Chlorine Dioxide absorption by potatoes in a packed bed
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Abstract
Chlorine dioxide is used in the food industry to extend shelf-life by decreasing the risk of foodborne infections and microbial damage. FruitGard® chlorine dioxide fumigant can be used to treat potatoes preventing spoilage from microorganisms. The objective of this experiment was to determine the chlorine dioxide mass transfer rate from the gas phase to the surface of potatoes. A two foot column was filled with 18kg of dry or wet potatoes. Both brown and red potatoes were used in the experiments. Four different FruitGard® application rates (grams of media/Kg potato) were use: 0.5, 2, 5, and 20. The doses were not to determine efficacy, but for the analysis of mass transfer rates. For the 20g/kg potato experiment, an Optek analyzer was used to measured the ClO₂ concentration at the outlet of the column. In the other experiments the ClO₂ concentration at the outlet was measure by bubbling the discharge gas through 5wt.% potassium iodine (KI) solution. In addition, potatoes were wounded (peeling a section of the potato) and the wound site was saturated with 5wt.% KI. ClO₂ readily penetrated the potato column at every dose. The color changes at wound sites demonstrated effective gas distribution in the pile. Wetted potato surfaces increased the mass transfer rate of ClO₂ compared to dry surfaces. Also, higher gas inlet concentrations increased mass transfer rate.

Apparatus

Figure 1.1 Potato Column Apparatus- blower(A), vibratory mixer(B), potato column(C), KI solution(D), Optek analyzer(E), sampling pump(F).

Figure 1.2 Wounded potatoes- wounded potatoes were located in three layers: bottom, middle and top. (4 potatoes per layer). They were randomly place in each layer.

Results

Part 1- Effect of inlet concentration on mass transfer rate

Table 1.1 Estimate ClO₂ absorbance (mg) at different FruitGard® Doses The ClO₂ at the outlet was measure by bubbling the discharge through 5wt.% KI. *ClO₂ inlet values were approximated from measure laboratory output profiles of the media at 15min.

<table>
<thead>
<tr>
<th>FruitGard® Dose (g media/Kg potato)</th>
<th>Estimated* ClO₂ Inlet (mg)</th>
<th>ClO₂ Discharge (mg)</th>
<th>Estimate ClO₂ absorbance (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>30</td>
<td>2.3</td>
<td>27.7</td>
</tr>
<tr>
<td>2</td>
<td>105</td>
<td>11.5</td>
<td>93.5</td>
</tr>
<tr>
<td>5</td>
<td>300</td>
<td>32.0</td>
<td>268.0</td>
</tr>
</tbody>
</table>

An increase in the FruitGard® dose also increases the mass transfer rate in the column. Which is represented by the ClO₂ absorbance in the table 1.1.

At all doses there was significant wound coloration, indicative of thorough gas distribution in the pile.
- Contact points between potatoes restricted mass transfer to those sites, as indicated by the non-coloration of certain parts of the wounds.
- Higher inlet concentrations resulted in darker colored wounds and demonstrated lower impact of contact points, indicative of greater mass transfer rate.
- There were no observable difference in the coloration of the sites between brown and red potatoes

Part 2- Effect of Surface Moisture on mass transfer rate

Figure 1.3 Wounded Potato sites saturated with 5wt.% KI  Picture A and B had an inlet dose of 0.5g media/Kg potato. Picture C and D had an inlet dose of 2g media/Kg potato. Picture E and F had an inlet dose of 5g media/Kg potato. All three doses were run for 15min.

Figure 1.3 Column outlet ClO₂ discharge rate (mg/min). The flow rate through the column was 9ft³/min, at a FruitGard® dosing of 20g media/Kg potato. Wet potatoes were soaked in water for 2 hours, drained and dried with a towel to remove excess water. The shape of the graph corresponds to the ClO₂ profile from the media. The system acts as a plug-flow reactor.

A lower discharge rate indicates a higher ClO₂ absorbance in the column. The gray curve shows a higher mass transfer rate for wet potatoes. This is consistent with published literature regarding the increase of gas absorbance on wetted surfaces.