

Improving Petrochemical, Bulk and Specialty Chemical Production Using the IRmadillo

What is it?

The IRmadillo is an in-line process analyser based on infrared light. It works by using a technique called FTIR spectroscopy to monitor the concentration of different chemicals with great accuracy and in real time. It can be calibrated to become a universal analyser measuring almost any chemical and property in liquids.

One thing that makes it different to other FTIR analysers is that it is robust and built to last. The Ex model is certified safe for use in hazardous and potentially explosive environments. The IRmadillo installs directly into your process to perform continuously in any production environment. Fit it and forget about it!

What's the point and why should I use it?

The IRmadillo monitors what's going on in your process in real time. There are three main ways you can benefit from better process monitoring with the IRmadillo:

Improve your efficiency – By having a trustworthy real-time measurement of your process, you can run closer to maximum operating limits. You can run closer to the product's specified maximum or minimum acceptable levels of components and reduce ongoing costs by minimising "product giveaway" while staying within your QC limits.

Improve your capacity – identify the exact moment when a batch process has consumed its reagents and reached optimum product level, then stop the process. Batch reactions can also go on to degrade the product if allowed to continue past their endpoint, and the IRmadillo lets you prevent this by identifying the endpoint at the right moment.

Fix problems early – the IRmadillo lets you see exactly what's going on in your process. If something does go wrong, you have time to fix it early to minimize impact. Continuous processes can be adjusted or diverted to holding tanks in time to avoid contaminating good product. Batch processes can be saved or terminated sooner to reduce any negative impact.

The IRmadillo empowers you to understand what your process is doing, enabling you to make informed decisions about how to improve or control it. This is something simply not possible with off-line sampling analysis techniques.



IRmadillo

How do I use it?

The IRmadillo is the first static-optics, robust FTIR that has been designed specifically to take mid-infrared out of the laboratory and into production zones. With an Ex model, its applications for use are almost endless in the petrochemical and specialty chemical industries. Any reaction or process in liquids that can be monitored by lab-FTIR instruments will be suitable for the IRmadillo. Some examples of use cases are below:

Batch and continuous reactions monitoring: FTIR is a classic technique for measuring chemical reactions including, but not limited to:

- Esterification
- Grignard reactions
- Urethane formation
- Alkylation
- Hydrogenation
- Elimination reactions
- Polymerisation

Distillation: measuring feed and product composition allows more efficient column operation, saving energy and increasing throughput.

Crystallisation: measuring both the solvent makeup (for mixed solvent crystallisation) and the supernatant during crystallisation better control over the crystallisation process can be achieved, reducing costs and improving efficiency.

We have been searching a long time for a rugged industrial infrared ATR spectrometer. We have found the IRmadillo to be compact, robust and easy to implement on-line.

...The instrument is working like clockwork, demonstrating remarkable stability and precision on our application.

Principal Scientist, international agrochemical company

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 a live update on chemical concentrations, or other properties, throughout your process. The IRmadillo is designed to communicate directly with your existing plant control system using either Modbus TCP/IP or OPC-UA. Your control room can then be provided with direct metrics rather than fundamental spectra.

The original spectra can be retrieved easily, however, for diagnosing process changes or unusual behaviour if observed. This gives simplicity for day to day use but powerful information when required by experts.

What sorts of chemicals can the IRmadillo measure?

Because the IRmadillo is built on FTIR spectroscopy it measures the fundamental vibrations of molecules. There is an enormous range of chemicals that have vibrations in the wavelength range of the IRmadillo meaning there truly are very few that cannot be measured by it.

The IRmadillo can also continuously track the progress of reactions allowing for end point detection whilst simultaneously measuring metrics for various other physical and chemical parameters.

How do I interface this with my process?

The IRmadillo has a wide range of optional interface designs. It is available with:

- Welded flange: 2" ANSI as a standard others available by request
- Cradle with a 2" flange
- Sanitary/tri-clamp compatible fittings
- Flow cells

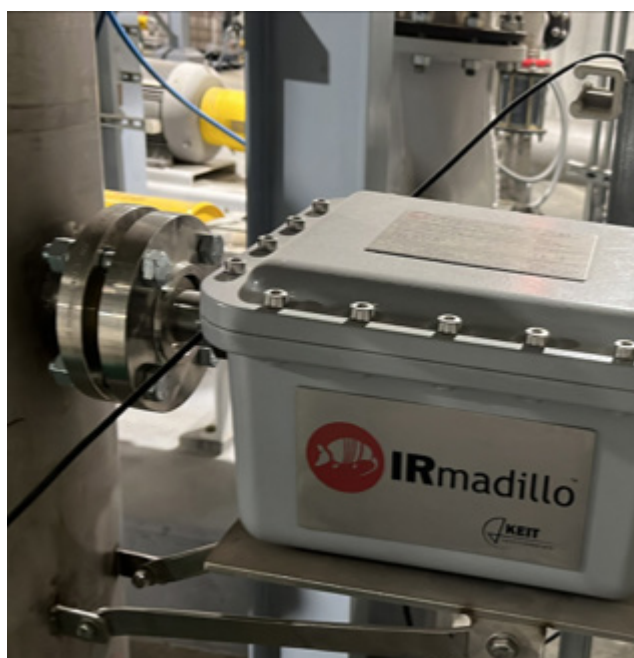


Figure 1: IRmadillo installed inline using a welded flange (left) and cradle (right).



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 are many industries and processes using NIR instruments successfully. However, some processes are simply not suitable for NIR as they are too complex or their concentrations are too low to be monitored effectively by NIR.

Near infrared (NIR/FT-NIR)

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. FT-NIR techniques also use a probe with a reflecting window in it that can easily get blocked with high solid loadings, which is common in many processes.

The IRmadillo uses an ATR probe that is minimally affected by bubbles or solids in the process, and uses mid-infrared wavelengths to optimise spectral information recorded.

Traditional FTIR

Traditional FTIR instruments involve an intricate array of moving mirrors in order to create an interferogram. This means that they need to be protected from vibration and movement whilst measuring – usually through the use of delicate mid-infrared fibres. These fibres have very low spectral throughput and are extremely fragile, meaning they are very difficult to use in manufacturing or industrial environments.

The IRmadillo has no moving parts (see below for an illustration of how it works), completely removing the need for fibres or protection from vibration.

Raman

Raman spectroscopy looks at similar features to mid-infrared, but the physics behind it are completely different. In Raman spectroscopy a laser is used to excite the molecules of interest, which then emit light slightly shifted in wavelength. This is used to create a spectrum. This can suffer from fluorescence in some cases or require damagingly high laser powers to obtain a strong spectrum. Different molecules respond well to Raman compared to FTIR – mainly those that are "polarisable". FTIR and Raman are broadly complementary – Keit would be happy to discuss the suitability of FTIR vs Raman for your given application and give an honest answer.

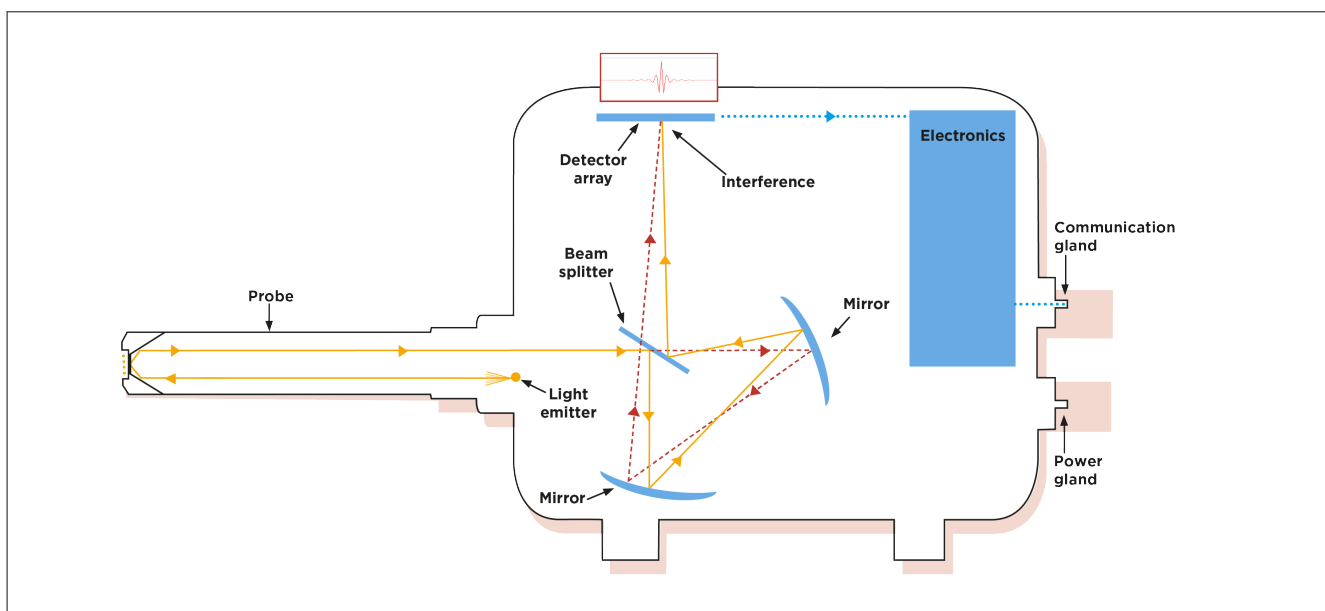


Figure 2: Schematic overview of the optical arrangement within the IRmadillo. The infrared light from the low-powered emitter is transformed into an interference pattern with respect to space (directly onto a detector array) instead of an interference pattern with respect to time (as happens with classical Michelson-based FTIR instruments). This gives the robustness, ruggedness and reliability that is inherent in the IRmadillo.



How does the IRmadillo measure properties?

The physical properties of a process – such as melting point, viscosity or vapour pressure – are all fundamentally dictated by the chemical makeup of the mixture. The IRmadillo observes the chemicals that are present in a liquid and records them as a spectrum. That spectrum can then be interpreted in a number of different ways.

By using physical property data (instead of raw concentration data) advanced chemometrics algorithms – such as PLS or SVR – can be used to directly measure those properties from raw spectra, “cutting out the middle man” of chemical concentrations if required.

This is particularly important with complex mixtures where the exact chemical makeup is not known – spectra to property calibrations do not need to know chemical makeup, only the property of interest.

IRmadillo Working Environments

Material & Process Environment	IRmadillo & IRmadilloEx/NA
ATR material	Diamond
pH range	0-14
Temp (analyte)	-20°C to +220°C
Hazardous environment certifications*	ATEX IECEX UKEx C1D2 JIS

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?

Keit gives you options to make it easy to start using an IRmadillo.

For all options, we'll help you install, train your team, and we can even calibrate a chemometric model.

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

