

## Selection of enzymes for pulp refining

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**Abstract:** *Selection of enzymes for pulp refining.* The goal of this research is to investigate the impact of enzymatic pre-treatment on pulp refining and provide guidelines for selection of enzymes enhancing refining process. For this purpose commercially available enzymes and enzyme preparations were used. This topic is very important because pulp refining process is very expensive and consumes about 50% of all electrical energy used in the process of paper manufacturing. Application of suitable enzymes may contribute significantly to reduction of energy consumption in paper production process.

*Keywords:* refining, enzymes, pretreatment, glucose, enzyme activity

### INTRODUCTION

Plant fibres are characterized by high rigidity, sometimes excessive length. As a result, paper products obtained directly from these fibers, without adequate treatment have a very loose structure, uneven transparency and relatively low tensile properties, especially low tear resistance. For papermaking pulps many properties are created through the mechanical treatment of the pulp in aqueous media. This process is called refining and is the most important operation in the manufacture of paper [1,2]. There is a reason for the old papermakers proverb that "Paper is created in the beater". During refining, the fibres become flexible, so as to form more and more dense structure and free spaces are also filled with fine fraction [3,4]. These factors affect the growth of the volume mass of paper, improve smoothness and reduce air permeability [5]. Application of enzymatic pre-treatment is currently one of the main direction aiming to improve efficiency of refining process. However, application of inappropriate enzymes to paper machine may also cause serious difficulties and runability problems [2].

### METHODS/ MATERIALS

Cellulosic pulp:

Bleached pine kraft pulp, dedicated for graphic paper. The main parameters of the pulp are:

- weighted average fiber length – 1,78 mm
- maximal breaking length - 8100 m
- maximal tear resistance - 800 mN

Enzymes:

The name of the enzyme preparation, with were used in this research:

- Xylanase from *Thermomyces lanuginosus*
- Cellulase from *Aspergillus* sp.
- NS-22119 - a mix of both xylanase and cellulase in obvious for the manufacturer proportions
- Cellulase from *Trichoderma resei*
- Ultraflomax - a mix of both xylanase and cellulase in obvious for the manufacturer proportions
- NS-22086 - a mix of both xylanase and cellulase in obvious for the manufacturer proportions

To determine the activity of the enzymes and select those with the most efficient use of the first determined amount of glucose extracted from the pulp during incubation with various enzymes.

The sample tubes have been filled by 1g b.d. pulp, 18ml distilled water / buffer and then dispensed with 1 ml portions of the enzymes. The prepared samples were placed in a water bath at 50°C for 15, 30, 60 and 120 min.

At this time, the samples were boiled in order to deactivate the enzyme and water from the tube obtained to determine the glucose content.

Water has been collected from a sample, by using 2 ml of the GODPOD test, after 15 minutes of incubations at room temperature, the amount of glucose in a samples was determined by using a spectrophotometer.

## RESULTS

The following tables presents enzymes activities, glucose concentration and tear resistance of paper produced from pulp pretreated with enzyme and then refined.

**Table 1.** Enzymes activity against carboxymethylcellulose, xylan and filter paper

The name of the enzyme preparation	Activity against		
	carboxymethylcellulose (cellulase)	xylan (xylanase)	filter paper (FPU)
Xylanase from <i>Thermomyces lanuginesus</i>	0,038 U/mg	7,46 U/mg	0,122
Cellulase from <i>Aspergillus sp.</i>	2,37 U/ml	4,68 U/ml	1,96
NS-22119	12,1 U/ml	19,7 U/ml	12,76
Cellulase from <i>Trichoderma resei</i>	4,18 U/ml	89,62 U/ml	12,76
Ultraflomax	13,5 U/ml	53,3 U/ml	60,66
NS-22086	80,58 U/ml	192,48 U/ml	112,12

**Table 2.** Glucose and reducing sugars concentration in the suspension after pretreatment of pulp with enzymes

The name of the enzyme preparation	Glucose concentration (mg/ml)	Reducing sugars concentration (mg/ml)
Xylanase from <i>Thermomyces lanuginesus</i>	0,13	0,25
Cellulase from <i>Aspergillus sp.</i>	0,2	0,61
Cellulase from <i>Trichoderma resei</i>	11,2	11,6
NS-22119	7,7	10,4
Ultraflomax	9,9	10,5
NS-22086	12,96	14,6

**Table 3.** Tear resistance of paper obtained after pretreatment of pulp with enzymes and refining for 30 seconds.

The name of the enzyme preparation	Tear resistance, mN
Xylanase from <i>Thermomyces lanuginesus</i>	333
Cellulase from <i>Aspergillus sp.</i>	0
Cellulase from <i>Trichoderema resei</i>	0
NS-22119	0
Ultraflomax	196
NS-22086	340

#### CONCLUSIONS:

According to the results obtained during the research cellulases and multienzyme preparation have too high activity for application as pretreatment for refining. Usage of these enzymes release too much of glucose to the suspension and degrade cellulose fibers so that it is impossible to form usable hand sheets of paper.

The most promising enzyme for this application is xylanase. This enzyme does not show very high activity and there is a very low glucose concentration in the suspension after pretreatment with this enzyme. Moreover, properties of paper obtained after pretreatment with this additive are reasonable good.

#### REFERENCES

1. HOLIK H.; „Handbook of Paper and Board” Willey, John&Sons Incorporated, 2006
2. EK M., GELLERSTEDT G., HENRIKSSON G.; „Pulp and Paper Chemistry and Technology”, Walter de Gruyter, 2009
3. PRZYBYSZ K., Technologia celulozy i papieru część 2. Technologia papieru, Warszawa 1997
4. PRZYBYSZ K.; „Technologia papieru: Papiernicze masy włókniste, część 1”, WIST, Łódź, 2007
5. SZWARCSZTAJN E.; „Technologia papieru, część I”, WPLiS, Warszawa, 1963

**Streszczenie:** *Dobór enzymów do mielenia papierniczych mas włóknistych.* Celem pracy jest zbadanie wpływu wstępnego traktowania enzymatycznego na proces mielenia i określenie wytycznych dotyczących doboru odpowiednich enzymów. W tym celu przebadano dostępne handlowo enzymy i preparaty wieloenzymowe. Zagadnienie to jest bardzo istotne, ponieważ mielenie papierniczych mas włóknistych jest procesem bardzo kosztowym i pochłania około 50% całkowitego zużycia energii elektrycznej w procesie produkcji papieru. Dobór odpowiednich enzymów może znacząco obniżyć zużycie energii w procesie wytwarzania papieru.

The authors gratefully acknowledge that this work was financially supported by the project LIDER/407/042/L-4/2013 founded by National Centre for Research and Development, Poland (NCBiR).

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