IOWA STATE UNIVERSITY
Extension and Outreach

Use of Inert Gases

Safety Hazard: The gases discussed in this document (nitrogen, argon, and carbon dioxide) can displace oxygen and cause asphyxiation. Carbon dioxide also is produced during fermentation, settles to low points, and is acutely toxic in high concentrations. Atmosphere inside confined spaces must be tested before and during entry (oxygen must be at least 19.5% and carbon dioxide must be below 0.5% or 5000 mg/L).

What is an "inert" gas?

"Inert" is the term used to describe substances that are not chemically reactive. However, reactivity is dependent on context. Historically, the noble gases (helium, neon, argon, krypton, xenon, and radon) were referred to as inert gases.

Nitrogen (N_2), argon (Ar), and carbon dioxide (CO_2) are commonly used inert gases in the wine industry because these have little or no reactivity with wine. These can be used individually or as a mixture in varying proportions. Oxygen (O_2) is reactive with many chemical compounds in wine and is therefore not inert.

Why use inert gas in winemaking?

Inert gases are used to protect wines from the effects of oxygen, which include oxidation and a higher risk of contamination by spoilage microbes. For more information on oxidation and microbial faults, see Iowa State University Extension and Outreach publication FS40 - Wine Fault Series, store.extension.iastate.edu/Product/15980. Inert gases also can be used to displace other gases that are dissolved in wine, such as when a wine has more dissolved CO_2 than desired.

Types of gases used in the winery

The use of a particular gas depends on the type of wine and intended purpose. Additionally, gases vary in cost and efficacy. See Table 1 for properties of inert gases used in winemaking.

It is important to note that CO_2 is a normal constituent of still table wine, and almost all finished wines contain some dissolved CO_2 (typically between 400 to 1000 mg/L of dissolved CO_2). The Alcohol and Tobacco Tax and Trade Bureau (TTB) limits the concentration of dissolved CO_2 in still wine to 3920 mg/L or under (27 CFR § 24.245). The sensory recognition threshold for CO_2 in wine is about 600 mg/L and is detected by a "spritzy" mouthfeel but not by flavor. The optimum level depends on the style of wine. Dissolved CO_2 can give a hint of freshness to a wine. In some wines, such as full-bodied reds, a higher concentration of CO_2 may accentuate a harsh character. Generally, white wines are produced with higher final CO_2 levels than reds.

Table 1. Properties of inert gases used in winemaking.

Gas	Solubility in water at 1 atmosphere (atm) of pressure and 20°C	Density at 1 atmosphere (atm) of pressure and 20°C	Notes
Nitrogen (N_2)	19 mg/L	1.17 kg/m3	Mixes easily with air; cannot be used to blanket.
Argon (Ar)	62 mg/L	1.66 kg/m3	Typically the most expensive. If using gas for blanketing, argon is preferred over nitrogen.
Carbon Dioxide (CO_2)	1690 mg/L	1.84 kg/m3	Will dissolve into wine from headspace. May be purchased as dry ice pellets.

Methods for using inert gas in the winery

Sparging

Sparging is used to remove dissolved oxygen or CO_2 from the wine. During sparging, the inert gas is introduced to the wine in the form of very fine bubbles. When the bubbles are dispersed, a partial pressure develops between the inert gas and the dissolved gas (O_2), forcing the dissolved gas out of 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 where the bubbles are in contact with the wine, and the more efficient the removal of dissolved gas. For this reason, a sparging stone with small pores (2 to 100 µm) may be used.

Flushing, Purging, or Blanketing

Flushing or purging with an inert gas implies displacing the air from an empty vessel, empty bottle, or other empty but confined space and replacing it with an inert gas. In the case of blanketing, an attempt is made to maintain a layer of gas over the wine surface. The purpose of flushing, purging, or blanketing is to discourage the growth of aerobic microbes and to prevent oxidation of the wine.

However, in most cases of blanketing, the inert gas mixes with air in the vessel's headspace and becomes distributed throughout the space. Unless oxygen concentrations in the headspace are tested with an oxygen meter, the effectiveness of the process cannot be determined.

When to use inert gas during winemaking operations

Inert gas should be used in situations where the wine is likely to be aerated. During processing, there are several occasions when the wine risks significant oxygen pick-up. The use of inert gases should be in conjunction with proper sulfur dioxide use throughout winemaking.

Wine Transfer

Whenever a wine is moved from one container to another it should be protected with an inert gas. This can be accomplished by displacing air from both the racking and receiving containers. To displace air, the receiving vessel should be purged from the bottom. This is carried out at a slow rate to minimize turbulence and mixing with air as the vessel fills with inert gas and the air is pushed out. Common practice involves using a volume of the gas that is two to five times the volume of the tank. However, an oxygen meter is the most reliable way to determine when an acceptably low oxygen concentration has been reached. It also is helpful to flush the hose and the pump with inert gas. A wine also may be sparged during pumping to reduce the dissolved oxygen concentration in the wine. Before and immediately after the wine is pumped, the oxygen concentration in the wine can be measured to determine the oxygen pick-up during the transfer.

Wine Storage with Ullage (Head Space)

Sometimes wine is stored in partially full containers. This permits prolonged air contact, which allows oxidation and promotes microbial growth. To prevent oxygen pick-up, the ullage (head space) should be flushed with inert gas and a minimal-oxygen environment should be maintained throughout storage. The gas should be frequently replenished to keep the oxygen level in the ullage space to a minimum concentration. The required frequency depends on the ability of the vessel to maintain a tight seal and the type of gas used. Winemakers will need to determine the acceptable cutoff for oxygen concentration, keeping in mind that 1 mg/L of oxygen will react with 4 mg/L of sulfur dioxide (SO_2) and assessing the total volume of headspace, the surface area of the wine, and the length of time it will be stored. It is generally recommended to keep headspace oxygen concentration below 0.5%.

Bottling

Wine is particularly prone to excess oxygen exposure at the time of bottling. The turbulence of wine with air in the tank, hoses, bottling equipment, and inside the bottle during filling encourages oxygenation. A wine also can absorb significant amounts of oxygen from the headspace in bottles after they are filled. For this reason, the transfer lines, bottling reservoir, and empty bottles should be flushed with inert gas prior to filling. Inert gas also may be applied to the headspace of the bottle before the closure is put into place.

References

Australian Wine Research Institute. Gas Adjustment. awri.com.au/industry_support/winemaking_resources/storage-and-packaging/pre-packaging-preparation/gas-adjustment/

Baguley, R. and McDonald, C. Appliance Science: The compressed chemistry of carbonation. 2015. cnet.com/news/appliance-science-the-compressed-chemistry-of-carbonation/

Cottrell, T. New Procedure for Handling Headspaces in Wine Containers. 2014. University of Kentucky Extension. uky.edu/hort/sites/www.uky.edu.hort/files/documents/headspaces.pdf

Dharmadhikari, M. Use of Inert Gases. Midwest Grape and Wine Industry Institute. extension.iastate.edu/wine/use-inert-gases.

Iland, P., et al. 2004. Monitoring the winemaking process from grapes to wine: Techniques and concepts. Campbelltown, Australia: Patrick Iland Wine Promotions Pty Ltd.

Letaief, H. Key Points of the Bottling Process. 2016. Wines Vines Analytics. winesvinesanalytics.com/columns/section/71/article/168227/Key-Points-of-the-Bottling-Process

McCaney, Conor. Gassing Regimens. 2018. Penn State Extension Wine & Grapes U. psuwineandgrapes.wordpress.com/2018/12/28/gassing-regimens/

Rankine, B. (1989). Making good wine. Sydney: Pan Macmillan.

Stamp, C. Indispensable Inert Gas. 2009. Wines & Vines. winesvinesanalytics.com/sections/printout_article.cfm?article=feature&content=66992

Zoecklein, B. Gases: Carbon Dioxide, Argon, and Nitrogen. (n.d.) Department of Food Science & Technology, Virginia Tech. apps.fst.vt.edu/extension/enology/downloads/wm_issues/Winery%20Gases/Winery%20Gases1.pdf

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