The efficiency of inert gas during racking

Part 1: Inert gases in winemaking

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Basic Wine

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Critical cellar practices involving the **movement of wine**, including racking, filtration, and pumping, all pose a threat of excess oxygen dissolving into the wine. The use of inert gas is often used to purge hoses, tanks, and headspaces with the aim of minimising oxygen exposure and the dissolution of oxygen into the wine.

Purging vs sparging

In winery terms, **purging** with an inert gas is when a confined gaseous space is filled with an inert gas with the aim of displacing oxygen thereby **reducing the oxygen concentration**. **Sparging** is the process of dispensing small bubbles of inert gas directly into the wine (liquid), usually with the aid of a sparging stone, with the aim of **displacing or removing dissolved oxygen** molecules in the wine, thereby lowering the dissolved oxygen concentration. This blog post (and the few to follow) will focus on the effectiveness of **purging**. For more information on the factors affecting sparging efficiency[1] please click here.

Racking and the use of inert gas

Racking is the process of transferring wine from one vessel to another, such as from tank to tank or tank to barrel. There are two main reasons why winemakers rack their wines. The first is to remove sediment. The second reason for racking is to enhance oxygen exposure and dissolution, which, for certain wine styles can contribute to the quality and development of the wine. However, for many wines (specifically white wines and fruit-driven Sauvignon blanc wines), **oxygen exposure during racking can have negative effects due to the oxidation of desirable aroma compounds**.

During wine transfer, there are three main areas for consideration in preventing wine oxidation:

1) **Source tank**: The tank that is being emptied.
2) **Destination tank**: The tank that is being filled.
3) **Transfer lines:** Hoses, lines and pumps.

Winemakers often use **inert gas during racking** operations to purge or flush the gaseous spaces to protect the wine from oxygen exposure, however, it has always been unclear how effective these preventative measures are in avoiding oxygen dissolution into the wine. Typical questions when using inert gases in the winery include:

1. **Which gases are most effective?**
2. **How much gas am I supposed to use?**

A recent study[2] investigated the **effectiveness of inertion** (displacing air with a chemically inactive gas) **during racking processes**. Some of the results of this study will be reported in the following blog posts. The current blog post will summarise some of the **key principles of the use of inert gas in the winery**.

Inert gases

Below is a summary of some of the **main characteristics of different gases** that are used in winemaking. For comparison, the density of air is 1.20 kg/m^3. All densities are reported at 20°C and 1 bar.

Nitrogen (N_2)

Nitrogen is probably the most used gas in winemaking (together with carbon dioxide) as it is easily obtained from air via adsorption by pressure change. **Nitrogen has a similar density to air** (1.17 kg/m^3) and therefore mixes with air, depleting or diluting the oxygen, rather than displacing it[3] (see dilution purging below). Nitrogen has a low solubility at typical cellar temperatures and atmospheric pressure (eight to nine times less soluble than carbon dioxide) making it ideal for sparging operations. Usually, a **greater volume of nitrogen gas is needed during purging operations** to obtain the desired oxygen concentration.

Carbon dioxide (CO_2)

Carbon dioxide is produced naturally during alcoholic fermentation and is therefore a normal constituent of still table wine. **Carbon dioxide is denser than air** (1.84 kg/m^3) and should effectively displace air during purging operations. The disadvantage of using carbon dioxide gas in winemaking is that the gas is **very soluble in wine** (107 L/hL at 20°C)[4], especially when a high-purity carbon dioxide is used and can result in increases in dissolved carbon dioxide in the wine after exposure. This is not always a disadvantage as some wines can benefit from increased dissolved carbon dioxide levels.

Solid carbon dioxide, more commonly known as **dry ice**, is often used during harvest and various winemaking processes to create an inert atmosphere via the process of **sublimation**. An additional benefit to the use of dry ice is that it can play a role in reducing the temperature of the direct environment.

A mixture of nitrogen and carbon dioxide (N_2/CO_2)

Premixes of nitrogen and carbon dioxide are often used in winemaking as its **densities are slightly greater than air while the risk of carbon dioxide dissolution is decreased**. The N_2/CO_2 mixture usually has a ratio of 80:20 (Aligal 12) or 70:30 (Aligal 13). The carbon dioxide in the mixture can still lead to increases in dissolved carbon dioxide in the wine (especially during sparging operations performed at lower temperatures[1,5]) but to a much lesser extent compared to when pure carbon dioxide is used.

Argon

Argon is an inert gas with a **greater density** than air (1.66 kg/m^3). This greater density allows the gas to displace air effectively. Argon is expensive, however, due to its effectivity in displacing air, **less of the gas is usually needed** to obtain proper inertion. The general lack of knowledge regarding the effective volume of argon needed to obtain inertion leaves the winemaker without proper guidelines. This results in the dispensing of more gas than is necessary, increasing the costs. For this reason, the gas is usually not preferred by winemakers.

A mixture of carbon dioxide and argon (CO_2/Ar)

A premixture of carbon dioxide and argon in a ratio of 20:80 results in a density of 1.70 kg/m^3 which is also **greater than air**. Therefore, the mixture can effectively displace air. The risk of CO_2 solubilising into the wine when using this mixture should also be considered.

Dilution purging (partial inerting) and blanket purging (total inerting)

In winery terms, for a space to be considered as inerted, the oxygen concentration **in the space should be less than 0.5% (or 5 hPa or 2.5 % air saturation)**[2]**.** Inerting operations in the winery can be applied to either achieve **partial inerting or total inerting**.

During **partial inerting (dilution purging)** the oxygen concentration is **gradually reduced** by continuously dispensing the inert gas into the enclosed space until the desired oxygen level is achieved. In winemaking, nitrogen is often used for dilution purging due to its similar density to air which causes the inert gas to mix with the air, causing a **dilution effect** as opposed to the air being systematically displaced.

Total inerting (blanket purging) is when the air (containing oxygen) is **completely displaced** by the inert gas from the bottom upwards ("blanketing"). The use of an **inert gas with a density higher than that of the gas to be displaced is important** in blanket purging. It is assumed that when an inert gas blanket is formed that the protective blanket will remain on top of the wine as the wine surface moves upwards or downwards, however, the formed "blanket" is not impermeable by air (and oxygen) and will over time lose efficiency. Continuous replenishment is required, especially when long-term protection is required.

Blanket purging (displacement) requires a low flow rate with velocities lower than 10 m/s to avoid turbulences and is recommended for tall and narrow vessels with a high height/diameter ratio. When the vessel to be inerted has a low height/diameter ratio, it is advised to use dilution purging to eventually obtain a low oxygen environment, however, this usually necessitates a larger volume of gas.

References

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