ABSTRACT

The production of aldehydes that inhibit microbial fermentations may occur when aqueous monosaccharides are exposed to temperatures above 150 °C under acid conditions common to biomass pretreatment processes. Concentrations of about 0.1% or higher of the degradation product, furfural, strongly inhibit fermentation as was confirmed for hydrolysate that contained 0.5% (v/o) furfural. This paper reports the removal of furfural by contacting a polymeric adsorbent, XAD-4, with biomass hydrolysate containing furfural. Liquid Chromatographic analysis of the remaining effluent showed that furfural concentrations were less than 0.01 g/L compared to the initial concentrations which were in the range of 1 to 5 g/L. Fermentation of the resulting sugars with recombinant E. coli ethanologenic strain K011 confirmed that the concentration of furfural in the polymeric adsorbent treated hydrolysate caused negligible fermentation inhibition. Fermentation of XAD-4 treated hydrolysate with E. coli K011 was nearly as rapid as the control medium, formulated with reagent grade sugars of the same concentration. Ethanol yields for both fermentations were 90% of theoretical.

MATERIALS AND METHODS

**Resin Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>XAD-4</th>
<th>XAD-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porous Volume (mL/gram)</td>
<td>0.98</td>
<td>1.14</td>
</tr>
<tr>
<td>Mean Surface Area (m²/gram)</td>
<td>525</td>
<td>450</td>
</tr>
<tr>
<td>Mean Pore Diameter (Å)</td>
<td>40</td>
<td>90</td>
</tr>
<tr>
<td>Particle Size (µm)</td>
<td>1.2 - 6.8</td>
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</tr>
</tbody>
</table>

**Furfural Adsorption**

- **Langmuir Isotherms**
- **Linear Isotherm Approximations**

**Ethanol Yield XAD-4 Treated Hydrolysate**

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</table>

RESULTS AND DISCUSSION

**Adsorption Column Design**

Assume Local Equilibrium

**Shock Velocity**

\[ v = \frac{1}{1 + \left( \frac{c}{c_0} \right)^n} \]

where:
- \( v \) = shock velocity (cm/min)
- \( c \) = concentration (mg/mL)
- \( c_0 \) = initial concentration (mg/mL)
- \( n \) = 1

\[ E = \frac{1}{1 + \left( \frac{c}{c_0} \right)^n} \]

**Predicted Shock Velocity**

9.25 cm/min

Actual Shock Velocity = 9.25 cm/min

**Ethanol Yield XAD-4 Treated Hydrolysate**

95% of theoretical

CONCLUSIONS

- XAD-4, a styrene based polymeric chromatographic resin, selectively removes furfural from biomass hydrolysate.
- Liquid Chromatographic analysis of the adsorption column effluent showed that furfural concentrations were less than 0.01 g/L compared to the initial concentrations which were in the range of 1 to 5 g/L.
- Fermentation of the resulting hydrolysates with recombinant E. coli ethanologenic strain K011 confirmed that the concentration of furfural in the polymeric adsorbent treated hydrolysate caused negligible fermentation inhibition.
- Fermentation of XAD-4 treated hydrolysate with E. coli K011 was nearly as rapid as the control medium with ethanol yields at 90% of theoretical.

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