Removing the Subjectivity from Winemaking

Winemaking is often considered more of an art than a science. However, it is the relative concentrations and presence of different chemical species that give a wine its flavor profile, mouthfeel, and other characteristics. By profiling and identifying a wine's chemical composition, it is possible to understand what makes a certain wine unique and this information can then be used in the winemaking process to achieve particular results.

Flavor Profile and Flavor Compounds

Red wines usually have their flavor profiles broken down into ten different categories: red wine, black fruit, floral aromas, herbaceous, pepper/spice, earthiness, baking spice and vanilla, leathery flavors, astringency, and body. Tannins, alcohol, body, sweetness, and acidity are considered the five basic characteristics of wine.

The challenge with translating these descriptions into a chemical analysis and categorization of the wine is that wine is a highly complex mixture consisting of hundreds of different chemical species belonging to a wide variety of chemical families. The main families of flavor compounds of interest include esters, sulfur compounds, pyrazines, and terpenes amongst others. For example, members of the terpene family of compounds are what give rise to aroma profiles that are typically described as floral or rose-like, green, and herbaceous.

As well as different terpenes giving rise to different aromas, subtle changes in the relative concentration of the chemical species also play an important role in determining the wine's overall flavor profile. Alongside this, sugars, polyphenols, and flavonoids influence the sweetness of a wine and ethanol contributes to the mouth-warming effect.

While also contributing to the flavor and characteristics of the wine, for winemakers need to be able to quantify sugar and alcohol content in their products. Sugar and alcohol are the main reactants and products in the fermentation process and so careful control of their concentrations is key in optimal product production. Knowing the alcohol concentration is also essential for labeling and sales of alcoholic products.

Application Note

What many winemakers are now doing is using online chemical analysis techniques as part of intentional process control to produce either higher quality wines or with specifically tailored profiles. Chemical analysis can be used in all the steps of the wine production such as the aging of wine or the fermentation. For example, changing the particular blends of yeast used can enhance the complexity of the flavor profile and help to reduce spoilage.

One analytical technique that works especially well for qualitatively and quantitatively identifying the typical flavor compounds in wine is near-infrared (NIR) spectroscopy.

NIR Identification of Functional Groups

NIR spectroscopy is a common analysis tool that can be used to efficiently identify the presence of overtones and combination bands of functional groups in a molecule. Each molecule that absorbs NIR radiation has a unique spectrum that can be used for unambiguous identification, and with the correct calibration information, can also be used for quantification.

NIR spectroscopy is very well-suited for analysis of flavor compounds in wine as many of these have functional groups that absorb very strongly in the NIR region so even low concentrations can be detected. Some of the compounds that can be identified include ethanol, sugars, flavanols, etc.

The advantage of using NIR spectroscopy over other analytical techniques such as liquid chromatography is that, with the right instrument, the analysis can be done online, with significantly shorter analysis times and is non-destructive. For this purpose, tec5 offers a Compact NIR Spectroscopy Systems (CNIRS) that can be used for both characterizations of ethanol, sugars, and other flavor compounds.

Inline NIR Analysis

For the wine industry, where online process optimization is often the goal, tec5's CNIRS instrument is ideal as it can be installed for inline analysis. The instrument covers the 1.10 – 2.50 µm wavelength range, so is compatible with measuring sugars, alcohols, and other flavor compounds including phenolic or lactone species.

Process control applications will benefit greatly from the excellent achievable signal to noise ratio exceeding 10 000, which means acquisition and analysis times can be minimized or flavor compounds only present in low concentrations can also be detected. Compounds that cause spoilage or unpleasant tastes in wine can be detected by consumers at the ppt level, so the excellent sensitivity of this device is essential for allowing for the screening of contaminants.7

tec5 has the option to supply advanced analytical software packages, including for methods such as multivariate data analysis, with the instrument. This means that, as well as the ease of installation of a single box device, the learning curve for maximum utilization of the spectroscopic data is minimized.

There are a variety of sample probes compatible with the CNIRS including immersion probes for use in liquids that could be easily interfaced into existing processing equipment for online monitoring. The idea is to offer a device that offers a cost-effective, flexible, and accurate alternative for batch sampling and offline analysis that can be in turn used to react to sudden changes in processing conditions.

Application Note

The use of NIR spectroscopy to identify wine characteristics has become a well-established technique over the last few years and using tec5's hardware solution of online analysis has several benefits for the wine industry, either for quality control and process monitoring or active process control for the creation of perfectly tailored wines.

tec5USA Spectrometry Solutions

tec5USA manufactures a full suite of spectrometry solutions suitable for in-line analysis in the wine industry.

tec5USA's Compact Near-Infrared Spectrometer (CNIRS) system is an efficient, compact, and low-cost alternative to traditional NIR spectrometers. Based on a Micro-Electro-Mechanical System (MEMS) Fabry-Perot interferometer sensor, the CNIRS is capable of measuring variable wavelength ranges within 1.10 – 2.50µm , with a signal-to-noise ratio exceeding 10,000. tec5USA integrated systems, available in a range of enclosure types, enable significantly cheaper sensor nodes as compared to conventional spectrometers.

The Compact UV-NIR Spectrometer is an extended-range UV/visible/IR spectrometer for measuring wavelengths in the 300 – 1100nm range. The system offers a wavelength accuracy of less than 0.3nm and is permanently wavelength calibrated to ensure reliably accurate measurements.

[tec5USA CNIRS in a stainless-steel enclosure]

In-line monitoring gives unprecedented ease and accuracy, allowing measurements to be obtained continuously and recorded automatically without human input and sample destruction. tec5USA's spectrometry systems provide an affordable, flexible, and accurate alternative to laborious, expensive, and destructive wet chemistry techniques for wine analysis. These techniques give enhanced control over the development of wines, enabling winemakers to accurately monitor fermentation progress, and gain insight into flavor compounds to inform decisions in the winemaking process (for example, the addition of oak chips or other barrel alternatives to simulate barrel-aging effects).

About tec5USA

tec5USA is the North American subsidiary of tec5 AG, who belong to the publically traded company Nynomic AG, an international group and leading manufacturer of products for permanent, non-contact and non-destructive optical measurement technology.

Rather than waiting for time-consuming laboratory measurements, tec5USA's instruments rapidly measure time-critical chemical and physical parameters to react immediately to deviations in the production line, permitting real-time process verification. This hence enables consistent quality, waste minimization and rework reduction, yield maximization, end-to-end supply chain optimization and pay per content.

Industries tec5USA serves are semiconductor manufacturing equipment, thin film technology, chemistry, petrochemistry, environmental technology, the mining industry, biotechnology and pharma, food, feed and beverages as well as agriculture.

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