

The Effect of Lignin Contents and S/G Ratio in *Populus* on the Release of

Fermentable Sugars During Dilute Acid Hydrolysis

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Summary

Samples of *Populus* having different lignin contents and S/G ratio (S: Syringyl-like lignin structures; G: Guaiacyl-like lignin structures) were hydrolyzed with dilute sulfuric acid to release fermentable sugars. The lignin contents varied from 22.7 to 25.8% and the S/G ratio from 1.8 to 2.3. The hydrolysis conditions (1w% solids, 1w% acid, 175°C maximum, 12-minute hydrolysis time) were chosen to achieve only partial hydrolysis of the hemicellulosic fraction. For example, the xylose yield of the 25.8% lignin and 2.3 S/G (high lignin, high S/G) sample was 30.1% of theoretical yield, and the xylose yield of the 22.7% lignin and 1.8 S/G (low lignin, low S/G) was 54.9% of theoretical yield. The calculated yield values of xylose were subject to statistical analysis. The results indicated that S/G ratio had significant effects on the yield of xylose whereas the lignin contents did not. However, the interaction effect of the lignin contents and S/G ratio was significant. The residual solids obtained at the end of the acid hydrolysis were hydrolyzed with an industrial cellulase. Neither lignin contents nor S/G ratio seemed to have effect on the rate of enzymatic hydrolysis of these solids.

Methods

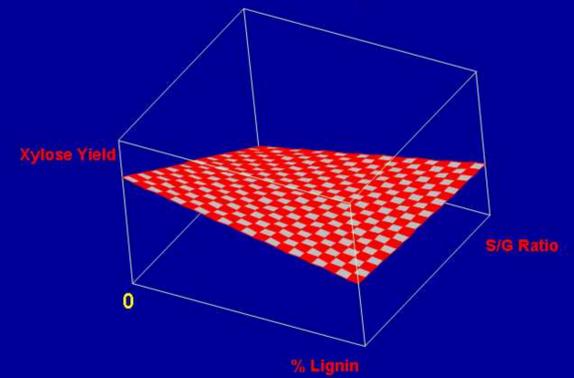
- * *Populus* stem samples ground and screened through 20 mesh screen.
- * Stainless steel reactor with thermocouple for temperature measurement heated in an oil bath.
- * Dilute acid hydrolysis experimental conditions: 1w% solids, 1w% acid, 175°C maximum, 12-minute hydrolysis time. Sample size: 1.5 g (dry weight). Samples were soaked in acid solution for 20 minutes prior to hydrolysis.
- * Enzyme hydrolysis experimental conditions: 3w% solids in 50 mM citrate buffer (pH 4.8) at 55°C.

Results and Discussion

Dilute Acid Hydrolysis Results

Sample	% Lignin	S/G Ratio	Xylose Yield	Pattern
242	24.6	1.9	0.426	Center
242	24.6	1.9	0.509	Center
242	24.6	1.9	0.4	Center
1093	25.8	2.3	0.334	High_High
1093	25.8	2.3	0.263	High_High
1093	25.8	2.3	0.307	High_High
1640	24.8	1.8	0.369	High_Low
1640	24.8	1.8	0.356	High_Low
1640	24.8	1.8	0.459	High_Low
1910	22.7	2.1	0.322	Low_High
1910	22.7	2.1	0.237	Low_High
1910	22.7	2.1	0.282	Low_High
1642	22.7	1.8	0.542	Low_Low
1642	22.7	1.8	0.556	Low_Low

Contour Profile



Analysis of Variance Table

The results indicate that the model is significant

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	0.1065	0.0355	19.866
Error	10	0.0179	0.0018	Prob>F
Total	13	0.1244		0.0002

Parameter Estimates

- * The effect of S/G Ratio is statistically significant and it has a negative impact on xylose yield
- * The effect of % Lignin alone is not significant, but the interaction effect of % Lignin and S/G Ratio is significant

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	1.6968	0.2693	6.3	<0.0001
% Lignin	-0.0142	0.0105	-1.35	0.2067
S/G Ratio	-0.4991	0.0684	-7.3	<0.0001
(% Lignin-24.22)*(S/G Ratio-1.99)	0.2523	0.0548	4.64	0.0009

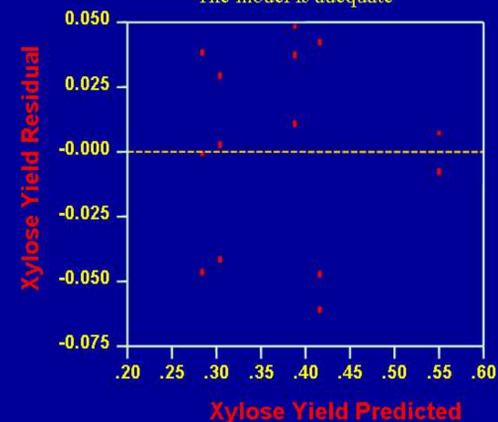
Lack of Fit Test Table

There is no lack of fit in the model

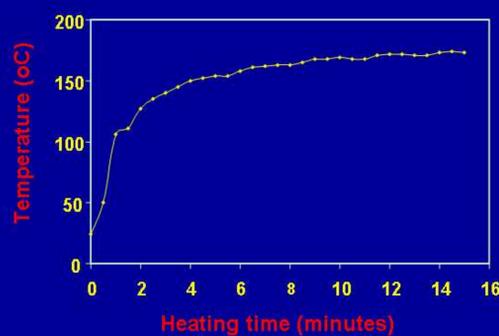
Source	DF	Sum of Squares	Mean Square	F Ratio
Lack of Fit	1	0.0046	0.0046	3.0981
Pure Error	9	0.0133	0.0015	Prob>F
Total Error	10	0.0179		0.1122
				Max RSq
				0.8931

Residual by Predicted Plot

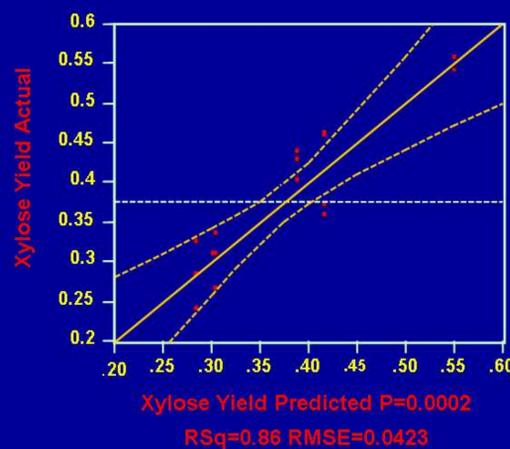
The model is adequate



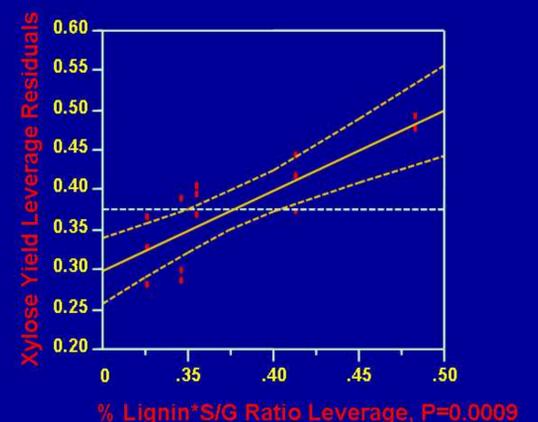
Temperature Profile in Acid Hydrolysis Reactor



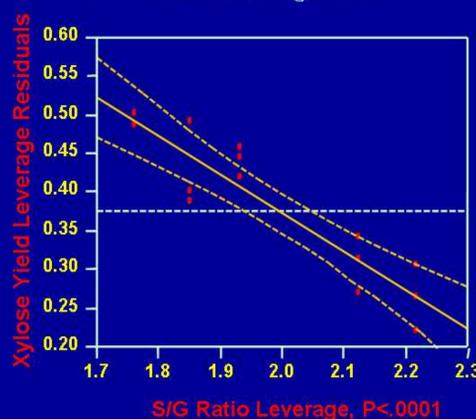
Response Xylose Yield - Whole Model Actual by Predicted Plot



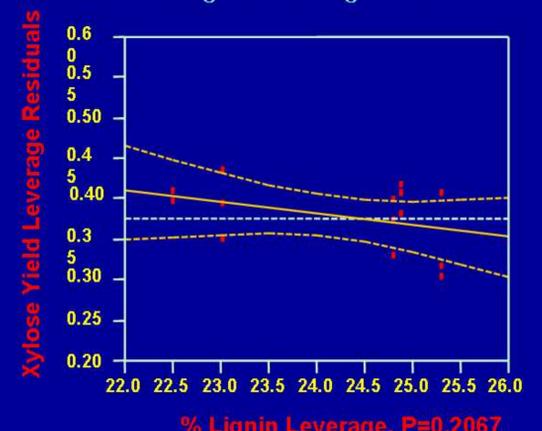
% Lignin * S/G Ratio Leverage Plot



S/G Ratio Leverage Plot



% Lignin Leverage Plot



Acknowledgement

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