Taking Control of Total Package Oxygen

Closure Parameters and Oxygen Audits are Key

Deborah Parker Wong

THE OXYGEN TRANSMISSION RATE (OTR) of a wine closure is just one of several factors that contribute to the total package oxygen (TPO) in a bottle of wine. According to Dr. Paulo Lopes, who conducts research and development at Santa Maria da Fiera-based Amorim & Irmãos, S.A. and has extensively studied the OTR of natural corks, closures are the least variable aspect when considering TPO. "We know precisely how much oxygen a closure will provide to the wine but only by accurately measuring oxygen during the bottling process are we able to make precision additions during winemaking," Lopes said.

Lopes' current research illustrates the oxygen release of natural cork over time, a measurement that is particularly relevant in the context of an oxygen audit designed to measure total package oxygen—the combination of the oxygen contained within the closure combined with the presence of atmospheric and headspace oxygen during bottling and the dissolved oxygen in the wine.

Oxygen Dynamics of Natural Cork

Not surprisingly, different grades of cork contain different amounts of oxygen; a longer, higher-quality Grade A cork with fewer lenticels will release less oxygen. "Longer corks are much more homogeneous in oxygen release," said Lopes. "Also, due to the [sloping] shape of the bottle neck, the cork is less compressed and thus releases less oxygen." To that effect, Amorim has created an online application which makes the OTR rates of its closures readily available. Lopes is also researching the contribution of cork phenolics to wine. "Phenols from cork in low amounts can help shape the oxygen reduction potential of a wine by polymerizing some compounds to reduce astringency and bitterness," he said. In effect, they provide extra protection against oxidation. "We're working to understand the relationship between cork length and different kinds of wine. By using the same approach as the barrel industry we'll be able to identify the optimal pairing between wine and cork."

On average, a natural cork will release up to one milligram of oxygen during the first six months in bottle and then continuously micro-oxygenate at just over one milligram from its cellular structure over a period of 60 months of storage. Although it's impermeable to atmospheric oxygen, oxygen from the cell structures of the cork travels through the plasmodems and lenticels into the wine.

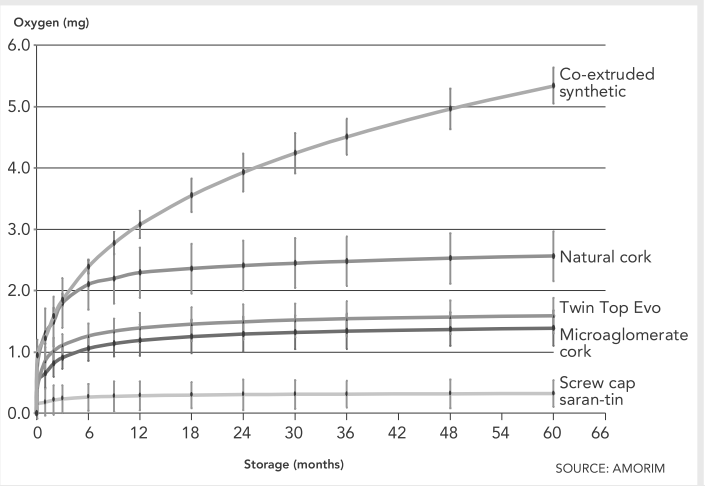
Corks used to seal wine bottles have a lifespan of about 25 years, after which they begin to lose elasticity and can start to let atmospheric air into the bottle along their sides. "After 10 years, a cork will lose only 1 to 2 percent of its elasticity," Lopes said. "And if stored in contact with the wine, it will absorb about three millimeters of wine. "

But it's the temperature and humidity of the storage space that ultimately dictate the lifespan of the cork, which initially consists of 80 to 90 percent air: an amount that decreases by 10 to 15 percent over time. Lopes explained that at temperatures below 20 °C (68 °F) and at 50 percent humidity, the head space in a wine bottle is as moist as vapor. According to Lopes, under these ideal conditions, there is no need to store bottles horizontally—that is, until the cork begins to lose elasticity.

Temperature has a significant impact on the properties of natural cork. When stored in temperatures above 20 °C, a cork will lose humidity faster than it can take in moisture from the headspace vapor or the wine and will eventually dry out. In the case of sparkling wine, corks absorb both liquid and gas as they pull carbon dioxide (CO_2) from the wine. The classic mushroom shape of a sparkling-wine cork is formed by its contact with CO_2. Lopes noted that when a sparkling wine is stored horizontally, the cork absorbs some of the wine and cannot recover the mushroom shape preferred by producers. While a straight-sided cork is the cosmetic result of horizontal storage, wine quality is unaffected.

Under Pressure

When comparing natural cork to other popular closures over a period of 60 months, Lopes has also determined that natural cork demonstrates better sealing capacity against atmospheric oxygen than manufactured and synthetic corks.



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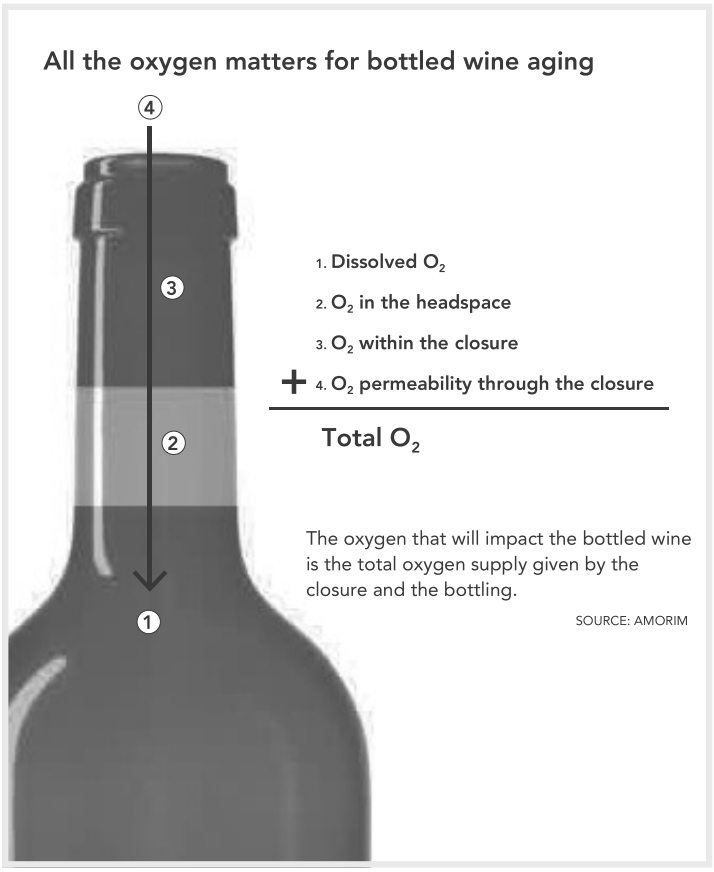
To further ensure the sealing integrity of each of its natural corks, Amorim has added a proprietary Sealing Verification System (SVE) technology to its production process that uses pressure to individually check the structural integrity of each cork. After being punched and sorted in the initial stages of production, corks are then pressure tested and either accepted or rejected by the system.

In an internal study of corks that were both approved and excluded by the SVE, Lopes found that SVE-approved corks maintained two mg/L more of free SO_2 in white wine after seven months of storage than corks that failed the pressure test. "With a good understanding of your TPO, the advantages of using a verified cork are two-fold: you can use lower levels of free sulfur, knowing that it won't be as variable over time, and your production will be more consistent as well," he said.



Despite the OTR of a natural cork closure, Lopes emphasized the need for a holistic approach to TPO, "The more we know, the less we have to intervene," he said. In studying TPO, he referenced the PreSens Precision Sensing GmbH analyzer to measure oxygen levels during winemaking and bottling. Don Huffman, director of sales and wine quality for North Carolina-based Vinventions, which distributes the analyzer in the United States under the tradename NomaSense O2 P300 and P6000, agreed. "Wineries fall short in having a complete understanding of their TPO," Huffman said.

According to Huffman, it's essential to measure the dissolved oxygen in a wine going on to the bottling line and to calibrate the line before each bottling run. He pointed out that the biggest variability for TPO can be found on a screw cap bottling line. "In a traditional screw cap line you're capturing air and you'll have a lot more potential headspace," he said. On average, headspace contains 65 percent of the TPO for a cylindrical closure and is as much as two to three times greater in a screw cap closure.

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Check Points and Inerting Practices Reduce TPO

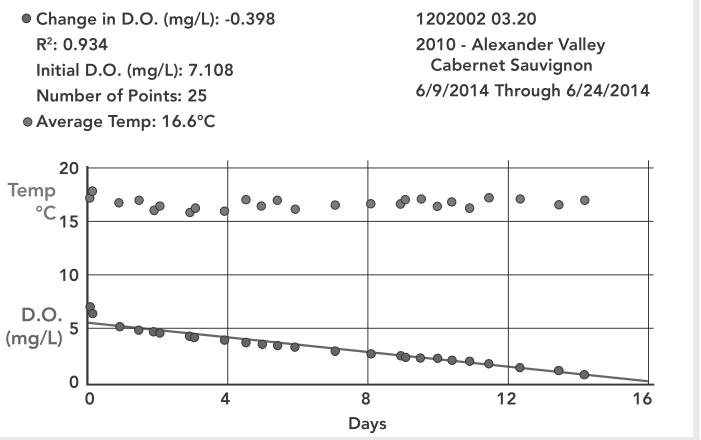
Conducting an oxygen audit to determine TPO typically begins with measuring and calculating the average dissolved oxygen (DO) in a tank prior to transferring the wine. Huffman referenced Vinventions' NomaSense Oxymeter which uses luminescence-based dots that adhere to a sight glass or bottle to measure the emission of light by the wine. The NomaSense portable unit is equipped with a probe, built-in barometer and temperature sensor, while a smartphone application runs the analyzer and manages the data via bluetooth.

According to Huffman, for an accurate average, it's essential to measure a spectrum of DO from the top to the bottom of a tank beginning with a sight glass reading to measure the DO, if any, of wine coming in to the tank and measuring DO again at the bottom of the tank at the valve.

Key check points for monitoring potential DO pick up include post filtration, as wine exiting a filter will naturally have a higher DO, and during cold stabilization and racking or transferring wine. Huffman suggested installing a sight glass just before the filling head on the bottling line, which should be inerted of oxygen before each run.

In a trial designed to reduce TPO conducted at Bodegas Osborne in Spain, TPO was measured at the beginning, middle and end of the bottling run. Winemakers identified a greater oxygen pick up at the beginning of the line and addressed the problem by inerting the line before wine was pushed into the system. The winery now achieves a consistent TPO at a maximum of 1 mg/L per bottle and an average around 0.7 mg/L. "With these types of check points in place, it's fairly easy to identify any problems," Huffman said. "More often than not, it's a .99 gasket or O-ring that is failing."

Given that the majority of TPO occurs in the headspace, measuring the oxygen content there post-bottling requires a companion analyzer that pierces the closure. Huffman suggested measuring the DO of the first bottles off the filling line and adjusting for any elevated levels of DO. The Nomasense Piercing System is a destructive measurement for still, sparkling and bag-in-box wine.



SOURCE: WINESMITH CONSULTING

Report tracking the rate of decline of DO measured using the NomaSense in an Alexander Valley Cabernet Sauvignon.

Assessing Reductive Strength

According to winemaker, chemist and author Clark Smith, who has used the NomaSense in his practice for five years, measuring TPO is all well and good but even more relevant is knowing a wine's "appetite for oxygen."

Using the NomaSense, Smith has developed an analysis to determine how robust or fragile a wine is based on how much oxygen it can consume before being at risk for detectable oxidation. He cited an example from a tasting presented at a recent conference that demonstrated the sensory differences that occurred in the same wine with a difference of 2 ppm TPO. Sample 1 was described by tasters as a classic, bright New Zealand Sauvignon Blanc and sample 2 as a fuller-bodied, richer Chardonnay.

"The scenario we see occurring in very reductive wines like the Sauvignon Blanc from this example is a rapid rate of decline in DO, resulting in a fragile wine that has no shelf life." Smith uses the NomaSense to measure a wine's appetite for oxygen by tracking the decline in the rate of its ability to consume oxygen, in effect measuring its reductive strength.

According to Smith, the dissolved oxygen in a delicate Sauvignon Blanc can decline at a rate of 10 ppm per day and reach zero within a few months. "In truth, the wine will have begun oxidizing long before the rate of decline has reached zero," he said.

Smith noted that different varietal wines have distinctly different oxygen appetites: even a light Pinot Noir can consume 7 mg/L of oxygen per day, while Petite Sirah can consume up to 14 mg/L over a period of 80 days with no adverse effects. "A big wine can gobble up its volume in oxygen and be all the better for it," he said.

In an effort to better manage the effects of dissolved oxygen, Smith developed a chart defining the oxygen appetite ranges for different varieties. He has further refined the procedure for accurately measuring dissolved oxygen using the NomaSense by eliminating the need to open a sealed bottle, which would introduce atmospheric oxygen. "We read the light-sensitive dot that's glued on the inside of the wine bottle (or sight glass) while putting the temperature probe in a bottle of water that's at the same temperature as the wine." For him, it's a nifty workaround that improves accuracy and avoids opening the sample repeatedly. Smith takes several readings, eliminates the outliers and averages the scores to achieve a very low margin of error. "I'm not aware of any better way of doing this type of analysis," said Smith, who charges $100 per 750 ml sample.

Another useful application Smith has found for NomaSense analysis is in determining the viability of older wines. Using a sample drawn from the bottle with a Coravin, Smith inserts the sample into a 30 ml test tube, seals it with a screw cap and uses the NomaSense Piercing System to determine the amount of DO. "From this analysis you can determine if the wine is viable or if it's dead." For collectors and those who invest to drink, this type of analysis can form the basis of purchase decisions.

In addition to identifying fragile or reductive wines, the incentives Smith has identified for determining a wine's oxygen appetite are many. Analysis provides winemakers the insight necessary to anticipate and proactively address any potential problems, guide blending decisions, forecast release dates, predict shelf life and, in relation to managing TPO, guide closure OTR selections. **WBM**