Shipwreck

Liuyang Han[1,2], Xingling Tian[3], Tobias Keplinger[4,5], Ren Li[1,2], Haibin Zhou[6], Kirsi Svedstrom[7], Yafang Yin[1,2], Juan Guo[*1,2], Ingo Burgert[4,5]

(1 Department of Wood Anatomy and Utilization, Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing 100091, China; 2 Wood Collections (WOODPEDIA), Chinese Academy of Forestry, Beijing100091, China; 3 Heritage Conservation and Restoration Institute, Chinese Academy of Cultural Heritage, Beijing 100029, China; 4 Wood Materials Science, ETH Zürich, 8093 Zürich, Switzerland; 5 Laboratory for Cellulose & Wood Materials, Empa, 8600 Dübendorf, Switzerland; 6 Pilot Base, Chinese Academy of Forestry, Beijing 102300, China; 7 Department of Physics, University of Helsinki, FI-00014 Helsinki, Finland)

Abstract: The effects of morphological structure, chemical structure, chemical composition, porosity, and structural changes of cellulose crystalline on nanomechanical properties of waterlogged wood cell walls due to long-time underwater degradation were in situ analyzed with nondestructive nanoindentation (NI), attenuated total reflection fourier-transform infrared imaging (ATR-FTIR imaging) and confocal Raman microscopy (CRM), etc. It was found that the structures of the C=O stretching vibration in the O=C-OH group and equatorially aligned hydrogen on the C2 atom in the mannose residue in polysaccharides were found seriously degraded; the lignin was slightly oxidized along with the degradation of carbohydrate; the amorphous polysaccharides in cellulose was revealed to be partly decayed; a huge number of mesopores occurred with the decrease of the relative crystallinity and the average crystal width in cellulose; what's more, bacteria decay was observed as a random mixture of intact and decayed fibers in transverse section. With all of these changes together, the resulting was a more than 25% decrease of the elastic modulus and hardness of WAW cell wall.

Keywords: *Hopea sp.* , anatomic structure, mechanical property, chemical structure

Vessel Segmentation of Hardwood Microscopic Images Using Convolutional Neural Networks

Xin He[1], Jian Qiu[2*]

(1 College of Big Data and Intelligent Engineering , Southwest Forestry University; 2* College of Materials Science and Engineering, Southwest Forestry University;)

Abstract: According to wood anatomy identification methodologies, wood anatomical characters such as size, shape, arrangement and distribution of various cells and tissue types found in wood are examined by experts at the microscopic level. This examination often takes a long time and relies on experts' specialized knowledge witch easily conducts a subjective judgement. In order to address these problems, an automated approach of vessel segmentation on the transverse plane of hardwood using convolutional neural networks is proposed. Firstly, a dataset which contains forty images, including 14 ring-porous, 13 semi-ring porous and 13 diffuse-porous hardwood anatomical features images are been built, all these images are selected from the FFPIR institute of Japanese. After that, all these images are labeled by taxonomic experts manually. The image numbers for training soar from 40 to 40000 by augmentation such as rotate, scale, skew and distort. Secondly, transfer leaning is undertaking by using VGG16 as a backbone, loading ImageNet as it's weights. 80% of the images are used as a training set while 20% of others as a test set are feed to the U-NET architecture convolutional neural network. Finally, varies images which come from China, the United States, Brazil, Africa be predicted by the network. The segmentation effect is evaluated by the comparison of artificial segmentation. The results suggest that the mean accuracy reached 93.7% and the segmentation results are rarely affected by the color shift, axial parenchyma, and rays. This method has a high generalization and strong robustness. It provides a reliable basis for the accurate calculation of the anatomical characteristics of vessels.

Keywords: Wood anatomy, Hardwood, vessel, segmentation, CNN, U-NET

Comparison of anatomical characteristics between the compression wood and sound wood of *Taxodium* hybrid‘Zhongshanshan’

Yang Zhao, Yujin Bi, Biao Pan

(Nanjing Forestry University, China)

Abstract: In order to explore the anatomical characteristics differences between compression wood and sound wood of *Taxodium* hybrid ‘Zhongshanshan’, By slicing and dissociating, we explore the differences between them in cell morphology and tracheid size.

The results show that the compression wood tracheids were oval and developed with thick cell walls. In consequence, intercellular spaces are prominent at the junction of tracheids in compression wood. However, the sound wood tracheids were quadrilateral or polygon. On the radial section, there are thread gaps and thread cracks embedded in the inner wall of the compression wood tracheid of *Taxodium* hybrid ‘Zhongshanshan’. Due to the influence of thread cracks, the border pit on the tracheid extend to both sides. And the tip of the compression wood tracheid should be twisted.

Average length of compression wood tracheids and sound wood tracheids were 2300.15μm and 2550.50μm respectively. The microfibril angles of compression wood is 42.2°and the microfibril angles of sound wood is 19.6°. The average thickness of the double wall thickness of compression wood is 12.42μm. The average thickness of the double wall thickness of sound woodis 5.69μm.

Keyword: *Taxodium* hybrid‘Zhongshanshan’, compression wood, sound wood, anatomical characteristics

XRD and FTIR Evaluation of PWF/WFP Lignocellulosic Films

Zuju Shu, Xiaoxu Xu, Runfang Jiang, Shuiqin Yu, Le Yao, Fei Zhou

(School of Light Textile Engineering and Art, Anhui Agricultural University, Hefei, Anhui 230036, China)

Abstract: By taking advantage of the dissolution of lignocelluloses in the ionic liquid [Amim]Cl, novel lignocellulose films based on poplar wood flour/waste filter paper (PWF/WFP) were developed through impregnation-hot pressing-regeneration technology. Based on the macroscopic analysis for the transparency and color of lignocellulosic films, XRD and FTIR were introduced to characterize the effect of the PWF/WFP mass ratio on the solubility of the blended raw materials, and further analyze its influence on the structure and composition of lignocellulosic films. The results showed that the difference of macroscopic transparency and color for each group was related to the solubility of the raw materials. The higher the solubility, the more transparent the lignocellulosic films were. When the amount of PWF was over 60 percent in the blend, its color was the main color of the lignocellulosic films. Compared with PWF, WFP was so easily dissolved by [Amim]Cl that the regenerated cellulose in group A was closely intertwined. Since partial dissolved cellulose became amorphous, the crystallinity thereof was lower than the crystallinity of the pure WFP. With the increase of the PWF's mass in the blend raw material, PWF can not be completely dissolved. The matrix formed by the dissolved portion was not tightly combined with the undissolved portion of the raw material. Therefore, the lignocellulosic films prepared by pure PWF (group F) had the worst integrity. Due to the difference of PWF/WFP mass ratio and the dissolution extent, the crystal form and crystallinity change were complicated. But the composition of each group had no change.

Keywords: ionic liquid [Amim]Cl, poplar flour/waste filter paper, lignocellulosic film

Study on non-destructive testing of lignin with anti-fluorescence interference SERS

Hui Zhang, Jing Li, Shengquan Liu*

(Anhui Agricultural University)

Abstract: The content and distribution of lignin in the cell wall of poplar wood have an important influence on the industrial application of wood. There are many methods detecting lignin of wood. Among them, Raman spectroscopy has good application prospect for its spectra are not extremely sensitive to polar materials such as water, and requires very few samples small sample volumes, such as microgram (milliliter) grade samples can be tested. Raman spectroscopy can be combined with microscopy, may detect cell structure in situ, and it can avoid destroying the cellular tissue. However, there are still some difficulties in practical application of Raman spectroscopy in testing of lignin, due to fluorescence interference of most biomass will produce a strong self – fluorescence when excited by short-wave light, the Raman spectral baseline will be raised to mask part of the Raman characteristic signal.

In this paper, polyaniline with specific morphology and surface roughness as SERS was prepared by free radical polymerization, and Toluidine blue was screened as an antifluorescence interfering agent, impregnated with poplar woods by ultrasound method. The DXR Raman type Fourier Raman spectrometer manufactured by Thermo Fisher Scientific was used for the detection the lignin, and of recorded wavelength range 3600-50 cm^{-1} (Stokes shift). The characteristic peak signal of lignin in the sample was amplified, and the fluorescence interference was successfully eliminated when exited by 532nm laser. It can be observed the characteristic peak intensity ($1600cm^{-1}$) of poplar woods without any treatment was 700 in Raman spectrometer. And the characteristic peak intensity of poplar woods combined with polyaniline and Toluidine blue increased by about 10 times, which is reach up to 10000.The results indicate the characteristic peak has certain enhancement effect when poplar woods combined with polyaniline and Toluidine blue.

Keywords: Raman spectrometer, antifluorescence interfering, SERS

A comparative study on the enrichment of heavy metal cadmium in poplar of Normal Wood and Tension Wood

Gong Rong[1], Yin Chu[1], Shengquan Liu[2]

(1 School of resources and environment, Anhui Agricultural University; 2 School of forestry and landscape architecture, Anhui Agricultural University)

Abstract: With *Populus deltoids* cv. I-69/55 as the research object, potted experiment was conducted by preparing soil with different concentrations of heavy metal Cd (5mg/kg, 20mg/kg, 50mg/kg, 100mg/kg), and untreated soil was set as the control. Under the same growth environment conditions, set up the poplar of normal wood (vertical growth) and tension wood (artificial crown tilt) two growth modes, through the determination of trace Cd pollution of heavy metals in different concentrations of poplar wood and normal growth should be wood of different growth period, in harvest when measuring different parts, different heights and tension wood in different regions of the content of heavy metal Cd, calculate the Bioconcentration factors (BCF) and Translocation factors (TF) as compared to normal wood and tension wood to heavy metal Cd enrichment capability. The results showed that: (1) in terms of growth amount, both normal and tension poplar trees could grow in heavy metal environment. The growth pattern of poplar and the concentration of Cd in the soil have an effect on the growth. The height of normal wood was 7.24%, 1.96%, 11.88%, 19.10% and 9.23% higher than that of tension wood. The ground diameter was 20.36%, 12.76%, 20.10%, 18.08% and 16.43% respectively. At low concentration, the inhibition of heavy metal Cd on the growth of tension wood was less than that of normal wood. The analysis of variance showed that the differences of height and diameter of poplar under different concentrations, different growth periods and different growth patterns were very significant. (2) the content of Cd in bark of different parts was the highest in normal wood and tension wood. However, with the increase of Cd concentration in the soil, the accumulation and distribution of Cd in different parts of poplar will change with the increase of heavy metal content in the soil. Under the low concentration, the Cd content in all parts of the tree is higher than that of the normal wood. The analysis of variance showed that the difference of Cd content of poplar was very significant under different concentrations and different parts, but the difference did not reach a significant level under different growth patterns; in different height of the trunk, under the lowest and highest Cd concentration, the content of Cd in different height of the trunk of the tension wood was higher than that of the normal wood, but in the middle Cd concentration, it was just the opposite. The analysis of variance showed that the difference of Cd content in Poplar under different concentrations was very significant, but it did not reach a significant level under different heights and different growth patterns; in different areas of the tree, the Cd content in the Tension Wood Area was 33.33%, 20.93%, 2.06%, 28.81% and 6.13% higher than that in the Opposite Wood Area. It shows that the absorption capacity of Cd in the Tension Wood Area is stronger than that in the Opposite Wood Area. The analysis of variance showed that the difference of Cd content of poplar was very significant under different concentrations, but the difference did not reach significant level under different regional treatments. (3) in the Bioconcentration factors, except that the BCF of the normal wood and the tension wood in the root are basically the same,

the other parts are all the tension wood larger than the normal wood. Among them, the BCF of leaves, trunk and bark in the tension wood is 30.91%, 4.76% and 29.21% larger than that of the normal wood, and the average BCF of the above ground part is larger than that of the underground part; in the Translocation factors, the TF of each part of the tension wood is larger than that of the normal wood. The TF values of the leaves, trunk and bark were 21.74%, 29.23% and 21.46% higher than that of the normal wood, respectively. Analysis of variance showed that the Translocation factors of poplar was significantly different in different concentrations and different parts, and significantly different in different growth patterns.

Keywords: Poplar, Normal wood, Tension wood, heavy metal Cadmium, enrichment capacity, transport capacity

Physical and mechanical properties of poplar wood chips with different thickness

Xiaoxu Xu, Shuiqing Yu, Runfang Jiang, Zuju Shu

(School of Light Industry and Art Design, Anhui Agricultural University, Hefei 230036)

Abstract: The poplar chips with different thickness were used as raw materials, and the microfibril angle, crystallinity and tensile properties were tested by X-ray diffractometer and universal material testing machine. The results showed that microfibril angle of poplar chips increased with the increase of thickness. But the crystallinity and tensile properties decreased with the increase of thickness. Further analysis of the data showed that the tensile properties were negatively correlated with the microfibril angle, while the tensile properties were positively correlated with the crystallinity. It can be seen that the selection of the thickness of poplar chips will directly affect the mechanical properties of the modified wood, thus providing a theoretical basis for the determination of the subsequent modification methods，modification mechanism and preparation of flexible packaging materials.

Keywords: poplar wood chips, microfibril angle, crystallinity, tensile properties

Study on the structural properties of Robinia pseudoacacia cv.Inermi

Rui Cao, Huangfei Lv, Cong Cao, Lizhuan Zuo, Bin Xu*

(Anhui Agricultural University Hefei 230036)

Abstract: *Robinia pseudoacacia* cv.Inermi is an excellent variety of the genus Fabaceae, which has the characteristics of fast-growing, straight trunk and non-thorn. In this studying, the anatomy properties of *Robinia pseudoacacia* cv.Inermi was studied. The results showed that the length and width of the fiber were 108.26μm and 25.91μm respectively. The ratio of length and width was 50.26. The wall-to cavity and diameter-to-cavity were 0.27 and 0.67. There was no signification difference. However, the tube diameter, wall cavity ratio and cavity diameter ratio were significantly different. The extracts was not as rich as traditional wood. The amount of tissue and pits on the tube wall were much than traditional wood. This may be the basis of its fast-growing physiological structure.

Keywords: *Robinia pseudoacacia cv.*Inermi, Microstructure structural, Anatomy properties

Comparison of anatomical properties of Drepanostachyum luodianense under different site conditions

Cong Cao, Huangfei Lv, Rui Cao, Lizhuan Zuo, Bin Xu*

(Anhui Agricultural University Hefei 230036)

Abstract:［(*Drepanostachyum luodiannse (Yi et R. S. Wang) Keng F.*］is an endangered plant in karst area.In this paper, the main anatomical characteristics of bamboo［ (*Drepanostachyum luodiannse (Yi et R. S. Wang) Keng F.* ］were studied under different site conditions (shady slope and sunny slope).The results showed that the average fiber length, width, double wall thickness, cavity diameter, wall cavity ratio were 1455.17 μ m, 10.59 μ m, 3.37 μ m, 7.23 μ m, 0.46, the average ratio of vessel, sieve tube, fiber, parenchyma tissue was 9.60%, 3.20%, 44.67%, 42.53%, and the average ratio of vascular bundle tangential width、radial width and ratio was 407.79 μ m, 303.03 μ m, 1.39. The diameter of the vessel was 130.27 μ m, and the vascular bundle density was 4.15 pieces / mm2. The average fiber length,width, double wall thickness, cavity diameter and wall cavity ratio of the flowering bamboos were 1810.01 μ m, 9.90 μ m, 3.08 μ m, 6.82 μ m and 0.50, the average ratio of the vessel, sieve tube, fiber and parenchyma tissue was 10.72%, 4.43% 45.01%, 39.84%, and the average ratio of the vascular bundle tangential width、radial width and ratio was 315.45 μ m, 293.40 μ m and 1.18. The diameter of the vessel r was 98.93 μ m, and the vascular bundle density was 7.60 pieces / mm2. Compared with the shady slope bamboos, the fiber of sunny slope is shorter, the vascular bundle tangential width and vessel tangentia diameter are larger, the vascular bundle distribution density is smaller, and other characteristics are not significantly different.

Keywords: shady slope and sunny slope, anatomical properties, fiber, vascular bundle

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Genetic method for Pterocarpus timber identification: optimizing the DNA extraction protocol and applying DNA barcodes

Yang Lu[1,2], Lichao Jiao[1,2*], Yafang Yin[1,2]

(1 Department of Wood Anatomy and Utilization, Chinese Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing 100091, China; 2 Wood Collections (WOODPEDIA), Chinese Academy of Forestry, Beijing 100091, China)

Abstract: Molecular genetic methods have numerous potential applications in wood forensic identification. The isolation of wood DNA is a crucial step in the process of genetic identification for wood tissues. However, there are still practical problems with the current wood DNA extraction method. For some valuable wood samples sent for forensic identification, the amount of usage is limited. Additionally, the identification process is so long that it often cannot meet the needs of law enforcement. This study describes an optimized protocol suited specifically for reducing the amount of sample usage and shortening the period of DNA extraction without decreasing the yield of DNA. Studies on sample amount per extraction, digestion time and DNA binding time were carried out by a series of gradient tests. The amounts of DNA extracted were evaluated with the copy numbers of target DNA barcodes (rbcL and matK) from Droplet digital PCR (ddPCR). The results indicated that 300 mg is an optimal sample amount when keeping the volume of DNA lysis buffer constant, which reduces the sample usage by 40%. Five hours is the optimal digestion time. Moreover, extending the time of DNA binding does not significantly increase the DNA yield from wood tissues. The protocol developed in this study shortens the period of DNA extraction from wood tissues by 57.69%. The DNA yields obtained using the optimized method in this study indicate good extraction efficiency, and the wood samples sent for certification were identified as Pterocarpus erinaceus using the barcode combination matK+ndhF-rpl32+ITS2. This method will be suitable for the broad applicability of DNA identification and conservation of global wood resources.

Keywords: DNA barcode, digestion time, droplet digital PCR, sample amount, timber identification, wood anatomy

Fast Prediction of Mechanical Properties of New Poplar Clones by Near-Infrared Spectroscopy

Ru Jia[1, 2], Rui Wang[1, 2], Yurong Wang[1, 2*]

（1 Research Institute of Forestry New Technology, Chinese Academy of Forestry, Beijing 100091; 2 Research Institute of Wood Industry, Chinese Academy of Forestry, Beijing 100091）

Abstract: Poplar has the advantage of fast growing and large accumulation. It is an important wood species for plantations in China. It is the premise and guarantee to realize reasonable processing and efficient utilization of clonal poplar by continuously revealing the mechanical quality characteristics of new clonal wood and finding a fast and non-destructive mechanical property testing method. 3 new poplar clones, clone 50 (*Populus deltoides* CL.'55/65'), clone 108 (*Populus euramericana* cv.‘Guariento’), clone N179 (*Populus nigra* CL.'N179'), were chosen as the objects and bending strength (MOR), bending modulus of elasticity (MOE), compressive strength parallel to grain and hardness of them were measured, and near-infrared spectroscopy (NIRs) was used on the prediction of these main mechanical properties except hardness. The results showed that MOR of three clones ranged from 65.8 to 68.0 MPa, MOE ranged from 9.2 to 10.0 GPa, compressive strength parallel to grain of three clones ranged from 33.0 to 37.9 MPa and hardness ranged from 1433 to 1540 N. On the whole, all three properties of each clones showed an increased trend from pith to bark, and for clone 50 and 108, the three properties increased more quickly from pith to middle than from middle to bark, but for clone N179, the trend was always moderate. For establishing best PLS models, different mechanical properties should use different methods. When establishing calibration models of MOR, the effect of calibration models using information of radial section and tangential section of comprehensive 3 clones with first derivative and S-G smoothing methods was best. And the correlation coefficients of calibration model (Rc) was found to range from 0.72 to 0.74, correlation coefficients of prediction model (Rp) ranged from 0.71 to 0.72. For MOE, the Rc of calibration models established by using the average spectra of radial section and tangential section combined with MSC and S-G smoothing methods were highest, ranging from 0.75 to 0.84, and Rp ranged from 0.69 to 0.80. Using spectra of cross section combined with MSC and S-G smoothing methods, the calibration model of compressive strength parallel to grain of comprehensive three clones had the best effect with Rc of 0.75 to 0.77, Rp of corresponding prediction models of 0.70 to 0.75. Different with MOR, the accuracy of the model established by integrating three clones was lower than that of the models established by a single clone for MOE and compressive strength parallel to grain.

Keywords: Poplar clones, Mechanical properties, Near-infrared spectroscopy

Exogenous Hormones Induces G-fibre Cell Wall Development in Hybrid Poplar Stems

Min Yu, Junlan Gao, Shengquan Liu*

(School of Forestry and Landscape Architecture, Anhui Agricultural University, Hefei 230036)

Abstract: Plant hormones play an important role in regulation of the reaction wood formation. Here, we report the effect of exogenous hormones on negative gravitropism and G-fiber cell wall development of the stem in woody angiosperms. The hybrid poplar seedlings and growth under natural or controllable condition are used as the research object, poplar seedling plantation as material in the slanted conditions were treated by different kinds of exogenous hormones including gibberellin (GA), auxin (IAA) and 24-epibrassinolide (BL). The morphology of gravitropic stems, anatomy and chemistry of secondary cell wall were measured. We furthermore analyzed the expression levels of cellulose biosynthetic genes by exogenous hormones treatments. The BL, IAA-treated seedlings showed no negative gravitropism bending, whereas application of GA dramatically enhanced negative gravitropic bending. All hormones treatment stimulated G-fiber formation and secondary xylem fiber elongation on the upper side of stems. GA can induced the production of more mature G-fibers on the upper side of stems. Immunolocalization and wood chemistry analyses of TW demonstrated that exogenous hormones treatments increased the cellulose content and modified the deposition of cell wall carbohydrates including arabinose, galactose and rhamnose in the secondary xylem. The expression of cellulose biosynthetic genes, especially those related to cellulose microfibril deposition PtCOBL4 was significantly upregulated in BL, IAA and GA treatments TW stems compared with control stems. The significant differences of G-fibers development and negative gravitropism bending in different hormones application suggests that plant hormones is important for secondary xylem development during tension wood formation. Our findings provide potential insights into the mechanism by which planthormones have regulatory roles in G-fiber cell wall development and secondary xylem cell wall carbohydrate biosynthesis, and accomplish negative gravitropism during tension wood formation.

Keywords: Gibberellin, Auxin, Brassinosteroids, Gelatinous layer, Cellulose biosynthesis, Cell wall carbohydrates

Research on rapid determination of lignin in poplar based on Fourier Transform Raman spectroscopy

Wenli Gao, Liang Zhou, Shengquan Liu*

(School of Forestry and Landscape Architecture, Anhui Agricultural University, Hefei 230036)

Abstract: As a common fast-growing wood, Poplar has broad applications. Lignin is one of the crucial factors in the development and utilization of poplar. At present, the commonly used method to detect chemical composition is chemical method, which was time-consuming, laborious and destructive to the sample. So it is of practical significance to solve these problems by rapid nondestructive testing of chemical components. In this study, the content of lignin in poplar was quantitatively analyzed by Fourier transform Raman spectroscopy. *Populus deltoides* CL.'55/65', *Populus euramericana* cv. 'Zhonglin46',and *Populus euramericana* CL. 'Sangju' was collected as the object of research and the samples were divided into training sample group and test sample group. The model parameters were determined by training samples and the model was corrected by testing samples. In order to obtain the spectrogram information of characteristic peaks, the Raman spectrogram of poplar need to be denoised, the fluorescence background be deducted. Then, Extract the principal component of the obtained Raman information. The obtained principal components were combined with lignin to establish a rapid detection model. The experimental results of *Populus deltoides* CL.'55/65', *Populus euramericana* cv. 'Zhonglin46',and *Populus euramericana* CL. 'Sangju' showed that the modeling results were in line with expectations. The method of rapid detection of lignin is effective and nondestructive.

Keywords: Raman spectroscopy, Lignin, Poplar

Comparative culm anatomy of metaxylem vessel pits in three different types of bamboo rhizome

Junji Luo[1], Rong Liu[1], Shuqin Zhang[1], Caiping Lian[1], Feng Yang[2], Benhua Fei[1*]

(1 Key Laboratory of Bamboo and Rattan Science and Technology of the State Forestry Administration, Department of Biomaterials, International Center for Bamboo and Rattan, Beijing 100102, China; 2 School of Materials Science & Engineering, Beijing Institute of Fashion Technology, Beijing 100029, China)

Abstract：【introduction】Not only are vessel pits vital for the passage of sap into adjacent cells, their anatomical morphology is also used as a tool to identify bamboo species. However, we lack detailed studies comparing the pits' structural parameters in culms of species with three rhizome types: sympodial bamboo, amphipodial bamboo and monopodial bamboo.【method】Scanning electron microscopy (SEM) observations were conducted to obtain the qualitative and quantitative characteristics of vessel pits in sympodial, amphipodial and monopodial bamboos, from twelve bamboo species in eight genera.【result】Sympodial bamboos possess small and ovoid bordered pits, whereas amphipodial bamboos contain an abundance of slit-like pits, with the greatest pit membrane length occurring in the vessel wall. Both minute and large pit sizes can be found in monopodial bamboos. This study identified the first compound pits ever to be found in a bamboo species and these were found to occur more frequently in amphipodial and monopodial bamboos than in sympodial. Using the distribution frequency of the pit chamber's horizontal diameter, we were able to determine pit size as being either small, medium or large.【conclude】The striking differences in the vessel pits' qualitative and quantitative characteristics could be the result by different climate and environmental factors.

Keywords: Sympodial bamboo, amphipodial bamboo, monopodial bamboo, bamboo anatomy, SEM

Effect of heat treatment on the wood microstructure and chemistry from outer to inner layers by AFM and FT-NIR

Demiao Chu[1], Shengquan Liu[1], Jun Mu[2,*], Sohrab Rahimi[3], Samuel Ayanleye[3]

(1 School of Forestry and Landscape Architecture, Anhui Agricultural University, Hefei 230036, China; 2 Key Laboratory of Wood Material Science and Utilization (Beijing Forestry University), Ministry of Education, Beijing, 100083, P.R. China.; 3 Department of Wood Science, University of British Columbia, Vancouver, BC, Canada)

Abstract: Heat treatment is thought to degrade wood especially on surface and cause gluing problems; this study focuses on microstructure and chemistry of different layers on heat-treated wood. The outer and inner surfaces formed by removing the 1, 2, and 3 mm surface layers of heat-treated poplar on the tangential section were investigated. Fourier-transform infrared spectroscopy (FT-NIR) and atomic force microscopy (AFM) detected the cell wall changes. FT-NIR revealed that the intensity of thermal degradation on inner layers alleviated as the removal depth increased. Additionally, AFM analyses showed cell wall's structure became stratified for heat-treated wood. Furthermore, the integration of microfibrils and matrixes declined while the surface strength and bonding capacity increased.

Keywords: Heat treatment, surface strength, thermal degradation, poplar wood

Application of AI Identification Technology in Customs' Wood Supervision

Zhiping Ding, Jingjing Wang, Xudong Chen

(Zhangjiagang Customs)

Abstract: Wood is a commodity of international trade and an important import strategic resource of the country. China imports over 100 million M3 wood per year, which worth over 19 billion US dollars. The species of wood and wood products are important parameters in customs' supervision. Different wood species claimed for different HS codes, regulatory requirements and tax requirements. And the differents of different wood species' price are huge, which are important to the tax collection. Also, the verification of wood species is important to the Protection of CITES endangered wood.

Keywords: Endangered wood species, AI, Wood identification

Research on Three Simple Wood Identification Methods Based on IAWA

Xian Wang, Huajie Shen, Qinglin Yu, jian Qiu

(College of material Science and Engineering, Southwest Forestry University, Kunming, 650224)

Abstract: The IAWA(International Association of Wood Anatomists) lists three method for rapid identification of hardwood species, including foaming test, chrome azurol-s test, and burning ashes test. However, these three methods are rarely used, and there is almost no report on the test results in the literature. The purpose of this study is to report the results obtained from the three test methods of 56 materials. The results showed that 9 out of 56 broadleaf materials had foaming reaction, 15 species were weakly positive, and 32 species were negative. Only six of the 56 species of materials showed a positive chrome-blue color reaction. In burning ashes test, there are 12 species bright white ashes, 14 species burning a tan ashes, there are 10 species burn into other color of ash, 19 species coal ash, the firing only 1 species burning charcoal.

Keywords: Hardwood species, Foaming test, Chrome azurol-s test, Burning ash test

Studies on Wood Anatomical Characteristics and Radial Variation Pattern of Ten Clonal Poplar Wood

Chuanxi Shi, Yingliang Yu, Yingqi Zhu, Yamei Liu, Liang Zhou, Shengquan Liu*

(Anhui Agricultural University School of Forestry &Landscape Architecture Hefei 230036)

Abstract: 【Objective】 The aim of this study is to explore the anatomical characteristics and radial variation pattern of ten clones of poplar wood which provided a theoretical basis for selecting poplar clones of excellent fast-growing plantations. 【Method】The anatomical characteristics and radial variation pattern of different poplar clones, such as fiber length, vessel length, double wall thickness and wall to lumen ratio, were studied by microscope imaging technique. 【Results】 The results showed that the average fiber length ranged from 975.61 to 1152.94μm and fiber width ranged from 15.35 to 21.17μm.The mean ranges of vessel length and width were 378.38 to 491.71μm and 57.24-95.54μm. The double wall thickness and mean cell diameter ranges were 3.01 to 4.36μm and 11.22 to 15.90μm. The average ranges of fiber length-width ratio, wall to lumen ratio and lumen to width ratio were 48.21 to 74.95, 0.18 to 0.41 and 0.72 to 0.85. The fiber length of the *Populus deltoides* CL.'Nanyang' is 1152.94μm, and the length-width ratio is 74.95. The minimum wall to lumen ratio of Populus × euramericana cl. ‘Bofeng 1’ is 0.18, and the lumen to width ratio is 0.85. The fiber length, vessel length fiber length-width ratio, lumen to width ratio and proportion of vessel gradually increased along the radial direction, while the vessel width and lumen diameter first increased and then decreased along the radial direction. The double wall thickness decreases first and then increases along the radial direction. The proportion of wood ray, proportion of fiber and wall to lumen ratio decreased gradually along the radial direction.【Conclusions】 Two excellent pulp clonal clones of *Populus deltoides* CL.'Nanyang' and Populus × euramericana cl. ‘Bofeng 1’ were selected from the ten clones. According to the radial variation pattern, it was found that the anatomical indexes near the 5th or 6th annual ring have met the requirements of pulp and papermaking, which provided a theoretical basis for the early selection and utilization of excellent paper-making clones.

Keywords: poplar, clone, wood, anatomical characteristics, radial variation

Variations of fiber characteristics at the internode and node of *Calamus sp.*

Haina Mi[1,2], Youhong Wang[1*], Jianfang Yu[2], Tao Zhang[2]

(1 School of Forestry and Landscape Architecture, Anhui Agricultural University, Hefei 230036; 2 College of Material Science and Art Design, Inner Mongolia Agricultural University, Hohhot 010018)

Abstract: In order to better guide the rational use of rattan and ease the increasingly tense contradiction between wood supply and demand, *Calamus sp.* was chosen as the object. Using the microscopic image analysis method, we used 3 sets of rattan samples at the 2m position between the node and the internode to statistically analyze and compare. The results showed that: the fiber length, width, length-width ratio, lumen diameter, double wall thickness of internode and node of *Calamus sp.* Were 981.779μm and 921.271μm,7.9μm and 8.7μm,130.822 and 113.021,3.716 and 3.699μm,4.070μm and 5.051μm respectively. From cortex to core the fiber length and length-width ratio of the internode showed a trend of first increasing and then decreasing, that of the node showed a trend of decreasing gradually. The fiber width and lumen diameter of internode and node decreased first and then increased. The thickness of the double wall thickness at internode and node decreased first then increased and gradually increased respectively. It can be known from the F-test at 0.05 level that the fiber width and double wall thickness existed significant difference. The Microfibril angle (MFA) varied from 39.38°to 46.03°with an average value of 42.71°. The CrI varied from44.10%-49.82%with an average value of 46.96%, and the CrI at the cane cortex was larger than that at the core.

Keywords: Calamus sp, internode, node, Morphological characteristics, Microfibril angle, Crystallinity index

Studies on Anatomical Characteristics of Bamboo-Willow Tension Wood

Yamei Liu, Liqun Jiang, Shengquan Liu

(School of Forestry & Landscape Architecture, Anhui Agricultural University, Hefei 230036)

Abstract:【Objective】 The aim of this study is to explore the wood anatomical characteristics of bamboo-willow and provide a theoretical basis for the use of bamboo-willow.【Method】 Two years old bamboo-willow seedlings were selected as materials, the anatomical characteristics were studied by microscope and electronic imaging technique. 【Results】The fiber length of bamboo-willow was belonged to medium level, the length in root was the longest, and secondly in middle area, the shortest in upper areas , the fiber length in tension wood area was longer than opposite areas; there were G-layer in tension wood fiber, the wall thickness of fiber with G-layer was thicker than normal fiber, the amount of G-layer appeared “thick-thin” transformation along radial direction, the amount of G-layer were maximum in root area, secondly in middle area, the least in upper area.

Keywords: bamboo willow, tension wood, anatomical characteristics, fiber, G-layer

Anatomy of vascular parenchyma cells: morphological characteristics and classification of bamboo [*phyllostachys edulis*]

Caiping Lian[1], Rong Liu[1], Junji Luo[1], Feng Yang[2], Shuqin Zhang[1*], Benhua Fei[1*]

(1 Key Laboratory of Bamboo and Rattan Science and Technology of the State Forestry Administration, Department of Bio-materials, International Center for Bamboo and Rattan, Beijing 100102, China; 2School of Materials Science & Engineering, Beijing Institute of Fashion Technology, Beijing 100029, China)

Abstract: Vascular parenchyma cells provide a critical metabolic and energetic link for xylem transport of water and mineral nutrients and phloem transport of photoassimilates. Understanding the morphology of these cells is required to understand their function. This study describes the morphology and classification of vascular parenchyma cells of moso bamboo by light microscopy and scanning electron microscopy. The key results reveal that vascular parenchyma could be divided into three categories according to cell geometric morphology: cells with two flat ends, cells with one flat end and one sharp end, and cells with two sharp ends. Additionally, there were two types of thickening patterns of the secondary wall, uniform and reticulate thickening, and both diffuse pitting and opposite-alternate pitting were observed. The average length, width, lumen diameter, double wall thickness, and area of the vascular parenchyma cells were 139.0 μm, 17.3 μm, 10.4 μm, 6.9 μm, and 51.1 μm2, respectively. Most vascular parenchyma cells are slender and thin-walled, and growth of the vascular parenchyma cells was not correlated in either the length or the width directions.

Keywords: moso bamboo, vascular parenchyma cells, geometric morphology, cell wall, pits arrangement, parameters