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Isobutanol from Renewable Feedstock—Process Optimization by Integration of Mass Spectrometry to two 8-fold DASGIP® Parallel Bioreactor Systems

James Glenn[1], Claudia M. Huether[2], and Christiane Schlottbom[2]*

[1] Gevo Inc., 345 Inverness Dr S C-310 Englewood, CO 80112, USA; [2] Eppendorf AG Bioprocess Center, Rudolf-Schulten-Str. 5, 52428 Juelich, Germany; *Corresponding author: schlottbom.c@eppendorf.com

Abstract

This application note describes the integration of a Thermo Scientific® Prima® dB Mass Spectrometer (MS) with DASGIP Parallel Bioreactor Control Systems implemented at Gevo®, Inc. in Englewood, Colorado. The availability of real-time MS data will aid in maximizing cell growth and isobutanol production.

Introduction

Isobutanol has broad market applications as a solvent and a gasoline blendstock that can help refiners meet their renewable fuel and clean air obligations. It can also be further processed using well-known chemical processes into jet fuel and feedstocks for the production of synthetic rubber, plastics, and polyesters. Isobutanol is an ideal platform molecule that can be made inexpensively using fermentation. The ability to automate the data analysis would increase production and reduce costs.

Gevo, a leading renewable chemicals and advanced biofuels company is developing biobased alternatives to petroleum-based products using a combination of synthetic biology and chemistry. Gevo plans to produce isobutanol, a versatile platform chemical for the liquid fuels and petrochemical market.

The main objective of implementing OPC communication

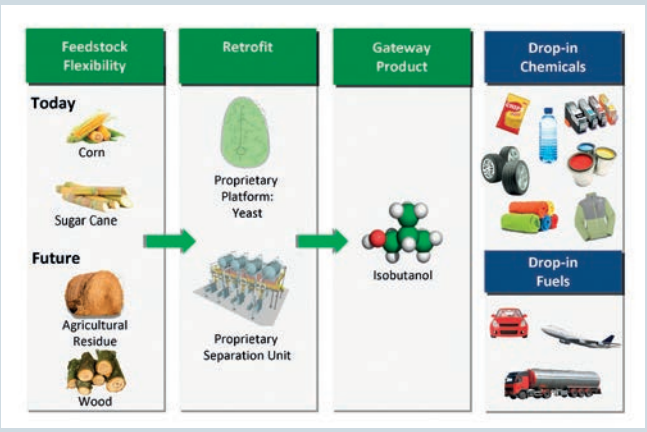

Figure 1: Isobutanol - a versatile platform Chemical

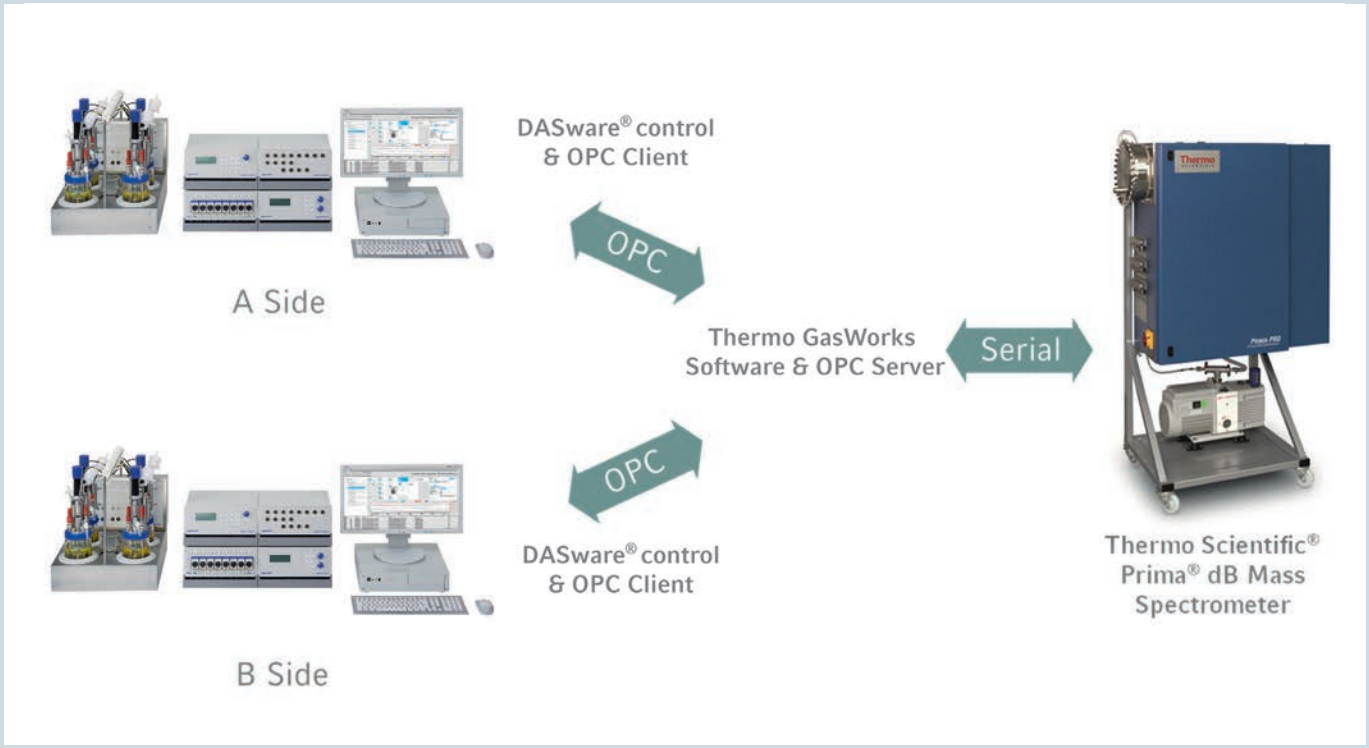

Figure 2: Schematic of the MS integration setup. Implementing OPC communication between the Thermo Scientific Prima dB Mass Spectrometer and the DASGIP Control Software (now DASware control) provided continuous exhaust results that were synchronized with fermentation data and viewed in real-time. The isobutanol production rates could be calculated online and were then available for data-driven control decisions.

between the Thermo Scientific Mass Spectrometer and the DASGIP Control* Software during a fermentation run was to optimize growth and isobutanol production through automation. The system previously in place at Gevo required that manual data calculations had to be performed by merging the bioreactor runtime data with the MS data to assess the fermentation performance.

Materials and Methods

Corn mash was used as a substrate for the production of isobutanol by fermentation. The fermentation process was carried out using two DASGIP Parallel Bioreactor Systems with eight vessels each. The working volume in all 16 bioreactors was 1L, respectively.

OPC communication was implemented between the Thermo Scientific Prima dB Mass Spectrometer and the DASGIP Control Software to provide real-time exhaust results. Script calculations were used to take the MS data as inputs and generate meaningful metrics to automatically analyze key fermentation operating values and quickly make process control changes.

Results and Discussion

By integrating the Thermo Scientific Prima dB Mass Spectrometer with the DASGIP Parallel Bioreactor System the calculation of key fermentation operating values was successfully automated. This automation streamlined the workflow and allowed for data-driven control decisions using the real-time exhaust based analytical results.

Before Automation:
Without integration of the MS and the DASGIP Parallel Bioreactor System using OPC, calculation of key fermentation operating values was time-consuming and labor-intensive.

Optimized by MS Integration:
Using OPC communication the real-time MS results were sent to the two DASGIP Control systems. Within the control system, the fermentation runtime data and the MS results were charted and transferred to the data historian with synchronized time stamps.

*DASGIP Control is now DASware® control 5.

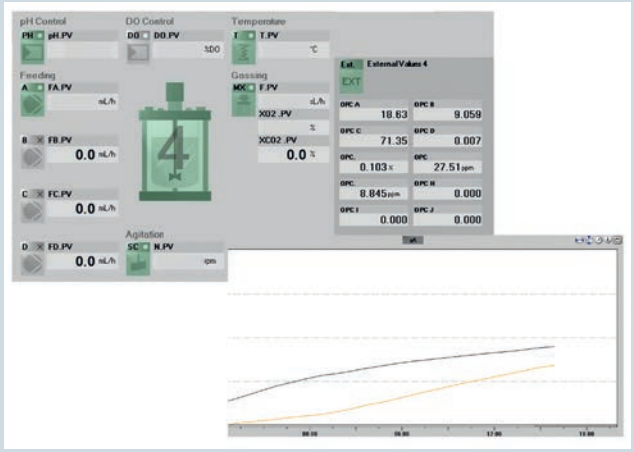

Figure 3: MS integration: data display and charts. The DASGIP Control bioreactor view showed online bioreactor runtime data including real-time MS results. Editable scripting allowed for online calculation of production rate and graphic display in defined charts.

Key fermentation operating values were calculated online from combined fermentation and MS runtime data, charted and sent to the data historian and were then available for data-driven control decisions. Set-up and script calculations were stored in a user-editable recipe.

Conclusion

With its comprehensive data management functions the DASGIP Parallel Bioreactor System allowed the seamless integration of the Thermo Scientific Prima dB Mass Spectrometer.

The most important success criterion was the ability to calculate isobutanol production rates in real-time giving instant feed back on the quality of run. The availability of the exhaustbased analytical results made data-driven control decisions possible. A secondary success criterion was the fermentation runtime data and MS data was logged with synchronized time stamps to allow for post-run analysis if needed.

Ordering information	Order no.
DASGIP® Parallel Bioreactor System for Microbial Applications, max. 250 sL/h gassing	
4-fold system with Bioblock	76DG04MBBB
8-fold system with Bioblock	76DG08MBBB
16-fold system with Bioblock	76DG16MBBB
4-fold system, benchtop	76DG04MB
8-fold system, benchtop	76DG08MB
16-fold system, benchtop	76DG16MB
DASware® control, incl. PC, OS, and licenses	
for 4-fold DASGIP® system	76DGCS4
for 8-fold DASGIP® system	76DGCS8
for 16-fold DASGIP® system	76DGCS16
DASware® analyze, OPC client professional incl. 1x tunneller licence (OPC DA e.g. for ext. analyzer with autosampler)	
for 4 vessels	76DWANA4P
for 8 vessels	76DWANA8P

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