Cellulose oxidizing enzymes for fibre processing

BioFuture2025 seminar
16.-17.4.2019 Lahti, Finland

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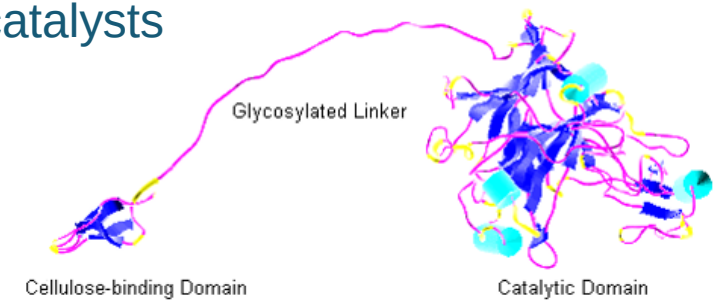
Diverse products from wood fibres

Enzyme technologies for processing of wood fibres

- **Enzyme-assisted technologies have been applied in**
  - Pulp bleaching and pitch control
  - Refining
  - Improvement of fibre reactivity
  - Modification fibre surface properties

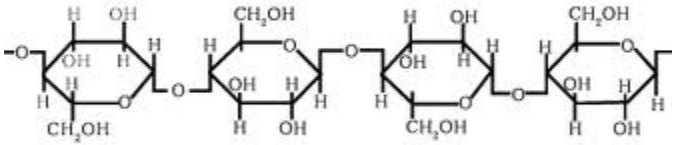
- **Benefits from using enzymes**
  - Reaction specificity
  - Mild conditions (T, pH)
  - Improved products, reduced energy and chemical consumption, renewable catalysts

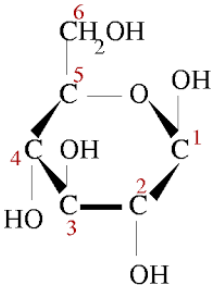
- **Enzyme-types**
  - Glycoside hydrolases
  - Oxidative enzymes
  - Esterases, lipases

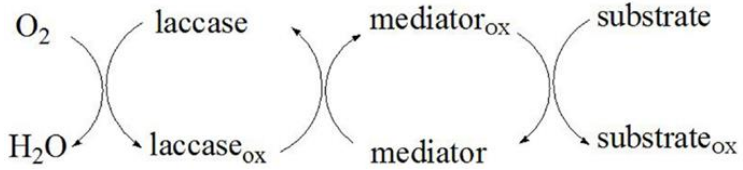


Enzymatic oxidation of cellulosic fibres

- Oxidation alters fibre properties (water retention, surface charge, strength, fibrillar interactions)
- Anhydroglucose units in cellulose can be oxidized in different positions, leading to formation of carboxyl and carbonyl functionalities and/or chain cleavage



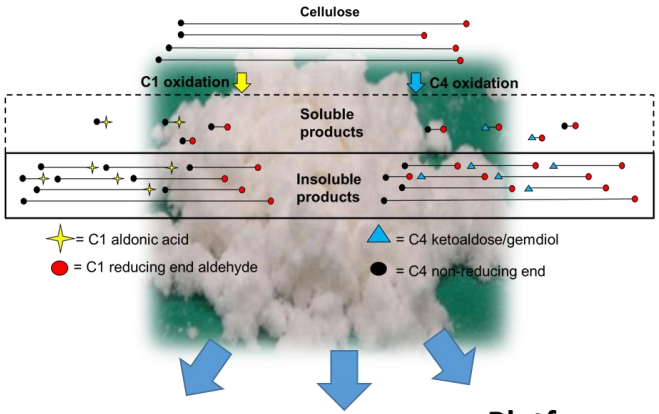




- Laccases (multicopper oxidases) can oxidize cellulose with aid of soluble mediators (TEMPO)

Lytic polysaccharide monooxygenases (LPMOs)

- **Large gene families** (in fungi, bacteria, animals, viruses)
- **Range of substrates** depends on LPMO
  - cellulose
  - chitin
  - starch
  - some hemicelluloses



- **Direct oxidation of cellulose**
  - At C1 position→ lactone → aldonic acid AND/OR
  - At C4 position → ketoaldose ↔ gemdiol
  - ➢ Cleavage glycosidic linkages

Regenerated cellulose products

Functionalised (Nano)celluloses

Platform sugars for fuels and chemicals

- Applied in **commercial enzyme products saccharification of lignocelluloses**
  - **Enhance hydrolysis of the recalcitrant polysaccharides**

Understanding on reaction mechanism of LPMOs is evolving

- **The oxidation occurs in presence of**
  - Oxygen or hydrogen peroxide

- **Electron donor/reducing agent**
  - Reduction of the Cu(II) to Cu(I) in the enzyme active site
  - Can react with molecular oxygen→ formation of hydrogen peroxide

Crystal structure of Tr AA9A extended catalytic domain 5O2W, Hansson et al. 2018 J. Biol. Chem. 292: 19099–19109

Reviewed in Bissaro B, Várnai A, Røhr ÅK, Eijsink VGH. 2018. Oxidoreductases and reactive oxygen species in conversion of lignocellulosic biomass. Microbiol Mol Biol Rev 82:e00029-18. https://doi.org/10.1128/MMBR.00029-18.

ERA-NET Forest Value project: From fundamentals to valorization: Enzymatic oxidation of cellulosic fibres and underlyig mechanisms (FunEnzFibres)

- **Project objective:** To explore the potential of lytic polysaccharide monooxygenases (LPMOs) in oxidative modification of cellulosic fibres. The research aims at developing sustainable refining and dissolving processes.
- **Duration:** 3 years (2019-2021)
- **Consortium:**
  - VTT Technical Research Centre of Finland Ltd
  - Norwegian University of Life Sciences (NMBU)
  - University of Natural Resources and Life Sciences (BOKU, Austria)
  - Industrial advisory board

Project structure

WP1 Selection, production and characterization of enzymes and substrates

WP2 Development of analytical methods for LPMO modified fibres

WP3 Enzymatic oxidation of cellulosic substrates

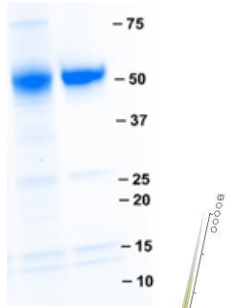
Enzymes from NMBU and VTT

Model cellulosic fibres

Methods to characterize the oxidation products

Industrial raw materials

Optimisation of reactions and application studies



https://www.researchgate.net/project/From-fundamentals-to-valorization-Enzymatic-oxidation-of-cellulosic-fibres-and-underlyig-mechanisms-FunEnzFibres

Teams and acknowledgements

Kristiina Kruus (Aalto University)
Kaisa Marjamaa (VTT)
Jenni Rahikainen (VTT)
Stina Grönqvist (VTT)
Nina Aro (VTT)
Anu Koivula (VTT)

Vincent Eijsink (NMBU)
Aniko Varnai (NMBU)
John-Kristian Jameson (NMBU)

Antje Potthast (BOKU)
Irina Sulaeva (BOKU)

ForestValue

Project FunEnzFibres is supported under the umbrella of ERA-NET Cofund ForestValue by **Academy of Finland, Research Council of Norway and Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW).** ForestValue has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773324."