

Wood Chemistry

# Wood Chemistry

## PSE 406/Chem E 470

### Lecture 3

### Wood Sugars

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Wood Chemistry

# Wood Carbohydrates

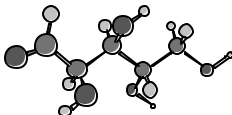
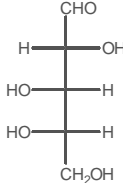
- Major Components
  - » Hexoses
    - D-Glucose, D-Galactose, D-Mannose
  - » Pentoses
    - D-Xylose, L-Arabinose
  - » Uronic Acids
    - D-glucuronic Acid, D Galacturonic Acid
- Minor Components
  - » 2 Deoxy Sugars
    - L-Rhamnose, L-Fucose

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# Wood Sugars: L Arabinose

- Pentose (5 carbons)
- Of the big 5 wood sugars, arabinose is the only one found in the L form.
- Arabinose is a minor wood sugar (0.5-1.5% of wood).


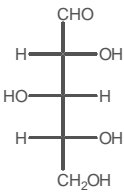



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# Wood Sugars: D Xylose

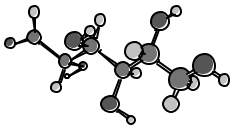
- Pentose
- Xylose is the major constituent of xylans (a class of hemicelluloses).
  - » 3-8% of softwoods
  - » 15-25% of hardwoods

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Wood Chemistry **Wood Sugars: D Mannose**

- Hexose (6 carbons)
- Mannose is the major constituent of Mannans (a class of hemicelluloses).
  - » 7-13% of softwoods
  - » 1-4% of hardwoods

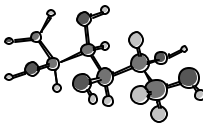


$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

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Wood Chemistry **Wood Sugars: D Glucose**

- Hexose (6 carbons)
- Glucose is the by far the most abundant wood monosaccharide (cellulose). A small amount can also be found in the hemicelluloses (glucomannans)




$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

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Wood Chemistry **Wood Sugars: D Galactose**

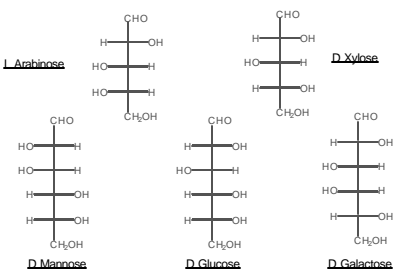
- Hexose (6 carbons)
- Galactose is a minor wood monosaccharide found in certain hemicelluloses
  - » 1-6% of softwoods
  - » 1-1.5% of hardwoods



$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

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Wood Chemistry **Wood Sugars**



$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$
 L-Arabinose

$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$
 D-Xylose

$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$
 D-Mannose

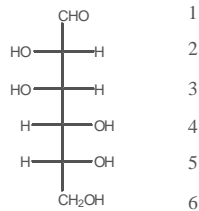
$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$
 D-Glucose

$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{HO} - \text{C} - \text{H} \\
 | \\
 \text{H} - \text{C} - \text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$
 D-Galactose

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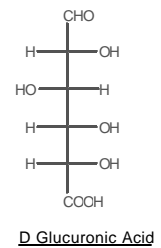
## Sugar Numbering System

- Aldoses are numbered with the structure drawn vertically starting from the top (the aldehyde group) as the #1 carbon.
- Numbering is important as we learn about ring formation and substitution.



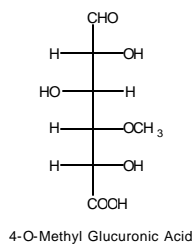
## Uronic Acids

- Uronic acids are polyhydroxy carboxylic aldehydes. The acid group is at the # 6 carbon.
- Only glucuronic and galacturonic acids exist in wood.
- They are minor components of hemicelluloses.



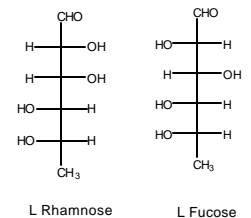
## Uronic Acids II

- In hemicelluloses, glucuronic acid often has a methyl ether at the # 4 carbon.
- This is important because this ether linkage is easily broken (during pulping/bleaching) resulting in the release of methanol.



## Deoxy Sugars

- Deoxy sugars are very minor constituents of cell wall polymers.
- Notice that the #6 carbon is a CH<sub>3</sub> group instead of an alcohol.



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## Ketoses

- Ketoses are polyhydroxy ketones. Fructose is the best known example.
- They are found in extremely limited amounts in wood but are found in larger amounts in some plants.
- Ketoses can be formed through alkaline rearrangements of aldoses.

$$\begin{array}{c}
 \text{CH}_2\text{OH} \\
 | \\
 \text{C}=\text{O} \\
 | \\
 \text{HO}-\text{C}-\text{H} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

Fructose

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## Aldonic acids

- Aldonic acids are polyhydroxy carboxylic acids. The acids group is on the #1 carbon.
- Aldonic acids do not occur naturally in wood.
- They are produced through the acid sulfite treatment of sugars.
  - » Xylonic, arabonic, gluconic, galactonic, and mannonic acids.

$$\begin{array}{c}
 \text{COOH} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{HO}-\text{C}-\text{H} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

D Gluconic Acid

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## Alditols

- Do not occur naturally in wood.
- Can be made by microorganisms.
- Made through the reduction of sugars.
- Commercial sweeteners.

$$\begin{array}{c}
 \text{CH}_2\text{OH} \\
 | \\
 \text{HO}-\text{C}-\text{H} \\
 | \\
 \text{HO}-\text{C}-\text{H} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

D Mannitol

$$\begin{array}{c}
 \text{CH}_2\text{OH} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{HO}-\text{C}-\text{H} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

D Xylitol

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## The Unloved Pentoses

(not found in wood polymers (D or L))

$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

D Ribose

$$\begin{array}{c}
 \text{CHO} \\
 | \\
 \text{HO}-\text{C}-\text{H} \\
 | \\
 \text{HO}-\text{C}-\text{H} \\
 | \\
 \text{H}-\text{C}-\text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

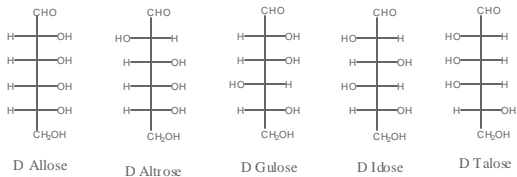
D Lyxose

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## The Unloved Hexoses (not found in wood polymers (d or L))



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## Physical Properties of Sugars

	Melting Point (°C)	H <sub>2</sub> O Solubility (g/100ml)	CH <sub>3</sub> OH Sol. (g/100ml)
Glucose	146	91/100	~1/100
Mannose	133	250/100	~1/100
Xylose	143-145	125/100	?
Fructose	Dec. 103	freely	7/100
Xylitol	93-94.5	64/100	6/100

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