

Deposits in Wood Micro-Structures of Some Wood Species

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Abstract

Implications of wood deposits in processing and utilization of wood species of *Terminalia superba*, *Daniella ogea*, *Distemonanthus benthamianus*, *Afromesia elata*, *Mansonia altissima*, *Tectona grandis*, *Gmelina arborea*, *Azelia Africana*, *Pterocarpus soyauxii*, *Guara cedrata*, *Holoptelea grandis* *Khaya ivorensi*, and *Gossweilerodendron bassalmiferun* were investigated in this study. Wood deposits such as resins, gum, crystals, silica, tannins and oils are usually deposited in the wood microstructures (e.g, parenchyma cells) thereby making it impossible for end users to assign wood for certain uses. When in abundance the deposits could pose a great threat during wood processing such as causing dulling effect on saws, difficulty in preservative absorption, inability to bond with other adhesives during board and laminated items production, and staining thereby reducing the aesthetic value of the wood. Some wood species not suitable for cement-bounded were found to be blocked with some deposits such as gum deposits. However, some deposits (tannins, resins and oils) identified in some wood species have made such woods useful in some industries such as leather industry making them of industrial importance and are found useful when abundantly present wood; some wood deposits also confer beauty and also protect wood against bio-deteriorating agents such as termites and beetles. This study revealed the presence of such deposits and their implication on wood processing and utilization; photomicrographs showing their various positions in wood micro-structure are also presented.

Keywords: vessels, parenchyma cells, deposits, utilization and suitability.

Introduction

Past research work has shown that various chemical deposits in the heartwood zone provided the natural durability of wood (Dilip, 1963). Silica, when present in sufficiently large quantity makes the wood resistant to marine borers provided the wood has compact texture. However, deposition of extractives on tracheid lumen walls and on pit structure was found to be a major factor affecting the permeability of redwood and incense cedar heartwood (Mon-Lin and Donald, 1980). Calcerous and gum deposits in the wood of Indian rosewood (*Dalbergia* spp) have also been found to pose problems, as Kaiser (2003) pointed out that logs with calcerous deposits are more prone to checking. Wood deposits can shorten the life span of cutting surfaces, and at the finish stage, although coloured deposits in the pores dissolve when solvents containing alcohol are used, and as a result, this can lead to stains; some wood species glue and finishes well but can create stain as a result of gum deposits which Balakrisman (2010) mentioned as being promoted by poor soils, drought and other hostile situations. The presence of extraneous materials in wood reduces yields of pulp and consumes much chemicals during their removal. Simon et al (2003) similarly observed

that kraft pulp handsheets made from a number of hybrid poplar (*Populus trichocarpa*) clones contains unusual surface deformations caused by vessel element mineral blockages of calcium salt deposit that survived chemical pulping and beating processes. The primary storage forms of photosynthate are starch and lipids content; an abundance of starch can lead to the growth of anaerobic bacteria (that produce ill-smelling compounds) which could make the tropical wood of *Ceiba pentandra* unusable but Chudnoff (1984). In the southern yellow pines of the United States, it was observed that high starch content also encouraged the growth of sap-stain fungi that, though they did not affect the strength of the wood, could nonetheless cause a significant decrease in lumber value for aesthetic reasons (Simpson, 1991). Several wood deposits such as gum, resin, tannin, crystals (of which the most common type is the rhomboidal crystals which are made of calcium oxalate), silicon and extractives have been found in most Nigerian wood species. Blue stains caused by some fungi feeding on wood deposits have been observed in some wood species like *Spondia spp* in Forestry Research Institute of Nigeria, Ibadan. Past research work in the same institute revealed that during the test for match making, the wood species of both *Celtis* and *Bosqueia* burnt with thick smelling smoke as a result of the presence of some deposits present in the wood specie (FRIN, 1965). This made them not suitable for match making. There is no property of wood, anatomical, physical, mechanical, chemical, biological, or technological, that is not fundamentally derived from the fact that wood is formed to meet the needs of the living tree. A complementary view is that any anatomical feature of wood can be assessed in the context of the tree's need for water conduction, mechanical support, and storage of biochemicals. To accomplish any of these functions, wood must have cells that are designed and interconnected in ways suitable to perform these functions. The lateral permeability and transverse flow is often very low in hardwoods owing to the fact that the vessels are sometimes blocked by the presence of tyloses and/or by secreting gums and resins in some other species. However, the presence of gum veins is often a natural protective response to injury in most Eucalyptus, while tannin has been extracted in wood species like *Rhizophora racemosa* (Dickson and Giwa, 1980) for the manufacture of leather. Gum deposits in some wood species have also been found useful in the production of adhesives by the appropriate industries; the dense fibre of *Xylia dolabridormis* are plugged with gum and this makes the wood resistant to wear and thus it is excellent for flooring. The gum resins in *Lignum vitae* is believed to make the wood self lubricating so that it can be useful for pulley blocks and for bushing the propeller shafts of ships. Abundance of gum deposit was observed in *Pinus carrbae* (Araucariaceae); most conifers will exude resin if wounded, virtually all pines will yield resin if tapped. Other conifers will exude resin spontaneously from branches and cones. Several genera of conifers produce resin in copious quantities (FAO, 1998), which are then harvested and put to a wide variety of uses. Resin from pine yields turpentine and rosin. *Pinus ellioti* and *Pinus palustris* produce resins of excellent quality and quantity

Many forest scientists appear to consider such wood properties as density and fibre length as the key wood quality attributes regardless of end uses; the building industry is mainly interested in strength, stiffness and dimensional stability but cares very little about other basic wood properties (Kliger *et al*, 1994) like the chemical deposition of the wood. Kliger *et al* ascribed this confusion to poor communication among forest management, wood manufacturing and wood-using sectors. The trunk or bole of a tree is composed of various materials present in concentric bands. Six layers can be identified from the outside of the tree to the inside: outer bark, inner bark, vascular cambium, sapwood, heartwood, and the pith. The outer bark helps to limit evaporative water loss as well as provides mechanical support to the inner bark, the phloem, which is the tissue through which sugars produced by photosynthesis are translocated from the leaves to the roots or growing

portions of the tree. The vascular cambium is the layer between the inner bark (phloem) and the wood (xylem). It is responsible for producing both the phloem and xylem. In both softwoods and hardwoods, the wood in the trunk of the tree is typically divided into two zones, each of which serves an important function distinct from the other: the actively conducting portion of the stem, in which the parenchyma cells are still alive and metabolically active, is the sapwood (the active, living wood that is responsible for conducting sap from the roots to the leaves) which has not yet accumulated the often-colored chemicals that set apart the nonconductive heartwood found as a core of darker-colored wood in the middle of most wood species. In addition to the fact that the sapwood is responsible for the conduction of sap, storage and synthesis of bio-chemicals, the living cells of the sapwood are also the agents of heartwood formation. An important storage function is the long-term storage of photosynthate. The carbon that must be expended to form a new flush of leaves or needles must be stored somewhere in the tree, and it is often in the parenchyma cells of the sapwood that this material is stored. In order for the tree to accumulate biochemicals, they must be actively synthesized and translocated by living cells. For this reason, living cells at the border between the heartwood and sapwood are responsible for the formation and deposition of heartwood chemicals, one of the important steps leading to heartwood formation (Hillis 1996). The heartwood is the darker-colored wood found to the interior of the sapwood. Heartwood functions in the long-term storage of biochemicals of many varieties depending on the species in question. These chemicals are known collectively as extractives. Oluyege (2007) linked the deposition of extraneous materials and wood cell characteristics to proper wood utilization by stating that extraneous materials are responsible for impermeability, beautiful colour, durability, susceptibility to bio-deteriorating agents, greasy feel, smell, difficulties in sawing, bonding and pulping which are characteristics of certain wood species. In the past it was thought that the heartwood was a disposal site for harmful by-products of cellular metabolism, the so-called secondary metabolites. This led to the concept of the heartwood as a dumping ground for chemicals that, to a greater or lesser degree, would harm the living cells if not sequestered in a safe place. A more modern understanding of extractives indicates that they are a normal and intentional part of the plant's efforts to protect its wood. Extractives are formed by parenchyma cells at the heartwood-sapwood boundary and are then exuded through pits into adjacent cells (Hillis 1996). In this way it is possible for dead cells to become occluded or infiltrated with extractives despite the fact that these cells lack the ability to synthesize or accumulate these compounds on their own. Extractives are responsible for imparting several larger-scale characteristics to wood. For example, extractives provide natural durability to timbers that have a resistance to decay fungi. In the case of a wood such as teak (*Tectona grandis*), famed for its stability and water resistance, these properties are conferred by the waxes and oils formed and deposited in the heartwood. Many woods valued for their colors, such as mahogany (e.g., *Khaya spp*), African blackwood (*Diospyros melanoxylon*), Brazilian rosewood (*Dalbergia nigra*), and others, owe their value to the type and quantity of extractives in the heartwood. For these species, the sapwood has little or no value, because the desirable properties are imparted by heartwood extractives. Eagle wood (*Aquilaria malaccensis*) has been driven to endangered status due to human harvest of the wood to extract valuable resins used in perfume making (Lagenheim 2003). Sandalwood (*Santalum spica-tum*), a wood famed for its use in incenses and perfumes, is only valuable if the heartwood is rich with the desired aromatic extractives. This work intends to bring into light the wood deposits in some selected wood species some of which had been found suitable or not suitable for certain end uses.

Materials and Methods

Herbarium specimens (leaves and bark) of the wood species of *Gmelina arborea*, *Terminalia superba*, *Daniella ogea*, *Distemonanthus benthamianus*, *Afromesia elata*, *Mansonia altissima*, *Tectona grandis*, *Azelia Africana*, *Pterocarpus soyauxii*, *Guara cedrata*, *Holoptelea grandis* *Khaya ivorensis*, and *Gossweilerodendron bassalmiferun* used for this study were collected, identified and confirmed at the herbarium of the Forestry Research Institute of Nigeria, Ibadan. Sectioning of wood samples was performed in three planes namely, the transverse, tangential and the radial sections using a microtome slicing machine. Each thin section was 20 μ thick. Wood deposits such as gum, resins, crystals, oils and other anatomical features present were observed using a hand lens while a Watson light microscope was used to confirm the presence of deposits in cells such as vessels, parenchyma cells and rays under 80 \times magnifications.

Results and Discussion

Rhomboidal crystals were observed in the microstructures of all the wood species investigated. Rhomboidal crystals (Plates 5 and 6) were observed in in chambered cells of *Terminalia superba* (elongated crystals in parenchyma cells), *Distemonanthus benthamianus*, *Afromesia elata*, *Pterocarpus soyauxii*, *Mansonia altissima*, *Azelia Africana*, *Khaya ivorensis*, *Daniellia ogea*, *Gossweilerodendron bassalmiferun* and *Guarea cedreta*. Silica deposits were observed in *Guarea cedreta* and *Distemonanthus benthamianus* while resin canals (Plates 2 and 4) were observed in *Gossweilerodendron bassalmiferun* (abundant resin), *Terminalia ivorensis*, *Gmelina arborea*, *Oxystigma spp* and *Daniella ogea*. Plates 1 and 3 show gum deposits which were also observed in *Gmelina arborea*, *Anogeissus leiocarpus*, *Distemonanthus benthamianus*, *Khaya ivorensis*, *Terminalia superba*, *Afromesia elata*, *Pterocarpus soyauxii*, *Guarea cedreta*, *Tectona grandis*, *Holoptelea grandis* and *Azelia Africana*. Tyloses were observed in *Terminalia superba*, *Pterocarpus soyauxii*, *Gmelina arborea*, *Tectona grandis* and *Holoptelea grandis*. Some odour (which might signify the presence of some extractives) was perceived in *Tectona grandis*, *Pterocarpus soyauxii*, *Guara cedreta* and *Distemonanthus benthamianus*.

Tyloses were abundant in *Gmelina arborea*. Past work revealed that the wood was very resistant to preservative penetration. Among the eight wood species investigated by Badejo (1984) and Oyagade (1994) for their compatibility with Portland cement, Danta (*Nesogordonia papaverifera*) was observed to be the most suitable while *Gmelina arborea* was found to retard setting of cement more than any of the eight species. A very low preservative absorption was also recorded for the heartwood of *Khaya ivorensis* owing to the densification of the cell walls with extraneous materials thereby restricting lateral penetration of preservative solution in radial and tangential directions. Badejo (1999) rated *Terminalia superba* and *Khaya ivorensis* unsuitable for wood-cement board manufacture among other hardwood species that were investigated, though further work by Badejo and Simatupang (1985) revealed that bond failure associated with use of *Terminalia superba* was due to high concentration levels of glucose, fructose, xylose and sucrose in the wood species. Furthermore, Sanderman and Kohler (1963) also found *Distemonanthus benthamianus*, *Melicia excelsa*, *Daniella ogea*, *Afromesia elata*, *Mansonia altissima*, *Pterocarpus soyauxii*, *Guara cedreta*, *Terminalia superba* and *Khaya ivorensis* not suitable for wood-wool board manufacture owing to their chemical deposition, but crystals, gum deposits, resin and tyloses characterized these wood species found not suitable wood-wool board manufacture. Alex and Regis (2005) affirmed that the unsuitability of these wood species for cement-bounded boards might also

be due to the presence of gummy deposit or some hydrophobic extractive deposits which could create a weak or an incomplete bonding when used with a water-based adhesive. The presence of gum deposits in the vessels walls of *Holoptelea grandis* was also found not to facilitate longitudinal passage of preservative solution into the cell cavities, though it was easy to saw probably owing to its lack of rhomboidal crystals and resin all of which have either blunt saw in *Cola gigantean*, *Oxystigma spp* and *Daniellia ogea* or made sawing difficult. On account of being very resinous *Gossweilerodendron bassalmiferon* was found not suitable for match making, while *Terminalia ivorensis* was also rejected for the same purpose based on the fact that it was impervious to paraffin impregnation, a very important characteristic for match making. Most of the wood species investigated are coloured owing to the presence either gum deposits (even in rays and parenchyma cells) or extractives. Coloured wood may increase the costs of bleaching pulp making as light-coloured wood species for mechanical process are normally selected in order to avoid high bleaching costs (Robert, 2004).

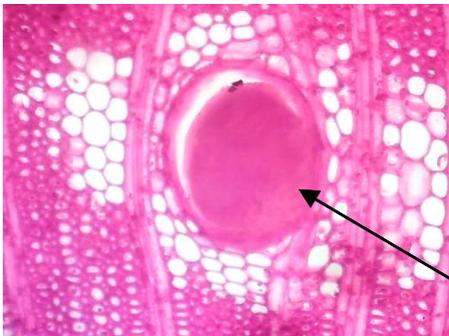


Plate 1: *Afzelia africana*, Tr. Sec.

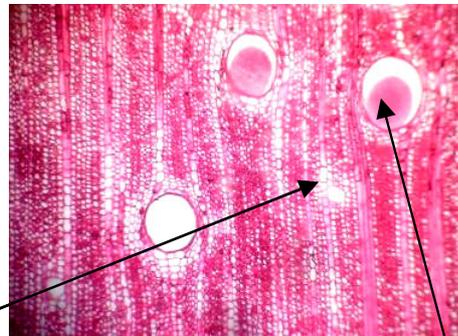


Plate 2: *Daniellia ogea*, Tr. Sec. Resin canals

Gum deposits

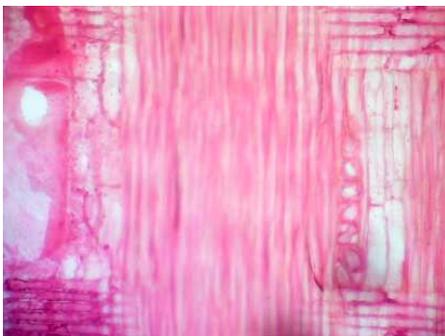


Plate 3: *Pterocarpus soyanxii*, RLS

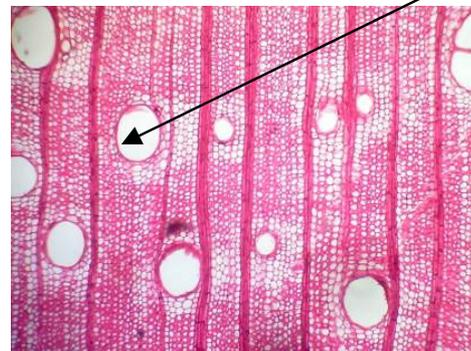


Plate 4: *Gossweilerodendron bassalmiferon* Tr. Sec.

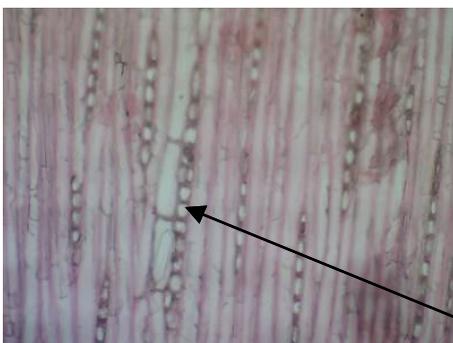


Plate 5: *Terminalia superba* TLS.

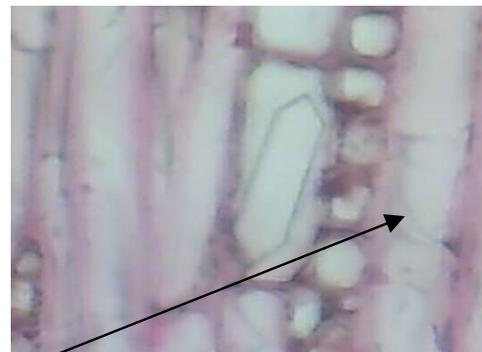


Plate 6: *Terminalia superba* TLS × 400

Elongated crystal

Conclusion

The utility of a wood species for a technological application can be directly affected by deposition of extractives, gummy substances resins, crystals and silica. Wood deposits may affect the suitability of wood species for certain end uses like panel products, building construction, pulp making, and furniture. They can also blunt cutting surfaces, and can lead to stains at the finish stage as earlier pointed out in this work. However the presence of these chemical deposits enhances the aesthetic status of wood end products making some wood based industries to prefer some wood species to others, for instance extractives give rise to attractive colour as well as prolong the service life of wood while crystals can confer a shining appearance on wood products especially when present in abundance.

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