Effect of Enzyme Species and Dosage on Production of Microfibrillated Cellulose from Mechanical Pulp Fines

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Background

Microfibrillated cellulose (MFC) fibres have been extensively studied as a reinforcing material in the papermaking industry and in the manufacture of bioresource-based composites. They are mechanically resistant and present a high surface area, which allows them to form strongly interconnected networks. However, the production of MFC by mechanical refining requires high specific energy, and, thus, process modifications are needed to enable implementation on the industrial scale.

Motivation

Two possible energy-saving methods are:

a) The **valorization of the fines** fraction of pulp (fibres of < 0.5mm length), usually discarded[1]

b) Enzymatic hydrolysis treatment prior to refining. It facilitates cell wall degradation and results in microfibrils of more desirable structure, size, and aspect ratio than untreated MFC[2]. The use of enzymes is also environmentally appealing since they are obtained from natural resources and require mild operating conditions. The interaction of enzymes and refining on MFC properties is still not well established.

Our project aims to elucidate the effect of different enzyme types at different dosages on fibre morphology.

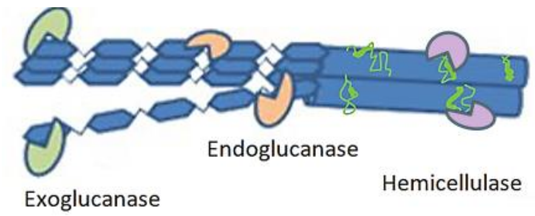

Fig 1. Schematics of enzymes action on a wood fibre (adapted from Celignis Analytical website[3]).

Methods

1. Pulp fibres of around 0.8mm length selected
2. Enzyme treatment at 3.5% pulp consistency incubated at 60ºC for 2 hr.
3. PFI refining to 5,000 revolutions
4. Evaluation of fibre morphology using *Fibre Quality Analysis* (FQA).

Enzyme types		
Refining Only	Endoglucanase	Endoglucanase Exoglucanase
Exoglucanase	Endoglucanase Exoglucanase Mannanase	Endoglucanase Exoglucanase Mannanase Xylanase

Dosage (%w/w)	pH	Temperature (°C)	Duration (h)
0.5 2.5 5.0	6.0	60	2

Results

- Pulp treated with Exoglucanase, Endoglucanase, and the Endo+Exo+Man+Xyl cocktail exhibited increasing length reduction with increasing dosage.
- Pulp treated with Endo+Exo+Man and Endo+Exo exhibited the greatest length reduction at a dosage of 2.5%.
- Treatment with Endoglucanase at a dosage of 5% proved to be very effective in length reduction (circa 33%) and in the formation of fines, which indicates a good fibrillation action.
- However, an increase in length reduction by the other enzyme treatments did not increase the production of fines, which indicates fibre cutting unaccompanied by fibrillation.

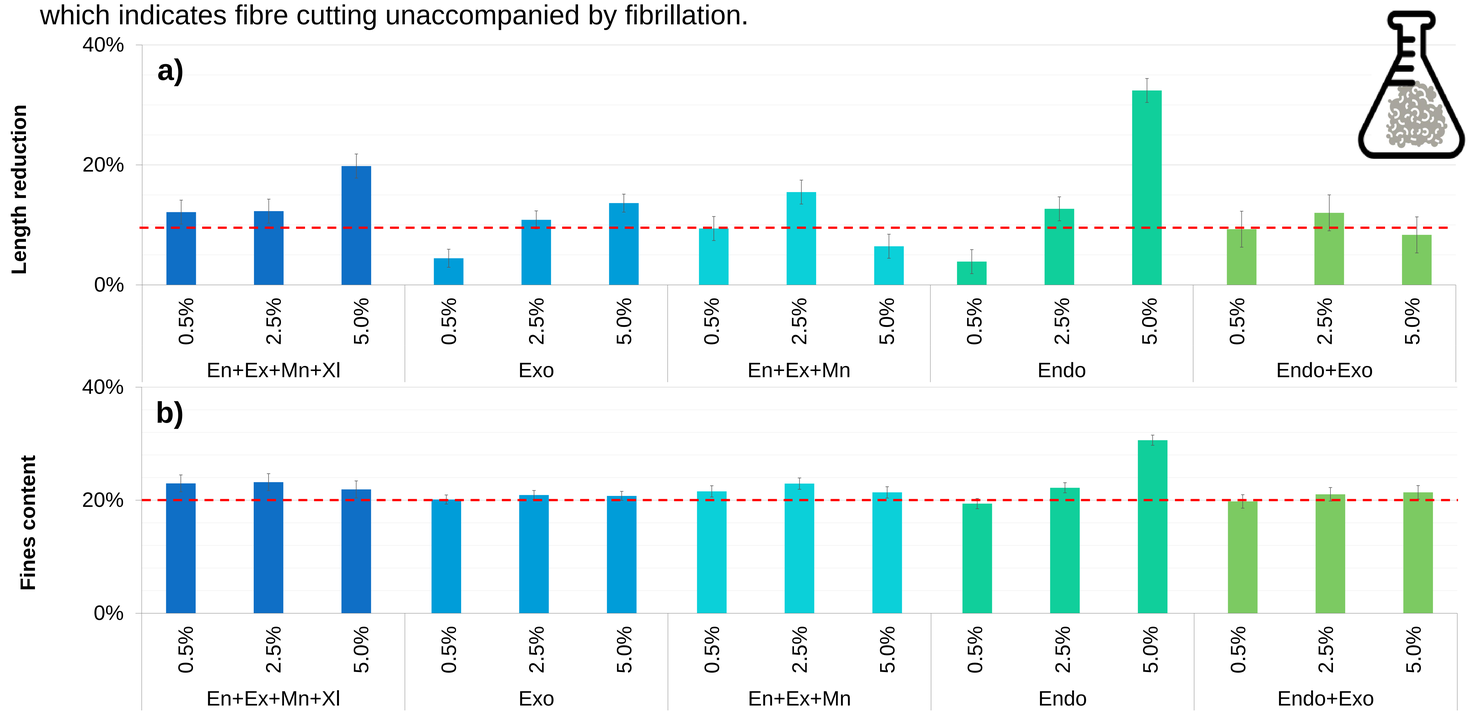

Fig. 2 Effect of enzyme type and dosage variation on a) fibre length reduction relative to untreated fibres, and b) fines content measured on FQA. Red dashed line indicates the result of refining without enzymatic hydrolysis.

Future

The next steps involve changing other enzymatic hydrolysis parameters such as: **incubation time, pH, and temperature**. In addition, gradually increase the **PFI refining level**. We will combine FQA results with microscopy to gain insight into which treatment generates optimal fibrillation for high bulk and high tensile strength applications. In addition, mechanical pulp has a significant amount of lignin in its fibres. MFC produced from mechanical pulp will present novel feature, such as greater hydrophobicity, and will enable innovative sustainable materials.

References

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3. Enzymatic Hydrolysis Tests at Celignis - Celignis Biomass Analysis Laboratory [Internet]. [cited 2022 Apr 26]. Available from: https://www.celignis.com/archive/enzymes.php

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