



Thermo Scientific Orion
Product and Application Guide



Winemaker's Guide to Chemistry Analysis

Recommended electrochemistry instrumentation and detailed application notes for winemaking

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Chemistry Analysis throughout the Winemaking Process

From grape to glass, great winemaking starts with a commitment to quality. Wine's unique attributes, like color, taste and smell, are all highly dependent on a series of chemical reactions and equilibriums throughout the various stages of winemaking. Monitoring and controlling these chemical reactions is part of the science and artistry of producing an exceptional, balanced glass of wine.

Winemaking Stage	Winemaking Process	Relevant Chemistry Analysis
Pre-fermentation processes	Monitoring grapes for harvest	Titrateable acidity pH monitoring
	Crush	Titrateable acidity Ammonia Nitrogen pH monitoring
	Must adjustment	Titrateable acidity pH monitoring Sulfur dioxide Ammonia Nitrogen
Fermentation processes	Maceration	Temperature pH monitoring Ammonia Nitrogen Sulfur dioxide
Post-fermentation processes	Sterile filtration	Turbidity/Clarity measurement Sulfur Dioxide
	Aging Racking	Turbidity/Clarity measurement Sulfur dioxide Dissolved oxygen monitoring in wine tanks/barrels pH monitoring Titrateable acidity Temperature
	Filtration and bottling	Dissolved oxygen monitoring in wine bottles Turbidity/Clarity measurement Sulfur dioxide Titrateable acidity pH

Detailed Application Notes for Winemaking

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Our experience makes the difference

Ensuring your winery is equipped with reliable, easy-to-use instrumentation helps ensure the quality of your product. This guide includes detailed application notes for the various stages in the winemaking process, as well as the recommended electrochemistry instrumentation, accessories and solutions.

We've been delivering liquid sensing solutions that make customers complex measurements routine to the pharmaceutical, food and beverage, and chemical industries for over 50 years. See what our durable, easy to use Thermo Scientific™ Orion™ meters and accurate, reliable sensors can do for your winemaking operation.

1
Start with a basic meter kit for pH, titratable acidity and ammonia nitrogen analysis.

2
Add an ORP electrode for sulfur dioxide analysis.

3
For dissolved oxygen analysis, select a convenient portable meter kit.

4
To measure the wine's visual clarity, add a turbidity measurement meter kit.



Great wines start with great chemistry

Analysis tools that make the difference you can taste.



Ensure product quality and exceptional taste throughout the winemaking process with Thermo Scientific™ Orion™ pH and ion selective electrodes, meters and solutions. Our instruments and solutions have been delivering accurate measurements of critical parameters for over 50 years. Thermo Scientific Orion analysis instruments combine excellent meter features with proven electrode technology to provide a complete package to meet your demanding quality standards. Choose from an assortment of standard measurement kits below, or pick-and-choose from our selection of individual products based on the type of analysis you are performing.

Dissolved Oxygen Analysis

Oxygen exposure can cause adverse effects during the winemaking process, including browning, aroma and flavor modification, and structural softening. For these reasons, dissolved oxygen (DO) measurement is extremely important for wineries. Optical DO sensor technology improves measurement efficiency with no required warm up time, maintenance solutions or stirring.

Recommended product: Thermo Scientific™ Orion Star™ A323 RDO/DO Meter Kit - STARA3235

This Dissolved Oxygen meter kit includes everything you need to start testing the oxygen exposure of wine samples, including a dissolved oxygen meter, optical DO sensor and portable carrying case.



Visual Clarity (Turbidity) Analysis

Accurate visual clarity measurements (turbidity) of wines at various stages of the winemaking process are critical for determining suitability for bottling. An infrared light source allows readings which are not affected by the deep color of red wines or the blush color of rosé wines.

Recommended product: Thermo Scientific™ Orion™ AQUAfast™ Turbidity Meter Kit - AQ3010

This turbidity meter kit includes everything you need to start testing the turbidity of wine samples, including a turbidity meter, primary standards to verify reporting accuracy, vials and portable carrying case.



pH, Titratable Acidity, Ammonia Nitrogen Analysis

pH, titratable acidity (TA) and ammonia nitrogen are critical measurements that affect the fermentation process and flavor of wine. pH strongly relates to a wine's stability and quality, while the level of nitrogen during fermentation affects the taste. Titratable acidity is an indicator of how acidic the final product will taste. Ammonia nitrogen is a major component of assimilable nitrogen, which is important to yeast growth and metabolism.

Recommended Product: Thermo Scientific™ Orion Star™ A214 pH/ISE Meter pH and Ammonia Kit - STARA2146

This pH and ammonia meter kit includes everything you need to start testing the pH, titratable acidity and ammonia nitrogen of wine samples, including a meter, pH electrode, ammonia electrode, temperature probe, stirrer probe, ammonia standards and solutions.



Sulfur Dioxide Analysis

The presence of sulfur dioxide in wine prevents microbial growth. Too little, and the wine may oxidize and suffer from bacterial growth. High levels of sulfur dioxide may cause the wine to exceed legal limits for sulfur dioxide. You can add an electrode to our pH meter and expand its capabilities to include the measurement of sulfur dioxide.

Recommended Product: Thermo Scientific™ Orion™ Sure-Flow™ ORP Electrode and ORP Calibration Standard

- Orion Sure-Flow ORP electrode - 9679BNWP
- Orion ORP calibration standard - 967901 (475 mL) or 967961 (5 x 60 mL)

For even better performance we recommend our ORP electrode with an iodide reference system.

- ORP/Iodide Electrode (Orion Residual Chlorine Electrode) - 9770BNWP



Trust Thermo Scientific products for your wine analysis

In addition to the recommended standard measurement kits on the front of this flyer, we offer additional products that address chemical analyses critical to winemaking, depending on your needs and budget. Refer to the chart below, or call your Thermo Scientific Orion distributor to find the best solution for your requirements.

Type of Analysis	Alternative Products	Relevant Features
pH, Total Acidity, Ammonia Nitrogen	Orion Star A211 pH benchtop meter kit – STARA2115	Budget-friendly meter alternative for pH and mV analysis
	Orion Star A321 pH portable meter kit – STARA3215	Portable meter for on-the-spot testing of pH and mV readings
	Orion ROSS Sure-Flow 8172BNWP electrode and Orion stainless steel ATC probe 927007MD for temperature measurement	Sure-Flow pH electrode has very easy-to-clean junction that works best with samples containing viscous or solid materials
	9512BNWP Standard Ammonia Electrode, 951006 ammonia standard, 951211 ionic strength adjuster	Add on to existing pH/mV meter for ammonia nitrogen analysis
	Orion Star A216 pH/RDO/DO benchtop meter kit – STARA2165	Space-saving alternative for combined pH and DO benchtop measurement capabilities
Dissolved Oxygen	Orion Star A326 pH/RDO/DO portable meter kit – STARA3265	Compact alternative for combined pH and DO portable measurement capabilities
	Orion O87020MD RDO optical dissolved oxygen probe	Long 6 meter cable for deep wine vats
Sulfur Dioxide using ORP	Thermo Scientific™ Orion™ Triode™ 9180BNMD ORP/ATC electrode	Built-in ATC temperature sensor for convenience
Visual Clarity (Turbidity)	Orion AQUAfast AQ4500 turbidity meter	Added capability to measure using white light or IR LED
Spectrophotometry	Talk to us about Thermo Scientific spectrophotometry products	Match your application requirements and budget



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For more information on Thermo Scientific Orion products, call your authorized distributor or visit thermoscientific.com

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Water Analysis Instruments

North America
Toll Free: 1-800-225-1480
Tel: 1-978-232-6000
info.water@thermo.com

Netherlands
Tel: (31) 020-4936270
info.water.uk@thermo.com

India
Tel: (91) 22-4157-8800
wai.asia@thermofisher.com

Japan
Tel: (81) 045-453-9175
wai.asia@thermofisher.com

China
Tel: (86) 21-68654588
wai.asia@thermofisher.com

Singapore
Tel: (65) 6778-6876
wai.asia@thermofisher.com

Australia
Tel: (613) 9757-4300
in Australia (1300) 735-295
InfoWaterAU@thermofisher.com

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Measuring pH in wine and juice

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

pH, red wine, wine-making, juice, proteins, sulfides, tannins, polyphenols.

Goal

The following application note includes the recommended equipment, procedures and maintenance for accurate pH readings.

Introduction

Since pH plays a critical role in wine making, measurements are taken throughout the winemaking process, from juice to finished wine. Typical pH levels in wine range from 2.9 to 3.9. Various components of juice and wine can challenge the performance of the pH electrode, including proteins, sulfides, tannins, and polyphenols. This note includes recommended equipment, procedures, and maintenance to assure accurate pH readings.

Recommended Equipment

- Thermo Scientific™ Orion™ pH meter (Star A211, VERSA STAR, or equivalent)
- Thermo Scientific™ Orion™ ROSS™ Sure-Flow™ pH Electrode (Cat. No. 8172BNWP), Orion Green pH Combination Electrode (Cat. No. GD9156BNWP), or equivalent
- Automatic Temperature Compensation (ATC) probe (Cat. No. 927007MD)
- Stirrer (Cat. No. 096019)
- Swing arm and electrode holder (Cat. No. 090043)
- pH electrode storage bottle (Cat. No. 910003)

Recommended Solutions

- pH 4.01 and 7.00 buffers (Cat. No. 910104, 910107)
- Electrode filling solution (Cat. No. 810007 for 8172BNWP, or Cat. No. 910008-WA for GD9156BNWP)
- Orion ROSS storage solution (Cat. No. 810001) or pH electrode storage solution (Cat. No. 910001)
- Deionized water (DI)
- pH electrode cleaning solution A (Cat. No. 900021-WA)
- pH electrode cleaning solution D (Cat. No. 900024)
- ~75% alcohol solution (methanol or ethanol in water).



Meter Setup

Connect the pH electrode, ATC probe, and stirrer to the meter. Set measurement mode to pH. In Setup, set the stirrer speed to 3, pH resolution to 0.01, buffer set to USA and read type to auto or continuous.

Note: When the ATC is connected properly, the true temperature (not the reference 25.0) will be displayed on the screen. The ATC will measure buffer and sample temperatures and will ensure precise automatic temperature-compensated readings.

Electrode Calibration

Before sample testing, perform a two-point pH calibration using pH 4.01 and 7.00 buffers. (See *Analysis instructions below for details on test protocol*). The electrode slope should be between 92 and 102%.

Sample Preparation

Place about 50 mL of sample in a small, clean beaker (about 100 mL size).

Analysis

Place the pH electrode, ATC, and stirrer into the electrode stand. Rinse each with DI water. Place probes and stirrer into the sample, immersing about 1-2 inches into the solution. Stir the sample continuously. When the meter indicates the reading is stable, record the pH to two decimal places (e.g., 3.39) and the temperature to one decimal place. (If using Autoread mode, the meter will lock on the final reading and automatically log the readings, when the log function is turned on in Setup). Between readings, rinse the probes and stirrer with DI water to remove any remaining sample.

Electrode Storage

After testing is complete, rinse pH electrode thoroughly with the ~75% alcohol solution or immerse for 5 minutes, then rinse thoroughly with DI water. Cover the fill hole and store pH electrode in a bottle of electrode storage solution. Change the storage solution biweekly or monthly. ATC should be stored dry.

Electrode Maintenance

Fill the electrode to the level of the fill hole each day, prior to testing. Weekly or biweekly, empty the fill solution and replace with fresh fill solution.

Electrode Cleaning

If the electrode begins to exhibit drift and/or is slow to respond, clean it as follows: Clean the electrode with Orion Cleaning Solution A according to the instructions, to remove proteins and restore the pH membrane. If further cleaning is desired, use Orion Cleaning solution D to remove organic compounds and restore the pH membrane.

Quality Control (QC)

Recommended QC procedures may include: calibration, calibration verification, sample duplicates, and/or QC samples.

Results of Measuring the pH of Red Wine

Precision	8172BNWP	GD9156BNWP
pH of Red Wine, avg. (n = 10)	3.41	3.42
Std .Dev.	0.02	0.01
Avg. Temp. (°C)	21.9	21.9
Avg. Response Time	< 30 sec	< 30 sec
Accuracy	8172BNWP	GD9156BNWP
pH 4 Buffer, avg. (n = 6)	4.01	4.01
Difference From Expected	0.00	0.00
Std .Dev.	0.01	0.01

Precision: Both Orion pH electrodes demonstrated excellent precision between test results for multiple replicates of wine and pH buffer as follows:

- Red wine - showing a standard deviation of <0.02 pH units
- pH 4 buffer - showing a standard deviation of 0.01 pH units.

Accuracy: Both Orion pH electrodes demonstrated excellent accuracy for multiple replicates of pH 4 buffer, showing a difference from expected value of 0.00 pH units (reads exactly as expected).

Speed: Both Orion pH electrodes demonstrated excellent response time. The time to a stable reading averaged less than 30 seconds for wine samples and pH 4 buffer.

References

Zoecklein et al. *Wine Analysis and Production*. Chapman and Hall. 1995.

AOAC International. *AOAC Official Method 960.19, pH of Wines*. Official Methods of Analysis (OMA), 16th edition. 1999. www.aoac.org

To purchase Thermo Scientific Orion pH meters, electrodes and other related products, please contact your local equipment distributor and reference the part numbers listed below:

Product	Description	Part Number
Electrodes	Thermo Scientific Orion ROSS Sure-Flow pH Electrode	8172BNWP
	Thermo Scientific Orion Green pH Electrode	GD9156BNWP
Meters	Thermo Scientific Orion Star A211 pH Benchtop Meter	STARA2115
	Thermo Scientific Orion VERSA STAR pH Benchtop Meter	VSTAR12
Solutions	Thermo Scientific Orion pH 4.01 and 7.00 Buffers	910104 and 910107
	Thermo Scientific Orion Filling Solution for 8172BNWP or GD9156BNWP pH Electrodes	810007 or 910008-WA
	Thermo Scientific Orion ROSS Storage Solution or pH Electrode Storage Solution	810001 or 910001
	Thermo Scientific Orion pH Electrode Cleaning Solution A	900021-WA
	Thermo Scientific Orion pH Electrode Cleaning Solution D	900024

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North America
Toll Free: 1-800-225-1480
Tel: 1-978-232-6000
info.water@thermo.com

Netherlands
Tel: (31) 020-4936270
info.water.uk@thermo.com

China
Tel: (86) 21-68654588
wai.asia@thermofisher.com

India
Tel: (91) 22-4157-8800
wai.asia@thermofisher.com

Singapore
Tel: (65) 6778-6876
wai.asia@thermofisher.com

Japan
Tel: (81) 045-453-9175
wai.asia@thermofisher.com

Australia
Tel: (613) 9757-4300
in Australia (1300) 735-295
InfoWaterAU@thermofisher.com

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Titrateable Acidity of Red Wine by Manual Titration (Potentiometric)

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

Titrateable acidity, red wine, manual titration, potentiometric, organic acids.

Goal

The following application note demonstrates a simple titrateable acidity titration method using a Thermo Scientific™ Orion™ pH electrode and meter to signal the endpoint.

Introduction

Titrateable acidity (TA) is a measure of acid content in wine, juice, or must. TA is usually reported in units of tartaric acid, malic acid, or citric acid. Because grapes contain significant amounts of organic acids, TA analysis is one of the most basic analyses in a winery lab. The acid content impacts the taste, color, and microbial stability of the juice. This application note demonstrates a simple TA titration method using an Orion pH electrode and meter to signal the endpoint.

Recommended Equipment

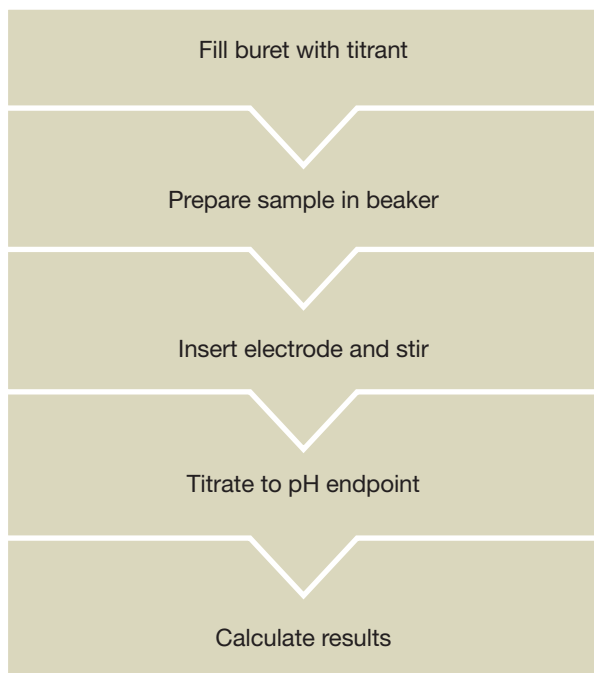
- Thermo Scientific™ Orion Star™ A meter, Thermo Scientific™ Orion™ VERSA STAR™ meter, or equivalent
- Thermo Scientific™ Orion™ ROSS™ Sure-Flow™ pH electrode 8172BNWP or Thermo Scientific™ Orion™ GD9156BNWP green pH electrode, or equivalent
- Orion automatic stirrer probe and paddle (Cat. No. 096019)
- Orion swing arm and electrode holder (Cat. No. 090043)
- 10 mL burette, burette clamp, ring stand



Required Reagents and Solutions

- Sodium hydroxide (NaOH) standard solution, 0.10 N or 0.067 N
- Orion pH 7.00 buffer (Cat. No. 910107)
- Orion pH 4.01 buffer (Cat. No. 910104)
- Orion 810007 ROSS filling solution or Orion 910008 Double Junction pH fill solution (for GD9156BNWP)
- Orion ROSS pH electrode storage solution (Cat. No. 810001) or Orion pH electrode storage solution (Cat. No. 910001)
- Deionized water (DI) of conductivity < 2 uS/cm
- Optional: potassium hydrogen phthalate (KHP); tartaric acid. *See appendix for preparation.*

Basic Titration Workflow



Meter Setup

Connect the Orion pH electrode and the stirrer probe to the meter. In Setup, select the pH mode, set read type to continuous, and set the stirrer speed to 3. Refer to the *Orion meter user guide* for more details.

Electrode Calibration

Perform a two-point pH calibration using pH 4.01 and 7.00 buffers. Stir the buffer during calibration. The electrode slope should be between 92 and 102%.

Titration Setup

Secure the burette on the clamp. Fill the burette with NaOH titrant solution and adjust the level to the zero mark. Eliminate bubbles.

Sample Preparation

Make sure the wine sample is at room temperature. To minimize interference from CO₂, degas an amount of the wine sample, e.g. 25 mL. Degas in a flask under vacuum for several minutes with agitation. Alternately, place a sample in an ultrasonic bath for a few minutes, bubble compressed air through to release excess CO₂, or heat a sample to almost boiling, agitate, and let cool.

Sample Titration

Pipette 5.0 mL of degassed wine sample into a 150 mL beaker containing 50 mL DI. Immerse the electrode and stirrer in the solution. Turn on the stirrer.

Titrate with the NaOH titrant at a faster rate in the beginning and a slower rate when the pH reaches 6.5. It is not necessary to wait for a stabilized reading before pH 6.5. Then, start to add titrant slowly until the pH just exceeds 8.2. This is the endpoint of the titration. Record the volume of titrant used (Vs). Calculate the TA in g/L tartaric acid in the wine sample using the equation on page 2. Repeat the titration as desired or required by user's protocol. After each titration, rinse the pH electrode and stirrer with DI and tap to remove excess water droplets.

Quality Control (QC)

Recommended QC procedures may include: titrant standardization, blank titration, analysis of tartaric acid standard or QC sample, and/or duplicate sample. For details, refer to the Appendix.

Results - Titratable Acids in Red Wine Samples

Results obtained using standard solutions prepared in lab and an Orion 8172BNWP electrode.

Red Wine Sample	TA (g/L tartaric acid)
Sample 1	5.82
Sample 2	5.90
Sample 3	5.87
Results Statistics	
Mean	5.86
RSD	0.70%

QC Sample*	TA (g/L tartaric acid)
Tartaric acid Standard (5.04 g/L)	5.05
Results Statistics	
Recovery	99.8%

*For details on QC sample, see Appendix.

Calculation

TA in sample:

$$\text{TA (g tartaric acid/L)} = \frac{(\text{N NaOH}) \times (\text{mLs NaOH}) \times 75}{\text{mLs of sample}}$$

Notes:

1. If sodium hydroxide is 0.067N and 5 mL of sample are used, then the equation simplifies to TA = mLs of NaOH titrant used.
2. To report results as g malic acid/L (e.g. for apple wines), multiply tartaric acid results by 0.893.
3. To report results as g citric acid/L (e.g. for fruit wines), multiple tartaric acid results by 0.853.
4. For greater accuracy, titrate a blank (50 mL of DI water). If more than 0.10 mL of sodium hydroxide titrant is required to bring pH to 8.2 or higher for the blank, then subtract that volume from the sample titration. Calculate TA:

$$\text{TA} = (\text{N NaOH}) \times (\text{mLs NaOH}_{(\text{sample titration})} - \text{mLs NaOH}_{(\text{blank titration})}) \times 75 / \text{mLs of sample.}$$

Appendix

Optional User Prepared NaOH Titrant Solution and KHP Solution for Standardization of Titrant

0.067 N NaOH titrant solution: Weigh 1.34 g NaOH pellets and quickly transfer to a 500 mL volumetric flask. Add DI to dissolve the pellets and fill to the mark. (Required reagents: NaOH, ACS grade)

0.033 N KHP solution: Dry KHP at 110 degrees C for 2 hours and cool in a desiccator. Weigh ~0.34 g of cool, dried KHP into a 50 mL volumetric flask and record the exact weight (Ws). Fill the flask to the mark with DI and mix well to dissolve the solid.

(Required reagents: KHP, ACS grade)

Standardization of Titrant – recommended for User Prepared Titrant and for quality control of any titrant solution

Pipette 10 mL KHP solution to 50 mL DI in a 100 mL beaker. Rinse the electrode and stirrer with DI. Immerse the electrode and stirrer in the solution. Turn on the stirrer. Tap to release air bubbles trapped on the surface of the electrode.

Adding NaOH titrant from the burette, titrate at a moderate rate. It is not necessary to wait for a stabilized reading when the pH is still far from 8.2. Start to add titrant slowly when the pH approaches 8. When the pH reading exceeds 8.2, the titration has reached the endpoint. Record the volume of titrant used (Vt) at the endpoint. Repeat the standardization procedure if required by user's protocol. Calculate the NaOH titrant concentration (T, mol/L) as follows:

$$\text{Normality of NaOH} = \frac{(\text{N KHP}) \times (\text{mLs KHP})}{\text{mLs NaOH}}$$

Results of an example titrant standardization are summarized in the following table.

Titrant Standardization	Endpoint Volume (mL)	NaOH (M)
Trial 1	5.60	0.0596
Trial 2	5.57	0.0599
Trial 3	5.61	0.0594
Statistics	Mean	0.0596
	RSD	0.4%

Optional Analysis of Tartaric Acid Standard – QC Sample

Weigh ~1.00 g tartaric acid into a 200 mL volumetric flask and record the exact weight (Wd). Dissolve and fill to the mark with DI water. The concentration of the tartaric acid standard is $5 \times Wd$ g/L. (The actual Wd was 1.0081 g in the Results section above. The concentration of the standard was calculated to be 5.0405 g/L).

Pipette 5 mL of tartaric acid standard into a 100 mL beaker containing 50 mL DI. Titrate with the NaOH titrant using the titration techniques described in Standardization of Titrant section. Calculate the concentration of tartaric acid using the equation for TA in sample (noted in Results section).



References

Zoecklein et al. Wine Analysis and Production. Chapman and Hall. 1995.

AOAC International. AOAC Official Method 962.12, Acidity (Titratable) of Wines. Official Methods of Analysis (OMA), 16th edition. 1999. www.aoac.org

To purchase the Orion meters, electrodes and solutions referenced in this application note, please contact your local equipment distributor and reference the part numbers listed below:

Product	Description	Part Number
Electrodes	Thermo Scientific Orion ROSS Sure-Flow pH Electrode	8172BNWP
	Thermo Scientific Orion green pH Electrode	GD9156BNWP
Meters	Thermo Scientific Orion Star A211 pH benchtop meter kit	STARA2115
	Thermo Scientific Orion VERSA STAR pH meter kit	VSTAR12
	Thermo Scientific Orion VERSA STAR pH/ISE/conductivity/RDO/DO meter kit	VSTAR92
Solutions	Thermo Scientific Orion ROSS All-in-One pH Buffer Kit	810199
	Thermo Scientific Orion ROSS pH Electrode Filling Solution	810007
	Thermo Scientific Orion Double Junction pH Electrode Fill Solution (For GD9156BNWP)	910008-WA
Accessories	Thermo Scientific Orion Automatic Stirrer Probe and Paddle	096019
	Thermo Scientific Orion Swing Arm and Electrode Holder	090043

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Water Analysis Instruments

North America

Toll Free: 1-800-225-1480
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InfoWaterAU@thermofisher.com

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Nitrogen Measurement in Wine

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

Nitrogen testing, ammonia nitrogen, winemaking analysis, nitrogen compounds, Yeast Assimilable Nitrogen (YAN), free alpha-amino nitrogen (FAN), primary amino nitrogen (PAN), fermentation testing.

Goal

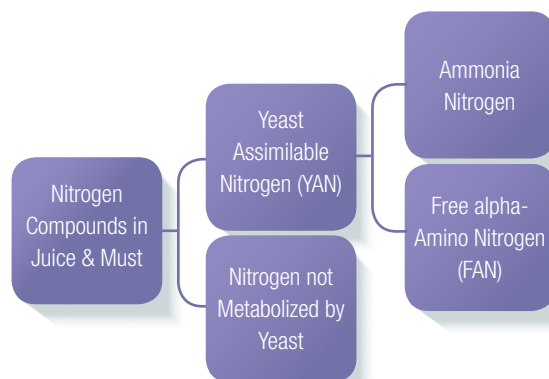
The following application note explains the importance of nitrogen testing in the winemaking process.



Introduction

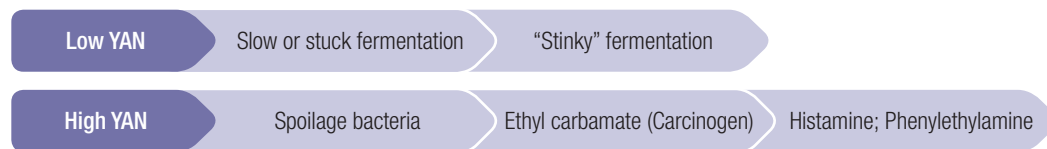
Nitrogen is a key nutrient for yeast growth, and is necessary for the successful fermentation of grape juice and must into wine. Nitrogen compounds in juice, must, and wine affect not only the fermentation, but the clarification, aroma, and final chemical composition of the wine. For these reasons, the analysis of nitrogen in the winemaking process is recommended for ensuring a quality wine.

The total nitrogen (N) content of grape juice/must is widely variable. It may be as high as >1000 mg N/L or as low as <50 mg N/L. However, not all nitrogen compounds in juice and must are available for yeast metabolism. The nitrogen that can be used by yeast is known as Yeast Assimilable Nitrogen or YAN. YAN is comprised mostly of ammonia (present as ammonium salts) and certain amino acids, often designated as free alpha-amino nitrogen (FAN¹) or primary amino nitrogen (PAN). Therefore, YAN = ammonia nitrogen + amino nitrogen. The relationship of nitrogen compounds is expressed by the chart to the right.



Testing for Nitrogen

Testing for nitrogen before and during the fermentation is desired. YAN that is too low or too high can have negative impacts on the winemaking process and the wine. Some possible impacts are listed below. Decisions on how much and what types of nitrogen to add will be informed by the results of the nitrogen testing.



Methods for Nitrogen Testing

There are several options for nitrogen testing that are available for a wine analysis laboratory. Some tests are for ammonia, some are for amino nitrogen, and some are for both. Some methods for testing can be done in any laboratory, while others require the advanced instrumentation which is typically found in a commercial laboratory. Here is a summary of some of the simpler tests that can be done in most any lab.

Test	Method	Equipment	Notes
Ammonia nitrogen	Ammonia Ion Selective Electrode (ISE)	pH/ISE meter	No filtration or color removal/blank required. Economical ammonia test option. A pH/ISE meter can also be used for pH, TA ³ , SO ₂ by Ripper/ORP, and potassium, with corresponding electrodes.
	Enzyme	Spectrophotometer or wine analyzer	Can also test for amino acids and other parameters, using different reagents. Initial equipment costs and prepared reagent costs tend to be higher.
Amino nitrogen	NOPA ²	Spectrophotometer	Can also test for ammonia and other parameters, using different reagents. Initial equipment costs and prepared reagent costs tend to be higher.
	Enzymatic	Spectrophotometer or wine analyzer	Can also test for ammonia and other parameters, using different reagents. Initial equipment costs and prepared reagent costs tend to be higher.
YAN	Micro formol titration	pH meter and burette	One test gives both nitrogen forms. Uses small amounts of hazardous formaldehyde. Most economical option.
YAN and TA ³	Micro TA and formol titration ⁴	pH meter and burette	One test gives three parameters. Uses small amounts of hazardous formaldehyde. Most economical option.

Equipment Recommendations for Testing

Ammonia Nitrogen	Amino Nitrogen +	YAN (and TA)
Thermo Scientific™ Orion Star™ A214 benchtop ⁵ or Star A324 portable pH/ISE meter	Talk to us about Thermo Scientific™ spectrophotometry products	Orion Star A211 benchtop ⁵ or Star A221 portable pH meter
Thermo Scientific™ Orion™ 9512HPBNWP High-Performance Ammonia Electrode	+ Can test for ammonia and other parameters as well	Thermo Scientific™ Orion™ ROSS™ 8172BNWP Sure-Flow™ pH electrode or Thermo Scientific™ Orion™ GD9156BNWP Green pH Combination electrode

We can match your testing requirements and budget to our analytical equipment. Call your authorized distributor or visit thermoscientific.com.

References

¹In some winegrowing areas, the term FAN is used to indicate free available nitrogen, rather than the term YAN. To avoid confusion, we will use the terms “amino nitrogen” and “ammonia nitrogen” here.

²Nitrogen by o-phthalaldehyde assay.

³Titrateable Acidity.

⁴Combined Titrametric Analysis of TA and YAN, Barry H. Gump, Vitis Research. (bgump@fui.edu; www.vitisresearch.com).

⁵Comes with stirrer capability.

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info.water.uk@thermofisher.com

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wai.asia@thermofisher.com

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Sulfur Dioxide in Wine by Manual Ripper Titration with a Platinum ORP Electrode

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

Wine analysis, Ripper titration, sulfur dioxide, platinum ORP electrode, iodine titrant standardization, SO₂.

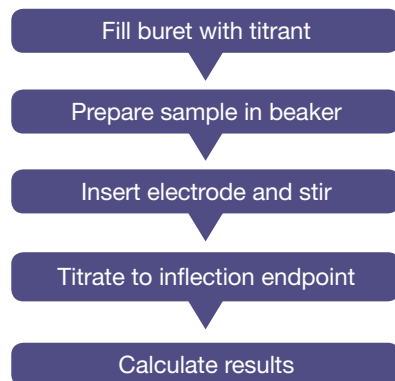
Goal

The following application note describes a simple way to analyze the sulfur dioxide in wine using a Thermo Scientific™ Orion™ 9778BNWP or 9678BNWP ORP Electrode and the Ripper titration method.

Introduction

SO₂ is widely used in wine production as a chemical antioxidant and inhibitor of microbial activity. SO₂ in wine is traditionally analyzed by Ripper titration using a color indicator. In this note, the same Ripper titration is performed by using an Orion platinum ORP electrode to signal the endpoint. The color and clarity of red wine does not interfere, thereby improving the results. This method provides a simple solution to SO₂ analysis in wine.

Basic Titration Workflow



Recommended Equipment

- Thermo Scientific™ Orion™ Versa Star™ pH/mV meter, Thermo Scientific™ Orion Star™ A Series pH/mV meter, or equivalent Orion pH/mV meter
- Thermo Scientific Orion 9778BNWP Glass Combination Platinum ORP Electrode or Thermo Scientific™ Orion™ Sure-Flow™ 9678BNWP Platinum ORP Electrode
- Stirrer probe (Cat. No. 096019)
- Swing arm stand (Cat. No. 090043)
- Electrode polishing strip (Cat. No. 948201)
- 10 mL burette, burette clamp, ring stand

Required Reagents and Solutions

- Purchased or prepared Iodine (I₂) standard titrant solution, 0.01 M (0.02 N)
- Sodium hydroxide (NaOH), 1 N
- 25% sulfuric acid (1+3 H₂SO₄)
- Electrode filling solution for ORP electrode (Cat. No. 900011)
- Deionized or distilled water (DI)

Optional:

- Standard sodium thiosulfate solution, 0.01 M (0.01 N)
- Sodium sulfite (Na₂SO₃)
- Sodium bicarbonate (NaHCO₃)

Meter Setup

Connect Orion electrode and the stirrer probe to the meter. In Setup, select the mV mode, set read type to continuous, and set the stirrer speed to 3. Refer to the Orion meter and electrode user guides for more details.

Titration setup

Secure the burette on the clamp. Fill the burette with iodine titrant solution and adjust the level to the zero mark. Consider standardizing the titrant before titrating samples. See *Hints and Tips* on the following page.

Sample Preparation

Make sure the wine sample is at room temperature.

Total SO₂: Add 25.0 mL of wine and 25 mL of 1 N NaOH to a 100 mL beaker. Mix and allow 10 min for hydrolysis then proceed immediately to the *Sample Titration*.

Free SO₂: Add 25.0 mL of wine to a 100 mL beaker. Proceed immediately to the *Sample Titration*.

Sample Titration

The Ripper titration should be done relatively quickly to avoid loss of SO₂ to the air. Rinse the electrode and stirrer with DI. Immerse the electrode and stirrer at least one inch below the liquid level in the beaker, with the stirrer just below the electrode. Turn on the stirrer. Stir gently so that a vortex is not created. Tap to release air bubbles trapped on the surface of the electrode.

Total SO₂: Add 10 mL of 25% sulfuric acid to the beaker.

Free SO₂: Add 5 mL of 25% sulfuric acid to the beaker.

Watching the mV reading, titrate at moderate speed with the iodine titrant. The mV values will not rise quickly, until near the endpoint (EP). The EP is considered the point where the largest mV change is observed per volume addition of titrant. See the following graph and description of the EP. Depending on the ORP electrode, generally look for the EP to occur between 275 to 375 mV.

Record the volume of titrant used (V_t) at the EP. Repeat the titration as desired or required by your protocol. After each titration, rinse the electrode and stirrer with DI and tap to remove excess water droplets.

Quality Control (QC)

Recommended QC procedures may include: standardization of the iodine titrant*, analysis of SO₂ standard* or QC sample, and/or replicates.

*See Application Note #016: Standardization of Iodine Titrant for Ripper Titration of Wines.

Calculation of Free or Total SO₂

SO₂ concentration in wine sample (mg/L)

$$\text{SO}_2 \text{ (mg/L)} = V_1 \times N_1 \times 25.6$$

V₁ = Volume of iodine titrant used at the endpoint of the titration (mL)

N₁ = Normality of the iodine titrant (certified or standardized value)

Results - Total SO₂ by Manual Ripper Titration with Orion Platinum ORP Electrode

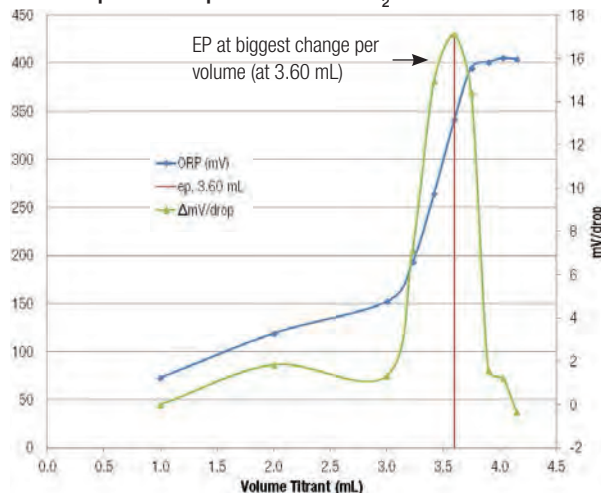
Red Wine Sample	Endpoint Vol (mL)	Total SO ₂ (mg/L)
1	3.80	80
2	3.60	76
3	3.65	77
Statistics	avg	78
	Stdev*	2.2
	RSD	2.8%

SO ₂ QC Sample	Total SO ₂ Result (mg/L)	Within ± 7 mg/L?*
49 mg/L	43	Yes

* per Zoecklein et. el, anticipated error is ± 7 mg/L

Endpoint Location – Platinum ORP Electrode

Graph of Endpoint - Total SO₂ in red wine



Note that at the EP, one drop of titrant will generally cause a mV change of >10 mV, while a mV change of >5 mV per drop generally means the EP is near, either quickly approaching or has just been passed. If another drop of titrant causes a smaller change than the last drop, the EP has passed, but if a larger change is observed, the EP is still approaching. Record the volume of titrant used (V_t) at the EP.

Hints and Tips for SO₂ Titration with Platinum ORP Electrode

- Per Zoecklein, consider using sodium bicarbonate to minimize loss of SO₂ during titration as follows: After the 10 minute hydrolysis (for total SO₂) and just before adding the 25% sulfuric acid, quickly add a pinch of sodium bicarbonate (0.5 g or less) to the sample. The solution will fizzle forming a CO₂ atmosphere to minimize loss of SO₂.
- Iodine Titrant Standardization: Iodine titrant solution ages and changes concentration over time. For higher accuracy, standardize the titrant daily or weekly before titrating samples. See Application Note #016: Standardization of Iodine Titrant for Ripper Titration of Wines.
- Refer to the electrode user guide for details on cleaning, storage, and maintenance recommendations to keep the electrode performing well. Main points for electrode care are summarized below.
- Filling solution - each day top up the filling solution in the electrode. On a weekly basis, drain and refill the electrode with filling solution, for best performance.
- Electrode Storage – store the electrode in 4M potassium chloride solution or store in water.
- Periodically clean the ORP electrode by stirring 1 minute in 75% methanol or alcohol. Wipe the platinum sensor gently with a lint free wiper afterwards.
- If periodic cleaning and refilling described above does not maintain or restore performance, clean with 0.1 to 1M HCl or Orion 900023 pH cleaning solution C. Follow directions (user guide or instruction sheet).
- To check the operation of the electrode, immerse the electrode in a portion of the 0.02N iodine titrant. Expect the mV reading to be near 410 mV (± 30 mV) within 1-2 minutes. If not, polish the platinum sensor gently with a lint free wiper, then drain and refill the electrode to restore proper readings.

Daily Care	Weekly Care	As Needed
<ul style="list-style-type: none"> • Top up fill solution • Store electrode in 4M KCl or water 	<ul style="list-style-type: none"> • Drain and refill the fill solution • Clean the electrode with 75% methanol or ethanol 	<ul style="list-style-type: none"> • Clean the electrode with HCl or Orion 900023 • Measure mV of titrant to check electrode operation

References

Zoecklein et al. *Wine Analysis and Production*, Chapman and Hall. 1995.

Napa Valley College. *Laboratory Analysis of Musts and Wines*, Viticulture and Enology Department. 2007.
<http://www.napavalley.edu/>

To purchase an Orion platinum ORP electrode, or other related products, please contact your local equipment distributor and reference the part numbers listed below.

Product	Description	Part Number
Meters	Thermo Scientific Orion Versa Star pH Benchtop Meter	VSTAR10
	Thermo Scientific Orion Star A211 pH Benchtop Meter	STARA2110
	Thermo Scientific Orion Star A214 pH/ISE Benchtop Meter	STARA2140
Electrodes	Thermo Scientific Orion Combination Platinum ORP Electrode, Glass Body, BNC Waterproof Connector	9778BNWP
	Thermo Scientific™ Orion™ Sure-Flow™ Platinum ORP Electrode, Epoxy Body, BNC Waterproof Connector	9678BNWP
Solutions	Thermo Scientific Orion Electrode Filling Solution for ORP Electrode	900011
	Thermo Scientific Orion pH Electrode Storage Solution	910001
Accessories	Stirrer Probe	096019
	Electrode Storage Sleeve and Base	810017
	Swing Arm Stand	090043
	Thermo Scientific Orion ATC Temperature Probe with Steel Body	927007MD



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Sulfur Dioxide in Wine by Enhanced Manual Ripper Titration with Platinum and Iodide Electrode

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

Wine analysis, sulfur dioxide, Ripper titration, platinum and iodide electrode, mV endpoint titration, SO₂.

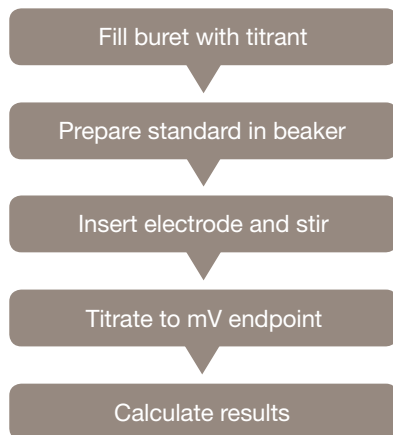
Goal

The following application note explains how to analyze sulfur dioxide in wine using a Ripper titration with a Thermo Scientific™ Orion™ 9770BNWP Platinum and Iodide Electrode.

Introduction

Sulfur dioxide (SO₂) is widely used in wine production as a chemical antioxidant and inhibitor of microbial activity. SO₂ in wine is traditionally analyzed by Ripper titration using a color indicator. In this note, the same Ripper titration is performed using an Orion 9770BNWP platinum and iodide electrode to signal the endpoint at a known mV value. The color and clarity of red wine does not interfere, thereby improving the results. The Orion 9770 electrode is fast, low maintenance, requires no fill solution, and is long-lasting. The mV endpoint titration is comparable to a Titratable Acidity (TA) determination to pH 8.2. This method provides a simple solution to SO₂ analysis in wine.

Basic Titration Workflow



Recommended Equipment

- Thermo Scientific™ Orion™ Versa Star™ pH/mV meter, Thermo Scientific™ Orion Star™ A Series pH/mV meter, or equivalent Orion pH/mV meter
- Orion 9770BNWP platinum and iodide electrode (residual chlorine ISE)
- Stirrer probe (Cat. No. 096019)
- Swing arm stand (Cat. No. 090043)
- Electrode polishing strip (Cat. No. 948201)
- 10 mL burette, burette clamp, ring stand

Required Reagents and Solutions

- Purchased or prepared Iodine (I₂) standard titrant solution, 0.01 M (0.02 N)
- Sodium hydroxide (NaOH), 1 N
- 25% sulfuric acid (1+3 H₂SO₄)
- Deionized or distilled water (DI)

Optional:

- Standard sodium thiosulfate solution, 0.01 M (0.01 N)
- Sodium sulfite (Na₂SO₃) or potassium metabisulfite (KMBS)
- Sodium bicarbonate (NaHCO₃)

Meter Setup

Connect the Orion electrode and the stirrer probe to the meter. In Setup, select the mV mode, set read type to continuous, and set the stirrer speed to 3. Refer to the Orion meter and electrode user guides for more details.

Titration setup

Secure the burette on the clamp. Fill the burette with iodine titrant solution and adjust the level to the zero mark. Consider standardizing the titrant before titrating samples. See *Hints and Tips* section on the following page.

Sample Preparation

Make sure the wine sample is at room temperature.

Total SO₂: Add 25.0 mL of wine and 25 mL of 1 N NaOH to a 100 mL beaker. Mix and allow 10 min for hydrolysis. After 10 minute, proceed immediately to the *Sample Titration*.

Free SO₂: Add 25.0 mL of wine to a 100 mL beaker. Proceed immediately to the *Sample Titration*.

Sample Titration

The Ripper titration should be done relatively quickly to avoid loss of SO₂ to the air. Rinse the electrode and stirrer with DI. Immerse the electrode and stirrer at least one inch below the liquid level in the beaker, with the stirrer just below the electrode. Turn on the stirrer. Stir gently so that a vortex is not created. Tap the electrode to release air bubbles trapped on the surface of the electrode.

Total SO₂: Add 10 mL of 25% sulfuric acid to the beaker.

Free SO₂: Add 5 mL of 25% sulfuric acid to the beaker.

Watching the mV reading, titrate at moderate speed with the iodine titrant. Expect the endpoint (EP) to occur near 555 mV (± 35 mV) when titrating red wine. The mV values will not rise quickly, until near the EP. The EP is considered the point where the largest mV change is observed per volume addition of titrant. See on the right for a graph and description of the EP.

Record the volume of titrant used (V_i) at the EP and the mV reading at the EP. For subsequent titrations of this wine today, titrate to this mV value. Repeat the titration as desired or required by user's protocol. After each titration, rinse the electrode and stirrer with DI and tap to remove excess water droplets.

Quality Control (QC)

Recommended QC procedures may include: standardization of the iodine titrant*, analysis of SO₂ standard* or QC sample, and/or replicates.

*Application Note #016: Standardization of Iodine Titrant for Ripper Titration of Wines.

Calculation of Free or Total SO₂

SO₂ concentration in wine sample (mg/L)

$$\text{SO}_2 \text{ (mg/L)} = V_i \times N_i \times 25.6$$

V_i = Volume of iodine titrant used at the endpoint of the titration (mL)

N_i = Normality of the iodine titrant (certified or standardized value)

Results - Total SO₂ by Manual Ripper Titration with Orion Platinum and Iodide Electrode (9770BNWP)

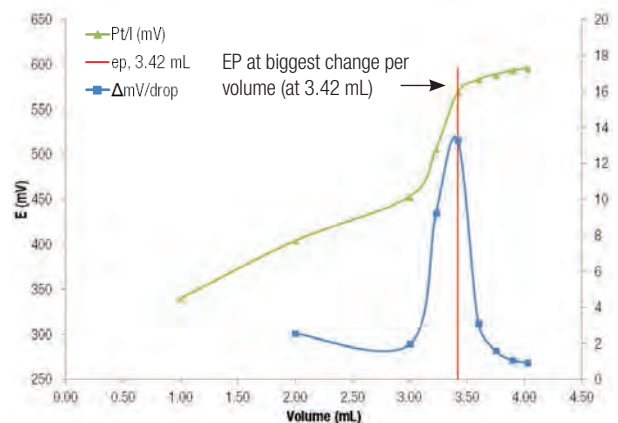
Red Wine Sample	Endpoint Vol (mL)	Total SO ₂ (mg/L)
1	3.53	75
2	3.42	73
3	3.65	78
Statistics	avg	75
	Stdev*	2.4

SO ₂ QC Sample	Total SO ₂ Result (mg/L)	Within ± 7 mg/L?*
68 mg/L	63	Yes

* per Zoecklein et. el, anticipated error is ± 7 mg/L

Endpoint Location – Platinum and Iodide Electrode

Graph of Endpoint - Total SO₂ in red wine



Note that at the EP, one drop of titrant will generally cause a mV change of >10 mV, while a mV change of >5 mV per drop generally means the EP is near, either quickly approaching or has just been passed. If another drop of titrant causes a smaller change than the last drop, the EP has passed, but if a larger change is observed, the EP is still approaching. Record the volume of titrant used (V_i) at the EP and the mV reading at the EP. For subsequent titrations of this wine today, titrate to this mV value.

Hints and Tips for SO₂ Titration with Platinum and Iodide Electrode

- Per Zoecklein, consider using sodium bicarbonate to minimize loss of SO₂ during titration as follows: After the 10 minute hydrolysis (for total SO₂) and just before adding the 25% sulfuric acid, quickly add a pinch of sodium bicarbonate (0.5 g or less) to the sample. The solution will fizzle forming a CO₂ atmosphere to minimize loss of SO₂.
- Iodine Titrant Standardization: Iodine titrant solution ages and changes concentration over time. For higher accuracy, standardize the titrant daily or weekly before titrating samples. See Application Note #016: Standardization of Iodine Titrant for Ripper Titration of Wines.
- Refer to the electrode user guide for details on cleaning, storage, and maintenance recommendations to keep the electrode performing well. Main points for electrode care are summarized below.
- Electrode storage - Thoroughly rinse the electrode with DI water and store the electrode dry.
- Periodically clean the electrode by stirring 1 minute in 75% methanol or alcohol. Wipe the platinum sensor gently with a lint free wiper afterwards.
- If periodic cleaning and refilling described above does not maintain or restore performance, clean by gently polishing the platinum sensor with an Orion 948201 polishing strip. See electrode user guide for details.
- To check the operation of the platinum and iodide (9770BNWP) electrode, immerse the electrode in a portion of the 0.02N iodine titrant. Expect the mV reading to be near 670 mV (± 20 mV) within 1-2 minutes. If not, polish the platinum sensor gently with a lint free wiper, then drain and refill the electrode to restore proper readings.

Daily Care	Weekly Care	As Needed
<ul style="list-style-type: none"> • Store electrode dry 	<ul style="list-style-type: none"> • Clean the electrode with 75% methanol or ethanol 	<ul style="list-style-type: none"> • Gently polish sensor • Measure mV of titrant to check electrode operation

References

Zoecklein et al. *Wine Analysis and Production*, Chapman and Hall. 1995.

Napa Valley College. *Laboratory Analysis of Musts and Wines*, Viticulture and Enology Department. 2007.
<http://www.napavalley.edu/>

To purchase an Orion platinum and iodide electrode, or other related products, please contact your local equipment distributor and reference the part numbers listed below.

Product	Description	Part Number
Meters	Thermo Scientific Orion Versa Star pH Benchtop Meter	VSTAR10
	Thermo Scientific Orion Star A211 pH Benchtop Meter	STARA2110
	Thermo Scientific Orion Star A214 pH/ISE Benchtop Meter	STARA2140
Electrodes	Thermo Scientific Orion Platinum and Iodide Electrode (Residual Chlorine ISE)	9770BNWP
Accessories	Electrode Polishing Strip	948201
	Stirrer Probe	096019
	Swing Arm Stand	090043



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Standardization of Iodine Titrant for Ripper Titration of Wines

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

Wine analysis, iodine titrant, Ripper titration, standardization workflow, sulfur dioxide titration, SO_2 titration.

Goal

The following application note explains how to determine the true concentration of the iodine titrant used for Ripper titration of wine by standardizing with a Thermo Scientific™ Orion™ 9770BNWP Platinum and Iodide Electrode or a Thermo Scientific Orion ORP electrode (e.g. 9778BNWP or 9678BNWP) and a standard solution of sodium thiosulfate.

Introduction

Since the concentration of the iodine titrant changes over time, for best accuracy, determine the true concentration of the iodine titrant by standardizing with a standard solution of sodium thiosulfate. Typically it is best to standardize daily or weekly.

Basic Standardization Workflow

Fill buret with titrant

Prepare standard in beaker

Insert electrode and stir

Titrate to endpoint

Calculate true titrant normality



Required Reagents and Solutions

Purchased or prepared Iodine (I_2) standard titrant solution, 0.01 M (0.02 N); deionized or distilled water (DI); standard sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) solution, 0.01 M (0.01 N). Optional: sodium sulfite (Na_2SO_3) or potassium metabisulfite (KMBS).

Meter and Titration Setup for Standardization

Prepare according to the SO_2 in Wine by Enhanced Manual Ripper Titration (Application Note 017) or Manual Ripper Titration (Application Note 018) method.

Standard Titration

Add 5.0 mL of 0.01 N sodium thiosulfate solution to 50 mL DI in a 100 mL beaker. Rinse the electrode and stirrer with DI. Immerse the electrode and stirrer at least one inch below the liquid level in the beaker. Turn on the stirrer. Tap to release air bubbles trapped on the surface of the electrode.

Watching the mV reading, titrate at moderate speed with the iodine titrant. The mV values will not rise quickly until near the endpoint (EP). The EP is considered the point where the largest mV change is observed per volume addition of titrant. Depending on the ORP electrode, generally look for the EP to occur between 325 to 425 mV when standardizing with sodium thiosulfate and the Orion platinum ORP electrode (e.g., Cat. No. 9778BNWP or Cat. No. 9678BNWP). Expect the EP to occur near 595 mV (± 20 mV) when standardizing with sodium thiosulfate and an Orion platinum and iodide electrode (Cat. No. 9770BNWP).

At the EP, one drop of titrant will generally cause a mV change of >10 mV, while a mV change of >5 mV per drop generally means the EP is quickly approaching or has just been passed. If another drop of titrant causes a smaller change than the last drop, the EP has passed, but if a larger change is observed, the EP is still approaching. Record the volume of titrant used (V_1) at the EP. When using the Orion platinum and iodide electrode, record also the mV value at the EP.

Repeat the standardization procedure if required by your protocol. When using the Orion platinum and iodide electrode, simply titrate to the EP mV value found for the

first titration. When using the Orion platinum ORP electrode, titrate to the largest mV change. Calculate the normal concentration of iodine titrant (N_1) for each portion of standard titrated, as follows:

$$N_1 = N_s \times 5 \div V_1$$

N_1 = Normality of the iodine titrant (certified or standardized value)

N_s = Normality of the standard thiosulfate solution

V_1 = Volume of iodine titrant used at the endpoint of the titration (mL)

Use the average N_1 result determined here when titrating wine samples.

Optional QC Sample – SO₂ Standard

Option 1 - Weigh 0.2956 g sodium sulfite (Na_2SO_3) and ~1.0 g citric acid into a 1 L volumetric flask. Dissolve and fill to the mark with DI water. This is equivalent to 150 mg/L total SO₂ stock solution. Pipette 10 mL of the SO₂ stock solution into a beaker and add 50 mL of DI water. This is equivalent to 60 mg/L SO₂ in a 25 mL wine sample.

Option 2 - Dissolve 3 KMBS (Campden) tablets in 2L of DI water for 426 mg/L SO₂ solution. Pipette 4 mL of the SO₂ solution into a beaker and add 50 mL of DI water. This is equivalent to 68 mg/L SO₂ in a 25 mL wine sample.

To purchase Orion meter, electrodes and solutions, please contact your local equipment distributor and reference the part numbers listed below:

Product	Description	Part Number
Meters	Thermo Scientific™ Orion™ Versa Star™ pH Benchtop Meter	VSTAR10
	Thermo Scientific™ Orion Star™ A211 pH Benchtop Meter	STARA2110
	Thermo Scientific Orion Star A214 pH/ISE Benchtop Meter	STARA2140
Electrodes	Thermo Scientific Orion Redox/ORP Electrode, Glass Body	9778BNWP
	Thermo Scientific Orion Platinum and Iodide Electrode (Residual Chlorine ISE)	9770BNWP
	Thermo Scientific™ Orion™ Sure-Flow™ Redox/ORP Electrode, Epoxy Body	9678BNWP
Accessories	Electrode Storage Sleeve and Bottle	810017
	Stirrer Probe	927007MD
	Swing Arm Stand	090043

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Measuring Clarity in Wine

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

wine clarity, turbidity, beverage quality, fermentation, barrel testing, filtration, wine tank testing.

Goal

The following application note explains how to measure the turbidity of red, white and rosé wine samples using a Thermo Scientific™ Orion™ AQUAfast™ turbidity meter. The analysis of wine turbidity may be used to evaluate chill haze, protein stability, and wine clarity. In this note, the evaluation of wine clarity is described.



Introduction

The Orion AQ3010 and AQ4500 Turbidity Meters allow quick and simple determinations of the clarity of white, rosé, and red wine samples. The following application note explains how to measure the clarity or “turbidity” of various wine samples using the AQ4500 in infrared mode and the AQ3010. Because the light source is infrared, the turbidity measurement is independent of color.

Recommended Equipment

- Orion AQ3010 Turbidity Meter and Orion AC3V25 Turbidity Vials
- OR
- Orion AQ4500 Turbidity Meter and Orion AC2T24 Turbidity Vials

Required Reagents and Solutions

- Orion AC301S Turbidity Standards (if using AQ3010)
- Orion AC45ST Turbidity Standards (if using AQ4500)
- Turbidity-free water (TFW), e.g., by filtration through 0.1 um filter, or equivalent water

Solutions Preparation

None

Meter Setup

None

Meter Performance Check/Calibration Verification

Orion AC301S and AC45ST styrene divinylbenzene (SDVB) polymer turbidity standards never need mixing. Do not shake the standards as this will introduce bubbles and cause them to read inaccurately until the bubbles dissipate.

AQ3010

Check meter accuracy by reading one or more turbidity standards (included with the meter) at the level of interest. For example, read the zero (0.02) and the 20 NTU standard. The zero should read <0.1 NTU and the 20 NTU standard should read within $\pm 10\%$, e.g., 18-22 NTU.

AQ4500

Review certificate of analysis of the turbidity standards and record the expected turbidity values for the IR Ratio mode.

Set the meter to the IR Ratio mode. Check meter accuracy by reading one or more turbidity standards at the level of interest. For example, read the zero (0.02) and the 1 NTU standard. The zero should read <0.1 NTU and the 1 NTU standard should read within $\pm 10\%$ from the expected value according to the Certificate of Analysis.

If the AQ3010 or AQ4500 meter performance check fails, take corrective actions as follows:

1. Wipe the vial carefully with a lint-free wipe to remove all fingerprints and liquid drips from the exterior, handle the vial by the cap only, and remeasure.
2. Tap the vial gently three times and let the vial sit for 60 seconds to allow for bubbles to release, then remeasure.
3. Using a clean vial (which reads <0.1 NTU when filled with TFW), pour a fresh portion of turbidity standard into the clean vial, wipe carefully, and measure.

Sample Vial (Cuvette) Storage, Soaking, and Rinsing

Store vials filled with TFW. Immediately after use, clean sample vials with laboratory detergent and rinse multiple times with TFW. **Note:** Standards may be stored in supplied glass sample vials until the standard reading is no longer in specification. See *Meter Performance Check* section for corrective actions when a standard reads out of specification.

Sample Storage and Preparation

In general, allow the samples to warm to room temperature before measurement. Mix the sample well, but do not introduce bubbles by shaking the sample. Use a little of the sample to rinse a clean sample vial twice. Mix the sample again and fill the rinsed vial.

Calibration - AQ3010

The meter is shipped precalibrated. The meter performance is very stable and does not require frequent

calibration. If a standard reading is not within criteria, take all necessary corrective actions (as described in the *Meter Performance Check* section) to improve meter readings. If corrective actions fail and recalibration is necessary, perform the recalibration only on the points that failed and do so with fresh portions of standard poured into clean vials. Ensure that all fingerprints and liquid drips have been removed from the exterior of the vial with a lintfree wipe before using. Handle vials by the cap only.

Calibration – AQ4500

The meter is shipped precalibrated. The meter performance is very stable and does not require frequent calibration. If a standard reading is not within criteria, take all necessary corrective actions (as described in the *Meter Performance Check* section) to improve meter readings. If corrective actions fail and recalibration is necessary, perform the recalibration in IR Ratio mode (see the *Initial Calibration* section of the Meter User Guide and an example on page 3).

Analysis

Gently invert the filled sample vial a few times to mix the sample well without introducing bubbles. Wipe the sample vial to remove all traces of liquids and fingerprints, place into meter, and press the measure key. Record the reading. Press the measure key to take duplicate measurement(s). Continue until readings stabilize and results agree, for example, within 5% or ± 0.02 NTU, whichever is higher.

Quality Control (QC)

Recommended QC procedures include: calibration verification, turbidity-free water analysis (optional), and sample duplicates.

Notes for Improved Accuracy of Low-Level Samples

If improved accuracy is desired, pay close attention to:

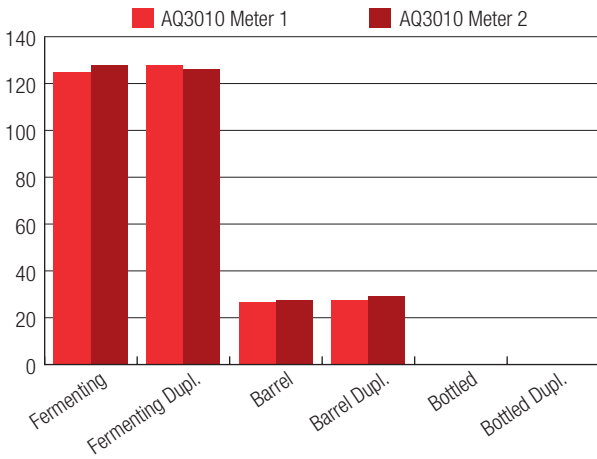
1. The cleanliness of the sample vials.
2. The quality of the TFW.
3. The handling of the standards and samples.
4. Use of matching vials.
5. Storing clean vials filled with TFW.
6. Use vials free of scratches or other imperfections.

For improved low-level accuracy, ensure that a clean vial filled with TFW reads <0.1 NTU before using that vial to test highly filtered wine. If a clean vial does not read <0.1 NTU, discard it or set it aside for further cleaning. If no clean vials read <0.1 NTU, the TFW may need degassing or a cleaner source of TFW may be required. See *ASTM D6855 Test Method for Test Method for Determination of Turbidity Below 5 NTU in Static Mode* for more information about low level turbidity readings.

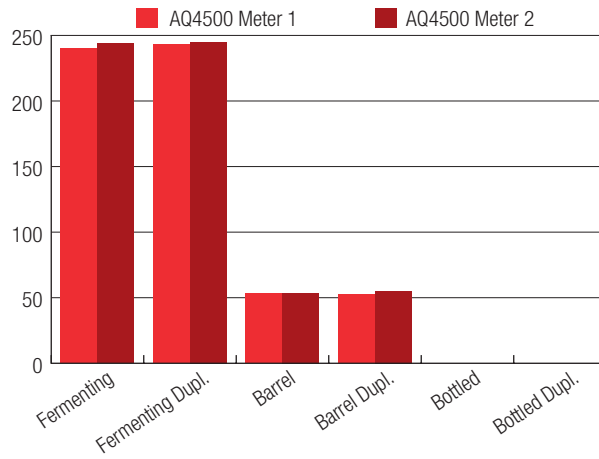
Result

Various wine samples, taken at different stages of the winemaking process, were tested for turbidity on the AQ3010 and AQ4500.

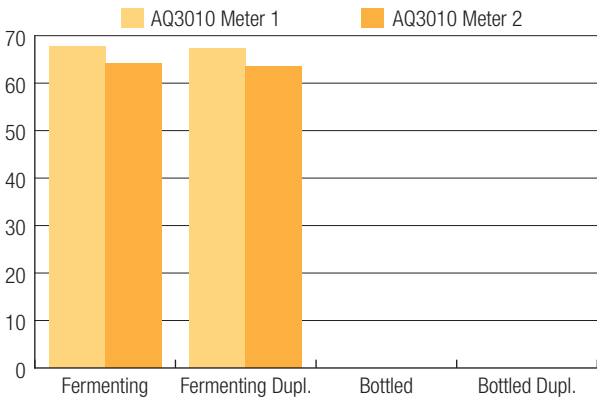
Turbidity of Red Wine (AQ3010)



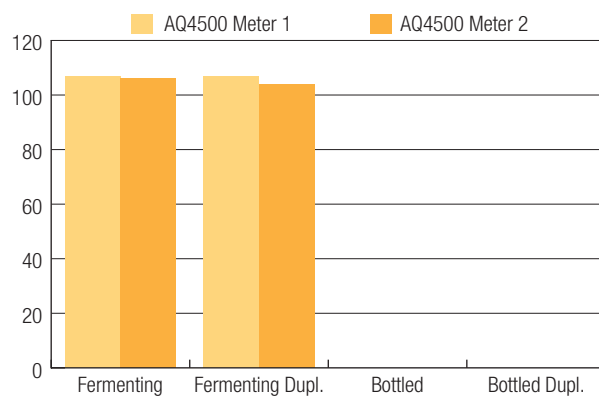
Turbidity of Red Wine (AQ4500)



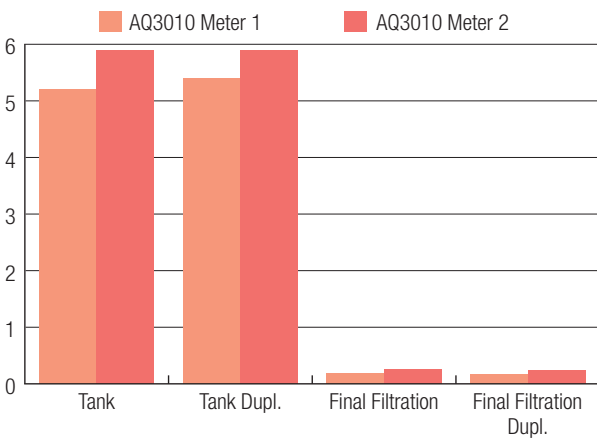
Turbidity of White Wine (AQ3010)



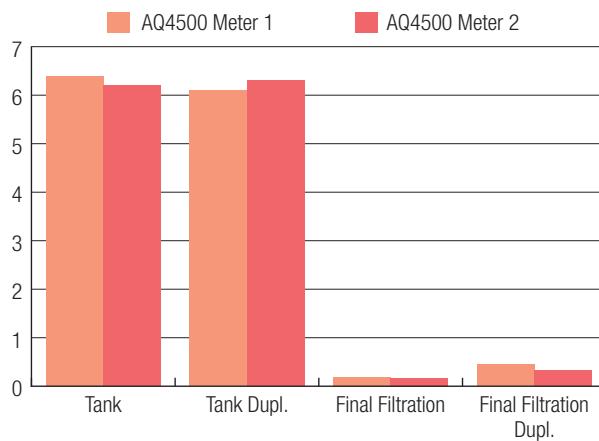
Turbidity of White Wine (AQ4500)



Turbidity of Rosé Wine (AQ3010)



Turbidity of Rosé Wine (AQ4500)



Results of Testing Turbidity Standards using an AQ3010 Meter

Expected Value	AQ3010 Meter 1	% Recovery	AQ3010 Meter 2	% Recovery
0.02NTU (<0.1)	0.00	NA	0.00	NA
20NTU	18.9	94.4%	20.1	100.5%
100NTU	96.3	96.3%	101	101.0%
800NTU	772	96.5%	798	99.8%

Results of Testing Turbidity Standards using an AQ4500 Meter

Expected Value	AQ4500 Meter 1	% Recovery	AQ4500 Meter 2	% Recovery
<0.1	0.00	NA	0.03	NA
0.93	0.95	102.2%	0.93	100.0%
9.54	9.30	97.5%	9.65	101.2%
99.4	99.6	100.2%	99.8	100.4%
708	742	104.8%	722	102.0%

Summary

The Orion AQ3010 turbidity meter allows accurate measurement of red, white, and rosé wines at various stages of the wine-making process. The infrared light source allows readings which are not affected by the deep color of red wines or the blush color of rosé wines.

The Orion AQ4500 turbidity meter allows accurate measurement of red, white, and rosé wines at various stages of the wine-making process. When measurements are performed in the infrared ratio mode, readings are not affected by the deep color of red wines or the blush color of rosé wines.

To purchase an Orion turbidity meter and other related accessories and solutions, please contact your local equipment distributor and reference the part numbers listed below:

Product	Description	Part Number
Turbidity Meter	Thermo Scientific Orion AQUAfast AQ3010 Turbidity Meter	AQ3010
	Thermo Scientific Orion AQUAfast AQ4500 Turbidity Meter	AQ4500
Accessories	Thermo Scientific Orion Turbidity Vials, for use with the AQ3010	AC3V25
	Thermo Scientific Orion Turbidity Vials, for use with the AQ4500	AC2T24
Solutions	Thermo Scientific Orion Turbidity Standards (0, 1, 10, 100, 1000 NTU), for use with the AQ4500	AC45ST
	Thermo Scientific Orion Turbidity Standards, for use with the AQ3010	AC301S



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Water Analysis Instruments

North America
Toll Free: 1-800-225-1480
Tel: 1-978-232-6000
info.water@thermo.com

Netherlands
Tel: (31) 020-4936270
info.water.uk@thermo.com

China
Tel: (86) 21-68654588
wai.asia@thermofisher.com

India
Tel: (91) 22-4157-8800
wai.asia@thermofisher.com

Singapore
Tel: (65) 6778-6876
wai.asia@thermofisher.com

Japan
Tel: (81) 045-453-9175
wai.asia@thermofisher.com

Australia
Tel: (613) 9757-4300
in Australia (1300) 735-295
InfoWaterAU@thermofisher.com

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Measuring the Dissolved Oxygen of Wine in Tanks

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

Wine quality, dissolved oxygen, RDO sensor, portable meter, beverage testing.

Goal

The following application note describes how to reliably measure the oxygen content of wine directly in the tank, using a Thermo Scientific™ Orion™ Rugged Dissolved Oxygen (RDO) Sensor with automatic temperature compensation and a Thermo Scientific™ Orion Star™ A223 RDO/DO portable meter.



Introduction

Wineries have become increasingly concerned with the oxygen incorporation in the wine during the bottling process. This is an extremely important issue that influences wine quality, stability, and longevity. Although oxygen is a part of the wine's natural aging process, adverse levels can cause discoloration to white wines and flavor degradation to both white and red varieties. The concentration of molecular oxygen should be measured in the wine before bottling begins, and throughout the entire wine making process.

By using a Thermo Scientific Orion RDO optical dissolved oxygen sensor and a Thermo Scientific Orion Star A223 RDO/DO portable meter, reliable oxygen measurements can be made directly in the tanks which hold the wine.

Equipment

- Orion Star A223 RDO/DO Portable Meter Kit – includes RDO optical DO sensor, portable meter armor, field case and USB computer cable (Cat. No. STARA2235)
or
- Orion Star A223 RDO/DO Portable Meter (Cat. No. STARA2230) or equivalent Orion portable RDO meter
- RDO Optical DO Sensor – includes calibration sleeve and stainless steel sensor guard (Cat. No. 087010MD)

Solutions

- Deionized water (DI)

Luminescence-Based Dissolved Oxygen Method

The oxygen content of wine must be monitored throughout the wine-making process. Using the RDO sensor with built-in automatic temperature compensation and a portable meter, reliable measurements can be made directly in the tanks which hold the wine.

RDO Sensor Setup

Refer to the RDO Optical Dissolved Oxygen Sensor User Guide for detailed assembly and preparation instructions for the RDO sensor. Place the RDO sensor into a calibration sleeve and moisten the sponge in the calibration sleeve with deionized water. Connect the RDO sensor to the 9-pin MiniDIN input on the meter. Once assembled, the RDO sensor can be used immediately.

Meter Setup

Turn the Star A223 RDO/DO portable meter on. The meter should automatically detect the type of DO sensor and update the measure type to RDO. In the measurement mode, set the measurement units to mg/L. Access the setup menu and update the RDO/DO channel settings to the following, as needed:

- Measure Mode: Auto
- Measure Unit: mg/L
- Resolution: 0.01
- Read Type: Auto Read
- Baro Pressure: Auto
- Salinity Correct: Manual (0.0)

Update the instrument settings to the following, as needed:

- Export Data: On
- Data Log: On
- Date / Time: Set current date & time

Sensor Performance Checks

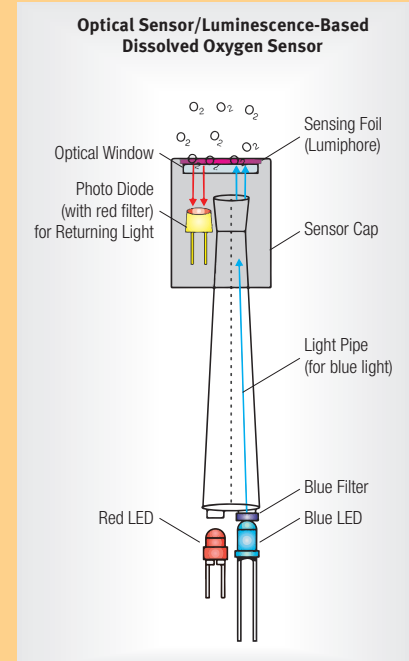
The RDO sensor should read between 98 and 102 % saturation in the calibration sleeve after calibration. The RDO sensor should stabilize during calibration within 2 minutes when working properly. Make sure to thoroughly rinse and blot dry the DO sensor after measuring samples and before placing into the calibration sleeve (see Comments section). Refer to the RDO sensor user manual if the sensor does not pass the performance checks.

Sensor Rinsing, Soaking and Storage

After each sample measurement, rinse the RDO sensor thoroughly with deionized water and blot the sensor dry with a lint-free cloth. For short term storage, overnight or between measurements, keep the RDO sensor in the calibration sleeve or a biochemical oxygen demand (BOD) bottle with water-saturated air. For long-term storage, keep the RDO sensor in the calibration sleeve.

Luminescence-Based Dissolved Oxygen Sensing

The Orion RDO Optical Dissolved Oxygen Sensor measures dissolved oxygen in liquid with a luminescence-based optical sensor. Using an optical sensor, the luminescence-based method monitors the time it takes to quench an excited lumiphore, which is inversely proportional to the concentration of oxygen.



luminescence-based is one of the three affirmed methods for dissolved oxygen measurement by the American Society for Testing and Materials (ASTM). The other two methods are the Winkler titration method and the electrochemical membrane method – both of which can also be performed using the Star A223 RDO/DO portable meter and Orion polarographic DO probe.

Sample Preparation and Preservation

Dissolved oxygen can be measured directly in the tank. Samples cannot be preserved. Measure samples on location for the best results, or immediately following sample collection. If samples must be collected and moved, use an air-tight container, fill completely with no air space, and keep the container sealed until immediately before measuring the sample.

Calibration

Prepare the calibration sleeve by moistening the sponge, squeezing out excess water, and inserting the RDO probe. Perform a water-saturated air (Air) calibration with the RDO probe in the prepared calibration sleeve. The water from the sponge will saturate the air in the calibration sleeve and act as the calibration standard. A stable reading of 100.0 % saturation should be displayed within about two minutes during the calibration.

Analysis

Rinse the RDO sensor with deionized water and blot excess rinse water off with a lint-free cloth. If measuring below the tank surface, attach the stainless steel sensor guard to the sensor to weigh and sink the sensor to the desired tank depth.

Place the RDO sensor in the tank, making sure that the temperature sensor is also submerged in the sample. Initiate a reading using the Auto Read measurement mode by pressing the measure key on the meter keypad. For best results, take a second reading to ensure the dissolved oxygen measurement is fully stabilized, as it may take the RDO sensor one to two minutes to fully stabilize in the wine sample. Use the second stable value for the oxygen content of the wine. Both readings will be saved in the meter data log.

Comments

It is important to thoroughly clean the RDO sensor after sample measurement. Rinse with deionized water and thoroughly blot all excess water with a lint free cloth several times before putting the sensor in the calibration sleeve. Rinsing following the completion of all sample measurements should take 5 to 10 minutes.

The Star A223 meter data log collects up to 1000 measurement sets with time and date stamp and the non-volatile meter memory preserves data, even with loss of power. Download Orion Star Com software to facilitate the transfer of the data log from the meter to a computer at www.thermoscientific.com/OrionMeters. Use the Orion Star Com software to export data to a Microsoft® Excel® spreadsheet or as a comma separated value file (.csv) or print data to a network or local printer.

Quality Control (QC)

Recommended QC procedures include: calibration, check of the thermistor (temperature sensor) response against a calibrated NIST-traceable thermometer, and recovery of an air-saturated deionized water sample.

Notes

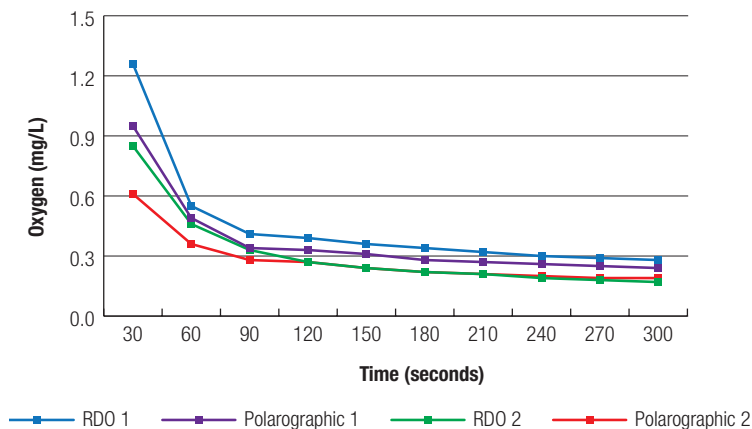
- Keeping the calibration sleeve clean and free from water or sample droplets is essential to getting good calibration and read back values in water-saturated air. Rinse the RDO sensor thoroughly with deionized water and wipe excess water with a lint-free cloth prior to putting the sensor in the calibration sleeve.
- RDO sensors do not require stirring or a sample stream for accurate measurements.
- RDO sensors are offered with 3, 6, 10, 15 or 30 meters cable lengths.
- If readings are slow or inconsistent, ensure the temperature sensor is completely submerged in the sample.
- If the temperature sensor is not in the sample, the DO readings will be incorrect.
- The RDO cap must be replaced every 365 days. The remaining RDO cap life can be viewed in the RDO/DO channel setup menu. The meter will display an error message when the RDO cap needs to be replaced.

Results

Dissolved Oxygen Readings in Wine Sample

Minute	Oxygen (mg/L)			
	Sample 1		Sample 2	
	RDO	Polarographic	RDO	Polarographic
1	0.55	0.49	0.46	0.36
2	0.39	0.33	0.27	0.27
3	0.34	0.28	0.22	0.22
4	0.30	0.26	0.19	0.20
5	0.28	0.24	0.17	0.19

DO Probe Responses in Red Wine



Summary

Using an Orion Star A223 RDO/DO portable meter with an RDO optical dissolved oxygen sensor enables wineries to continually produce high quality wines. Because the RDO sensor is designed to measure the wine directly in the tank, dissolved oxygen measurements can be made with speed and accuracy. The speed, accuracy and precision of the RDO sensor is equivalent or superior to current DO measurement techniques.

Visit www.thermoscientific.com/water for additional information on Thermo Scientific Orion products, including laboratory and field meters, sensors and solutions for pH, ion concentration (ISE), conductivity and dissolved oxygen analysis plus spectrophotometry, colorimetry and turbidity products.

To purchase an Orion Star A223 RDO/DO portable meter, Orion RDO sensor and other related products, please contact your local equipment distributor and reference the part numbers listed below.

Product	Description	Part Number
Portable Meters	Thermo Scientific Orion Star A223 RDO/Dissolved Oxygen Portable Meter	STARA2230
	Thermo Scientific Orion Star A223 RDO/Dissolved Oxygen Portable Meter Kit with RDO Optical DO Sensor, Portable Meter Armor, Field Case and USB Computer Cable	STARA2235
	Thermo Scientific Orion Star A326 pH/RDO/DO Portable Meter Kit with ROSS Ultra Low Maintenance Gel pH/ATC Electrode, RDO Optical DO Sensor, Portable Meter Armor, Field Case, Calibration Solutions and USB Computer Cable	STARA3265
	Thermo Scientific Orion Star A329 pH/ISE/Conductivity/RDO/DO Portable Meter Kit with ROSS Ultra Low Maintenance Gel pH/ATC Electrode, Conductivity Sensor, RDO Optical DO Sensor, Portable Meter Armor, Field Case, Calibration Solutions and USB Computer Cable	STARA3295
RDO Sensors	Thermo Scientific Orion RDO Sensor with 3 Meter Cable	087010MD
	Thermo Scientific Orion RDO Sensor with 6 Meter Cable	087020MD
	Thermo Scientific Orion RDO Sensor with 10 Meter Cable	087030MD
	Thermo Scientific Orion RDO Sensor with 15 Meter Cable	087050MD
	Thermo Scientific Orion RDO Sensor with 30 Meter Cable	087100MD
Accessories	Calibration Sleeve for RDO Sensors	087003
	Stainless Steel Protective Sensor Guard for RDO Sensors	087002
	RS232 Computer Cable	1010053

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Water Analysis Instruments

North America

Toll Free: 1-800-225-1480
Tel: 1-978-232-6000
info.water@thermo.com

Netherlands

Tel: (31) 020-4936270
info.water.uk@thermo.com

China

Tel: (86) 21-68654588
wai.asia@thermofisher.com

India

Tel: (91) 22-4157-8800
wai.asia@thermofisher.com

Singapore

Tel: (65) 6778-6876
wai.asia@thermofisher.com

Japan

Tel: (81) 045-453-9175
wai.asia@thermofisher.com

Australia

Tel: (613) 9757-4300
in Australia (1300) 735-295
InfoWaterAU@thermofisher.com

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Measuring the Dissolved Oxygen of Wine in the Bottle

Water Analysis Instruments, Thermo Fisher Scientific

Key Words

Wine quality, dissolved oxygen, RDO sensor, portable meter, beverage testing.

Goal

The following application note describes how to reliably measure the oxygen content of wine directly in the bottle, using a Thermo Scientific™ Orion™ Rugged Dissolved Oxygen (RDO) Sensor with automatic temperature compensation and a Thermo Scientific™ Orion Star™ A223 RDO/DO portable meter.



Introduction

A bottle of wine's oxygen content has a great effect on its quality, stability and longevity. This is why monitoring and controlling the oxygen incorporation at different stages of the wine-making and bottling process is becoming a growing concern for wineries. Although oxygen is a part of the wine's natural aging process, adverse levels can cause discoloration to white wines and flavor degradation to both white and red varieties. To ensure the consumer is getting the highest quality product, measuring the concentration of molecular oxygen of wine after bottling is very important.

By using a Thermo Scientific Orion RDO optical dissolved oxygen sensor and a Thermo Scientific Orion Star A223 RDO/DO portable meter, reliable oxygen measurements can be made directly in the bottles of wine.

Equipment

- Orion Star A223 RDO/DO Portable Meter Kit – includes RDO optical DO sensor, portable meter armor, field case and USB computer cable (Cat. No. STARA2235)
or
- Orion Star A223 RDO/DO Portable Meter (Cat. No. STARA2230) or equivalent Orion portable RDO meter
- RDO Optical DO Sensor – includes calibration sleeve and stainless steel sensor guard (Cat. No. 087010MD)
- Silicone tubing

Solutions

- Deionized water (DI)

Luminescence-Based Dissolved Oxygen Method

The oxygen content of wine must be monitored throughout the wine-making process. Using the RDO sensor with built-in automatic temperature compensation and a portable meter, reliable measurements can be directly in the wine bottle.

RDO Sensor Setup

Refer to the RDO Optical Dissolved Oxygen Sensor User Guide for detailed assembly and preparation instructions for the RDO sensor. Place RDO sensor into the calibration sleeve. Remove the sponge from the bottom of the calibration sleeve. Moisten it with DI water, squeeze out excess water, and replace the sponge. Connect the RDO sensor to the 9-pin MiniDIN input on the meter. Once assembled, the RDO sensor can be used immediately.

Meter Setup

Turn the meter on. The meter should automatically detect the type of DO sensor and update the measure type to RDO. Access the setup menu and update the RDO/DO channel settings to the following, as needed:

- Measure Mode: Auto
- Measure Unit: mg/L
- Resolution: 0.01
- Read Type: Auto Read
- Baro Pressure: Auto
- Salinity Correct: Manual (0.0)

Update the instrument settings to the following, as needed:

- Export Data: On
- Data Log: On
- Date / Time: Set current date & time

Sensor Performance Checks

A properly calibrated RDO sensor should read between 98 and 102 % saturation in the calibration sleeve. If not, recalibrate the sensor. The RDO sensor should stabilize during calibration within 2 minutes when working properly. Make sure to thoroughly rinse and blot dry the DO sensor after measuring samples and before placing into the calibration sleeve (see Comments section). Refer to the RDO sensor user manual if the sensor does not pass the performance checks.

Sensor Rinsing, Soaking and Storage

After each sample measurement, rinse the RDO sensor thoroughly with deionized water and blot the sensor dry with a lint-free cloth. For short term storage, overnight or between measurements, keep the RDO sensor in the calibration sleeve or a biochemical oxygen demand (BOD) bottle with water-saturated air. For long-term storage, keep the RDO sensor in the calibration sleeve.

Sample Preparation and Preservation

No sample preparation required. Dissolved oxygen can be measured directly in the wine bottle.

Calibration

If not already done, prepare the RDO according to the *RDO Sensor Setup* procedure. Perform a water-saturated air (Air) calibration with the RDO probe in the prepared calibration sleeve. A stable reading of 100.0 % saturation should be displayed within about two minutes.

Analysis

Slide a ring of silicon tubing over the RDO sensor, sliding it up the probe to just below the threads. For details see Notes below. Rinse the RDO sensor with deionized water and blot excess rinse water off with a lint-free cloth. Place the RDO sensor in the bottle. The silicone ring should make a seal with the bottle. Place the bottle on its side so the neck becomes flooded with wine, covering both the dissolved oxygen and temperature sensors on the RDO probe. Initiate a reading using the Auto Read measurement mode by pressing the measure key on the meter keypad. For best results, take a second reading to ensure the dissolved oxygen measurement is fully stabilized, as it may take the RDO sensor one to two minutes to fully stabilize in the wine sample. Use the second stable value for the oxygen content of the wine. Both readings will be saved in the meter data log.

Comments

It is important to thoroughly clean the RDO sensor after sample measurement. Rinse with deionized water and thoroughly blot all excess water with a lint free cloth several times before putting the sensor in the calibration sleeve. Rinsing following the completion of all sample measurements should take 5 to 10 minutes.

The Orion meter data log collects up to 1000 measurement sets with time and date stamp and the non-volatile meter memory preserves data, even with loss of power. Download Orion Star Com software to facilitate the transfer of the data log from the meter to a computer at www.thermoscientific.com/OrionMeters. Use the Orion Star Com software to export data to a Microsoft® Excel® spreadsheet or as a comma separated value file (.csv) or print data to a network or local printer.

Quality Control (QC)

Recommended QC procedures may include: calibration, check of the thermistor (temperature sensor) response against a calibrated NIST-traceable thermometer, and measurement of a zero DO solution, such as 5% sodium sulfite.

Notes

- Silicone tubing is necessary to make a seal so the bottle can be laid on its side, immersing the probe and temperature sensor in the sample while keeping all of the wine in and ambient oxygen out of the bottle. The RDO sensor and temperature sensor are not immersed in the sample if the bottle is sitting upright. Use a piece of soft silicone tubing with an inner diameter of 1/2 to 5/8 inch and outer diameter of 5/8 to 3/4 inch with a wall thickness of 1/8 inch. Cut a ring of tubing that is 1/4 to 1/2 inch wide. Before measuring the wine sample in the bottle, slide the ring onto the probe and push it up to just below the threads.
- Keeping the calibration sleeve clean and free from water or sample droplets is essential to getting good calibration and read back values in water-saturated air. Rinse the RDO sensor thoroughly with deionized water and wipe excess water with a lint-free cloth prior to putting the sensor in the calibration sleeve.

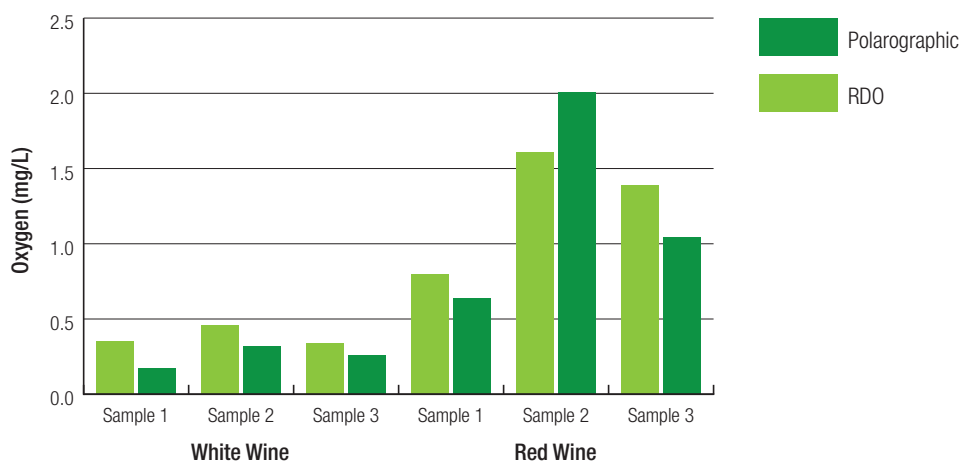
- RDO sensors do not require stirring or a sample stream for accurate measurements. The speed, accuracy, and precision of the RDO sensor are equivalent or superior to the traditional polarographic sensor measurement.
- If readings are slow or inconsistent, ensure the temperature sensor is completely submerged in the sample.
- If the temperature sensor is not in the sample, the DO readings will be incorrect.
- The RDO cap must be replaced every 365 days. The remaining RDO cap life can be viewed in the RDO/DO channel setup menu. The meter will display an error message when the RDO cap needs to be replaced.



Results

Dissolved Oxygen Readings in Wine Bottles

	Oxygen (mg/L)			
	White Wine		Red Wine	
	RDO	Polarographic	RDO	Polarographic
Sample 1	0.35	0.17	0.80	0.64
Sample 2	0.46	0.32	1.61	2.01
Sample 3	0.34	0.26	1.39	1.04
Temperature (°C)	21.5	21	21.3	21.1



Summary

Using an Orion Star A223 RDO/DO portable meter with an RDO optical dissolved oxygen sensor enables wineries to continually produce high quality wines. Because the RDO sensor allows the wine to be measured directly in the bottle, dissolved oxygen measurements can be made with speed and accuracy. The speed, accuracy and precision of the RDO sensor is equivalent or superior to current DO measurement techniques.

Visit www.thermoscientific.com/water for additional information on Thermo Scientific Orion products, including laboratory and field meters, sensors and solutions for pH, ion concentration (ISE), conductivity and dissolved oxygen analysis plus spectrophotometry, colorimetry and turbidity products.

To purchase an Orion Star A223 RDO/DO portable meter, Orion RDO sensor and other related products, please contact your local equipment distributor and reference the part numbers listed below.

Product	Description	Part Number
Portable Meters	Thermo Scientific Orion Star A223 RDO/Dissolved Oxygen Portable Meter	STARA2230
	Thermo Scientific Orion Star A223 RDO/Dissolved Oxygen Portable Meter Kit with RDO Optical DO Sensor, Portable Meter Armor, Field Case and USB Computer Cable	STARA2235
	Thermo Scientific Orion Star A326 pH/RDO/DO Portable Meter Kit with ROSS Ultra Low Maintenance Gel pH/ATC Electrode, RDO Optical DO Sensor, Portable Meter Armor, Field Case, Calibration Solutions and USB Computer Cable	STARA3265
	Thermo Scientific Orion Star A329 pH/ISE/Conductivity/RDO/DO Portable Meter Kit with ROSS Ultra Low Maintenance Gel pH/ATC Electrode, Conductivity Sensor, RDO Optical DO Sensor, Portable Meter Armor, Field Case, Calibration Solutions and USB Computer Cable	STARA3295
RDO Sensors	Thermo Scientific Orion RDO Sensor with 3 Meter Cable	087010MD
Accessories	Calibration Sleeve for RDO Sensors	087003
	Stainless Steel Protective Sensor Guard for RDO Sensors	087002
	RS232 Computer Cable	1010053



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Water Analysis Instruments

North America

Toll Free: 1-800-225-1480
Tel: 1-978-232-6000
info.water@thermo.com

Netherlands

Tel: (31) 020-4936270
info.water.uk@thermo.com

China

Tel: (86) 21-68654588
wai.asia@thermofisher.com

India

Tel: (91) 22-4157-8800
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Singapore

Tel: (65) 6778-6876
wai.asia@thermofisher.com

Japan

Tel: (81) 045-453-9175
wai.asia@thermofisher.com

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India

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wai.asia@thermofisher.com

Singapore

Tel: (65) 6778-6876
wai.asia@thermofisher.com

Japan

Tel: (81) 045-453-9175
wai.asia@thermofisher.com

Australia

Tel: (613) 9757-4300
in Australia (1300) 735-295
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