High Mass Transfer Bioreactors for Methane Fermentation

CALYSTA Energy

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Josh Silverman[1], Earl Solis[1], Ronald Shaver[2], Dinesh Arora[2] and Luan Nguyen[1,3]
[1)] Calysta Energy, Inc., [2)] Celanese Corp., [3)] lnguyen@calystabio.com

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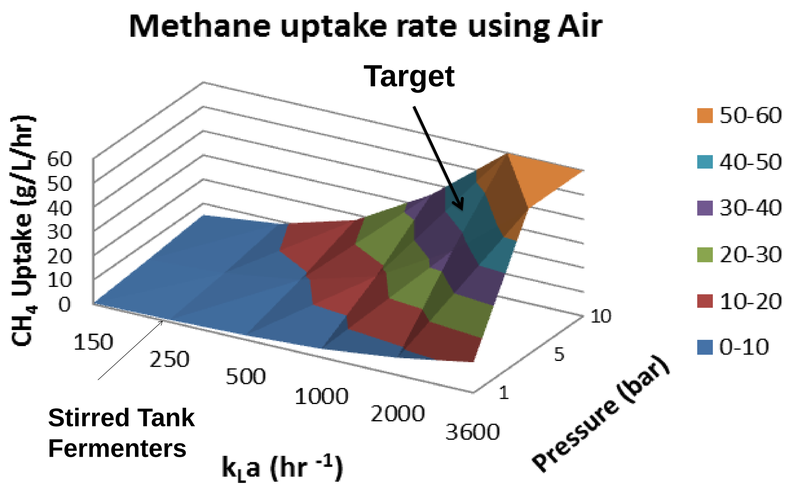
Abstract

The objective of this project is to develop key bioreactor technology to enable efficient methane-to-liquid fuels fermentation processes.

Gas Fermentation Challenges

Methane-based fermentation is fundamentally different from 'traditional' glucose-based fermentation for several reasons including: the low solubility of methane in aqueous solution, the need to co-feed multiple (explosive) gasses at high mass transfer rates while simultaneously allowing efficient extraction of CO2, and significant heat loads generated from the metabolism of the high-energy methane substrate. These issues are more similar to those faced in 'traditional' chemical reactor design where many approaches to mitigate the above issues have been developed.

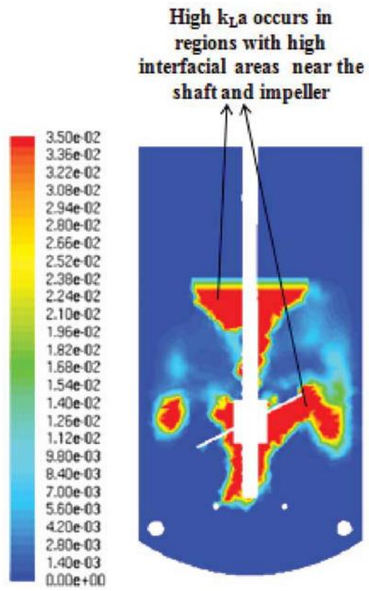


Achievement of productivity targets (>25 g/L/hr) require improvements in k_La in order to use air as a feedstock.

Approach

- Use Computational Fluid Dynamics (CFD) to model best existing high mass transfer bioreactor designs
- Identify key limitations in current designs and develop novel approaches for gas-fed fermentation
- Build a demonstration unit and validate operating parameters according to the design

Typical stirred tank fermenters show high mass transfer only near areas of active mixing. Most of the gas transfer occurs in a small fraction of the total volume.



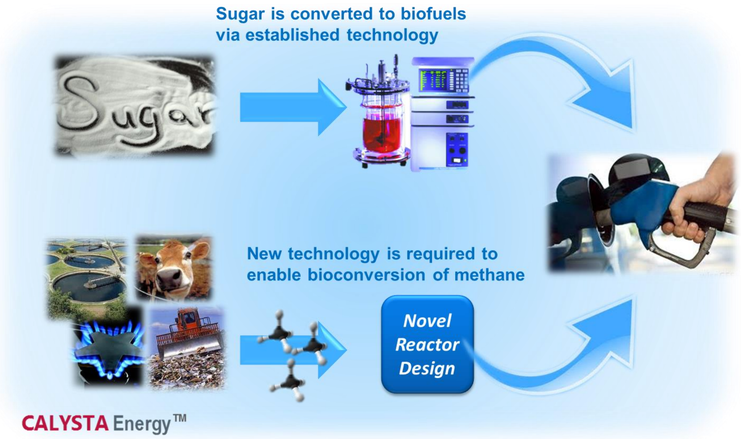
Sharma C, Malhotra D, Rathore AS. Review of Computational Fluid Dynamics Applications in Biotechnology Processes. *Biotechnol. Prog.* 2011; 27:1497-1510.

Team

- Celanese – Experts in CFD modeling of multi-phase systems and 'traditional' reactor designs
- Calysta – Experts in methanotroph fermentation, protein/metabolic pathway engineering and high mass transfer biological process development

Technology Impact

- Enable a wide range of gas-fed fermentations (syngas, CO_2, electrofuels etc.) using the same platform technology
- Make the newly developed bioreactor technology available to the broader research community at large
- Allow for utilization of small-scale and remote natural gas/methane resources



Key Milestones & Deliverables

Metric	State of the Art (Stirred Tank)	Proposed
k_La	200 hr^{-1}	> 2500 hr^{-1}
Methane uptake rate	<10 g CH_4 /L/hr	>50 g CH_4 /L/hr
Heat Removal	N/A	>400 kW/m^3
Productivity	< 2 g/L/hr	> 25 $g/L_{reactor}/hr$
Process CapEx	N/A	<$100,000/BPD

>10x Improvements in Gas-Fed Fermentation Growth Rates

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