Touch button control of fuel ethanol fermentation

Fuel ethanol producers are quietly getting on with the essential job of making sustainable fuel and what's more, they're improving the process all the time.

Advances in efficiency are being made across the board. The ability to predict yield and segregate corn at intake is just one example. Further into the process, another area under development is in fermentation – probably the most critical part of making fuel ethanol, but also the most vulnerable as infection with unwanted microbial activity can literally eat away at millions of dollars of production in process.

Although methods based on HPLC analysis provide a wealth of information, time-to-result, cost-per-sample and the need for trained laboratory personnel remain barriers to gaining the level of information needed for effective fermentation control. There is room for something faster, cheaper and easier, especially for those that don't happen to have a premier league laboratory on site.

Near Infrared, so well known for applications such as testing grain at intake, has been investigated by many, but questions remain about its ability to detect infection indicators which are typically only present at low-levels. The field of infrared analysis technology is not finished there though as another related technology has just the right credentials to fill the gap. Enter Fourier Transform Infrared (FTIR).

FTIR has proven benefits, including speed, low cost and simplicity. Results for several parameters are delivered in no more than two minutes. You can analyse as much as you like at no extra cost and anyone can perform the test. FTIR also appears to be particularly well suited to picking up infection indicator parameters.

A prototype application of the technology has been on test at ethanol plants in the U.S. and the concept is attracting significant interest.

Unlimited testing by anyone

For Brian Wrenn, research director at the National Corn-to-Ethanol Research Centre (NCERC) the speed of the new monitoring option is especially interesting. He describes how with conventional testing there can be an eight to ten hour gap between tests and then the actual test will take about an hour to deliver results: around 20 minutes for the test, plus the additional time for pulling the sample and setting up. "A lot can happen within an hour and it can be maddening to wait" he says.

Antibiotics provide a solution, but who wants to use more than absolutely necessary, both with respect to cost and the possibility of residues contaminating distillers grain by-products? Rapid testing can improve monitoring and allow a more proactive approach to fermentation control where the use of antibiotics is minimised.

The ability to test as much as you like at no extra cost is also noted by Mitchell Feldman, laboratory manager at Abengoa Bioenergy of Nebraska.

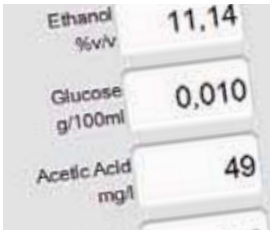
"With HPLC, the filters are at least a dollar per sample and the vials are at least ten cents so you are saving a dollar ten with every sample you run," says Feldman. On a normal day, the laboratory at the 88 million gallon per year capacity plant runs between 50 and 60 samples. But if issues arise, they will run a hundred or

Measurements are simple to perform for anyone working in the plant

1. Select sample type

2. Load sample

3. Press start



4. Await result

5. Wipe clean

so depending on what needs to be measured. Although only occasional, the need to replace columns for HPLC systems, also contributes to costs. "When you run as many samples as we do, it all adds up," says Feldman.

FTIR analysis technology is available in an easy-to-use form and the test model used at Abengoa Bioenergy of Nebraska is a compact, simple-to-use instrument that is no more complicated than your average drinks vending machine. "Anyone can use it," says Feldman.

The usability associated with FTIR analysis is also noted by NCERC director John Caupert. "Training is a huge issue in the industry," says Caupert who has testified to the U.S. House of Representatives on the need for improved training in what he sees as one of the few growth areas for the U.S. economy at present. The speed and ease of use would be a tremendous advantage. "Someone like me can use it and I am not a chemist or an engineer," he says.

Milk, wine and now fuel ethanol

FTIR technology may be new to the ethanol industry but not to others, as the need to monitor fermentation is by no means unique.

Winemakers can get just as many grey hairs waiting for the outcome of fermentation as ethanol producers. But in contrast, many have given themselves an edge in the form of analytical technology that can deliver results for key measurements whenever needed, effectively providing an early warning system for potential problems.

In simple terms, the FTIR method works by shining infrared light through the sample. This picks up the vibrational activity of chemical functional groups. The information is then decoded using a well known mathematical function (the Fourier Transform). The technique has been in use for decades for testing milk and, as mentioned, in the wine industry where it was first used in 1999.

Sniffing out acetic and lactic acid

FTIR measures all the regular parameters involved in fermentation control, sugars, (maltose and glucose) and ethanol. Plus a proven strength of FTIR technology is that it provides the sensitivity required to pick up parameters often discernable in low concentrations such as the all important acetic and lactic acid. In this way it offers a more powerful alternative to the better known near infrared analysis method.

A term you will hear in connection with FTIR is the 'signature' left by a chemical component that can be picked up at specific areas of the infrared light wavelength.

Cornmash provides lots of different signatures and the FTIR technology is ideal for sniffing out acetic and lactic acid amongst the mass of data. At the same time, studies indicate that it is also better at measuring the more prominent components. "NIR seems to work, but with FTIR it is more specific," says Wrenn.

Feldman shares the interest in the ability to track infection indicators. In measuring lactic and acetic acid the technology really shines in giving reproducible results," he says. "They are very low level, so they are hard to measure with NIR, but we found that the FTIR instrument actually does a very good job of measuring these low level parameters."

Same procedure, more information

Infection control is especially important at facilities like the one at the Abengoa Bioenergy Nebraska plant where a continuous fermentation process involving eight tanks is used. "A small infection in early fermentation, translates into a big problem by the time you get to the end of fermentation," says Feldman.

He explains how, if they see a problem coming, they will take more samples to check that everything is heading in the right direction. At around a million gallons per tank, a big investment is involved given that a million gallons of corn mash is not cheap on today's market. Millions of dollars are in process, just in terms of grain.

"We don't lose a whole tank, but you do lose yield," explains Feldman with reference to the fact that an infection is either consuming sugar or alcohol. Bacteria in the tank are converting sugar and ethanol to something else, either lactic or acetic acid.

It is when we are reminded of such basic facts, that the advantages of a rapid and simple-to-use control method light up in neon. FTIR analysis simply makes getting the required control data quicker and more cost effective. "It would be the same with HPLC, but the biggest benefit with FTIR is the time and the cost, which are both excellent," says Feldman.

Hourly tests a reality

At the time of writing, the FOSS FTIR BioFoss™ unit has been in operation at Abengoa Bioenergy of Nebraska for several months now where it is showing great promise. It has also been installed at a handful of other ethanol plants throughout the corn-belt where it over time will reduce the reliance on the HPLC for routine analysis.

In the meantime, the potential of FTIR is already clear. As an accessible and rapid method, FTIR can help to reduce use of antibiotics, ensure maximum yield and avoid nasty surprises during the fermentation step. Above all, it could make testing by anyone in the plant a matter of routine. "Why not do tests every hour," questions Wrenn from NCERC.

More information about FOSS solutions for Biofuel at: www.foss.dk/biofuel ■

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