

Hydrothermal Treatment with Phosphoric Acid for Enzymatic Saccharification of Rice Straw

Seiichi Inoue* and Tadahisa Yoshimura

Biomass Technology Research Center (BTRC)
National Institute of Advanced Industrial Science and Technology (AIST)
2-2-2 Hiro-suehiro, Kure, Hiroshima 737-0197 Japan
Tel: +81-823-72-1990 Fax: +81-823-72-1990 E-mail: s.inoue@aist.go.jp

Abstract

Hydrothermal treatment of rice straw was conducted at 140-180 °C with or without phosphoric acid. The yield of monosaccharide obtained from the rice straw using hydrothermal treatment was low. However, when 50mM phosphoric acid solution was used to hydrothermal system, most of xylan in rice straw was successfully hydrolyzed to xylose and some amount of glucan was also converted into glucose at 160 °C for 15 min. The maximum xylose and glucose yields were 54.1 and 15.0 % at this condition, respectively. The xylose yield decreased with the increase of the reaction temperature at higher than 160 °C. It is expected that the monosaccharide, such as xylose, was converted into decomposed products.

The remained cellulose residue after hydrothermal treatment with phosphoric acid at 160 °C for 15 min was easily saccharified to glucose by enzymatic hydrolysis. After the enzymatic saccharification, the glucose yield was 81.6 %.

Keywords: Rice straw, Hydrothermal treatment, Phosphoric acid, Saccharification

* Author to whom any correspondence should be addressed.

National Institute of Advanced Industrial Science and Technology (AIST)
Seiichi INOUE and Tadahisa YOSHIMURA

INTRODUCTION

Ethanol derived from biomass has the potential to be a sustainable transportation fuel. However, to avoid conflicts between human food use and industrial use of crops, the agricultural residue is considered as feedstock¹. In Japan, one of the agricultural residues is rice straw which produced about 9.6 Mt-dry annually².

Phosphoric acid can be used for the additive of the hydrolysis like sulfuric acid. However, it is low environmental loading compound. After neutralization of hydrolysate with NaOH, the salt formed is sodium phosphate. This salt used as nutrient by microorganisms³.

In this study, hydrothermal treatment with phosphoric acid for enzymatic saccharification of rice straw were examined.

EXPERIMENTAL

Hydrothermal treatment:

Hydrothermal treatment was carried out in a 100 ml autoclave.
Rice straw (<2 mm) :3g
H₂O or 50mM phosphoric acid solution :30 ml
Initial pressure: 3 MPa
Reaction temperature: 140-200 °C
Holding time at designed temperature: 15min

Enzymatic Saccharification⁴:

Enzyme : Enzyme cocktail was mixed with acromonium cellulase, β-glucosidase and hemicellulase of 10 FPU/g-rice straw.

RESULTS

1. Feedstock



Table 1 Chemical components of the rice straw

	Glucan [%]	Xylan [%]	Lignin [%]	Ash [%]
Rice straw	34.4	13.6	24.1	17.7

2. Hydrothermal treatment

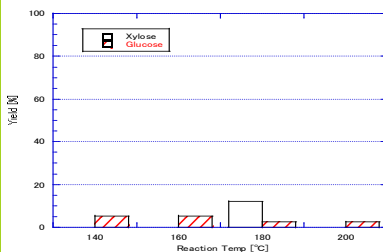


Fig. 1 Yields of xylose and glucose after hydrothermal treatment

Saccharification
50°C, 72 h

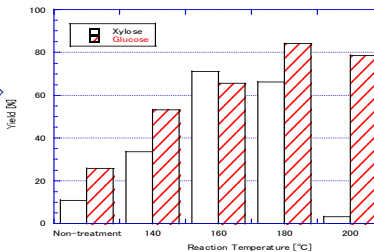


Fig. 2 Yields of xylose and glucose after saccharification

- When the hydrothermal method was used as a pretreatment for enzymatic saccharification, xylose and glucose yields increase remarkably.

- After saccharification, xylose yield decreased at 200 °C. It indicated that hemicellulose, such as xylan, was converted into excessive decomposed compound at high temperature hydrothermal treatment.

3. Hydrothermal treatment with phosphoric acid

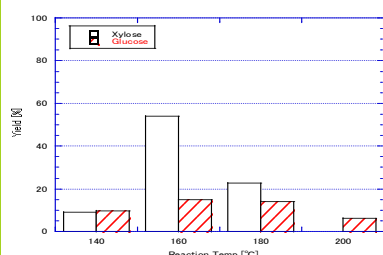


Fig. 3 Yields of xylose and glucose after hydrothermal treatment with 50mM phosphoric acid solution

Saccharification
50°C, 72 h

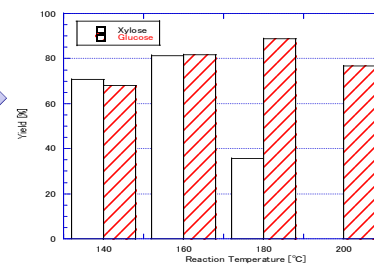


Fig. 4 Effect of hydrothermal treatment with phosphoric acid on yields of xylose and glucose after saccharification

- When phosphoric acid was added to the hydrothermal system, the yield of xylose increased remarkably.

- After saccharification, glucose yield increased compared with hydrothermal treatment at 160 °C.

CONCLUSION

- When hydrothermal method was used as a pretreatment for enzymatic saccharification of rice straw, xylose and glucose yields increased remarkably.

- Hemicellulase is unnecessary for enzymatic saccharification in this system, because xylan was hydrolyzed to xylose using hydrothermal treatment with phosphoric acid.

- It is shown that hydrothermal treatment with phosphoric acid contributes to low temperature pretreatment for enzymatic saccharification.

REFERENCES

- 1) S. Kim *et al.*, *Biomass Bioenergy*, 26, 361 (2004)
- 2) Y. Matsumura, *et al.*, *Biomass Bioenergy*, 29, 347 (2005)
- 3) S. Gamez, *et al.*, *J. Food Eng.*, 74, 78 (2006)
- 4) Yano *et al.*, 2nd Biomass Kagakuikai Proceedings, Hiroshima, 2007, p24 (in Japanese)

Acknowledgements

This work was supported by Regional Biomass Energy Project, Ministry of Agriculture, Forestry and Fisheries, Japan. The authors thank Ms. Yuko Atarashi for her assistance with HPLC analysis.