

## BevSense VS-3000 Beverage Monitor White Paper

### Mid-Infrared Monitoring of Beverages using ATR spectroscopy

Real-time Measurement of Brix, Acid, Ethanol and CO2

[www.beveragesensors.com](http://www.beveragesensors.com)

#### Mid-Infrared monitoring of Beverages using ATR spectroscopy

Attenuated total reflection spectroscopy is a method that is used by mid-infrared filterometers to measure beverages in-situ. A filterometer is a solid-state infrared spectrometer using an array of infrared sensors with filters to separate out infrared bands to identify and quantify ingredient concentrations. VitalSensors uses a five channel Mid Infrared filterometer in the 2.5-5.0um region to look at many common food products including, varieties of wine, beer, juices, dairy products including milk and yogurt, sodas, sport drinks and traditional vinegars, barbeque sauce, ketchup, mustard and spirits including scotch, bourbon, sake and vodka.

Traditional methods for measuring fluid concentrations use density meters, sound velocity meters, refractometers, temperature/pressure measurements, mass flow meters, titrations and PH meters. These traditional indirect methods of measuring concentration are becoming less desirable as the number of ingredients in beverages increase. Most traditional methods have one to two measurements to determine ingredients while many beverages have increased the number of ingredients for increased variety. The VS3000E has seven simultaneous measurements including two temperature sensors to differentiate ingredients in food.

#### Technology:

BevSense VS3000E mid infrared optical sensors use a three-bounce sapphire ATR crystal to measure beverages in-situ. Each VS-3000E sensor can measure up to four concentrations and temperature. See Figure 1.

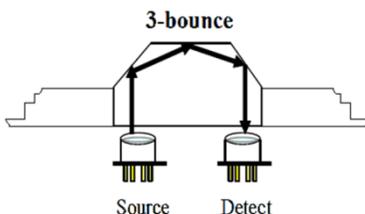


Figure 1

Mid-Infrared ATR sensors measure fluids between 2.5um and 5.0um are an ideal platform for measuring fermentations. Ethanol and sugars including HFCS, sucrose, dextrose, lactose, glucose and maltose can be measured and differentiated in the CH stretch. Beverage acids including citric, phosphoric, malic, tartaric, lactic, quinic and acetic all have signatures in the OH stretch. The VS3000E looks at several lines in the OH stretch to give total Acid content for fermentation. CO2 has a unique infrared signature at 4.7um.

#### Fermentation using VS3000 ATR probe



Figure 2 VS3000E probe attached to Research White Wine Fermentation tank inside tank view.

The interface to the process is 316L stainless, virgin PEEK and sapphire making it extremely rugged. Chart 1 displays five White wine fermentations showing the reduction in Sugar and the production of Ethanol. This measurement is done directly on a fermentation tank

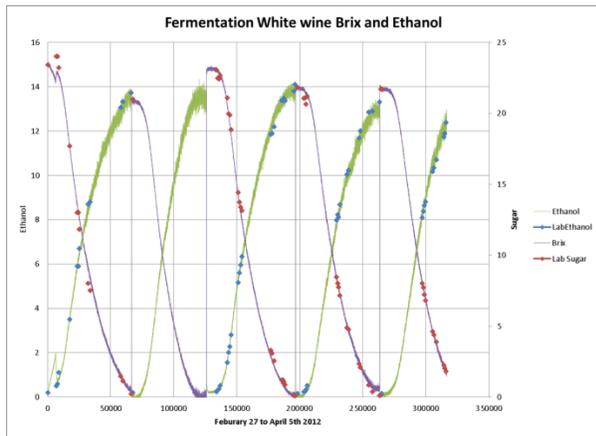


Chart 1

The Chart 2 shows the regression for ethanol for these fermentations. There is a 99.75% confidence level for these measurements.

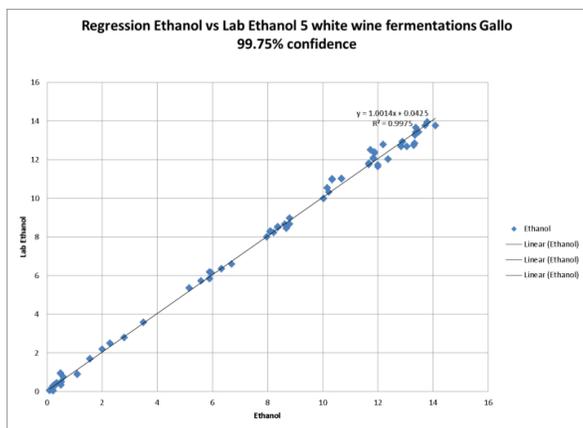


Chart 2

Chart 3 shows a beer fermentation from a joint study between BevSense the EU and the University of Nottingham:

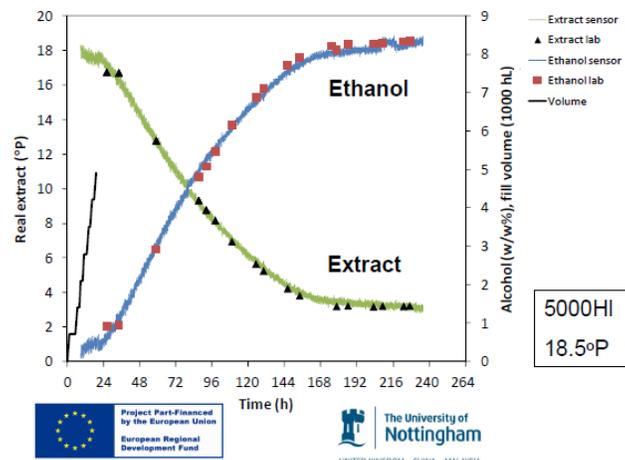


Chart 3

This shows excellent correlation between both Ethanol and Extract to the lab. Similar data exists for Wine Vinegar, Yogurt and other fermentations

**Blending using VS3000E ATR probe**

Chart 4 shows a Brix measurement in Soda on a tankless blender. VS-3000E real-time brix data for soft sugared and diet soft drinks. VS-3000E brix correlation to lab reference samples is excellent allowing for blending control. The VS3000E measures at 24 times per second allowing for blending without a mixing tank. Product transitions in the data can be seen clearly. The resolution of the VS-3000 sensors allows for clear product differentiation without the use of other lab tests. Real-time brix data greatly reduces lab testing as well as leading to a higher quality product and plant optimization.

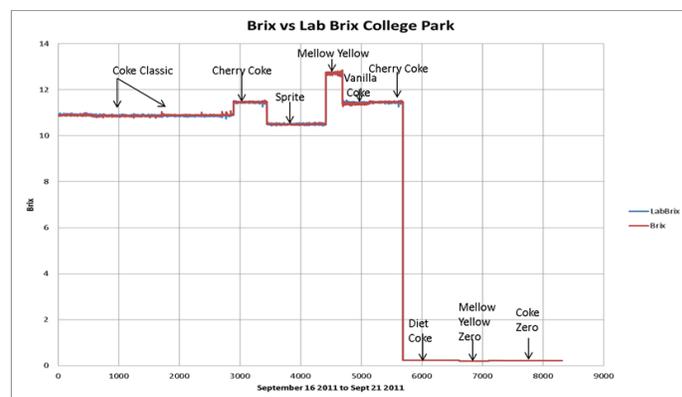


Chart 4

VS-3000E real-time Brix and Acid data for syrup gives extremely fast transition time between soft drink syrups.

Chart 5 shows a <=4 second transition between products on a tankless blender. A traditional density measurement has an approximately 30 second transition period. This causes less product to be produced from the same amount of syrup.

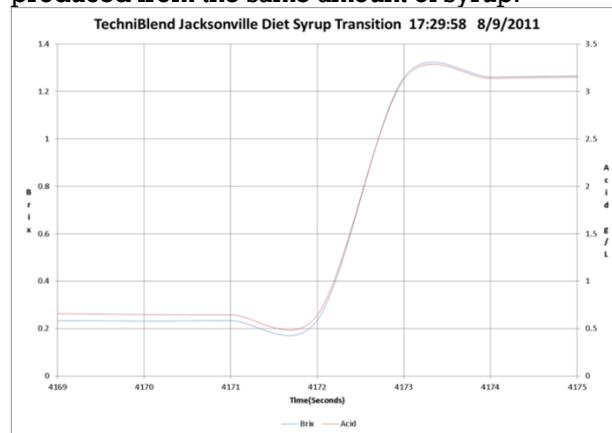


Chart 5

Chart 6 shows real time Brix and Acid for Acetic Acid products Ketchup, mustard and Barbecue sauce. Similar results exist for vinegars.

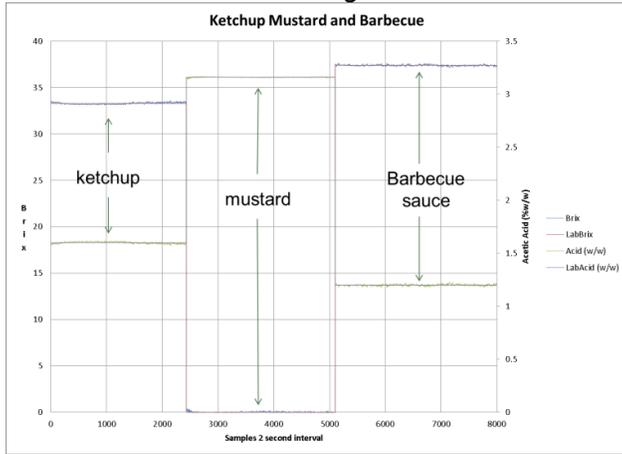


Chart 6 Acetic acid and sugar Ketchup Mustard and Barbecue Sauce on Tank

### Finishing line using VS3000E ATR probe

VS-3000E Alcohol by volume probe is an ingredient probe for products that have become much more complex. Beer used to be mostly lager with few ingredients and now there are Brown Ales, Porters, Beer from Oats, Stouts, Ales...etc. Mid Infrared ATR spectroscopy can separate the ingredients and give accurate concentrations over a large mixture of beers.

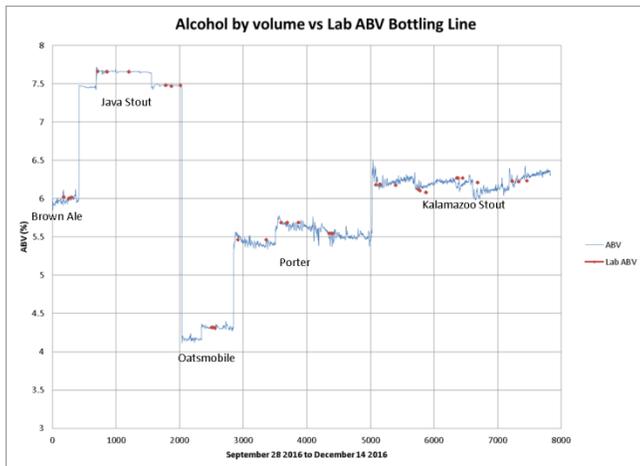


Chart 7 ABV vs Lab ABV various beer types and concentrations

There is a 99.73% correlation of concentration over a very large variance of ABV concentrations and beer ingredients.

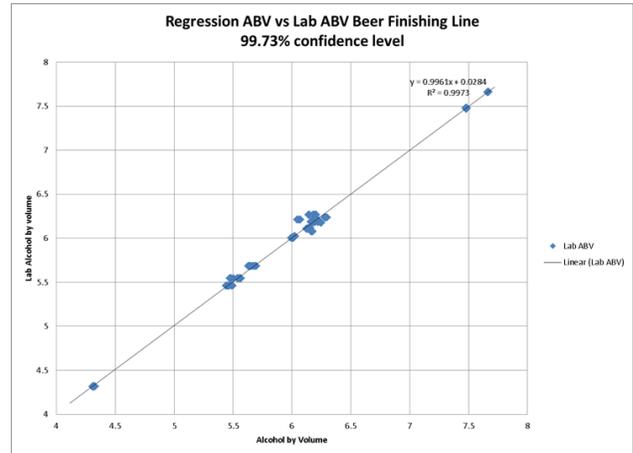


Chart 8 regression ABV vs Lab ABV finishing line

### Benefits

VS-3000E infrared optical sensors yield highly accurate real-time results of Brix/Sugar, Acids and carbonation in foods we eat every day including soft drinks, fruit juices, syrups, chocolate, dairy products like yogurt and milk and sports drinks. They can also be used in measuring the conversion of sugar to ethanol in many types of beer, wine of all varieties and spirits. They are used to measure the fermentation, blending and the finished product including carbonation. The VS-3000 have low cost of ownership and can measure up to four concentrations, temperature and product transitions.

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