Detoxification of sugarcane hemicellulosic hydrolyzate using a fixed bed column packed with encapsulated lamellar double hydroxide

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Abstract
Brazil is the world's largest producer of sugarcane. The lignocellulosic biomass of sugarcane (bagasse) is an excellent source for use in bioprocesses, once removed the inhibitory compounds formed during the pretreatment of the biomass. To remove them, the use of lamellar double hydroxides (LDH) as an adsorbent has been proposed. In this context, the aim of this work was to develop a process that allows the detoxification of the sugarcane hydrolyzate in a fixed bed column packed with LDH encapsulated in alginate. A complete experimental design (CCRD) was used to study the effect of the mass of adsorbent, flow and temperature on the adsorption of the inhibitors. Furfural and Hydroxymethylfurfural, the main inhibitors, were selectively removed. Intermediate temperature, greater mass of adsorbent and higher flow favored their adsorption. Acetic acid and sugars were not separated.

Key words:
Adsorption, detoxification, hemicellulosic hydrolyzate

Introduction
Brazil is the world's largest producer of sugarcane, with production forecast for the 2018/19 crop of 620.4 million tons. In order to be used in bioprocesses, the sugarcane lignocellulosic biomass (straw and bagasse) must undergo a pretreatment step, which releases fermentable sugars by breaking the bonds between cellulose, hemicellulose and lignin. However, since the pretreatment can produce inhibitory compounds that are toxic to the fermentative microorganisms, such as acetic acid and furanics; a detoxification process is necessary to remove these inhibitors. This detoxification can be carried out with adsorption processes using alternative adsorbents, as is the case with Lamellar Double Hydroxides (LDHs). LDH is a mineral solid that has great adsorption capacity due to the large surface area of its interlamellar spaces, which can be occupied by different molecules. In this context, the aim of this work was to develop a process that allows the detoxification of the sugarcane hemicellulosic hydrolyzate in a fixed bed column packed with LDH encapsulated in alginate.

Results and Discussion
The LDH (hydrotalcite type, with 70% MgO) was firstly calcined at 500 °C for four hours, to remove interlamellar anions, and then encapsulated in alginate to prevent its intumescence, based on the patent BR1020140178430. The encapsulated particles were packed in a fixed bed column and the adsorption process was studied using a complete Central Composite Rotational Design (CCRD), whose variables and answers are shown in Chart 1. To evaluate the effect of the mass of adsorbent, flow and temperature on the breakthrough and exhaustion times, 17 trials were performed (with 3 repetitions at the central point).

Chart 1. Variables and answers of the CCRD

<table>
<thead>
<tr>
<th>Mass (g)</th>
<th>Flow (mL/min)</th>
<th>Temp. (°C)</th>
<th>Answers (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.68 (6.0)</td>
<td>-1.68 (0.4)</td>
<td>-1.68 (25)</td>
<td>Breakthrough and exhaustion times of each adsorbate</td>
</tr>
<tr>
<td>-1 (7.2)</td>
<td>-1 (0.52)</td>
<td>-1 (32)</td>
<td></td>
</tr>
<tr>
<td>0 (9.0)</td>
<td>0 (0.7)</td>
<td>0 (42.5)</td>
<td></td>
</tr>
<tr>
<td>+1 (10.8)</td>
<td>+1 (0.88)</td>
<td>+1 (53)</td>
<td></td>
</tr>
<tr>
<td>+1.68 (12.0)</td>
<td>+1.68 (1.0)</td>
<td>+1.68 (60)</td>
<td></td>
</tr>
</tbody>
</table>

Although acetic acid could not be separated from the sugars, the process was able to selectively remove the furanics, which are the main inhibitors, thus allowing the detoxification of the hydrolyzate.

Conclusions
The detoxification process developed was capable of selectively removing the furanic inhibitors from the hydrolyzate. Acetic acid and sugars were not separated.

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