PRODUCTION OF BIOETHANOL FROM EUCALYPTUS SAWDUST USING DIFFERENT PRETREATMENTS IN BIOREFINERY APPROACH

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Introduction

Sawdust is a lignocellulosic residue from the pulp and paper industry that can be used as a raw material to obtain fuel bioethanol and other marketable products, under a biorefinery concept. The co-production of bioethanol and other products requires a fractionation process that preserves the hemicellulose and lignin fractions and constitutes an effective pretreatment for the hydrolysis of cellulose.

Autohydrolysis and alkaline pretreatments (kraft, NaOH, NaOH-H_2O_2) were studied to enhance cellulose enzymatic hydrolysis, preserving xylan and lignin fractions for further processing.

The bioethanol production from some of the pretreated solids were evaluated by Presaccharification and Simultaneous Saccharification and Fermentation (PSSF).

Materials and methods

Raw material

Eucalyptus sawdust was provided by a local pulp factory (UPM, Uruguay).

Autohydrolysis (A)

160-170°C, 12-150 min, LSR* 6-8 g/g

NaOH-H_2O_2 (S)

50-100°C, 30-240 min, 8-16% NaOH-H_2O_2, LSR* 7 g/g

Enzymatic hydrolysis

Enzyme commercial preparation Cellic CTec 2 (kindly provided by Novozymes, Brazil)

Conditions: 48ºC, citrate buffer (pH 4.8), 150 rpm, 96 h, 13-16% solids

PSSF

Microorganism: *Saccharomyces cerevisiae* PE-2

Experimental conditions:

Presaccharification: 25 FPU/g glucan, 150 rpm, 48°C, 24 h, LRS* 7.5 g/g

Simultaneous saccharification and fermentation: 100 rpm, 35°C, initial cell concentration 1x10^8 cells/mL

(*) LSR: liquid to solid ratio

Combined pretreatment

Autohydrolysis + NaOH pulping (ASP):

Autohydrolysis: 170°C, 90 min, LSR* 7 g/g

NaOH pulping: 155°C, 90 min, 12% NaOH

Autohydrolysis + Kraft pulping (AKP):

Autohydrolysis: 170°C, 90 min, LSR* 7 g/g

Kraft pulping: 155°C, 140 min, alkali charge 10.5%

Results and discussion

The eucalyptus sawdust showed high lignin and glucan contents comparing to others lignocellulosic materials (Table 1).

The combined pretreatment, autohydrolysis followed by an alkaline stage, improved enzymatic hydrolysis (glucan hydrolysis efficiency 90%) obtaining high ethanol yield as well as high recoveries of lignin and xylan in the liquids, respectively (Table 2, Figure 1).

Table 1. Composition of eucalyptus sawdust.

Component	Weight percent (% dry weight)
Ash	0.8 ± 0.1
Extractives (ethanol/water)	5.3 ± 0.3
Glucan	40.6 ± 1.7
Xylan	13.7 ± 0.2
Arabinan	1.0 ± 0.3
Klason lignin	27.0 ± 0.6
Acid soluble lignin	3.3 ± 0.2
Acetyl groups	2.8 ± 0.1

Table 2. Experimental data for the best conditions.

Assays	Lignin recovered (%)[1]	Xylan recovered (%)[1]	Glucan recovered (%)[1]	Hydrolysis efficiency (%)[2]	Ethanol concentration (g/L)	Overall efficiency (%)[3]
A[4]	19 ± 1	87 ± 2	96 ± 1	60 ± 1	9 ± 1	42 ± 1
S[5]	3 ± 1	2 ± 1	99 ± 1	31 ± 2	*	*
AKP	95 ± 2	76 ± 2	72 ± 2	90 ± 3	57 ± 3	73 ± 2
ASP	98 ± 1	76 ± 2	76 ± 2	75 ± 3	58 ± 3	81 ± 1

[1] Data calculated on the basis of original sawdust composition.
[2] Hydrolysis efficiency was calculated based on the theorical glucose concentration from glucan content of treated solid.
[3] Overall efficiency based on the theoretical ethanol concentration from original glucan content of sawdust.
[4] Experimental conditions: 170°C, 40 min, LSR 7 g/g
[5] Experimental conditions: 75°C, 240 min, 16% NaOH-H_2O_2
* PSSF test was not carried out due to the low hydrolysis efficiency achieved for this pretreament.

Conclusions

The best overall efficiency was reached for the eucalyptus sawdust pretreated by autohydrolysis followed by NaOH pulping, an ethanol yield of 250 L/t (dry basis) was obtained, and 110 kg of lignin and 50 kg of xylose per ton of dry sawdust for further processing were respectively recovered.