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Using the IRmadillo to detect Lactic and Acetic Acid in Ethanol Fermentations

Key Words

- Fuel ethanol
- Lactic Acid
- Acetic Acid
- Bacterial Infections
- Yield Maximisation
- FTIR

Abstract

Bacterial contamination in ethanol fermentations can have damaging impacts, in mild cases leading to a drop in ethanol yield, and in more severe cases requiring plant shut down and sterilisation resulting in significant loss in revenue. Detecting the signs of these contaminations early allows the operator to limit the impact and avoid significant losses.

Introduction

Lactic acid bacteria are the most common biological contaminants occurring in the fermentation of corn for ethanol production. The growth of these bacteria reduces the amount of sugar available for conversion to ethanol as well as the micro-nutrients required for optimal yeast growth. This results in reduced ethanol production. In addition, the accumulation of bacterial by-products, such as lactic and acetic acid, inhibits yeast growth and may result in "stuck" fermentations that require costly shut-downs. Infections can be halted or minimised through the use of expensive antibiotics and the sooner an infection is identified, the less antibiotics are required to counter the infection. Early detection of infections is therefore key to maximising yields and minimising antibiotic use.

Spectroscopy as an Analytical Tool

Spectrometers allow continuous and detailed measurement of chemical concentrations in real time. The majority of process spectrometers are based on near infrared light, which is fundamentally less informative than mid infrared light. Conventional mid infrared spectrometers (which often use a Fourier transform and so are referred to as "FTIR spectrometers") have sensitive moving parts and fragile fibre probes making them wholly unsuitable for production environments such as ethanol refineries.

The IRmadillo is a process analyser that uses FTIR spectroscopy but with static optics, removing the need for moving mirrors or fibre probes, dramatically improving stability, reliability and ruggedness.

Example use case - Lactic Acid Detection

This application note presents data from an ethanol refinery in Iowa, measuring the concentration of lactic and acetic acid during fermentation. The plot below (fig 1) shows measurements over time for 5 consecutive fermentations. Fermentation 1 experienced a significant bacterial infection resulting in a spike in lactic acid to 1.4 %w/v (normal is approx 0.2%w/v) and a spike in acetic acid of approx 0.3 %w/v (normal is approx 0 %w/v). Ethanol at drop in fermentation 1 was 7 %w/v, well below the normal of approx 14 %w/v. We can also see that, over the following 4 fermentations, the levels of lactic acid are elevated, but decreasing, and the ethanol drop value is lower than normal between 12 and 13 %w/v. Only by the 5th fermentation does lactic acid drop to more normal levels and ethanol at drop return to expected levels.

With the IRmadillo installed, the operator is able to see the rapid increase in lactic and acetic acid levels and is therefore in a position to correct the course of the fermentation, improving yield very significantly in the first fermentation and also in the following fermentations, albeit to a lesser extent.

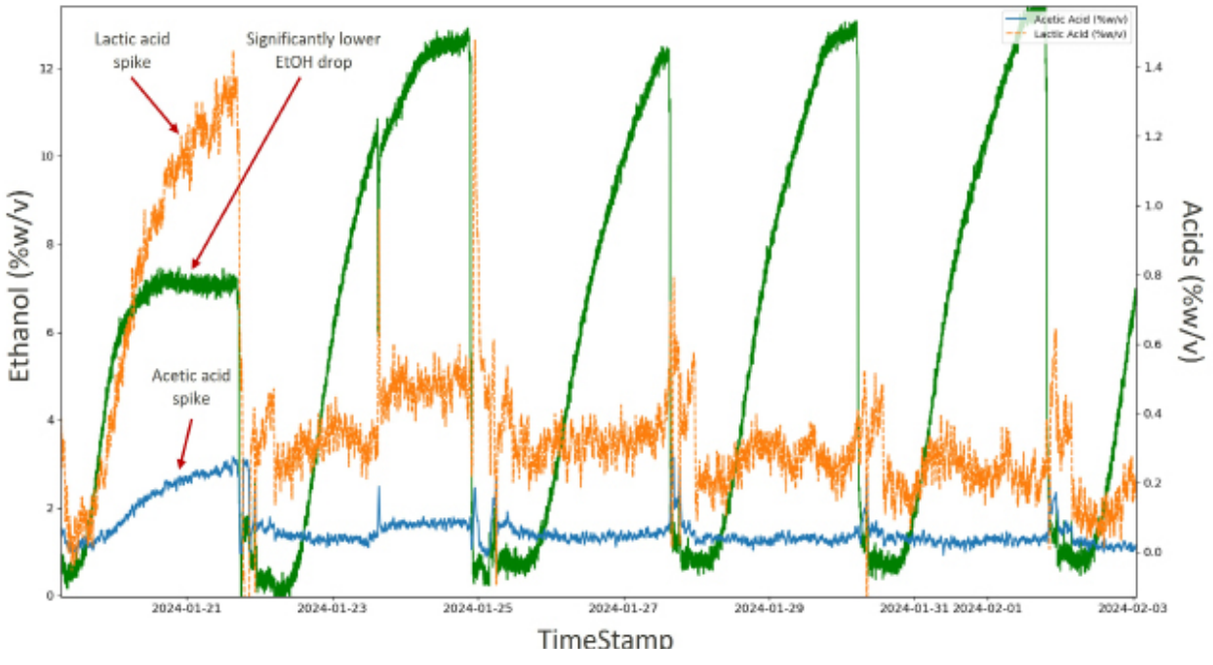

Figure 1: Concentration trace over five consecutive fermentations, showing the results of a bacterial infection in fermentation 1 with elevated lactic and acetic acid levels and reduced ethanol production. The subsequent 4 fermentations also show evidence of infection with an ongoing negative impact on ethanol yield

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Chemical	Range	Accuracy
Ethanol (w%/v)	0 - 15	0.25
Lactic Acid (w%/v)	0 - 1.5	0.056
Acetic Acid (w%/v)	0 - 0.35	0.015

Table 2: Measurement accuracy for species of interest in fermentation during bacterial infection

Conclusion

Bacterial infections, while relatively rare, can be very damaging to process and plant economics when they occur. The ability to manage an infection and minimise its impact on yield relies on catching the infection early while remediation is still possible. The IRmadillo spectrometer has proven to be an accurate early-warning system for bacterial infections, allowing operators to treat the infection early and reduce any loss in yield

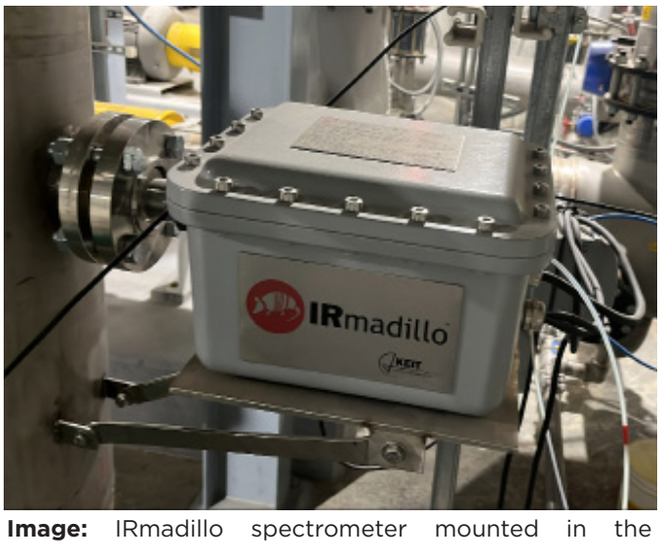

Image: IRmadillo spectrometer mounted in the recirculation loop of an ethanol fermenter

Keep in Mind

The IRmadillo can be calibrated to measure a large range of chemicals at the same time. This work shows the use for DP4, DP3, DP2, DP1, lactic and acetic acids, glycerol and ethanol measurement. We also measure acetal, methanol and propanol levels, but the IRmadillo can also be calibrated to measure applications in ethanol propagation, FAN, PAN and fusels in fermentation – all at the same time, in real time.

Contact us

+44 (0) 1235 431260

(Sales) enquiries@keit.co.uk

(Product Support) support@keit.co.uk

www.keit.co.uk

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4 Zephyr Building, Eighth Street, Harwell Campus, Didcot, Oxfordshire, OX11 0RL, United Kingdom

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