A toast to spectroscopy: How Compact Spectrometers are used in ethanol product research

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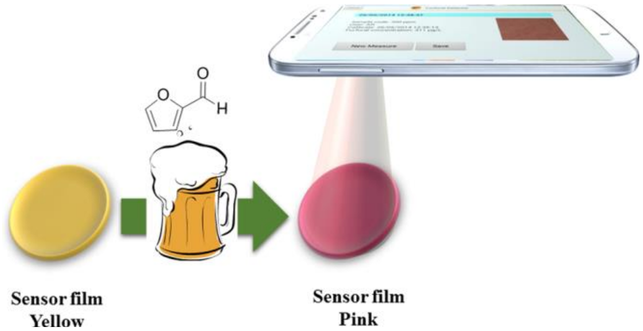
Alcoholic beverages seem like a simple concept at first: take something sugary, throw in some yeast, and ta da! The sugars are fermented into ethanol. But the reality is more complex, even for mass produced products like Budweiser and Charles Shaw. For example, wine characteristics are often determined by when the grapes are picked. The longer grapes remain on the vine, the more tannins ripen and the more sugar forms. For late harvest wines and ice wines, which are expected to be sweet, this is not a problem. However, for red wines where tannis are desirable, the wine is usually dry, meaning all sugar has been fermented to ethanol. Too much sugar means a high alcohol content for dry wines. This is just a small part of how grapes are grown, called viticulture. This doesn't cover making wine from said grapes, let alone touching on other types of alcoholic beverages. Here's a sampling of how StellarNet customers are contributing to these complex processes.

Beer

One interesting concept in the consumption of alcoholic beverages is aging. For some beverages, such as wine and bourbon, aging is beneficial. For others, such as beer, aging is detrimental. Rico-Yuste *et. al.* created a chemosensor to help determine the furfural content of beers [1]. Furfural is one of the main compounds that indicates a beer's age; the higher the furfural concentration, the older the beer and the lower the quality. The researchers developed a polymer film that balanced flexibility and reproducibility with sensitivity. The film changes from yellow to pink as the concentration of furfural increases and this color change can even be detected by a smartphone. The researchers used a StellarNet white light source to measure the absorbance spectra of these films. Most importantly, these films were highly specific to furfural, making an easy and inexpensive way to measure beer age.



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Wine

Speaking of grape harvesting, Michael Fadock worked on a spectroscopic method to determine the appropriate time to harvest grapes [2]. Currently, grapes are transported to a lab to measure the sugar content (in units of °Brix), pH, and titratable acids. When these quantities reach a certain threshold, the grapes are harvested. However, there is usually a delay between when the grapes are sent to the lab and when the results are available. Fadock combined reflection spectroscopy with partial least squares to predict the three quantities without having to measure them, using a BLACK-Comet spectrometer to collect the spectra. He was able to predict the °Brix with good accuracy, but pH and titratable acid predictions were less accurate.

Another important property of grapes is where they are grown, such as Napa or Bordeaux. This is captured by the protected designation of origin (PDO), which is a target of forfeiters. Current techniques for determining PDO are expensive, time-consuming, and destroy large amounts of sample. Moncayo *et. al.* combined laser-induced breakdown spectroscopy (LIBS) with neural networks to create a new technique for confirming PDO [3]. Using a BLUE-Wave spectrometer, they measured the Mg, Ca, K, and Na spectral lines of wines to input into the neural network model. This produced predictions that were >98% accurate for new wine samples, including some that didn't have a PDO.

The Manufacturing Process

Because ethanol is so volatile, a lot of the ethanol produced in fermentation evaporates into the air. This can create a number of hazards, including fire, health, and environmental. Therefore, it is imperative to have accurate ethanol gas sensors. Parthibavarman *et. al.* synthesized a Co-doped SnO_2 material for ethanol sensing [4]. They used a white light source and BLUE-Wave spectrometer to characterize the material through UV-vis reflectance, among other techniques. They discovered that the band gap decreases with increasing Co content. As a sensor, the material was sensitive to ethanol, showed a quick response time when ethanol gas was introduced, and showed reversibility when ethanol gas was turned off.

Aside from environmental hazards of ethanol gas, there are also waste products from the fermentation process to consider. Han *et. al.* investigated a new method for the remediation of waste, using ethanol as a model organic compound [5]. Generally, an iron-based Fenton reaction with hydrogen peroxide is used to oxidize organic waste, but the reaction creates waste of its own. A magnesium-based catalyst produces water as the only byproduct, leading to a cleaner reaction. The researchers demonstrated the reaction with Mn_3O_4 instead of an iron compound. They monitored the hydrogen peroxide through UV-vis spectroscopy, collected by a BLUE-Wave spectrometer. The magnesium catalyst was not as efficient as the iron catalyst, but it was indeed cleaner. The reaction mechanism was also different.

A lot of effort and research goes into a glass of alcohol. These are just a few of the ways that spectroscopy can participate in the process. I'll raise my glass to that!

References

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