

## Evaluation of recycled fibers by hydrolysis

VIERA KUČEROVÁ, LENKA HALAJOVÁ, KATARÍNA JAĎUĐOVÁ,  
MARTA LAUROVÁ

Department of Chemistry and Chemical Technologies, Faculty of Wood Sciences and Technology, Technical University in Zvolen, Slovak Republic

**Abstract:** *Evaluation of recycled fibers by hydrolysis.* Pulp and paper industry produce a lot of waste which contains the rest of pulp fibers. Solution is burning and gaining energy. The most effective way to execute pulps fibers are hydrolyses. Acquirement sugars maybe further utilize e.g. for fermentation of monosaccharide on ethanol (how potential raw material, which replacement fossil fuels).

In this paper there is described influence of acid hydrolysis with 1 % H<sub>2</sub>SO<sub>4</sub> (temperature 140, 160 °C, time 30, 60, 90, 120 min, hydromodule 1:40 (w/v)) on samples of recycling fibers from waste paper. Rhamnose, arabinose, xylose, manose and glucose were determined in hydrolysate by the gas chromatography.

Volatile compounds like acetic acid, propionic acid, methanol, ethanol and 2-furaldehyde were specified by the gas chromatography.

*Keywords:* recycled fibers, saccharides, hydrolysis, gas chromatography

## INTRODUCTION

Pulp and paper industry produce a lot of waste which contains the rest of pulp fibers. Solution is burning and gaining energy. The most effective way to execute pulps fibers are acid hydrolysis. Acquirement sugars maybe further utilize e.g. for fermentation of monosaccharide on ethanol (how potential raw material, which replacement fossil fuels).

Many lignocellulosic raw materials, e.g Populus, switchgrass (Foston, Ragauskas 2010), pseudo paper sludge (Torii et al. 2010), secondary pulp/paper-mill sludge and sewage sludge (Zhang et al. 2010), have been evaluated for their potential bioconversion as biomass energy crops. Cellulose can effectively be deconstructed by enzymatic hydrolysis into its constituent monomer and fermented to ethanol. The economics of biofuel production is very dependent on the overall sugar yields and energy cost associated with biomass deconstruction (Foston, Ragauskas 2010).

During acid hydrolysis of recycling fibers of various characters are released into hydrolysates. The saccharides are cleaved from the fibers in the form of oligo- and water soluble polysaccharides, they are hydrolysed into the monosaccharides. The formed monomeric and oligomeric products undergo the next reactions e.g. dehydration and oxidation. 2-furaldehyde, acetic acid and another carboxyl acid were created by destruction reactions of monosaccharides. These substances act inhibitory when the following treatment of hydrolysates e.g. for enzymatic production of bioethanol (Delgenes et al. 1996).

The main aim of this research was to determine optimal conditions (temperature, time) by which is given out the maximum of the saccharides extracts.

## MATERIAL AND METHODS

### *Material*

On the acid hydrolysis was used sample of recycling fibres from waste paper, which was collected from the technological part after the fine sorting and concentrating on belt filter. Next the sample was torn and dried at temperature of room.

### *Acid hydrolysis*

Sample of recycling fibers from waste paper was hydrolysis with 1 % H<sub>2</sub>SO<sub>4</sub> into the stainless autoclaves under conditions: temperature 140, 160 °C, time 30, 60, 90, 120 min, hydromodule 1:40 (w/v).

### *Analyses of hydrolysates*

Monosaccharides and oligosaccharides released from recycling fibers (after hydrolysis of glycoside bonds in liquor by 4 % (w/w) H<sub>2</sub>SO<sub>4</sub> at 100 °C for 4 hours) were determined in the form of aldonitril acetates by gas chromatography (Kačík, Kačíková 2009).

Volatile compounds as acetic acid, propionic acid, methanol and 2-furaldehyd were specified by the gas chromatography (Kačík et al. 2007).

## RESULTS AND DISCUSSION

The saccharide portion of recycling fibres from waste paper mainly hemicellulosic was released in the form of monomeric and low-molecular forms of polysaccharides (oligomers) into the solution. Hemicelluloses are the least resistant components. They are a mixture of mainly amorphous heteropolysaccharides, so their thermal degradation takes place in a large temperature range (Bourgois et al. 1989). In the obtained hydrolysates there were present all saccharides (pentoses and hexoses) e.g. L-arabinose, D-xylose, D-mannose, L-rhamnose, D-glucose. The maximum concentration of the monosaccharides was at the temperature of 140 °C in the time 30 minutes (Fig. 1). The monosaccharides amount during those conditions decreased in rank: D-xylose, D-mannose, L-arabinose, L-rhamnose and D-glucose (Tab. 1). Yield of monosaccharides at 160 °C was less than at 140 °C (Fig. 1).

Tab. 1 Contents of monosaccharides in hydrolysates

Temperature (°C)	Time (min)	Concentration (mg.dm <sup>-3</sup> )				
		L-arabinose	D-xylose	D-mannose	L-rhamnose	D-glucose
140	30	126	741	167	68	54
	60	42	386	188	51	185
	90	47	293	193	7	352
	120	50	451	203	23	271
160	30	23	310	62	25	53
	60	12	111	64	16	153
	90	12	22	29	3	100
	120	5	9	15	2	48

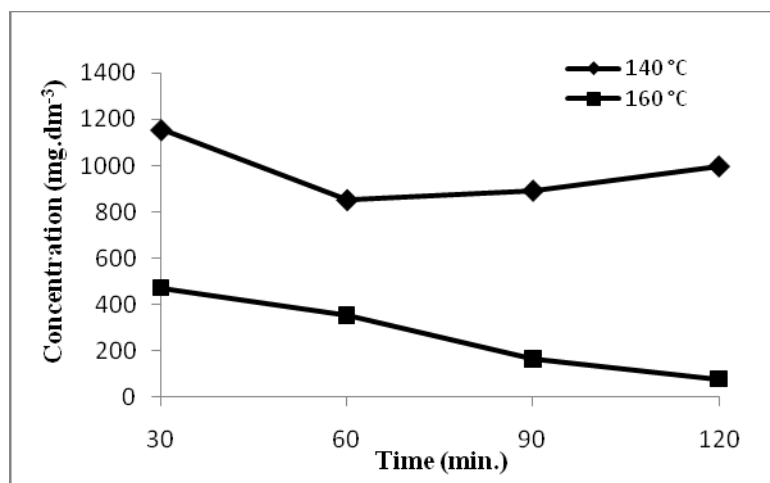


Fig. 1 The concentration of monosaccharides in hydrolysates

By using conditions at temperature 140 °C and 160 °C was the maximum oligosaccharides yield at 160 °C and 30 min (Fig. 2). Under these conditions was determine the most amount xylose, then manose and glucose (Tab. 2). The contrentation of xylose and manose deceased with time.

Released amount of oligosaccharides decreased with increasing time about 91 %

Tab. 2 Contens of mono- and oligosaccharides in hydrolysates

Temperature (°C)	Time (min)	Concentration (mg.dm <sup>-3</sup> )				
		L-arabinose	D-xylose	D-manose	L-rhamnose	D-glucose
140	30	112	640	408	27	265
	60	114	645	416	39	275
	90	63	532	328	2	808
	120	46	441	351	12	719
160	30	107	863	568	17	449
	60	26	178	195	24	612
	90	6	54	92	8	389
	120	10	12	23	5	136

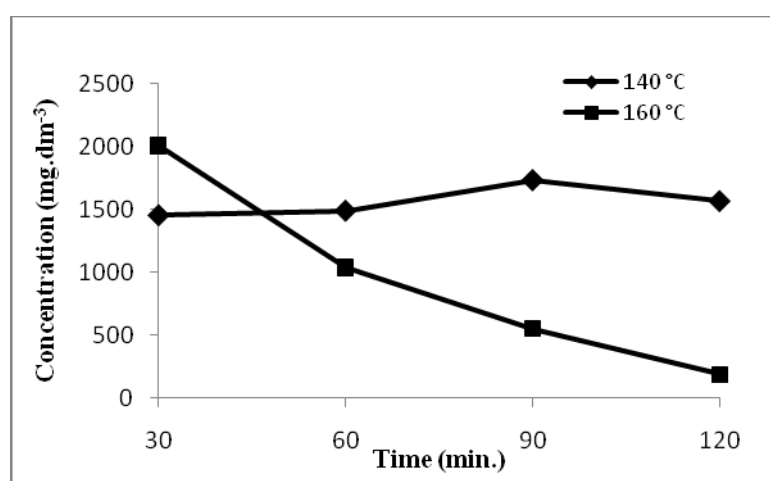


Fig. 2 The concentration of mono- and oligosaccharides in hydrolysates after hydrolysis of glycoside bonds

The volatile compounds like acetic acid, propionic acid, methanol and 2-furaldehyde, were created simultaneously with production of saccharides. The maximum amount of the

acetic acid was recorded at the 140 °C and 160 °C. This acid accrues from acetic groups like a result of deacetylation, which is the primary reaction of glucuronoxylan in acid medium. The least representation had methanol, generated by cleavage reaction methoxylic groups and is extremely toxic. The 2-furaldehyde arises from pentose by dehydration but also can accrue from hexose (Emsley, Stevens 1994).

Tab. 3 Contents of volatile compounds in hydrolysates

Temperature (°C)	Time (min)	Concentration (ml.dm <sup>-3</sup> )			
		Methanol	Acetic acid	Propionic acid	2-furaldehyde
140	30	0,24	2,50	1,56	0,89
	60	0,22	2,28	1,46	0,94
	90	0,21	2,27	1,47	0,86
	120	0,21	2,21	1,44	0,89
160	30	0,22	2,22	1,44	0,90
	60	0,22	2,23	1,45	1,07
	90	0,22	2,23	1,46	1,04
	120	0,21	2,22	1,46	1,07

## CONCLUSIONS

Lignocellulosic biomass may be used as a potential source of renewable energy via biochemical conversion of cellulose to second generation biofuels like cellulosic ethanol.

From the obtained results we can conclude:

- maximum concentration of the monosaccharides was at the temperature of 140 °C in the time 30 minutes,
- yield of monosaccharides at 160 °C was less than at 140 °C,
- released amount of oligosaccharides decreased with increasing time about 91 %,
- volatile compounds like acetic acid, propionic acid, methanol and 2-furaldehyde, were created simultaneously with production of saccharides.

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**Streszczenie:** Hydroliza odpadowego ścieru drzewnego. Przemysłpapierniczy produkuje dużo odpadów zawierających włókna drzewne. Rozwiązaniem problemu utylizacji jest spalanie. Najbardziej efektywną metodą odzysku jest hydroliza, uzyskane cukry mogą być użyte do produkcji etanolu, zastępującego paliwa nieodnawialne. Artykuł opisuje wpływ hydrolizy z 1 %  $H_2SO_4$  na próbki włókien. Zmierzono zawartośćcukrów oraz substancji lotnych.

Corresponding authors:

Viera Kučerová, Katarína Jaďud'ová,  
Lenka Halajová, Marta Laurová,  
Department of Chemistry and Chemical Technologies,  
Faculty of Wood Sciences and Technology,  
Technical University in Zvolen,  
T.G.Masaryka 24, 960 53 Zvolen,  
Slovak Republic  
e-mail: laurova@vsld.tuzvo.sk