Wood Anatomy

Chemical composition of wood

presentation

INVESTMENTS IN EDUCATION DEVELOPMENT

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

What is wood like?

Wood

- complex of chemical components, especially of biopolymers
- chemical composition→ submicroscopic structure → microscopic structure

Primary components (90–97 %)

- *polysaccharide fractions:* cellulose (35–55 %) a hemicelluloses (20–35 %)
- *polyfenolic fraction:* lignin (15–36 %)

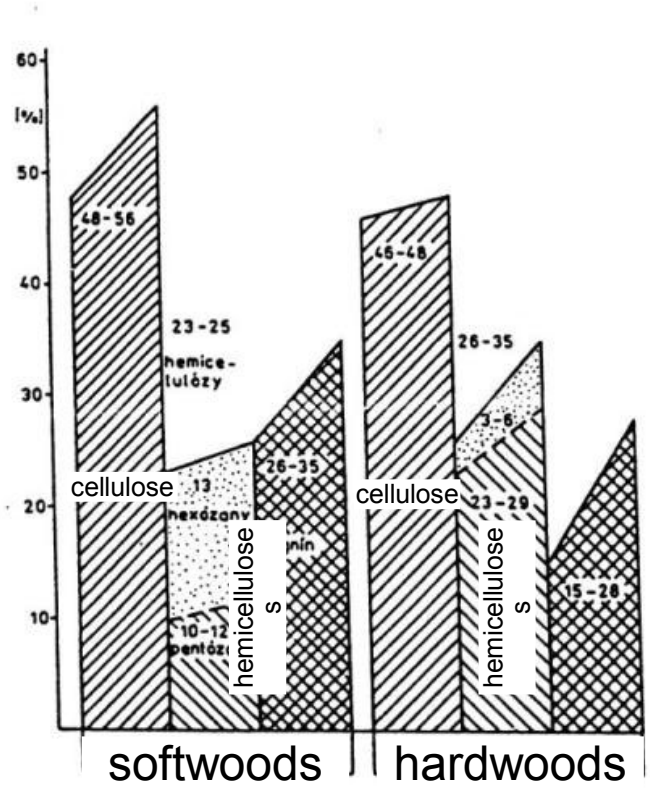
Secondary components (3–10 %)

- inorganic substances (ash)
- organic substances

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Percentage of primary components in softwoods and hardwoods



Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Wood

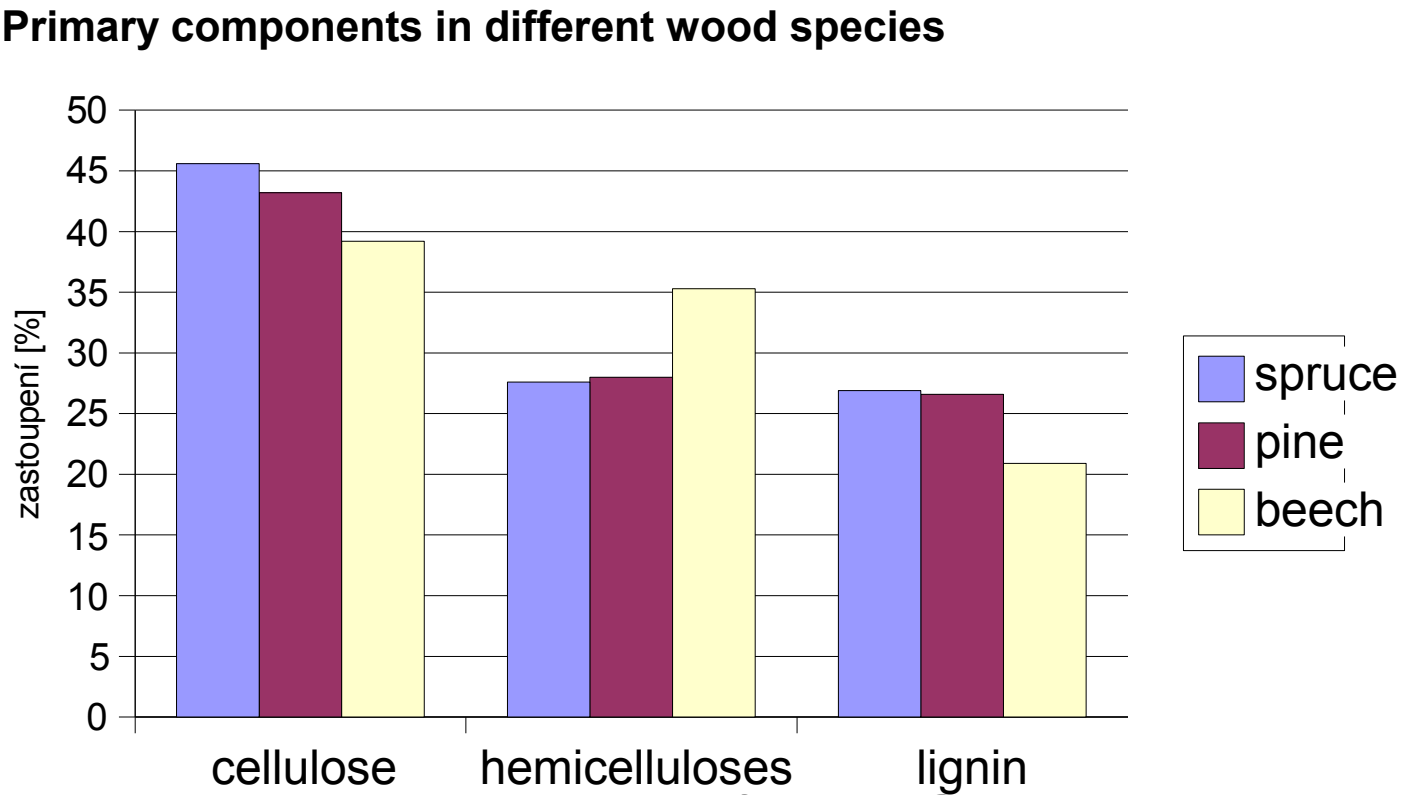
- elementary composition of wood (= amount of C, H, O):
  C – 49.5 % (average values)
  H – 6.3 %
  O – 44.2 %
  Elementary composition is almost the same for all of wood species.

Chemical elements in wood of trunk (Bučko, 1995)

WOOD	Elements (%)			
	C	H	O	N
spruce	50,3–51,4	6,1–6,3	41,6–43,1	0,1–0,9
fir	50,4–51,3	5,9–6,0	43,4–44,0	0,1–0,8
pine	49,5–49,6	6,4	44,0–44,4	0,9
oak	49,4–50,6	6,1–6,2	41,8–44,5	1,2
beech	48,5–50,9	6,1–6,3	42,1–45,2	0,12–0,9

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components



Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

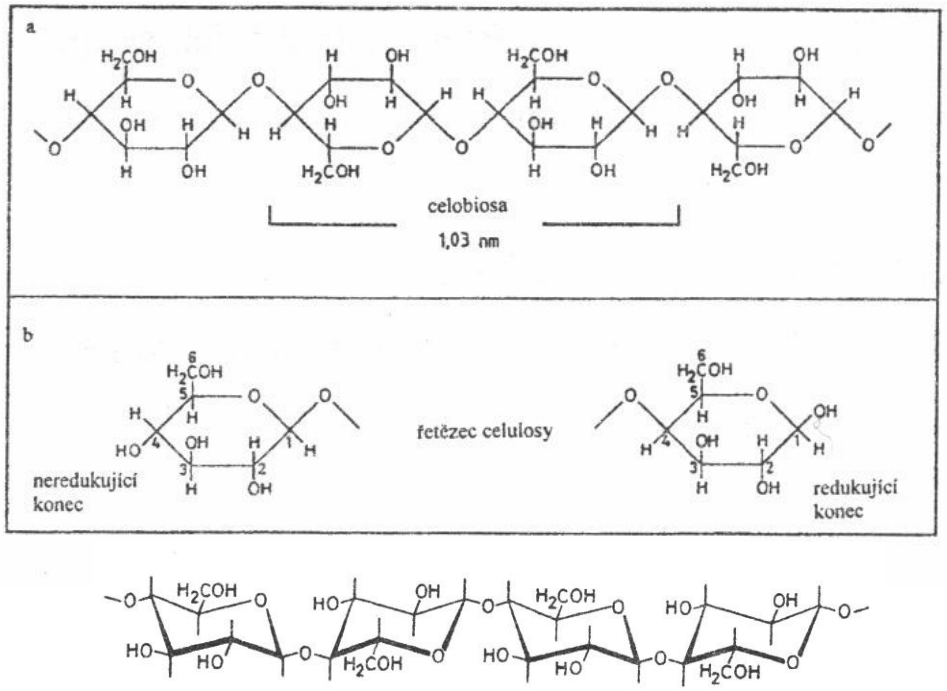
Cellulose

- the most abundant substance in the world
- it forms the skeleton of cells
- in *softwoods:* 46–55 %, in *hardwoods:* 41–48 %
- the basic unit: **anhydro-D-glucopyranose residues** -
- degree of polymerization: 5,000–14,000

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Cellulose

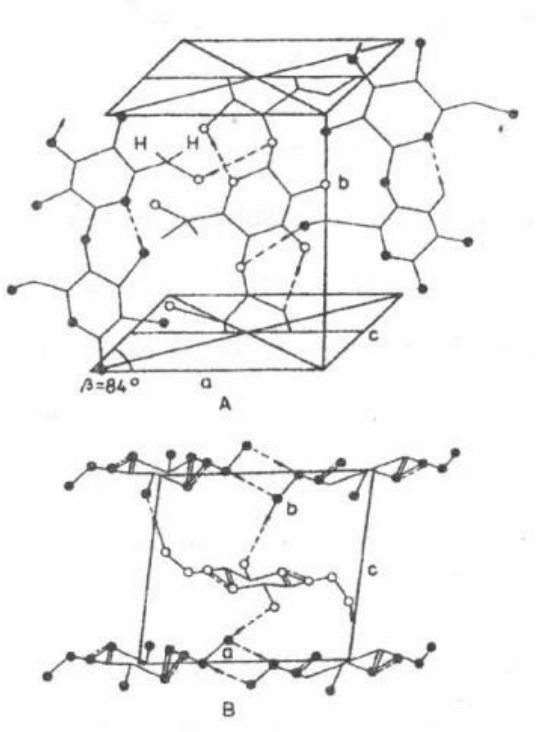


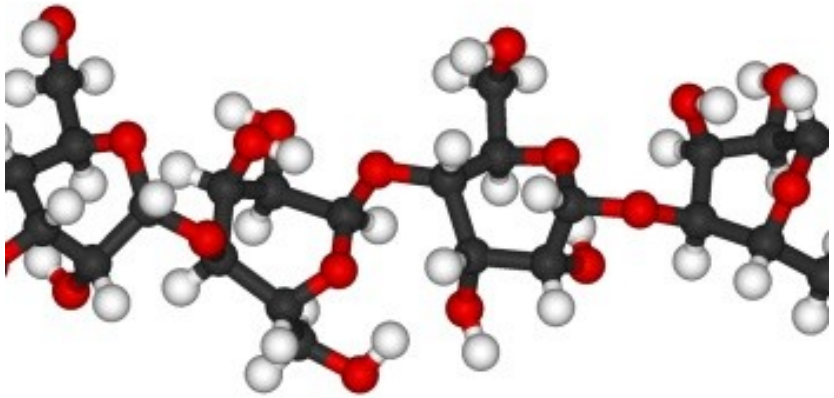
Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Cellulose

-- hydrogen bonds between adjacent cellulose chains → 3D structure





Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Cellulose

Two structural types:

- *crystalline form* (70 %) - regular structure
- *amorphous form* (30 %) - without 3D structure

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Cellulose

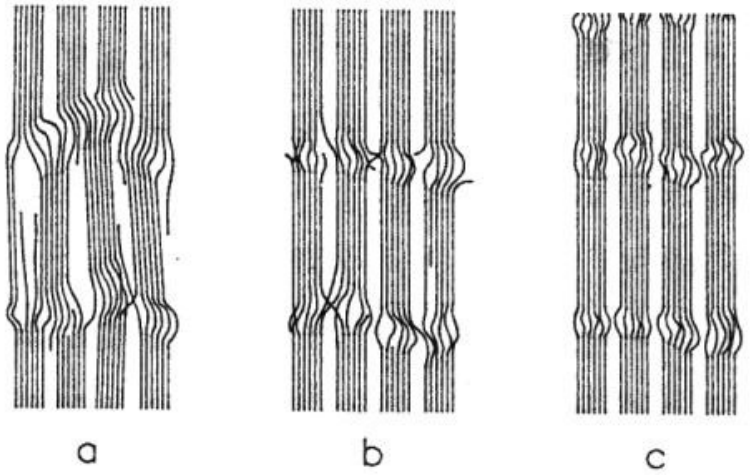
Higher amount of crystalline form results in:

→ higher wood density

→ higher modulus of elasticity (MOE)

→ higher strength in tension

→ lower shrinkage/swelling



Basic models of cellulose chains arrangements in fibrils.

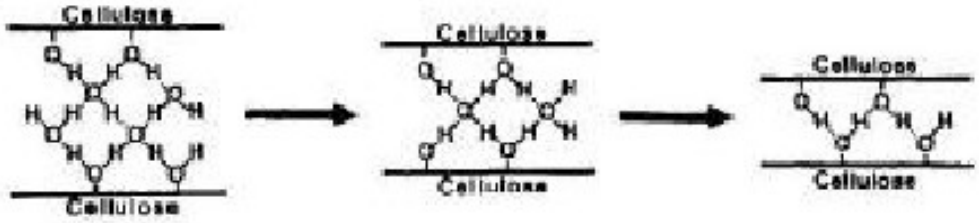
Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Cellulose

Molecules of water are linkaged between OH-groups → cellulose chains are moving away → **wood swelling**

The reverse process is **wood shrinkage**.



The proces of molecules of water removing = shrinkage. The right figure: no water content amount.

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Hemicelluloses (Polyoses)

= a mixture of other polysaccharides in wood

- degree of polymerization: 100–200
- heteropolymers
  = more than one type of basic unit (monomer)

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Hemicelluloses (20–35 %)

- categories:

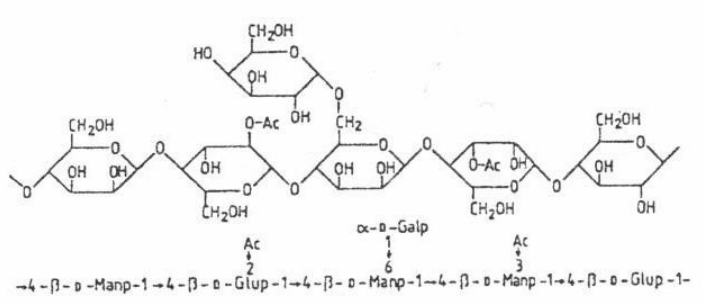
a) xylans

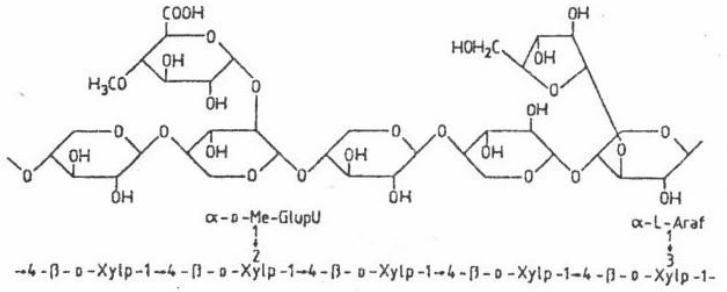
hardwoods (up to 35 %)

- main units: *pentoses*
- D.P. 100-200

softwoods (10–15 %)

- D.P. 70–130





Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

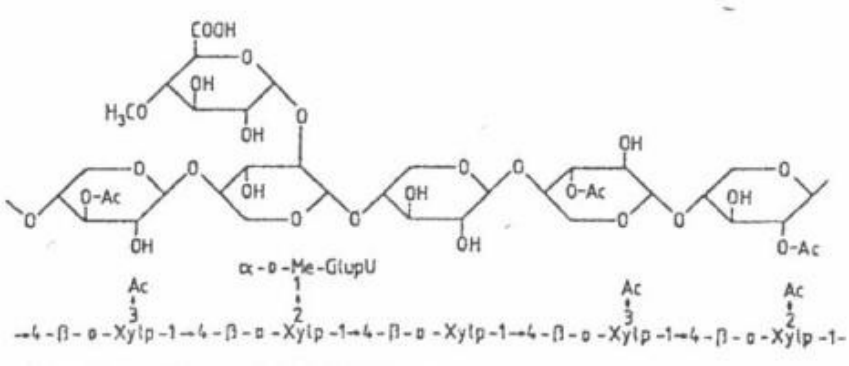
Hemicelluloses

b) glucomanans

- main units: hexoses
- D.P. 60–70

softwoods (up to 20 %)

hardwoods (3–5 %)



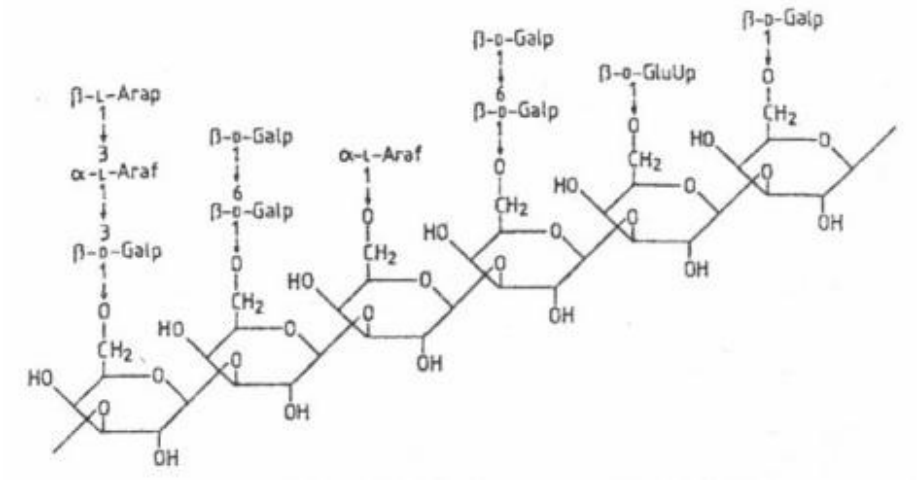
Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Hemicelluloses

c) galactans

- low content amount in pine, beech, birch, acer: 0,5–3 %
- in wood of larch: 10–20 %
- higher content amount in compression wood



Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Lignin (15–36 %)

- next to cellulose the most abundant organic substance in the world
- 3D macromolecules
- chemical bonds especially to hemicelluloses
- irregular distribution within cell wall
- softwoods (24–33 %), hardwoods (19–28 %)

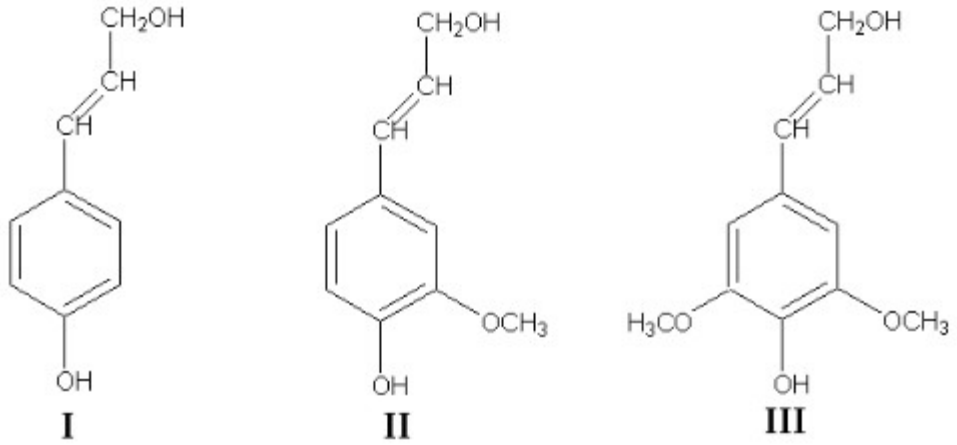
Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Lignin

Lignin is amorphous polyphenolic substance

Main units (precursors):



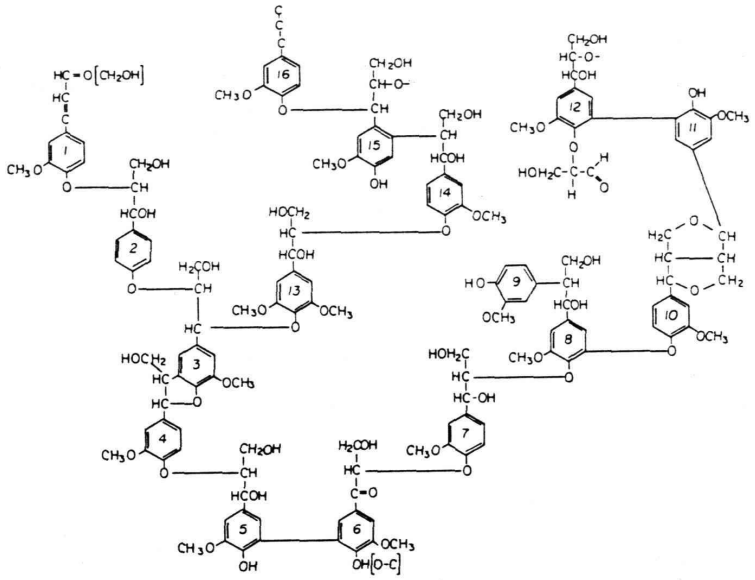
p-kumaryl alcohol *coniferyl alcohol* *sinapyl alcohol*

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Lignin

- no regular pattern in its structure → a mixture of heterogeneous substances
- its structure is presented by models only



Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Lignin

softwoods

- *guajacyl lignin* = coniferyl alcohol (95 %) + p-kumaryl alcohol

hardwoods

- *guajacyl-syringil lignins* = coniferyl alcohol + sinapyl alcohol
- higher variability in its structure

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Lignin

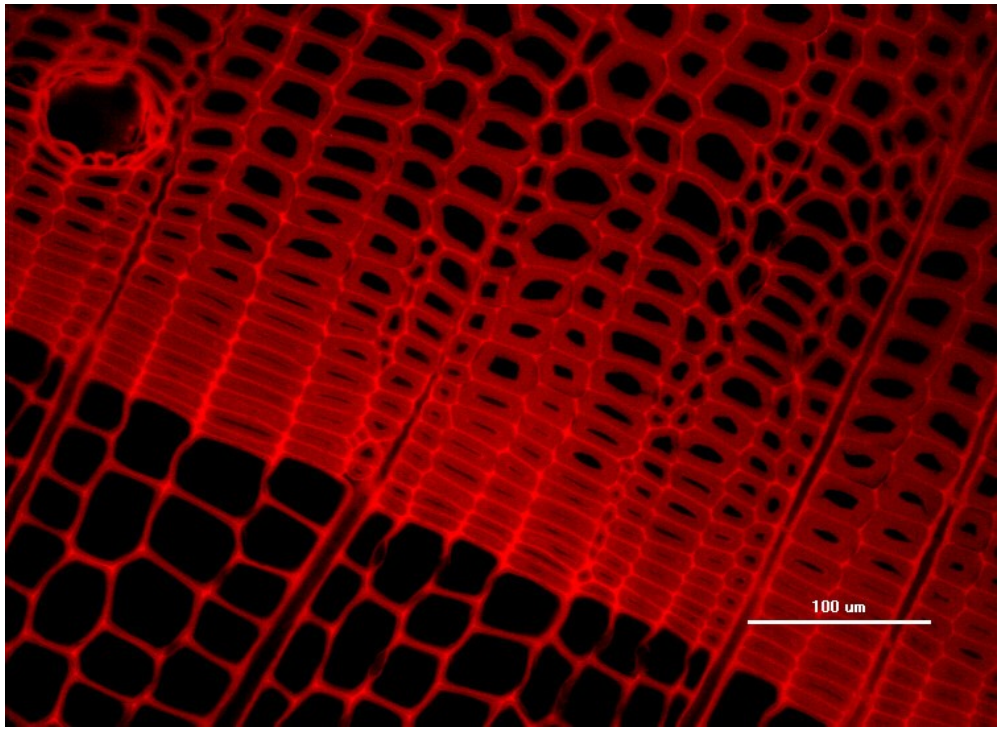
It affects wood properties:

- improves wood stiffness
- it improves wood strength properties (compression, bending)
- it lowers wood permeability for water
- it improves wood resistance to fungi

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Primary components

Lignin – autofluorescence



Autofluorescence of lignin. Transverse section of wood of spruce.

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Secondary components

Secondary components (3-10 %)

Substances in small amount in wood volume.

They can be located in

- cell walls
- intracellular spaces
- in lumina

Their presence can affect wood colour, odour, resistance.

a) organic compounds *(extractives)* – 1–5 % of wood volume

b) inorganic compounds *(ash)* – up to 1 % of wood volume

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Secondary components

inorganic compounds

- salts of Ca, K, Mg
- in form of crystals
- up to 25 % of them may be removed from wood by water

- salts of Ca: up to 50 %
- very small amount of Mn, Na, P, Cl

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Secondary components

organic compounds

saccharids

- *pectins*
- *starch* (= amylosa + amylopectin) – important cell food

fenolic compounds

improves resistance of wood

- *lignans*
- *flavanoids*
- *stilbens* – keep colours same
- *tannins* – in chestnut or oak heartwood

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018

Secondary components

organic compounds

terpens

- in softwoods with resin canals

other compounds

- many other substances of low amount
- for example: proteins, alcaloids etc.

Supported by the European Social Fund and the state budget of the Czech Republic, project InoBio – CZ.1.07/2.2.00/28.0018