THE ROLE OF VISCOSITY IN MESOPHILIC ANAEROBIC DIGESTION

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Background
Anaerobic digestion is the biological process in which organic matter is converted into biogas. Anaerobic digestion is conducted by several classes of microorganisms, each of which use the product of the previous microorganism reaction as its substrate.

Figure 1. Steps in the anaerobic digestion process
Source: https://www.researchgate.net/publication/262033577_Biogas_Generation_through_An_Anaerobic_Digestion_Process__An_Overview

- The first step in the anaerobic digestion process, when the proteins, carbohydrates, and lipids are converted into amino acids, sugars, and fatty acids is the hydrolysis phase. Physically, during the hydrolysis phase, hydrolytic enzymes are breaking down and solubilizing particulate substrate.
- The hydrolysis step is considered to be the rate-limiting step in the anaerobic digestion process. The hydrolysis rate was the parameter that was used for the sake of comparison to determine the level of the activated sludge’s performance on the batch scale. A higher hydrolysis rate is taken to mean a higher level of performance.

- The hydrolysis rate is determined as the average gas production rate displayed on the biogas production rate curve once the curve reaches a steady state. Figure 4 shows a typical biogas production rate curve.

- The diffusivity affects the rate of substrate transport through the activated sludge biofilm and the boundary layer.

- Literature suggests that the kinetics within activated sludge are diffusion-limited.

Objectives
- Explore the role of the bulk viscosity in determining the performance of activated sludge within MAD.

Methodology
- Batch tests were performed to analyse the effect of viscosity on the hydrolysis rates. 250 mL bottles were used and each condition was tested in triplicate. The batch bottles were connected to Respirometers and the biogas production was monitored over the course of a 24-hour time period.

- The biogas production rate curves were produced from the Respirometer data for each batch test and were normalized based on the weight of the volatile solids in each batch bottle.

Figure 3. Respirometers attached to batch test set-up

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- There were negligible differences in hydrolysis rates for increased bulk viscosities at various %TS concentrations. This phenomenon is shown in Figure 6.

- There was no correlation between increasing %TS and decreasing hydrolysis rates at any of the shear rates evaluated.

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Results & Discussion

Test 1: Objective: Determine impact of viscosity by varying total solids concentrations at various shear rates.

<table>
<thead>
<tr>
<th>Mixing Rate (rpm)</th>
<th>Shear Rate (sec^-1)</th>
<th>%TS</th>
<th>Viscosity (mPa)</th>
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<tr>
<td>300</td>
<td>73</td>
<td>5.17</td>
<td>59.5</td>
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<tr>
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<td>73</td>
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<td>300</td>
<td>73</td>
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<td>73</td>
<td>7.63</td>
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<td>8.58</td>
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<tr>
<td>300</td>
<td>73</td>
<td>10.32</td>
<td>286.9</td>
</tr>
</tbody>
</table>

Table 1. Batch conditions used for Test 1

- There is a strong correlation between increased hydrolysis rates and increased shear rates.

- There was no correlation between increasing %TS and decreasing hydrolysis rates at any of the shear rates evaluated.

- Changing the bulk viscosity of activated sludge affects only the boundary layer of the flocs. Changing the shear rate acting on the activated sludge also affects only the boundary layer of the flocs.

- There were negligible differences in hydrolysis rates for increased bulk viscosities, which indicates that changing the diffusivity of the boundary layer does not have a significant impact on the effective diffusivity of the activated sludge.

- The correlation between hydrolysis rates and shear rates indicates that with higher shear rates, the diffusion resistance due to viscosity is less because at higher shear rates, the viscosities at various %TS concentrations are smaller and thus less limiting.

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