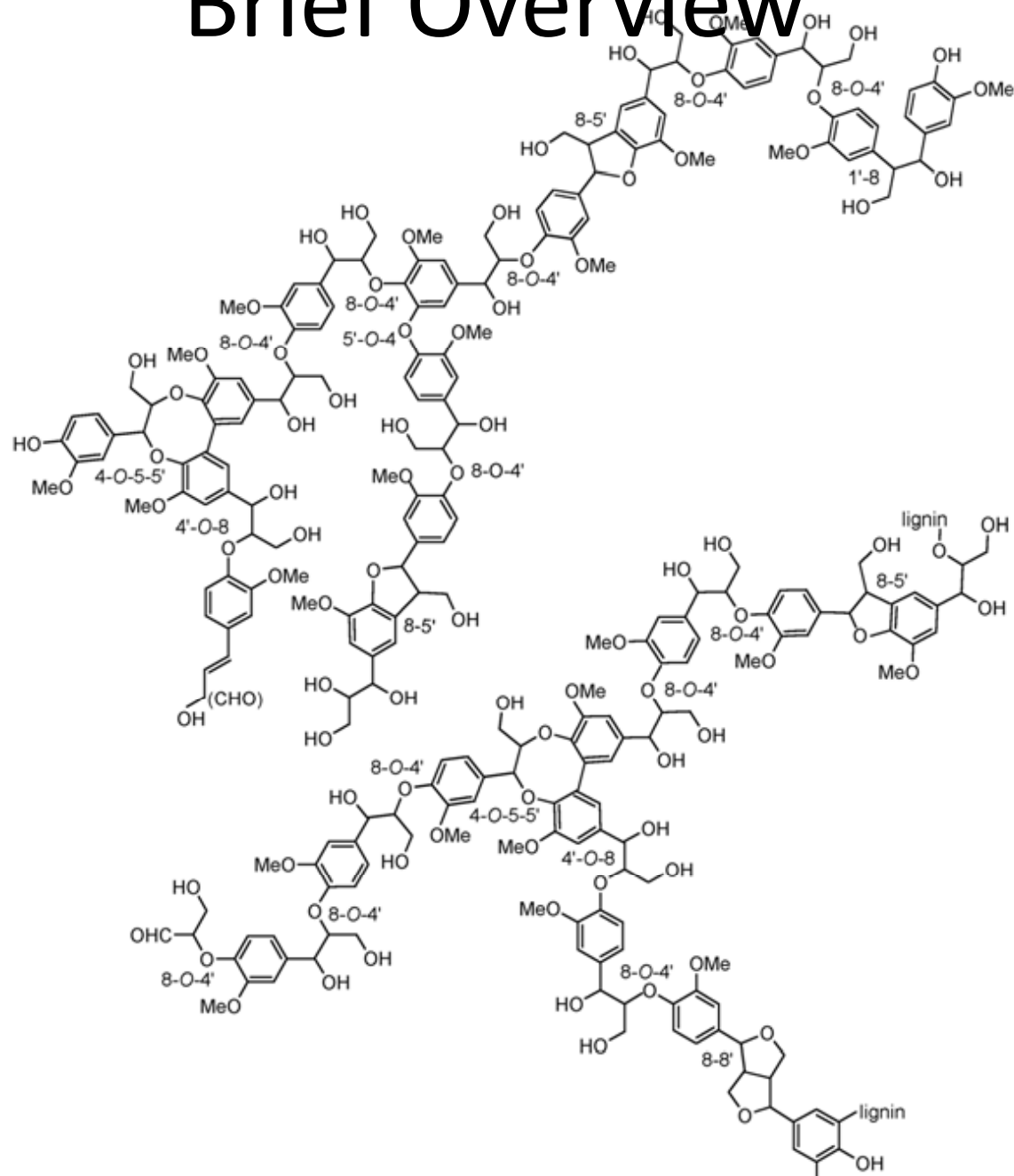


Lignin Applications

Brief Overview



Lignin Applications: Concrete



- Low levels of lignin and modified lignin can yield
- High performance concrete strength aid
 - Concrete grinding aid
 - Reduce damage of building external wall caused by moisture and acid rain
 - Set retarder for a cement composition
 - Sulfonated lignin contributes higher adsorption properties and zeta potential to cement particles, and hence shows better dispersion effect to the cement matrix.
 - Select lignins can improve the compressive strength of cement pastes

Lignin Applications: Antioxidant



- Lignin acts as free radical scavengers
- Lignin provides thermal protection to:
 - Styrene /butadiene/rubber polymer
 - Rubber
 - Polypropylene
 - polycaprolactam
- Lignin's natural antioxidant properties provides use in cosmetic and topical formulations.
- Lignin sulfonate-containing cosmetic compositions have been developed for decorative use on skin

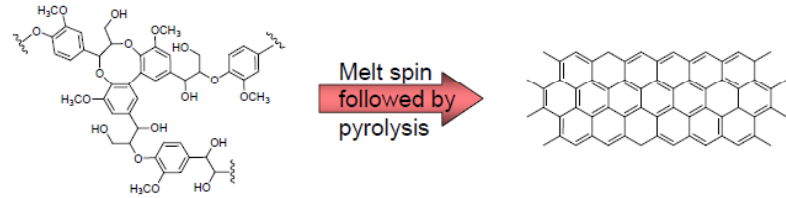
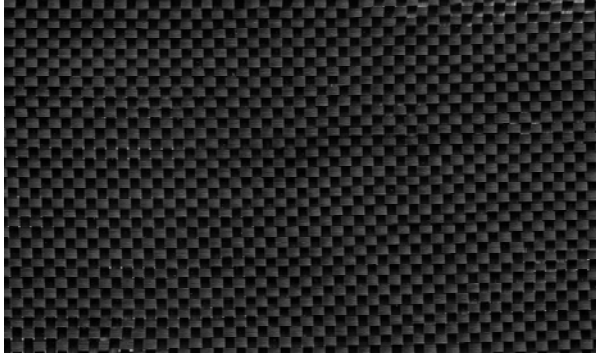


Lignin Applications: Asphalt



- Crack filling composition involving quaternary ammonium salt, aliphatic amine, lignin amine, imidazoline, and amide.
- Water stability of an asphalt mixture can be improved by adding 0.3% lignin fibers
- Asphalt-emulsifying agent containing SW Na lignin salt with an av. mol. wt. of 200-100,000 (Na lignosulfonate or Na lignophosphate, and the lignin is that broad-leaf pine or needle-leaf pine) has the proper HLB value, slow demulsification speed, proper frothing ability, and strong foam stability.
- Lignin amine additive has been shown to provide a warm mix additive that can modify the combination state of asphalt and stone material surface; modifying the fluidity; and decrease production cost of the asphalt mixtures

Lignin Applications: Carbon Fiber and Related

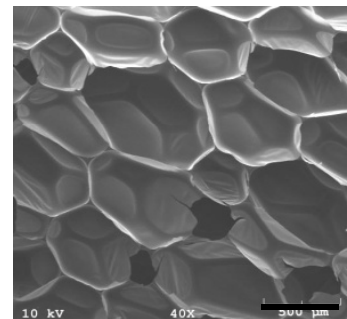


- Native lignin or industrial lignin can be used for carbon fibers
- Carbon nanotubes have been made from lignin/lignosulfonates.
- Lignin-based activated carbon fibers have been prepared by initial synthesis of lignin-phenol-formaldehyde (LPF) resins with varied lignin contents, 8-20%, resp., and then the melt spinning and thermal treatments.
- Kraft lignin has been found to undergo strong adsorption on multi-walled carbon nanotubes

Lignin Applications Board Binder



- Lignin along with a diisocyanate used for production of fiberboards, strawboards, particleboards, oriented strand boards, wood fiber insulation boards, etc.
- Grafted lignin or liginosulfonate component, and resin. Binder yields low cost composite materials with having a reasonable wet strength
- A lignin based modifier has been added to formaldehyde based binder systems such as phenol formaldehyde (PF), urea-formaldehyde (UF), melamine formaldehyde (MF), resorcinol formaldehyde (RF) and/or tannin formaldehyde resins. The lignin based modifier may used for panel boards such as plywood, hard board, medium density fiberboard or particleboards



Lignin Applications Foams – Plastics/Polymers



- Lignin based rigid polyurethane
Excellent in flame retardance
- Epoxy resin comprises an epoxy resin and a curing agent, wherein the curing agent is a lignin-derived acid anhydride
- S-free lignin has been used for automotive brakes and epoxy resins for printed circuit boards.
- Polyphenylene oxide-based polymers and lignin esters blends exhibit modulus of elasticity, tensile strength, and elongation at break values that are comparable or greater than the polyphenylene oxide-based polymer alone. The blends provide properties comparable to the polyphenylene oxide-based polymers, yet utilize less polymer.
- Lignin can act as a water absorption inhibitor and as fluidization agents when used with polyamide when mixed in solid or melt form and processed by injection molding, blow molding, extrusion, or blow extrusion to fabricate articles.
- The use of alkali lignin poly(propylene carbonate) improves thermal stability and mechanical properties

Lignin Applications – Dust Control



- Lignin, glycerin in water applied upon the surfaces of dust-yielding situations like coal mines, coal transportation by rail car, and stock yards, etc.
- Select Ca lignin sulfonate powders have been shown to stabilize widespread contamination following a nuclear accident, field studies demonstrate a dependence on the weather conditions and the benefits is a short-term corrective action.
- Dust movement can be controlled by spraying a road surface with an emulsion of asphalt, lignosulfonic and water

Lignin Applications - Paper



- Lignin as a sizing agent
- Polymerization of acrylamide and hydroxymethylated shown to enhance tensile strength of paper by about 40%
- Phenolic resin for wet curtain paper
- Packaging laminate comprising a barrier layer of lignin and oligo- or polysaccharides, where the lignin and oligo- or polysaccharides are at least partly covalently bonded to each other in a matrix

Lignin Applications – Chemicals



Phenols prepared by taking lignin reacting with a H-supplying solvent at elevated temperature/pressure

Ligin depolymerization provides routes to:

- Cresols
- Catechols
- Resorsinols
- Quinones
- Vanillin
- Guaiacols

Lignin Applications – Battery



Lignin enhances performance of energy storage devices.

Lignin forms a thin layer on the graphite powder surface which prevents the graphite powder from decreasing H overvoltage and does not affect condition of the graphite powder.

Lignin can suppress generation of $4\text{PbO} \cdot \text{PbSO}_4$ during the drying and drying time is shortened..

Lignin Applications – Fuel



Oxygenate Fuel Additive

- Alkaline fragmented/purified lignin mixed with diesel using surfactants/emulsifiers
- Hydroliquefaction comprising successive hydroconversion stages under high H pressure
- Hydroconversion occurs with supported catalyst and a suspension of lignin and a H donor solvent
- Polymetallic catalysts supported on at least slightly basic materials and hydrogen convert lignin to hydrocarbons
- Catalytic conversion of lignin to green gasoline/diesel by a combination of pyrolysis, thermal cracking, hydrocracking, catalytic cracking, or hydrotreatment
- Lignin catalytic hydrogen reduction of carbon-oxygen bonds and the catalytic disproportionation of carbon-oxygen or carbon-carbon bonds. The catalysts may be formed from a metal precursor such as ruthenium or vanadium and a bidentate ligand.

Lignin Applications – Heat



Artificial fire log using cellulosic materials and non-petroleum based wax using lignin and 1,3-propanediol derived from a renewable resource. with improved flame properties.

Indulin AT lignin when added to wood pellets produces better quality pellets and had higher fuel value.

Lignin Applications – Grease



Ca lignin sulfonate, mol. wt. of $\geq 10,000$ g/mol, has been used to thicken base grease to form a lubricating grease

A grease with a wax/lignin had improved corrosion protection properties.

Wear resistance of the tools is increased by using a grease containing hydrolytic lignin.

Lignin sulfonate provides antifriction properties to grease providing longer lubrication life.

Lignin Applications – Dispersants



Dye dispersant is prepared from sulfate/sulfite pulping liquors, crosslinked with sulfite/formaldehyde, products exhibits good dispersion, property, heat-resistant stability, high temp. dispersion property, fiber staining property and azo dye reducing property

Chemically modified lignin has been used as a dispersing agents, complexing agent, flocculent, thickener or auxiliary agents for coatings, paints or adhesives.

Oil Well Drilling Muds

Coal-water slurry dispersant

A lignin-derived material has been reported to be a good as a dispersant for soils and applications shown for cleaning and/or laundry detergent compounds

A mixture including polycarboxylic acid, and lignin sulfonic acid has been used for cleaning aluminum plates to prevent calcium scaling

Lignin sulfonates have been used as biodegradable and nontoxic emulsifiers or dispersants for emulsion or dispersion polymerization

Jet printing ink was prepared including sulfonated lignin

Lignin Applications – Agriculture



- Slow-release urea is composed of 90-99% urea
1-10 lignin wt.%
- Lignin is used either directly or chemically modified, as a binder, dispersant agent for pesticides/herbicides, emulsifier, and as a heavy metal sequestrate
- Lignin nutrient medium has been applied as an additive for restoring vegetation on road slope and bare mountain
- Oxidized and pulverized lignin when blended with other chemicals has been used as a soil water retention agent in acidic dry land or desert soil, or as a binder for fertilizer.

Summary

Advent of Biorefinery has developed several new sources of lignin

New Translation Applications are growing every Day!