

Wood Chemistry

Wood Chemistry

PSE 406/Chem E 470

Lecture 20: Uses of Wood Chemicals

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Agenda

- Modifications and uses of:
 - » Cellulose
 - » Hemicelluloses
 - » Lignin
 - » Extractives

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Chemical Uses of Cellulose

- As a product, most cellulose is found in pulp products (300 million tons/yr pulp).
- A small amount (<1% of pulp) of cellulose is isolated and sold as a chemical product; a polymeric material.
 - » Cellulose must be free of lignin and hemicelluloses; this is dissolving pulp mainly produced through acid sulfite pulping
 - » The pulping and bleaching processes are hard on cellulose reducing molecular weight significantly.
- As a chemical product, cellulose is sold as cellulose derivatives.

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Cellulose Nitrate

- Inorganic esters
- $\text{HONO}_2 + 2\text{H}_2\text{SO}_4 \rightleftharpoons \text{NO}_2^+ + \text{H}_3\text{O}^+ + 2\text{HSO}_4^-$
- $\text{NO}_2^+ + \text{HO-Cell} \rightleftharpoons \text{NO}_2\text{-OH-Cell} \rightleftharpoons \text{NO}_2\text{-O-Cell} + \text{H}^+$
- Uses
 - » Ping pong balls (ds=1.9-2.0)
 - » Lacquers: fingernail polish (ds=1.9-2.3)
 - » Gun cotton (ds=2.4-2.8)

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Cellulose Acetate

- Organic ester
- Uses
 - » Textile fiber
 - » Plastics (acetates): used to make photographic films, etc.
 - » Lacquers

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Cellulose Organic Ethers

- Carboxymethyl cellulose, alkyl cellulose (methyl, ethyl), hydroxyalkyl cellulose
 - » Mostly used as thickening agents
 - Student example: used to thicken cheap ice cream products without having to add cream.

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Rayon

- Pure regenerated cellulose.
- Rayon is manufacture from cellulose xanthate
- Uses
 - » Fabric (demand for rayon is fashion dependent).
 - » Fibers in tires.

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Hemicelluloses

- During Kraft pulping, hemicelluloses mainly oxidized to low molecular weight carboxylic acids.
- In acid sulfite pulping, hemicelluloses are cleaved to individual sugars.
 - » Fermentation of 6 carbon sugars to alcohol.
 - Requires liquor from softwood cook.
 - Alcohol is used in gasohol, as solvents, and in the manufacture of white vinegar.
 - » Five carbon sugars are isolated from hardwood liquors through chromatography for conversion to xylitol (sweetener).

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The Sad Reality of Lignin

- The total amount of lignin processed each year is roughly (very) 100 million tons.
- Approximately 1 million tons/year sold globally.
 - » Most as lignosulfonates from acid sulfite pulping.
 - » A small amount is from the kraft process.
- The sad reality of lignin is that almost all of the lignin isolated in pulping operations is burned.



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Lignosulfonates

- Lignosulfonates is the name for a product containing sulfonated lignin and other wood chemicals.
 - » Mainly from the acid sulfite process.
 - » A small amount from NSSC and sulfonated kraft lignin.
- Before becoming lignosulfonates (marketable product), this material (spent sulfite liquor) is "cleaned up".
 - » Pulping chemicals are removed.
 - » Sometimes non lignin compounds (sugars, etc) are removed chemically, biologically, or through physical methods.
 - » Often the lignin is chemically modified.
 - » Product is concentrated to a molasses thickness product or to a powder.

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Lignin Uses

- Dispersant
 - » Concrete, Dyes, Gypsum wallboard
- Binder
 - » Road dust control, animal feed
- Emulsifier (Think an oil and vinegar salad dressing)
- Chelating agent
 - » Oil Well Drilling Fluids, Micronutrient Fertilizers
- Raw material for chemical production
 - » Vanillin (softwood), DMSO (kraft lignin)

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Concrete Dispersant

- Concrete is made up of 3 ingredients: Cement, sand, and aggregate.
- Water is mixed in to make a workable slurry and to harden the concrete.
- By using a dispersant like lignosulfonates, less water can be used to get the same viscosity slurry. This makes stronger concrete.



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Gypsum Wallboard (I)

- Gypsum wallboard is what Americans use for walls.
- It is basically a plaster of Paris sandwich with paper as the slices of bread.
- The plaster of Paris is applied as a slurry to the paper.



Image borrowed from G-P Gypsum Web Site

Gypsum Wallboard (II)

- A large amount of excess water is needed to allow the slurry to flow across the paper.
- This excess water is removed in an oven which requires lots of energy.
- By using a dispersant like lignosulfonates, less water is used which equals saving in energy and money.
- Herr Professor has a patent in this area.

Dye Dispersant

- Dyes used to dye cloth are water insoluble.
- In order to dye cloth, dye particles are dispersed in water. What this means are the dye particles are small enough that they pretty much act like they are dissolved. A dispersant keep them apart so they don't get big and sink. Sulfonated lignins do this very well. After dyeing, the lignin is washed out.

Binding-Dust Control

- Dusty roads are considered a health hazard by the government and thus dust control is mandated



- Dust can be controlled with water, lignosulfonates or calcium chloride.

Binding-Dust Control

- Lignosulfonates cause the particles to pack closer together and also to adhere.
- This process forms a dust “free” and also more stable road.



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Pellet Binder

- The natural stickiness of lignosulfonates help them function as a pellet binder; it helps hold the material together.
 - » Feed pellets (Alfalfa, fish meal, etc.)
 - » Granulation aids (lime for lawns, etc)



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Oil Well Mud Thinner

- During the drilling of wells, clay slurries (muds) are pumped down the well to carry up the cuttings. Specially modified lignosulfonates (chromium) are used as thinners. The thinners impart special properties to the mud.



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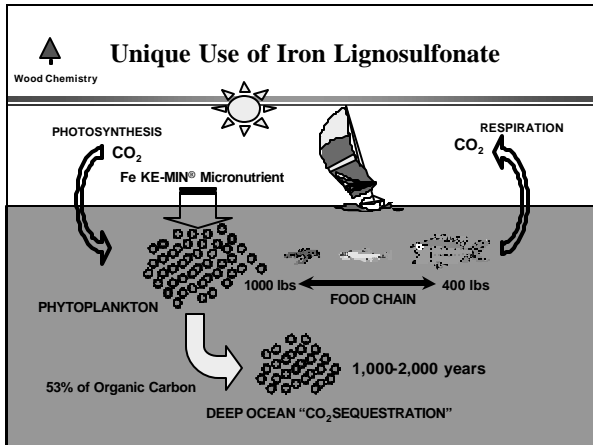
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Micronutrient Fertilizer

- Plants need trace metals just like people do. Unfortunately, many of these metals are not available to the plant because they are absent or not water soluble.
- Lignosulfonates will chelate or hold on to these metals making them available to plants either through soil or foliar applications.

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Other Uses

- Leather tanning
- Battery separator
- Carbon black dispersant
- Water treatment and cleaning solutions
- Adhesives
- Ore Flotation
- Pear flotation aid

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Key Points on Lignin Use

- I have listed a large number of uses
 - » Even with all these uses the total sales of lignin is only 1-2 % of what is isolated in pulping.
 - » There is no huge volume use for lignin (like gasoline) to drive the market.
- Mostly lignin sells because it is cheaper than petroleum based products. There are instances, however, where lignin sells because it is better than the competition.

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Extractives

- We covered extractive use as we went. Here is a list of extractives isolated from the pulp & paper industry for sale.
- Turpentine (monoterpenes)
- Tall Oil
 - » Rosin (resin acids)
 - » Fatty acids
 - » Sterols (don't forget Benecol)
- Tannins (limited amounts)

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