Fermentation Monitoring

Bruker Optics Near Infrared (NIR) spectrometers can be used to determine multiple components per measurement to analyze fermentation process.

Fermentation is a very complex process and many parameters can affect the final alcohol content and overall yield. In the industry today, most distilleries or fuel ethanol plants use HPLC (high performance liquid chromatography) for fermentation monitoring, including measurements of sugars, acids, glycerol, and alcohol. All these components are interrelated and it is very important to keep track of them at each stage of the fermentation, but there are disadvantages to use HPLC as the primary monitoring tool:

- It is time consuming: per sample analysis is at least 20 minutes, which does not include the sample preparation, instrument calibration and the after analysis wash out time. This prevents a laboratory staff to keep up with the demand for fermentation sample results. In addition, it cannot be used as a real time trouble-shooting tool to identify problems in the early stage before yield is compromised.
- HPLC can only analyze soluble components. To extract the components of interest from the mash, it must be centrifuged or filtered to retain the liquid portion. This will compound the error, because the solid portion that is removed has sugars, acids, and alcohols still bound to the solid particles, thus make the results not accurate.
- Results are not always as accurate as required.
- The technician must be highly skilled.
- Accessories can be quite expensive (i.e. columns, chemicals, filters).

On the contrary, NIR analysis is fast and can simultaneously determine multiple components per measurement within 1 minute. It is a non-destructive method and fermentation samples can be analyzed as is, thus there is no sample preparation, no waste and no pollution. In addition, it is simple to use and high precise and accurate. Fermentation sample can be analyzed in a glass beak in diffuse reflectance mode using Bruker Optics MPA™ integrating sphere channel or MATRIX™-I system mounted with off-center rotator, which are specially designed for inhomogeneous sample analysis. The predictive errors of the calibration models Bruker currently used to monitor corn fermentations in distillery are described in Table 1.

Table 1

Component	Approximate RMSECV
Ethanol	0.14
Dextrins	0.5
Dextrose	0.46
Maltose	0.52
Lactic Acid	0.11
Glycerol	0.07

Table 1. RMSECV values for fermentation parameters

Troubleshooting is one of the largest paybacks for an NIR spectrometer. Over the course of one year, one lab technician can measure 5600 corn mash samples with just one NIR spectrometer. The fermentor can be monitored at 12–40 hr intervals and the final percent alcohol can be predicted. If the values are lower than expected, a course of action can be determined. Troubleshooting of fermentors is performed by checking if the correct amount of enzyme or yeast was added, or auditing the plant for mechanical failures. An example of mechanical failures is an increase in lactic acid values and decrease in ethanol in one fermentor, in which case the Butterworth washer must be inspected closely to determine if it is rotating properly. As another example, if the alcohol content is too low, check for small leaks in the cooling coil. NIR technology can assist in identifying and fixing problems in the early stage before yield is compromised.

NIR spectroscopy is an asset that allows distillery and fuel ethanol plant to rapidly perform research on different protocols to optimize fermentations, including changing enzymes, process parameters or nutritional supplements. If the fermentor is 200,000 liters and the average fermentation finishes when alcohol content reaches 9.6%, this means that the plant will produce 19,200 absolute liters of alcohol per fermentor. With the assistant of NIR, if after the fermentation optimization, the average alcohol content is raised to 10.6% per fermentor, then 21,200 absolute liters of alcohol are now made in each feremento r. . If 1000 fermentors are set per year in a plant to produce a certain amount of alcohol, the one percentage point increase in fermentor alcohol content means that plant can now set only 905 instead of 1000 fermentors to produce the same amount of alcohol. This means considerable savings in raw materials, processing fuel, steam, labor, maintenance, and equipment.