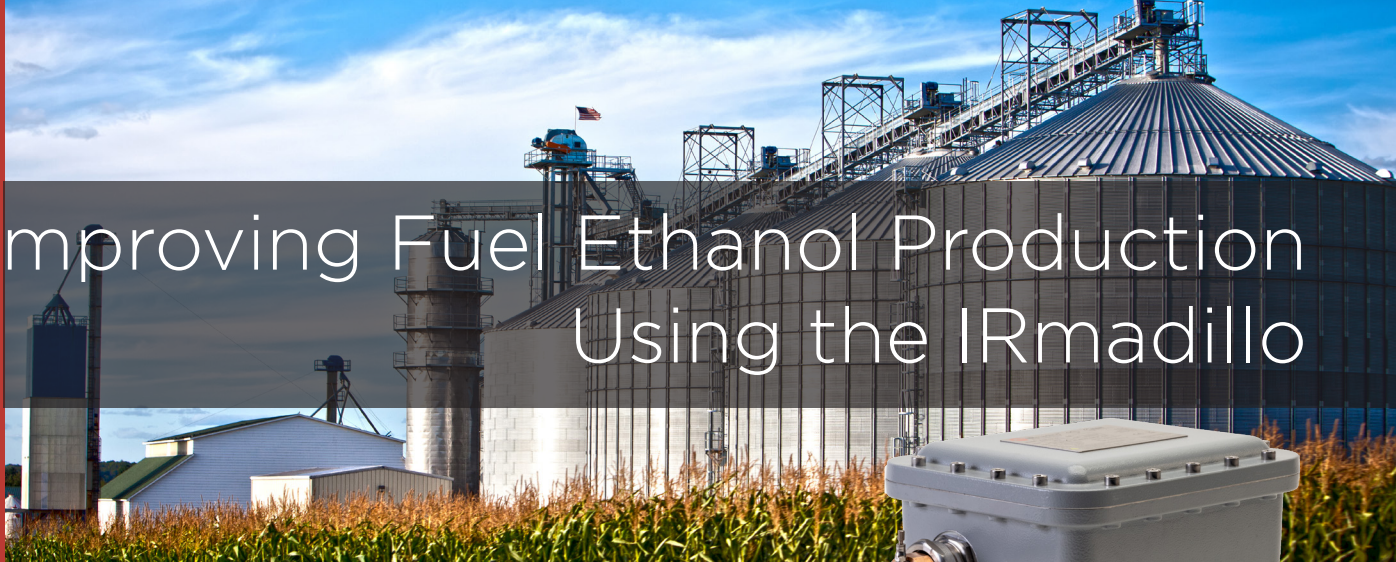# Improving Fuel Ethanol Production Using the IRmadillo

IRmadillo™

What is it?

The IRmadillo is an in-line process analyzer based on infrared light. It works by using a technique called FTIR spectroscopy to monitor the concentration of different chemicals with great accuracy in real time.

One thing that makes it different to other FTIR analysers is that it is robust. It's built to last. Not only last, but it installs directly into your process lines & vessels and performs continuously in any production environment. Fit it and forget about it!

Real-time measurement of chemical concentrations

The IRmadillo monitors what's going on in your fermentation as your sugars convert into ethanol in real time - think of it as an HPLC but measuring the fermentation 24 hours a day, 7 days a week, without the need to sample or wait for the result.

Possible uses for the IRmadillo

The IRmadillo can be installed in a huge range of processes and installation points. Keit can provide examples and ideas for how to use the analyzer, but previous locations include:

Liquefaction

Dextrose equivalent for higher solids loading: Measure the sugar concentrations to calculate dextrose equivalent. This lets you run at higher solids loading, decreasing heating costs - then you can dilute downstream to 32.5 % for fermenter feed.

Measure soluble protein in feed: Measure protein in liquefaction to optimise ammonia or urea addition in fermentation, reducing costs without compromising performance.

Corn oil

Optimize centrifuge control: Measure the amount of corn oil in centrifuge inlet or outlet to better control the separation and optimize the amount of pure corn oil produced as a valuable by-product.
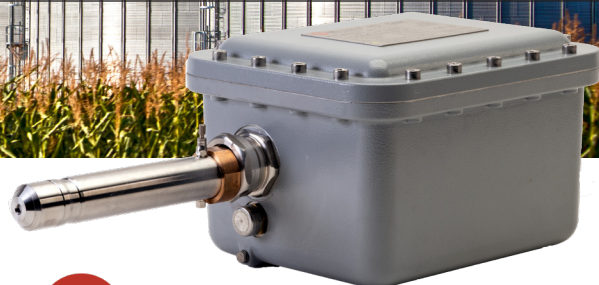
Fermentation

Monitoring lactic acid levels: If lactic acid rises early on, it may indicate potential contamination. If you've spotted an infection early, you're much more likely to be successful in resolving it with antibiotics. You can also be much smarter with your use of antibiotics, driving down costs.

Measure FAN and PAN: Measure FAN and PAN in real-time, ensuring that the optimium nitrogen levels are present for productive yeast, without over-feeding - reducing urea and ammonia costs.

Long-term improvement projects: De-risk improvement projects by having real-time feedback on changes made or experiments performed. Understand the short, medium and long term impacts of improvement projects ranging from temperature changes through to sugar feed, enzyme or yeast formulation changes.

Distillation

Residual ethanol in column bottoms: Measure the residual ethanol to ensure it is being efficiently distilled and collected, and that you're not throwing away product.

Acetaldyhde and fusels in column tops: Measure acetaldehyde, fusels and other volatile molecules in ethanol product, ensuring the product purity and quality is as desired - enabling real-time control of the distillation column.

"The IRmadillo mid-infrared spectrometer is the most robust instrument that we have seen in the market for real time monitoring of ethanol fermentation."

Julian Parra, Engineering and Technology Manager

Pannonia Bio

Maximise efficiencies through trustworthy, real-time results

You may well be running your own improvement programs to maximise production and efficiency. But without a trustworthy, on-line measurement, improving performance may be slow and almost impossible.

The IRmadillo gives you the level of information you'd expect from a lab measurement, but coupled with on-line analytical capabilities, it provides you continuous updates. This means you can make a change and get real-time updates on what it does to your process.

What will I see when I use it?

The IRmadillo software contains its calibration and runs the measurement in real time. This means you'll get an update on chemical concentrations (normally in %wt but that can be changed to whatever units you're used to using) over the whole process.

The graph below shows example fermentation over 5 weeks to give a representation of the output. These batch trends can then be exported into text files for further analysis by your team for process optimization if needed.

The IRmadillo will also send concentration data to your DCS, PLC or SCADA in real time. The standard communications protocols are OPC-UA over Ethernet, or Modbus TCP over Ethernet.

How do I insert the probe into my process, and what about cleaning it?

The IRmadillo is fitted with a diamond tipped probe, meaning it can happily survive clean in place (CIP) practices with caustic washing. It is rated to ~ 600 psig (40 barg) , so will withstand direct contact with the caustic wash stream. It has an operating temperature range of up to 430 °F (220 °C) in case you intend to use for distillation or liquefaction applications.

There are a variety of different ways to seal the probe in your tank, but a simple port and flange assembly will seal the probe into your tank or vessel. We can also supply an intermediate ball valve to add an extra level of protection should you ever need to remove the probe mid-way through a fermentation
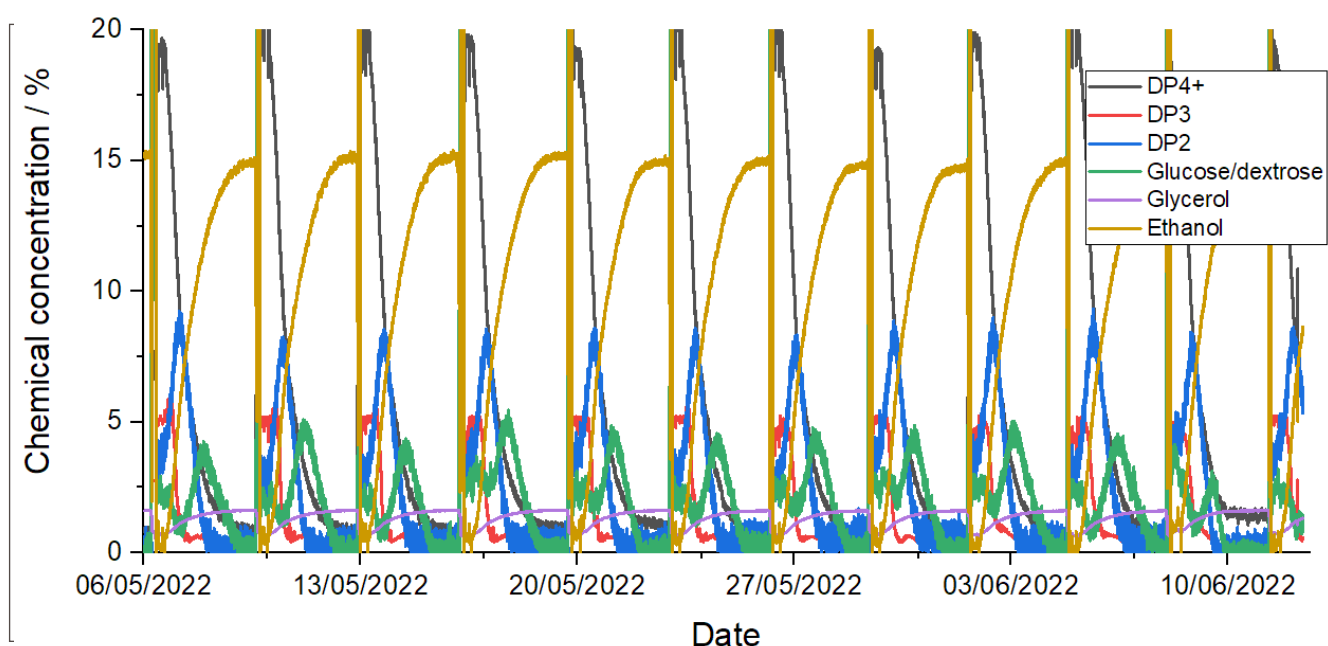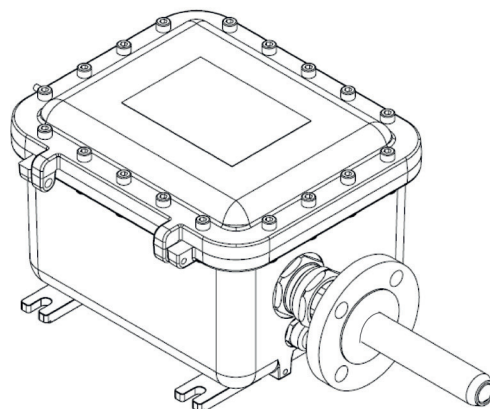

Figure 1: Corn ethanol fermentations over multiple weeks monitored by the IRmadillo - calibrated for DP4+, DP3, DP2, glucose/dextrose, glycerol, and ethanol for real-time, continuous measurement

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I tried FTIR before and it didn't work…

Don't confuse FTIR (mid-infrared) with FT-**NIR** (near infrared). Infrared light comes in a few different wavelengths, and there was a big push a few years ago to get near-infrared instruments (FT-NIR) into production faciliites.

Near infrared is very different to the mid-infrared light that the IRmadillo uses (FTIR). FT-NIR instruments don't actually look directly at the chemical bonds, but at "overtones". This is a bit like trying to recognise someone from their shadow rather than looking at their face. It gives you a rough idea who it is, but to get full understanding you need the full picture.

We give an example of this in the graph below, showing a comparison of the IRmadillo with an FT-NIR instrument monitoring glucose, fructose and ethanol during a sucrose fermentation.

The FT-NIR has much bigger error for the glucose and ethanol, and cannot monitor the fructose at all. This means it would never be able to differentiate between DP4+, DP3 and maltose – while the IRmadillo can clearly distinguish between the sugars and all other components.

What's the performance of the instrument?

The exact performance depends on the process you use, but a typical error of measurement is shown below.

Chemical	Measurement error / %wt
DP4+	0.60
DP3	0.50
DP2/Maltose	0.50
DP1/Glucose	0.30
Lactic Acid	0.005
Glycerol	0.06
Acetic Acid	0.005
Ethanol	0.20

The IRmadillo does not try to out-perform HPLC for error and detection limits, but it can give so much more information over a much shorter time. It also tells you when to take an extract for HPLC — using your staff much more efficiently and effectively.
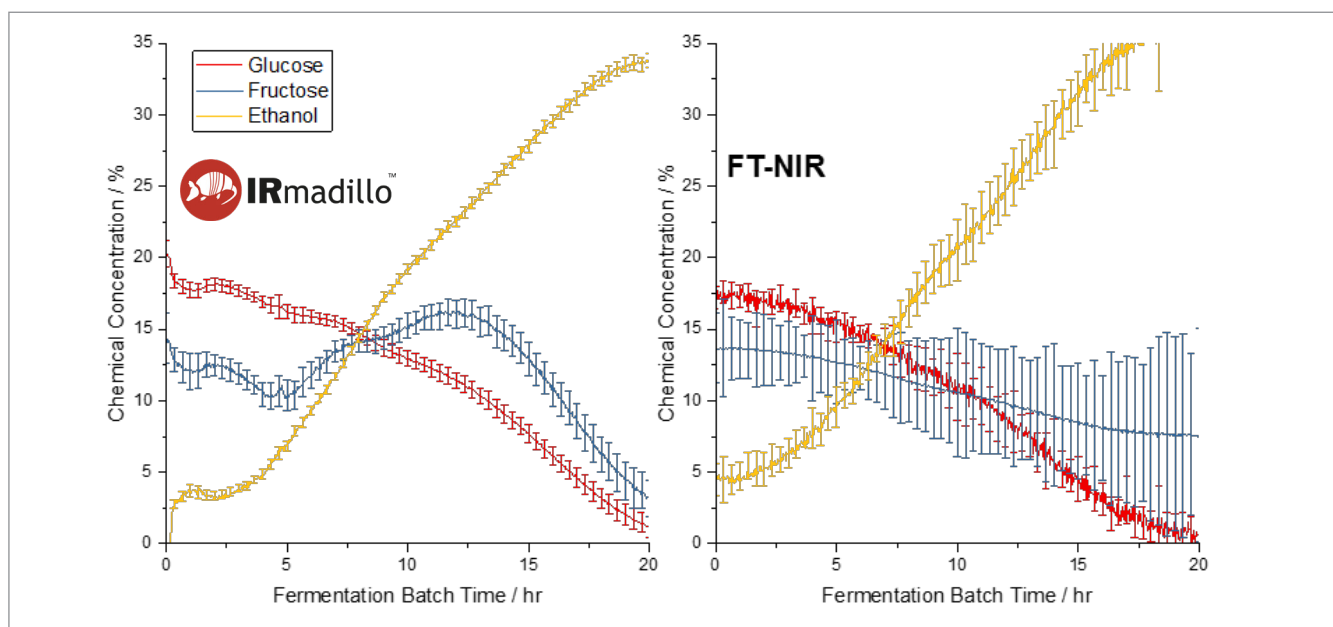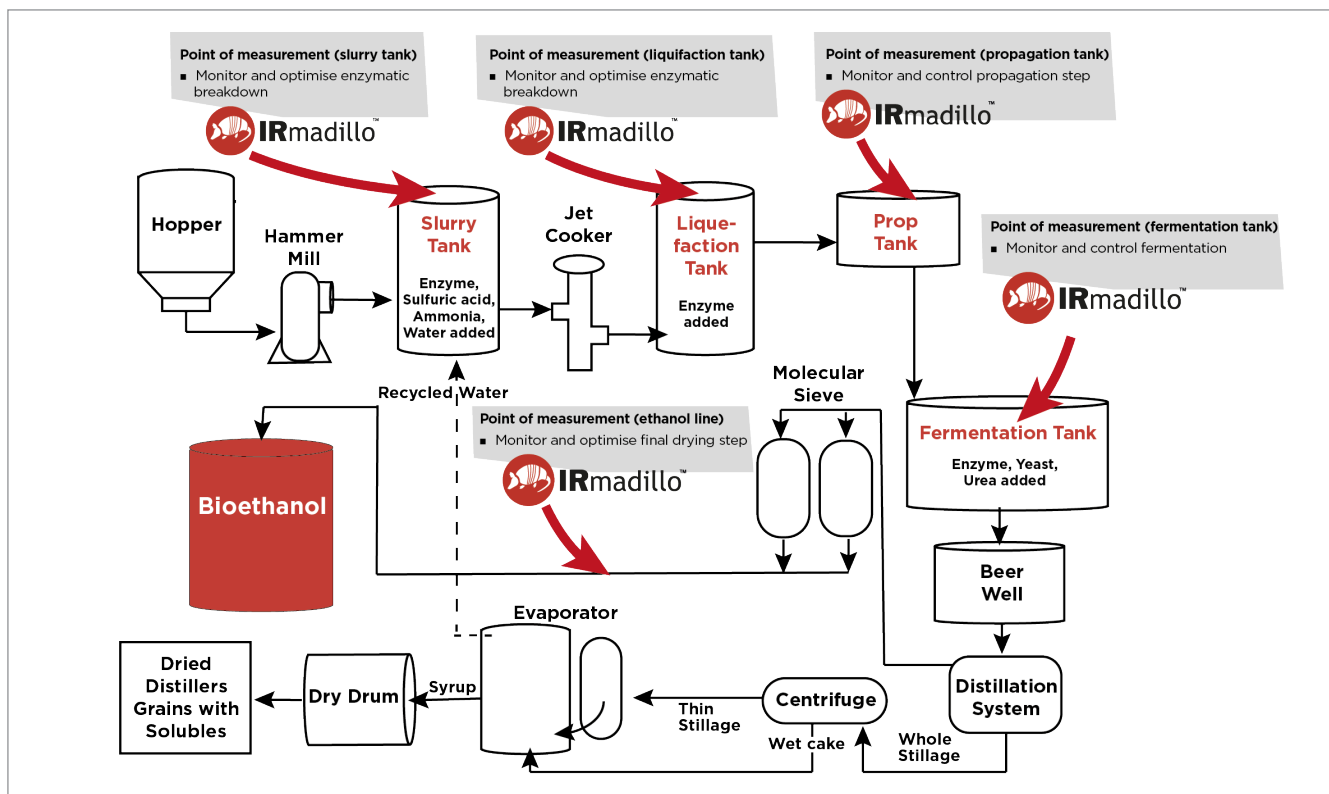

Figure 2: Comparison of the mid-infrared IRmadillo vs. near infrared (FT-NIR) monitoring a fermentation process. Note the much larger error bars on the FT-NIR analysis (right) making differentiation nearly impossible between glucose (red lines) and fructose (blue lines), while the IRmadillo (left) clearly defines each component.

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Monitoring the whole ethanol process

The IRmadillo can be calibrated to be a universal analyzer for the entire ethanol process, not just fermentation. It has applications in distillation control, liquefaction, propagation and oil separation.

If there is a chemical you'd like to measure in real-time, it's likely the IRmadillo is the tool to do it.

Interested in finding out more?

Contact us to find out more details. Let us know about your process and what you'd like to be able to measure in real time.

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I'm interested. What's next?

Rental

Want to try one out? Keit will provide an IRmadillo suited to your process operating environment and bill you monthly for an agreed span of time. Easy to renew, you have control over how long you keep it - from a few months to an even longer rent-to-own plan.

Purchase

Own your IRmadillo outright to monitor your process on-line and in real time as you see fit.

Begin your discussion today on how you can get an IRmadillo installed into your system. **enquiries@keit.co.uk**