

Case Study Lignin Is Hug Natural Product There Multiple Applications

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Abstract- Lignin is Polymer Most It has potential for a very selective depolymerization. Lignin is a resin that ensures grass shrubs and trees are lignified. It fills the spaces in the cell walls of plant between The cellulose fibers, rendering them rigid. The presence of lignin holds even 100 meters high, robust and upright redwood trees. Every year millions of tons of lignin accumulate in paper mills as residual material. If lignin burned then the beige brown powder is converted into material. Biocarbon is a similar atomic structure to graphite carbon fiber that can be used to reinforce plastics, metals, and ceramics. As study started producing carbon fibre based on lignin. As an aromatic prestructure of the subsequent carbon fiber Lignin has advantages containing 60 percent of carbon atoms. Corbon yield and quality had been law.and lignin is a wood component that is a very promising resource. At this time, it is used for generating energy almost exclusively. Studies in populations of forest tree hybrids have shown a negative correlation of biomass growth (usually measured as wood volume) and lignin content (Kirst et al., 2004; Novaes et al., 2009). The control of growth and lignin appears to be highly regulated, implying that selection for improved growth rate could effect a reduction in lignin content. Trees with increased biomass and reduced lignin would provide a yield advantage for pulp and paper production, as well as for production of biofuels.

Keywords- Lignin, present lignin, Applications, production of biomass, production of biofuel, production biocarbon fiber

I – INTRODUCTION

Lignin is well-known as the second most abundant biopolymer on Earth (Freudenberg and Neish, 1968; Sarkanen and Ludwig, 1971; Lewis and Sarkanen, 1998). Except for plants grown under water (or in juvenile condition, such as in annual crops), the planet's method of harnessing solar energy and recycling carbon dioxide, water, and oxygen through photosynthesis involves the formation of lignin. Lignin is always the minor component (by mass) of lignocellulosic plant species, and it plays a major and important role in the mechanical (bonding and stiffening), nutritional, and soil preservation role of nature. The process of lignification, and the structural details of lignin, have been the subject of numerous recent articles, and reviews (Forss and Fremer, 2003; The Ljungberg Textbook, 2008). This paper reviews the issue of lignin's variability, and specific aspects of its utilization potential in structural

materials. While lignin has captured major markets as water-soluble derivative for many decades, The case study will attempt to illustrate the fundamental principles of how nature's approach to the assembly of recyclable but interfacial-failure-proof materials can (a) be adopted for the design of structural materials involving lignin; and (b) how these materials can draw specific benefits from lignin's original structural design and properties. Many of these principles have been the result decades ago of studies focused on both biochemical (i.e., wood formation and thus lignification) and papermaking (and thus delignification) techniques, which constitute the basic roots of our understanding of lignin without being readily connected to present-day polymer and materials science literature. *We studies about the production and application huge amount of biomass and biofuel biocarbion fiber.* The balance between lignin biosynthesis and biomass growth is mediated, at least in part, at the level of transcription, and expand previous

results to show specific regulation within gene families of monolignol biosynthesis. Finally, we suggest a model of physiological control for the regulation of the relationship of wood formation and lignin content in trees. Wood, used by human societies for millennia, remains one of the world's most abundant raw materials for industrial products and renewable energy. Wood is the secondary xylem of vascular plants, a tissue formed from the terminal differentiation of the inner side of the cambial meristem for vertical and horizontal transport of water, nutrients, and extractives. The secondary cell wall structure and composition of wood are the primary determinants of its physical and chemical properties, and of its energy content. Wood is typically composed of about 25% lignin, and 70% cellulosic carbohydrates, with roughly 45% cellulose and 25% hemicelluloses (Sjostrom, 1993).

II - OBJECTIVES OF STUDY

The main objectives of the study are:

1. Find natural lignin present in nature.
2. Production of biomass.
3. Production of biofuel
4. Biocarbon fiber.

Lignin – a cheap and renewable resource

Lignin is a polymer that ensures the lignifications of grasses, shrubs and trees. It fills the spaces between the cellulose fibres in the cell walls of plants, making them rigid. The presence of lignin keeps even 100-metre-tall redwood trees sturdy and upright. Every year, millions of tons of lignin accumulate as residual material in paper mills. Current practice is to burn it, but the project partners are now working on transforming the beige-brown powder into a material that can be spun into threads, and then converted in a further process into anthracite-coloured carbon fibres.²

Lignin uses are stringent regulations for dust control, demand for high quality concrete admixtures and dispersants, and carbon rich products (activated carbon, carbon filler, resins etc.).

While lignin is fundamental to growth and adaptation of herbaceous and woody plants (Sarkanen and Ludwig, 1971; Boerjan et al., 2003; Ralph et al., 2007; Heitner et al., 2010; Vanholme et al., 2010), it is not clear how much lignin is needed or how much its composition may vary. Within a plant, lignin content can vary greatly in different tissues; for example, lignin is very low in young shoots and high in wood. In different tree species the lignin content of wood can vary from 15% to 40% (Sarkanen and Ludwig, 1971). Within a species, average

lignin content of wood is much less variable, often ranging only a few percent (Einspahr et al., 1964; van Buijtenen et al., 1968). Lignin content is also increased or decreased in wood formed under gravitropic stimulation or mechanical stress (known as reaction wood; Timell, 1969, 1986; Andersson-Gunneras et al., 2006). In softwoods (gymnosperms), compression wood may be up to 40% lignin, and in hardwoods (angiosperms), tension wood fibers have a specialized gelatinous cell layer that is almost devoid of lignin (Timell, 1969).

Lignin composition is also highly variable. There are two main types of subunits in lignin. One derived from coniferyl alcohol monomers forms guaiacyl (G) units, resulting in a lignin typical of softwoods. A second monomer sinapyl alcohol forms syringyl (S) units after polymerization. A mixed type of lignin with both G and S units is typical of hardwoods, and is characterized by the ratio (S/G ratio) of subunits. The S/G ratio varies greatly among hardwoods (Sarkanen and Ludwig, 1971).

In herbaceous and field crops, significant reductions in lignin have been achieved by traditional breeding, spontaneous mutation, and by transgenesis. In general, reduced lignin is associated with depressed yields (Pedersen et al., 2005). However, in many cases, lignin can be reduced without reducing yield or fitness. Genetic background and diverse environments have a significant role.

Lignin Applications in Materials

Lignin is the second most abundant natural material on the earth. Commercially, it is generated as a waste product from the paper and ethanol production. The worldwide production of lignin is approximately 100 million tonnes/year valued at USD 732.7 million in 2015. It is expected to reach \$913.1 million by 2025 with compound annual growth rate (CAGR) of 2.2%. Two principal categories of lignin are ligno-sulphonate (~88%) and kraftlignins (~9%), however a new category organosolv (~2%) is now gaining popularity due to the production of second generation biofuels (bioethanol production).

The bonding and stiffening attributes of the different forms of isolated lignins have been harnessed in man-made polymeric materials for many decades with varying success. Owing to lignin's character as small, mostly spherically-shaped, multifunctional molecule, the longest and most intensively investigated application has been the use in thermosetting materials in general, and specifically in phenolic resins for wood bonding

(Hemingway and Conner, 1989).

Lignin, making up to 10–25% of lignocellulosic biomass, is the second most abundant natural polymer [3], [4], [5]. Lignin is insoluble in water and stable in nature and acts as the “glue” that connects cellulose and hemicellulose. Lignin (Fig. 1b) is a three-dimensional, highly cross-linked macromolecule composed of three types of substituted phenols which include: coniferyl, sinapyl, and p-coumaryl alcohols (Fig. 1c) by enzymatic polymerization yielding a vast number of functional groups and linkages [6], [7], [8]. As a natural and renewable raw material, obtainable at an affordable cost, and great chemical and physical properties, lignin's substitution potential extends to any product currently sourced from petrochemical substances. The areas in which lignin is applicable include: emulsifiers, dyes, synthetic floorings, sequestering, binding, thermosets, dispersal agents, paints and fuels to treatments for roadways [9], [10].

The resulting resins are frequently limited to low rates of addition and extended cure times (Lewis and Lantzy, 1989). The handicap of the limiting solubility and thermal deformability of isolated commercial (Kraft) lignins has been demonstrated to be reversible to different extents by chemical modification. Lignins from non-commercial, experimental sources, however, such as organosolv or steam explosion lignins, with an abundance of T_g -lowering intermonomer ether bonds, can offer lower T_g 's as well as more compatible chemistry (Glasser, 2000).

Other applications in thermosetting polymeric materials have included a range of network-forming polymers crosslinked using isocyanate, polyamine, polyacrylate, epoxy etc. resin chemistry (Glasser, 1989; Wang and Glasser, 1989). In applications that rely on resin formulations using non-alkaline or non-aqueous conditions, chemical modification or molecular fractionation becomes mandatory since most industrial lignin sources are insoluble in most common solvents. The same is true for applications in thermoplastic materials, where thermal processability requires the restoration of moderate T_g 's.

1 Process of formation of biomass

One type of biomass which covers mostly of plant molecules is lignocellulosic biomass. Structurally, it composes of cellulose, hemicellulose and lignin. Cellulose and hemicellulose are mainly monomeric sugar linked to form polymer [4]. However, lignin consists of phenylpropane units, which cross-linked with

tight and varied chemical bonds [4]. Thus, lignin complexity makes it difficult to be degraded as compared to almost unified type of bonding of cellulose and hemicellulose. Nonetheless, a few researchers have found ways to enhance degradability of lignin through recent pretreatment technologies [4, 5].

In populations of forest tree hybrids have shown a negative correlation of biomass growth (usually measured as wood volume) and lignin content (Kirst et al., 2004; Novaes et al., 2009). The control of growth and lignin appears to be highly regulated, implying that selection for improved growth rate could effect a reduction in lignin content. Lignin is a complex phenolic polymer that provides an embedding material for the cellulosic polymers of the secondary cell walls. It is also the major polymer in the middle lamellae between adjacent cell walls (Plomion et al., 2001; Boerjan et al., 2003). Lignin provides the hydrophobic surface that allows plants to transport water to heights greater than 100 m (Carder, 1995; Koch et al., 2004) and contributes to the mechanical strength that can support trees weighing more than 2,000 metric tons (Fry and White, 1938). Lignin's physical and chemical properties also serve as a barrier against the invasion of pests and pathogens (Vance et al., 1980; Bhuiyan et al., 2009). For the forest products industries, lignin is the major barrier to efficient extraction of cellulose fibers for pulp and paper production. For the bioenergy industries, lignin is a barrier to saccharification for production of liquid biofuel (Li et al., 2003; Chen and Dixon, 2007).

III - LIGNIN VARIATION

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2 Production of biofuel

In lignocellulose biomass, cellulose and hemicellulose make up approximately 60% of the dry weight, while lignin accounts for 20% - 25%. Lignin is a class of complex organic polymers that form important structural materials in the support tissues of vascular plants and some algae. Lignin is particularly important in the formation of cell walls, especially in wood and bark, because it lends rigidity and impedes wood decay. Current commercial cellulosic ethanol production processes mainly consist of three steps: pretreatment, enzymatic hydrolysis, and fermentation. The pretreatment process reduces the resistance of biomass cell walls for the enzymatic hydrolysis process. In enzymatic hydrolysis, exposed cellulose chains are decomposed into fermentable sugars, which are subsequently converted to biofuel (e.g., ethanol) in the fermentation process. When the cellulose material is converted into ethanol, lignin is left in the form of solid

waste residues. In some cellulosic biofuel manufacturing system designs that consider cogeneration, these lignin residues are burned directly for electricity generation or heating up steam

Naturally, a lignin polymer molecule consists of 800-900 carbon atoms. It is much larger than the required molecule size of transportation fuels, which usually contains 8-20 carbon atoms.

Generally, converting the lignin contained in lignocellulosic biomass into fuels includes 3 steps: (1) separating lignin polymer from lignocellulose material; (2) depolymerizing lignin polymers by cleaving the long chain lignin into monomers and dimers [8]; (3) catalytically upgrading the depolymerized lignin into fuel-range hydrocarbon [9]. However, converting the lignin residues from lignocellulosic ethanol production does not need step (1) and (2). That is because lignin has already been depolymerized under the severe reaction conditions during the pretreatment process. High purity lignin is separated when cellulose and semi-cellulose are converted into fermentable sugars. Therefore, converting pretreated lignin residues from lignocellulosic ethanol production only requires a catalytic upgrading process, i.e. Step (3).

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gives the relationship between variables which shows that one variable actually causes changes in another variable. In this paper, a statistical regression analysis method of fifty two data points of drinking water in different source at four fields (i.e., Khaparkheda Water Supply, Koradi Gram Panchayat, Koradi Devi Mandir and Bokara) for Nagpur city with hot and dry climate, in Maharashtra, center of India was carried out. Samples were collected during October 2013 to May 2014. This technique was based on the study and calculating the correlation coefficients between various physicochemical parameters of drinking water. The results were further compared with drinking water quality standards issued by World Health Organization (WHO) and it was deduced that most of the water samples are not potable.

3. Biocarbonfibres

Carbon fibre is increasingly found in airplanes, cars and wind turbines. Carbon fibre is still made from oil and relatively expensive. However, this is soon to change. Researchers from the German Institutes of Textile and Fibre Research in Denkendorf (DITF) are working on the development of cost-effective carbon fibre made of

lignin, a by-product of papermaking.

Carbon fibre has an atomic structure that is similar to that of graphite, consisting of sheets of carbon atoms arranged in a regular pattern. Carbon fibre can be used to reinforce plastics, metals and ceramics. "Carbon fibre composites are the stiffest material known to man, but low in density," says Dr. Erik Frank, who heads up the Carbon Fibre and New Materials department at DITF. Lightweight components that need to tolerate heavy loads or withstand high temperatures usually contain carbon fibre.



New energy-saving oven at the DITF used for the stabilisation of precursor fibres of carbon fibre.

As the 1960s/70s, researchers began to produce lignin-based carbon fibre. Lignin has the advantage that it consists of 60 percent carbon atoms and has the aromatic prestructure of the subsequent carbon fibre. However, carbon yield and quality have been low. With the now patented process, Frank's team can recover half the amount of carbon originally present in the lignin. Anything below this value would be uneconomical. The carbon yield is therefore similar to polyacrylonitrile-based carbon fibre and higher than that using cellulose, another biobased raw material alternative.

The biggest problem so far has been that the long polymer chains of lignin are broken down into fragments during the cellulose pulping process in the paper industry. The precursor fibre becomes brittle and fragile, and is therefore difficult to process. To avoid this and stabilise the precursor fibre, Frank's team mixes the lignin mixture with high molecular weight cellulose before feeding it into the melting process. In the long term, however, Frank wants to use only pure lignin because lignin and cellulose interfere with one another. "We take small molecule fragments of lignin and connect them into a long chain of molecules via a chemical component," explains the chemist. As a result, carbon fibre precursors can be produced exclusively from cheap lignin.

IV - CONCLUSIONS

- Negative correlation of lignin with biomass
- Analyses of lignin and growth in inter specific mapping populations of Eucalyptus and Populus indicate a clear association between cell wall composition and plant growth. Microarray analysis of transcript abundance in a segregating population of Eucalyptus grandis × globulus hybrids found that transcripts from most of the genes encoding enzymes of the monolignol biosynthesis pathway were coordinately down-regulated in fast-growing individuals (Kirst et al., 2004). Chemical analysis of wood from individual trees demonstrated a 10% reduction in lignin among the fastest-growing trees relative to slow growers and an increase in the S/G ratio in slow-growing trees (Kirst et al., 2004)
- Drost et al., (2009, 2010) detected a negative correlation between biomass growth and transcript levels for most of the genes recently inferred to be important in lignin biosynthesis in *P. trichocarpa* (Shi et al., 2010). The correlation with biomass is not observed in most gene family members not significantly expressed in xylem tissue.

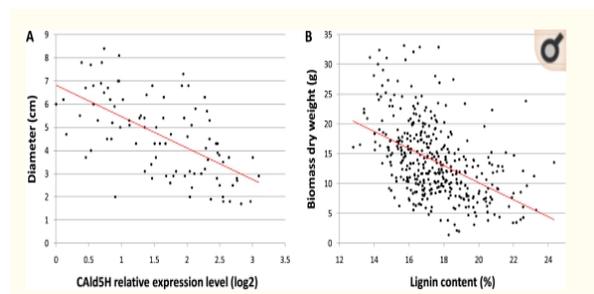


Fig.2 A, Diameter growth and transcript level for CALd5H (for coniferaldehyde 5-hydroxylase; also known as F5H, for ferulate 5-hydroxylase) are negatively correlated ($r = -0.62$; P value < 0.0001) in a hybrid backcross population of Eucalyptus (Kirst et al., 2004). CALd5H was the gene with the highest correlation to diameter growth. Similar results from Populus are shown in Figure 2. B, The negative correlation ($r = -0.48$; P value < 0.0001) between growth and lignin is based on measurements made in 396 genotypes of Populus family 52-124 (Novaes et al., 2009).

The above-ground biomass was also negatively correlated with S/G ratio (-0.59). Cellulose was positively correlated with growth ($r = 0.58\%$, P value < 0.001). While the primary points of regulation of C partitioned to lignin or cellulose biosynthesis, are not

known, it is clear that there is coordinated transcriptional control of genes involved in monolignol biosynthesis. Similar to the results previously observed in *Eucalyptus* (Kirst et al., 2004), expression of lignin biosynthesis genes was coordinated with above-ground growth in the segregating family of *Populus* analyzed by Novaes et al. (2009). Analysis of this population with whole-transcriptome microarrays developed to discriminate among members of gene families (Fig. 2; Drost et al., 2009, 2010) detected a negative correlation between biomass growth and transcript levels for most of the genes recently inferred to be important in lignin biosynthesis in *P. trichocarpa* (Shi et al., 2010). The correlation with biomass is not observed in most gene family members not significantly expressed in xylem tissue.

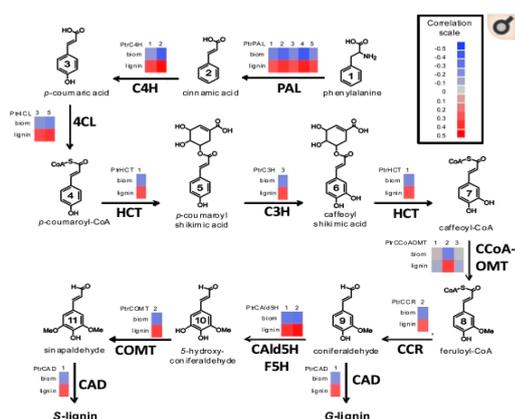


fig.3 Correlations (Spearman) of biomass growth (biom) and lignin levels with transcript abundance of specific monolignol biosynthetic genes in a interspecific pseudo-backcross pedigree of *Populus* (family 52-124). Analysis of lignin and microarrays estimates of relative abundance are from Novaes et al. (2009) and Drost et al. (2010). Each step of the pathway is shown with the specific genes known to be highly expressed in differentiating xylem in *P. trichocarpa* (Shi et al., 2010). Abbreviations of the monolignol biosynthetic enzymes are as follows: PAL, Phe ammonia-lyase; C4H, cinnamate 4-hydroxylase; HCT, hydroxycinnamoyl-CoA shikimate/quinatehydroxycinnamoyl transferase; C3H, p-coumarate 3-hydroxylase; CCoAOMT, caffeoyl-CoA O-methyltransferase; CCR, cinnamoyl-CoA reductase; CAld5H, coniferaldehyde 5-hydroxylase; COMT, caffate 3-O-methyltransferase.

- lignin conversion to hydrocarbon biofuel into traditional lignocellulosic ethanol production systems. Using the NREL 2011 bio-ethanol production process design with 67 million gallons of ethanol production

capability as benchmark case, the proposed strategy can lead to the production of 16 million gallons of hydrocarbon fuel in addition to ethanol.

- the lignin component was higher than that of most grasses used to create biocarbons [25,26].
- Lignin is an abundant resource on earth and with pulp and paperindustry and second generation biorefineries generating large amountsof lignin as coproduct, valorizing this resource can lead to higher profitsfor these industries as well as better environmental performance. Manyviable products including, fuel, chemicals and materials obtainable bylignin valorization have been demonstrated and many research effortshave been done in developing processes that could produce valuablelignin-derived compound. Lignin valorization can result in desired va-luable chemical compounds with the use of right technology, and theright equipment. Despite the significant number of research and pro-mising results published, lignin is still underutilized in industry. Lignin-derived products have shown so far that they have the potential tosignificantly reduce the environmental impact of products. In addition,to attract industry in producing lignin-derived products, a continuedinvestigation of cost-effective lignin valorization technologies is re-quired. Using tools such as techno-economic analysis and life cycleanalysis can help in identifying benefits and challenges for a scaled upproduction of lignin-based products and help bring the lignin valor-ization technology from the infancy stage to the next step. Developmentand design of lignin valorization based on the principle of eco-friendlyeconomy will help to grow integrated biorefinery industry and it willalso help to make the existing pulp and paper industry more profitable.

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