

Wood Chemistry

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PSE 406/Chem E 470


Lecture 21: Decay (Part 1)

PSE 406: Lecture 23 1

Wood Chemistry

Introduction to Deterioration

- Plant matter is constantly under attack by fungi, insects, bacteria, marine borers and the weather.
- It is estimated that roughly 1/10 of the forest products generated each year are destroyed.
- While this can be bad, without these processes we would be buried in a sea of old dead plant matter.




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PSE 406 Emphasis

- While weathering, insects and marine borers cause substantial damage, we are going to focus on decay caused by fungi and bacteria.
- In particular, we are going to discuss some of the biology involved but mostly the chemistry.




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Fungi

- The wood deteriorating fungi are organized into three groups:
 - White rot fungi
 - Brown rot fungi
 - Soft rot fungi
- This image shows fungal fruiting bodies (sporophores).
 - These are structures that release the reproductive spores. The fungi are actually inside the tree.




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White Rot Fungi

- This group of organisms is known as white rot because of their ability to degrade lignin.
 - » The decaying wood looks white.
 - » Cellulose and hemicelluloses are also degraded.
- Largest number of species belong to Basidiomycotina
 - » Xyariaceous and Diatrypacous also numerous.
- White rot fungi typically decay hardwoods
 - » They will decay softwoods but hardwoods are their food of choice.
- Simultaneous decay: All the cell components are degraded simultaneously from lumen outwards.
- Preferential decay: Lignin and hemicelluloses are removed selectively across the cell wall leaving cellulose.


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Brown Rot Fungi

- With brown rot fungi, cellulose and hemicelluloses are degraded with only limited lignin degradation.
 - » Decayed wood is brown and crumbly.
- Most species belong to Basidiomycotina.
- Brown rot fungi typically decay softwoods.
- Attack starts at the cell lumen and works outwards.
 - » Cellulose is rapidly degraded.


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Soft Rot Fungi

- Soft rot occurs in areas where plant matter is in contact with excessive amounts of moisture.
- The term soft rots comes from the soft appearance of the decayed surface.
 - » When dry the wood surface is cracked.
- Members: Ascomycetes and Fungi Imperfect.
- Degradation is mainly through cavity formation in the secondary wall.
- Soft rot fungi attack holocellulose; lignin protects the plant.

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Molds and Blue Stain Fungi

- Wood is often stained by these organisms with little loss of structural integrity.
 - » Particularly in softwoods, some strength loss in hardwoods.
- Molds: Aspergillus, Penicillium etc.
- Blue Stain Fungi: Philaphora, etc.
- These organisms typically attack non lignified parenchyma cells and pit membranes.

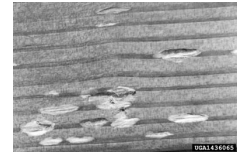
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Bacteria

- Two forms of attack:
 - » Degradation of pit membranes and parenchyma cells leading to increased permeability.
 - Aerobic and anaerobic
 - Typically a problem when wood stored in ponds.
 - » Cell wall degradation
 - This type is typically aerobic
- Can attack both lignin and holocellulose although typically lignin more difficult to deal with.
- Does not compete well against fungi so needs some condition to thrive: ie reduced oxygen, etc,

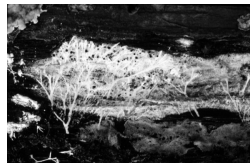
What do Fungi Need?

- Favorable temperature
 - » Fungi do not like cold
- Oxygen
 - » Water storage suffocates them.
- Moisture
 - » They need moisture but see above bullet.
- Adequate food supply including nitrogen.



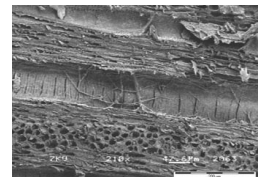
How Does This Happen?

- This is a picture of highly degraded wood.
- What you see are the fungal bodies known as hyphae. They grow through the plant matter like little worms.
- The organisms arrive as spores (transported by a variety of methods).



Movement of Hyphae

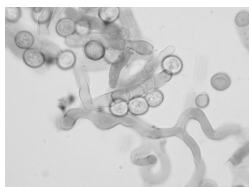
- This SEM picture shows fungal hyphae inside hardwood xylem.
- The hyphae enter the cells through openings (pits, etc) or can bore directly through the wall (chemically)





How Do Fungi Destroy the Cell Wall Material?

- This is a very complex question which is not well understood.
- The process is enzymatic. Fungi possess a wide variety of cell wall degrading enzymes:
 - » Cellulases, hemicellulases, etc.



How do Enzymes Function?

- Enzymes are very very large proteins.
 - » Enzymes have very specific functions: they cause chemical reactions to occur in exact fashions.
 - » A very large number of enzymes have been isolated from fungi and their functions identified.
- Fungal hyphae release enzymes to degrade cell wall components: this reaction is extra cellular
- Enzymes are too large to penetrate into the cell wall structure and react with cell wall components. How does degradation occur?
 - » This is the big unknown question.