PRODUCTION OF BIOETHANOL FROM SILVER FIR WOOD

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Abstract. The aim of this study was the production of bioethanol from waste wood by autohydrolysis, enzymatic hydrolysis and fermentation with *Saccharomyces cerevisiae*. The major components of waste wood are cellulose, hemicellulose and lignin. Cellulose and hemicellulose are carbohydrates that were extracted from wood and converted into bioethanol. Autohydrolysis pretreatment was investigated for conversion of hemicellulose in liquid fraction and cellulose and lignin separation in solid fraction, at selected ranges of temperatures (180-200°C) and time (5-15 min). The enzymatic hydrolysis of pretreated material was performed for carbohydrates obtaining. The autohydrolysis pretreatment performed at temperature of 190°C and 10 min gave the best bioethanol concentration (37 g/l).

Keywords: wood, renewable source, bioethanol

INTRODUCTION

Woody biomass is an abundant source, cheap renewable resource, available in large quantities. Biomass from softwood, for example silver fir wood, is a very abundant feedstock (Muńoz C et al., 2011). The production of bioethanol from lignocellulosic biomass is the mandatory European targets (10% replacement of fossil fuel for transport at 2020). Conversion technologies for producing bioethanol from cellulosic biomass resources such as forest materials, agricultural residues and urban wastes are under development and have not yet been demonstrated commercially (Romaní A. et al., 2011). Lignocellulosic biomass has a great interest due to the high content of carbohydrates. Lignocellulosic biomass contains approximately 42% cellulose, 23% hemicellulose and 28% lignin. Cellulose is the polymer of glucose and hemicellulose is a mixture of polysaccharide formed from glucose, mannose, galactose, xylose and arabinose. Lignin is a three-dimensional polymer of phenylpronane with units of guaiacyl, and syringyl, but the lignin cannot be uses as a source of bioethanol (Sabiha-Hanim S. et al., 2011; Teramoto Y. et al., 2008). The process to convert wood to bioethanol consists in four stages: (1) a pretreatment to make the wood susceptible to hydrolysis; (2) hydrolysis of cellulose and hemicellulose; (3) yeast fermentation of the sugar solution, separation of lignin residue and, finally (4) distillation/recovery and purifying the ethanol (Teramoto Y. et al., 2008). Pretreatment is an important tool for practical cellulose conversion and is crucial before enzymatic hydrolysis. It is necessary to alter the structure of cellulosic biomass. The pretreatment such as: steam-explosion, dilute acid, concentrated acid are the common pretreatment used (Jones B. W.et al., 2013; Senila, L. et al., 2012).

Autohydrolysis is a green method for separation of cellulosic materials from wood. This method is carried out by heating an aqueous suspension of the wood. The hemicellulose is solubilized in liquid fraction, and the cellulose and lignin is recovered in solid fraction. So, a delignification method is necessary for elimination of lignin from cellulosic materials (Nakagame S., 2011; Zhang J. et al., 2004). Generally, bioethanol can be produced by different methods, such as: separate hydrolysis and fermentation (SHF), simultaneous saccharification and fermentation (SSF), and by consolidate bioprocess (CHP) (Nakagame S., 2011; Sun et al., 2004). The objective of this study is to investigate the effects of the pretratament of silver fir wood for bioethanol obtaining.

MATERIALS AND METHODS

Sample preparation. The experimental procedure used to convert silver fir wood to bioethanol is show schematically in Figure 1.

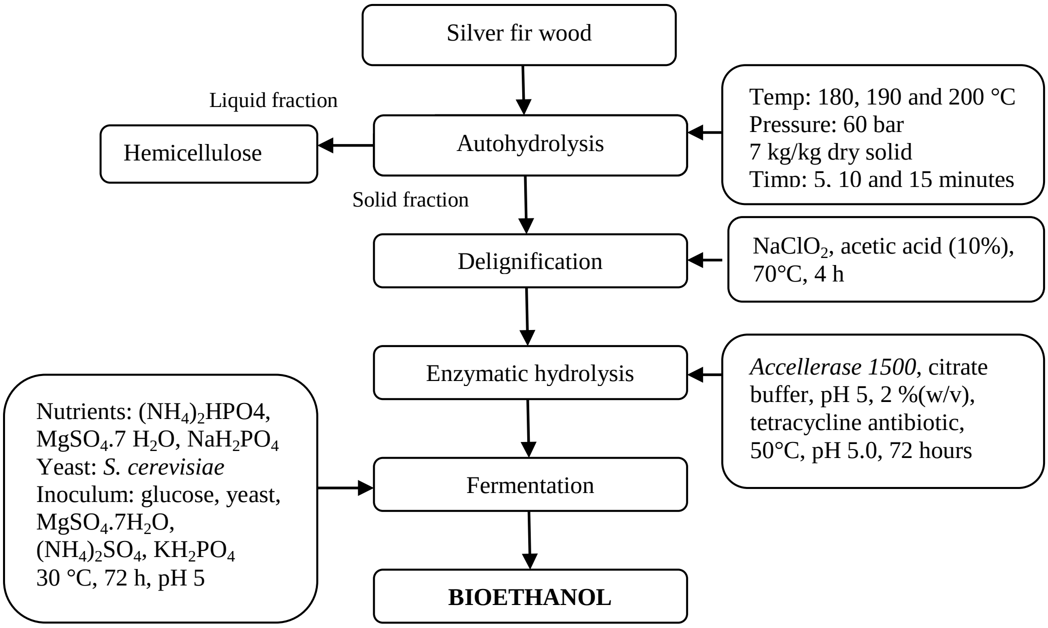

Fig. 1. Schematic presentation of the procedure to convert silver fir wood to bioethanol

RESULTS AND DISCUSSION

The silver fir, the raw material, is composed from glucan (corresponding to cellulose), a mixture of pentoses and hexoses (corresponding to hemicellulose), lignin, ash, protein and other components. Chemical composition of silver fir wood was determined and is shown in Table 1.

Table 1.

Composition of silver fir wood (percent of dry material)

Carbohydrates	
Cellulose	46.0 ± 0.5
Hemicellulose	24.0 ± 0.1
Lignin	
Acid-insoluble	25.2 ± 0.1
Acid-soluble	1.8 ± 0.2
Ash	0.3 ± 0.1
Extractives	1.3 ± 0.1
Others	1.4

The chemical composition of raw material used in this study is presented in Table 1. These values are in agreement with those reported in literature.The initial composition of the silver fir wood indicated that the cellulose (46.0%) was the most abundant fraction, followed by lignin (27.0%) and hemicellulose (24.0%). The hemicellulose content was determined to be 24.0%, by subtracting the α-cellulose content from the holocellulose content (70.0%).

The content of solid yield and composition of solid fraction resulted after autohydrolysis pretreatment is presented in Table 2.

Table 2.

Solid yield and composition of solid fraction resulted after autohydrolysis pretreatment

Autohydrolysis condition	**180°C**			**190°C**			**200°C**		
	5 min	**10 min**	**15 min**	**5 min**	**10 min**	**15 min**	**5 min**	**10 min**	**15 min**
Solid yield (g/100 g raw material, on dry basis)	81.5	79.5	76.5	75.3	74.6	73.6	73.1	72.2	71.9
Cellulose	48.6	56.6	50.6	52.3	57.8	55.9	56.3	59.5	54.9
Hemicellulose	6.2	4.7	4.2	3.8	3.3	2.5	1.1	0.0	0.0
Lignin	38.6	35.6	36.6	36.8	37.8	38.5	38.2	38.7	39.5

The solid yield (81.5-71.9) of pretreated wood decreases with the temperature increasing. The solid fraction recovered after autohydrolysis pretreatment contains cellulose and lignin. Autohydrolysis caused direct hydrolysis of hemicellulose in sugars. In solid fraction both cellulose and lignin are recovered, due to extremely insolubility of cellulose and lignin in water at high temperature and pressure, according to our previous studies (Senila L. et al., 2014). Delignification of solid fraction was done for lignin removal. *Accellerase 1500* was used to investigate the enzymatic hydrolysis of cellulose.

Bioethanol content from fermentation broth was analysed for its constituents. The method used for bioethanol analysis was SPME extraction and then analysed by GC-MS. Figure 2 shows the gas chromatogram of fermentation media obtained after fermentation of sugars resulted from wood.

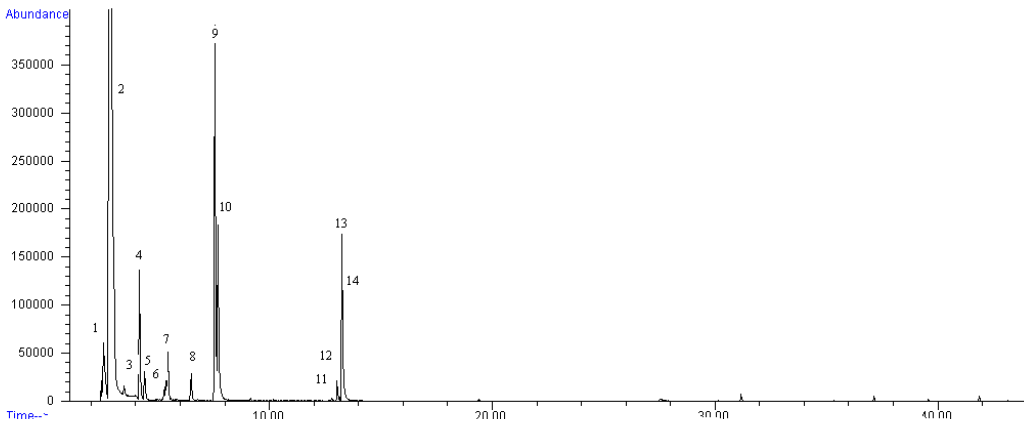

Fig. 2. The GC-MS chromatogram of fermentation medium obtained after autohydrolysis pretreatment of wood

The compounds identified in Figure 2 ware: **1**. dimethyl ether; **2**. ethanol; **3**. malonic acid; **4**. ethyl acetat; **5**. 2-methyl-1-propanol; **6**. butyric acid; **7**. acetic acid; **8**. 2,5-dimethylfuran; **9**. 1-pentanol; **10**. 2-methyl-1-butanol; **11**. 3-methyl-1-pentanol; **12**. isoamyl acetate; **13**. 2-methyl butyl acetate; **14**. ciclohexanol.

The ethanol concentration was 37 g/l.

CONCLUSIONS

Silver fir wood can be used as renewable resource for production of bioethanol. Autohydrolysis method was used as pretreatment method for hemicellulose separation. Delignification method was applied for lignin removal before enzymatic hydrolysis. Fermentation of sugars obtained after enzymatic hydrolysis was used for production of bioethanol.

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