

Use of Inert Gases

By Murli Dharmadhikari

Nitrogen and carbon dioxide are the most commonly used inert gases in the wine industry today. In some cases a mixture of these two gases in varying proportions is also used. The use of a particular gas depends on the type of wine and intended purpose.

Nitrogen

Nitrogen is present in the air. The solubility of nitrogen in water at atmospheric pressure and at 20°C is about 19mg/L. It is about 8 to 9 times less soluble than CO₂. Due to low solubility; it is often used for sparging wine.

Carbon dioxide

Carbon dioxide is produced naturally during the fermentation. Its solubility in water at atmospheric pressure and 20°C is about 1.69g/L. The gas is heavier than air. Its density at 0°C is 1.52 as compared to the density of air which is about 1.0.

It is important to note that CO₂ is a normal constituent of still table wine, and almost all finished wines contain some dissolved CO₂. The recognition threshold for CO₂ in wine is about 0.6g/L. Wine usually contains between 0.4 to 1.0 grams per liter of CO₂. The optimum level depends on the style of wine. Dissolved CO₂ (carbonic acid) gives a hint of tartness and freshness to a wine. It seems to improve palatability and enhance the flavor. In some wines, such as full-bodied reds, a higher concentration of CO₂ may accentuate the harsh character. Generally, white wines are produced with higher CO₂ levels than reds.

White Wines

Nitrogen can be used for sparging a white wine to remove dissolved oxygen, but it may also strip CO₂ off below the optimum level rendering the wine less palatable. Wines with less than 0.2g/L CO₂ are considered to lack freshness. To overcome the problem of CO₂ stripping, either CO₂ alone or a mixture of CO₂ and nitrogen in the ratio of about 3 parts CO₂ to 1 part nitrogen is recommended. To prevent air contact with wine, flush the empty space or blanket the ullage with CO₂.

Red Wines

In handling red wines, nitrogen is the gas of choice for sparging. However, to retain a small amount of dissolved CO₂ in some reds, a mixture of 2 parts nitrogen and 1 part CO₂ may be more desirable.

For the purpose of blanketing or flushing air from the empty space, use of CO₂ is advised. However, caution should be exercised since CO₂ is very soluble and a red wine can pick up higher than optimum levels of CO₂.

The best approach is to try these gases individually or as a mixture to achieve different objectives and develop a plan that best suits your needs.

There are two ways in which the inert gases are used:

- 1) sparging,
- 2) flushing, and blanketing.

Sparging

Sparging is used to effectively remove dissolved oxygen (or CO₂) from the wine. The process of sparging is based on the application of a scientific principle known as Henry's Law, which states that the solubility of a gas in a liquid is proportional to the partial pressure of that gas in the gaseous atmosphere in contact with the liquid. During sparging the inert gas is introduced in the wine in the form of very fine bubbles. When the bubbles are dispersed, a partial pressure develops between the inert gas (N₂ or CO₂) and the dissolved gas (O₂). The difference in partial pressure causes the dissolved gas (O₂) to leave the wine. The efficiency of sparging is influenced by many factors, such as bubble size, contact time between the gas and wine, temperature of the wine, gas pressure, and the flow rate of gas in relation to the flow rate of wine.

The smaller the bubble size for a given volume of gas, the greater the interface area and the more efficient the stripping of oxygen. The bubble size is determined by the porosity of the sintered element in the sparging unit. Usually a maximum bubble size of about .03 mm diameter is considered acceptable for sparging.

As far as the contact time is concerned, the longer the contact time, the more efficient the sparging. The sparging is usually done at a temperature of 59 to 68°F and at a pressure of 1 to 2 atmospheres. The suggested flow rate of the inert gas in relation to the flow rate of wine is in the range of 0.1 v/v to 0.3 v/v. This means a flow rate of 0.1 to 0.3 liters of inert gas per liter of wine. In some situations a higher rate such as 0.3 to 0.8 liter of gas per liter of wine may be required to achieve the desired results.

Flushing or Blanketing

Hushing or purging with an inert gas implies displacing the air from an empty vessel, empty bottle, or any other empty but confined space with an inert gas, usually CO₂. In the case of blanketing, an attempt is made to maintain a layer of gas over the wine surface.

Wineries use various means to achieve a purging, flushing, or blanketing operation. For example, some wineries use a gas cylinder and a hose connected to the cylinder and equipped with a valve to control the flow of gas. The gas is allowed to flow into the space from which the air is being displaced. This procedure is often used to top the head space in partially filled tanks, barrels, or other containers. Some wineries bubble the gas through the wine and expect the gas to form a layer or blanket on the top of the wine surface. The amount of gas used is usually estimated. The effectiveness of this latter procedure is rarely tested and is questionable.

In some cases the ullage space in a partially filled container is blanketed with CO₂ on a regular basis. It is assumed that CO₂ being the heavier gas will form a layer above the wine surface and thus protect the wine from the air (keep oxygen away). In reality this rarely works. CO₂ does not form a permanent layer; it eventually is uniformly distributed throughout the empty space. In a way it dilutes the oxygen concentration in the space. Unless O₂ concentrations in the ullage space are tested, the effectiveness of the process cannot be ascertained. Some people use a lighted candle to test oxygen concentration. A lighted candle or a lighter is placed in the blanketed ullage space. If the candle goes off, it is concluded that the oxygen concentration is sufficiently low. This kind of test is not valid and should not be relied upon. Air contains 20.9% O₂ by volume. When the O₂ concentration in air drops below 16.5%, the candle quits burning. The object of flushing or blanketing should be to lower the O₂ concentration to 0.5% by volume or lower. To discourage the growth of aerobic microbes, the O₂ concentration should be checked with an oxygen meter whenever a gas is used to displace the oxygen.

Practical Suggestions for Using Inert Gas

Inert gas can be used in those situations where the wine is likely to be aerated. During processing, there are several occasions when the wine faces the danger of oxygen pick up. Some important occasions include:

- 1) wine transfer
- 2) bottling
- 3) wine stored with ullage space

Wine Transfer

Whenever a wine is moved from one container to another it should be protected with an inert gas such as CO₂. This can be accomplished by displacing air from both the racking and receiving containers. To displace air, the vessels should be purged with 3 to 7 volumes of the gas. It is also helpful to flush the hose and pump with gas. A wine may also be sparged during pumping. This will remove the oxygen already dissolved in the wine. After the wine is pumped, with or without sparging, the oxygen concentration in the wine should be checked.

Bottling

The wine is particularly prone to oxidation at the time of bottling. The turbulence of wine with air inside the bottle during the filling operation encourages oxidation. For this reason, the bottles should be flushed with CO₂ or nitrogen prior to filling. A wine can also absorb significant amounts of oxygen from the headspace in bottles after it is filled. The modern bottling machines are now equipped to purge the bottles with inert gas before and after filling. The goal at bottling should be to reduce oxygen levels to 1 ppm or less.

Wine Storage with Ullage Space

Sometimes wine is not stored full in containers. This permits prolonged air contact which can cause oxidation and microbial growth. Oxygen pickup from the air space above the wine can be rapid. Peynaud (1981) reported that in a wine kept in contact with air, about 1.5 ml/L of O₂ was absorbed in the first hour (surface area of 100 cm²). In 4 hours, the upper layer was saturated. To prevent the problem of oxygen pickup, the ullage space should be flushed with inert gas (CO₂) and a blanket should be established and maintained to keep oxygen out. The blanketing should be done by introducing the gas into the ullage space with a gas diffuser. The gas should be frequently replenished to keep the O₂ level in the ullage space to less than 0.5%. The concentration of O₂ in wine should be about 1 ppm or less.

There are several types of systems available in the market that can be installed to deliver the inert gas. These systems usually include a source of gas, gas lines with valves, and pressure regulators connected to the bottom of the tanks. The flow rate of gas into the tank is regulated. When the tank is emptied the gas flows in. When the tank is filled, the gas flow stops and the gas from the tank is allowed to escape through a pressure relief device.

