Acid Hydrolysis of Corn Stover Hemicellulose by Low-Liquid Percolation Process

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INTRODUCTION

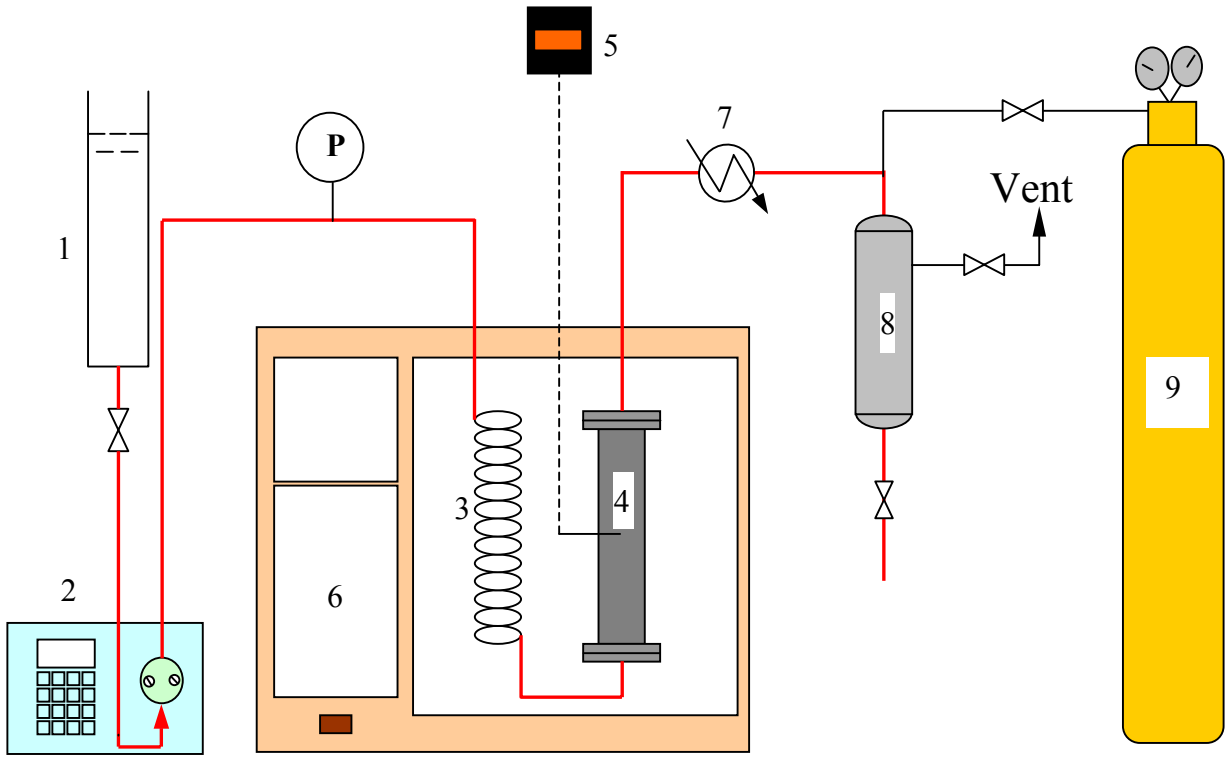
- Dilute-acid treatment is a well-established pretreatment process.
- Recovery of the hemicellulose sugars is an important factor in the process economics.
- Percolation reactor is suitable for biomass pretreatment because of: (1) high sugar yield as a result of immediate discharge of sugar products minimizing sugar decomposition; and (2) high sugar concentration obtainable by high solid/liquid ratio.

OBJECTIVES

This research was undertaken to optimize the percolation process such that the concentration and yield of hemicellulose sugars are maintained at high level in dilute-acid hydrolysis of corn stover.

The experimental conditions covered: 160-180^{o}C, 0.2-1 wt% of sulfuric acid, and broad range of acid flow rate.

EXPERIMENTAL SETUP



1, acid tank; 2, HPLC pump; 3, preheating coil; 4, percolation reactor; 5, thermometer; 6, GC oven; 7, heat exchanger; 8, product collecting tank; 9, N_2 gas.

RESULTS AND DISCUSSION

Sugar Decomposition During Preheating Stage

Table 1. Sugar Content in Corn Stover after Preheating and Water-Washing

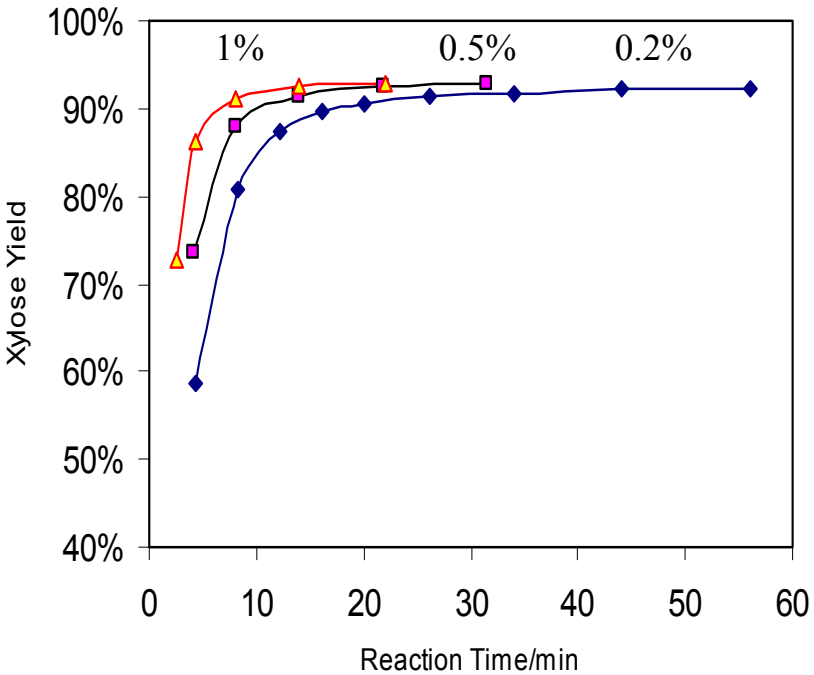
(preheating time 25 minutes, final temperature 180°C)

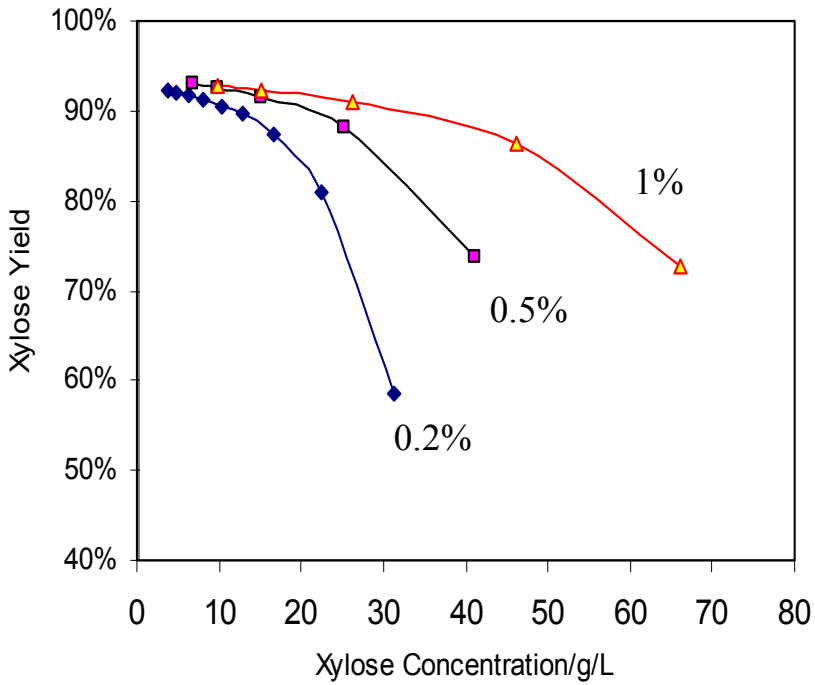
	Sugar Content Retained in the Solid after Washing	Sugars in Wash Water	Estimated Sugar Loss by Decomposition
Glucan	95.5%	~0	4.5%
Xylan	81.2%	11.4%	7.4%
Arabinan	56.1%	19.5%	24.4%

RESULTS AND DISCUSSION

Effects of Acid Concentration

(1% acid,180°C)



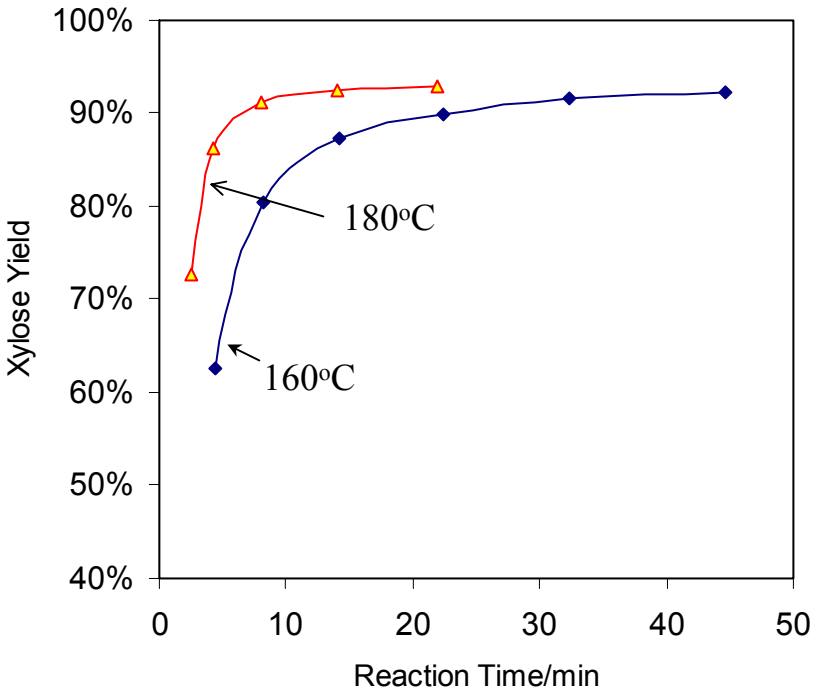


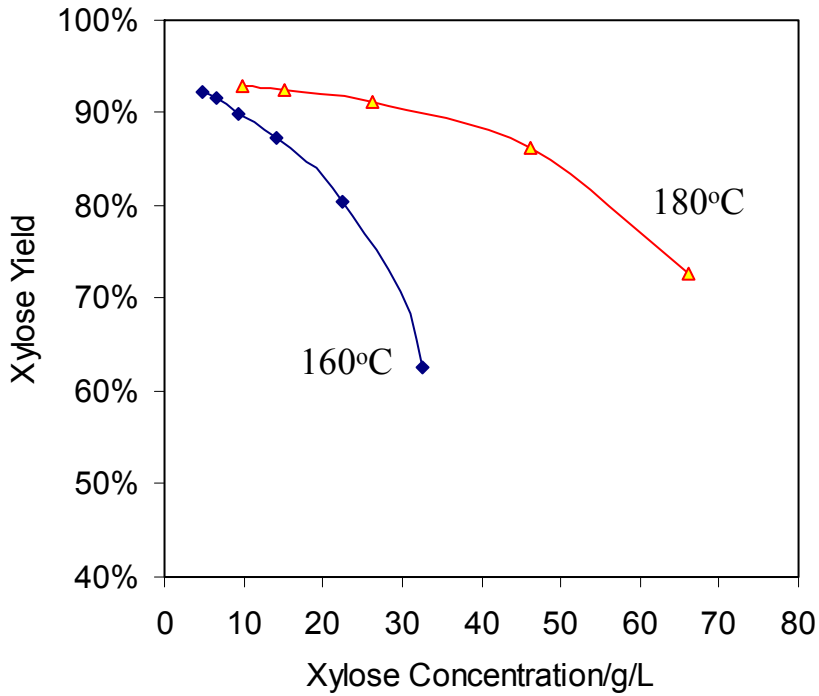
- For all acid levels applied, the maximum xylose yields surpass 90%.
- Acid concentration has significant effect on xylose production.

RESULTS AND DISCUSSION

Effects of Temperature

(1% acid, 10ml/min)



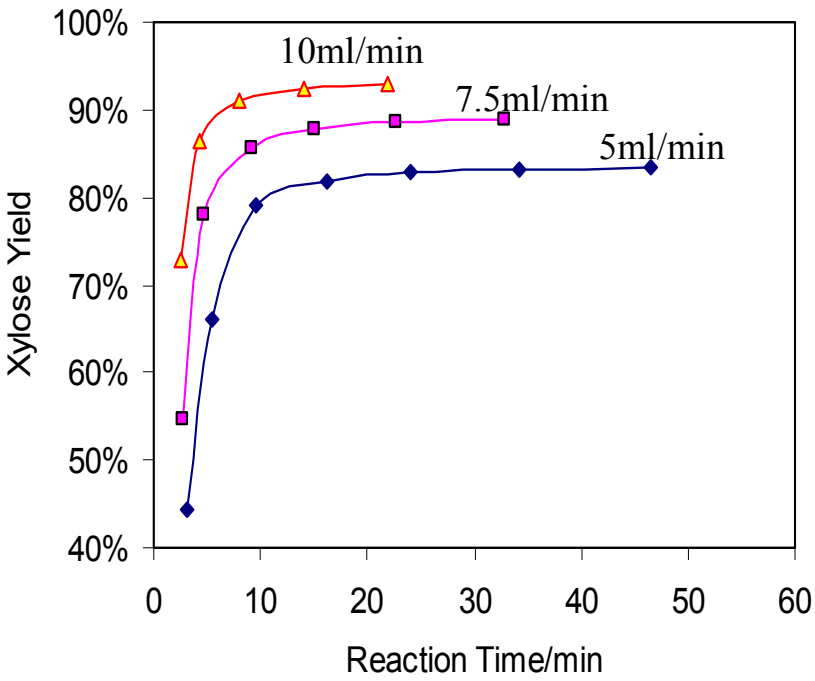


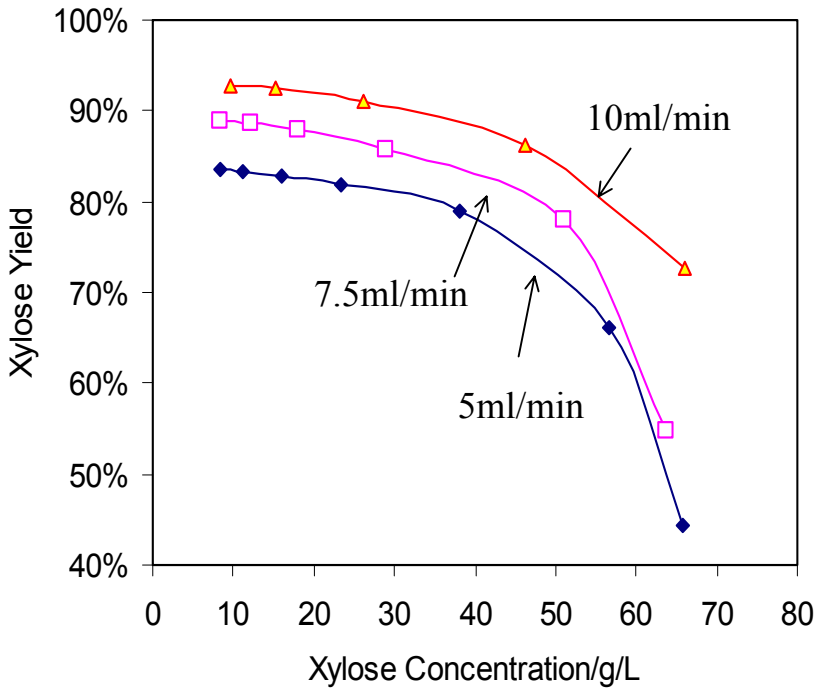
- The maximum xylose yields observed are between 89% to 93%.
- Temperature has significant effect on xylose production.

RESULTS AND DISCUSSION

Effects of Acid Flow Rate

(1% acid, 180°C)





- The maximum xylose yields observed are within 84% - 93%.
- Xylose production rate increases as flow rate increases.

RESULTS AND DISCUSSION

- All of the three reaction and operational factors (acid concentration, temperature, and acid flow rate) showed positive effects on xylose (monomer+oligomers) production.
- Increase of flow rate imposes two opposing effects on the product concentration. Higher acid flow rate introduces more liquid to the reactor with the tendency to dilute the product. On the other hand, xylose production is accelerated by fast flow raising the concentration.

RESULTS AND DISCUSSION

- Sugar decomposition is not the sole reason for the variation of yield by different flow rate because yield difference among various rates diminished with time.
- Presence of buffering components in biomass appears to be one of the main factors influencing the effect of flow rate.
- Higher flow rate provides more acid to overcome the neutralizing effect of buffering components and lowers pH. The increased acidity raises the hydrolysis rate.

RESULTS AND DISCUSSION

- The presence of optimum acid flow rate (10ml/min) that maximizes the sugar concentration is the result of combined effects of acid neutralization, sugar decomposition, and acid flow dilution.

CONCLUSIONS

- High concentration of hemicellulose sugars (primarily of xylose) is obtainable by using a percolation reactor with no prewet application, which was operated at high temperature, high acid level and a particular acid flow rate.
- The effect of acid flow rate on xylose production was related to the neutralizing ability of biomass.
- The presence of the particular acid flow rate that gives maximal sugar concentration is essentially the combined result of three factors: acid neutralization, sugar decomposition and acid flow dilution.

ACKNOWLEDGEMENTS

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2. Esteghlalian, A., Hashimoto, A. G., Fenske, J. J. and Penner, M. H., (1997), *Biores. Technol.* **59**, 129-136