Percent Alcohol 3 Ways

Anna Katharine Mansfield, Assistant Professor, Cornell University - NYSAES
First published in *Cellar Dweller – December 2010*.

Why to run it: To satisfy legal labeling and reporting requirements

What it measures: The percent ethanol by volume in wine

Basic bench-top: Ebulliometry

Materials:

- Ebulliometer, including calculation disk
- Alcohol burner
- Graduated cylinder
- Ice
-

Analysis time: 20 minutes per sample, plus two 15-minute blank runs

Accuracy: ± 0.5% v/v

Hazards: The boiling chamber gets very hot, so care should be taken when draining samples. Proper ventilation is recommended to prevent headaches from the fumes produced from boiling wine.

Cost: $1000 for ebulliometer purchase

Theory and Practice: Ethanol has a lower boiling point (bp) than water at a given atmospheric pressure, so the higher the concentration of ethanol in the wine, the lower the wine's bp. In this analysis, the bp of distilled water is compared to the bp of a wine sample. The initial water bp reading is used to set the calculation disk (included with the ebulliometer) to compensate for the actual atmospheric pressure at the time of analysis, which is necessary for the observed bp of the wine on the wheel to be aligned with the correct percent ethanol. In situations where atmospheric pressure changes quickly, such as during the approach of a thunderstorm, results can be skewed. Wines with residual sugar greater than 2% may also result in erroneous measurements, and while sweet wines may be diluted for measurement, the amplified potential for relative error makes this somewhat unreliable. Finally, it's important to pack the condenser column of the ebulliometer with ice during wine analysis, as any vapor lost will contain a disproportionate amount of ethanol, resulting in erroneously low ethanol measurements.

Calculation wheel for an ebulliometer. The writing at the top is French for "I hope I don't have to pay a higher tax rate."

Introductory instrumental: Hydrometry

Materials:

- Hydrometer indicating percent alcohol with divisions of 0.1%
- Graduated or hydrometer cylinder
- Distillation apparatus (flask, condenser, Kjeldahl connector)
- Water bath

Analysis time: 30 minutes

Accuracy: ± 0.1 % v/v in principle; in practice, there are many opportunities for error.

Hazards: None

Cost: $10-20 for hydrometer purchase; $500 for distillation apparatus.

Theory and Practice: Hydrometers exploit the fact that a liquid exerts a buoyant force equal to the weight of the volume displaced by a solid. This means that the denser the fluid, the higher the hydrometer floats in it. Because ethanol is less dense than water, hydrometers will float lower in a wine with a higher ethanol concentration. Wine solids, such as reducing sugars, make it impossible to take an accurate ethanol reading from a wine sample because they also increase density. Since these solids are not transferred during distillation, it's possible to distill ethanol from a known volume of wine, dilute the distillate to the original volume with water, and then take a hydrometer reading to determine ethanol content. Sulfur dioxide and acetic acid are steam distillable, however, and high concentrations of either in the original wine can skew analysis results. Corrections can be made to limit their effects.

Chemistry geek: Gas Chromatography-Flame Ionization Detector (GC-FID)

Materials:

- Gas Chromatograph with Flame Ionization Detector
- High-polarity GC column
- Injection syringe
- Vials and caps
- Hydrogen and helium gas
- Ethanol standards

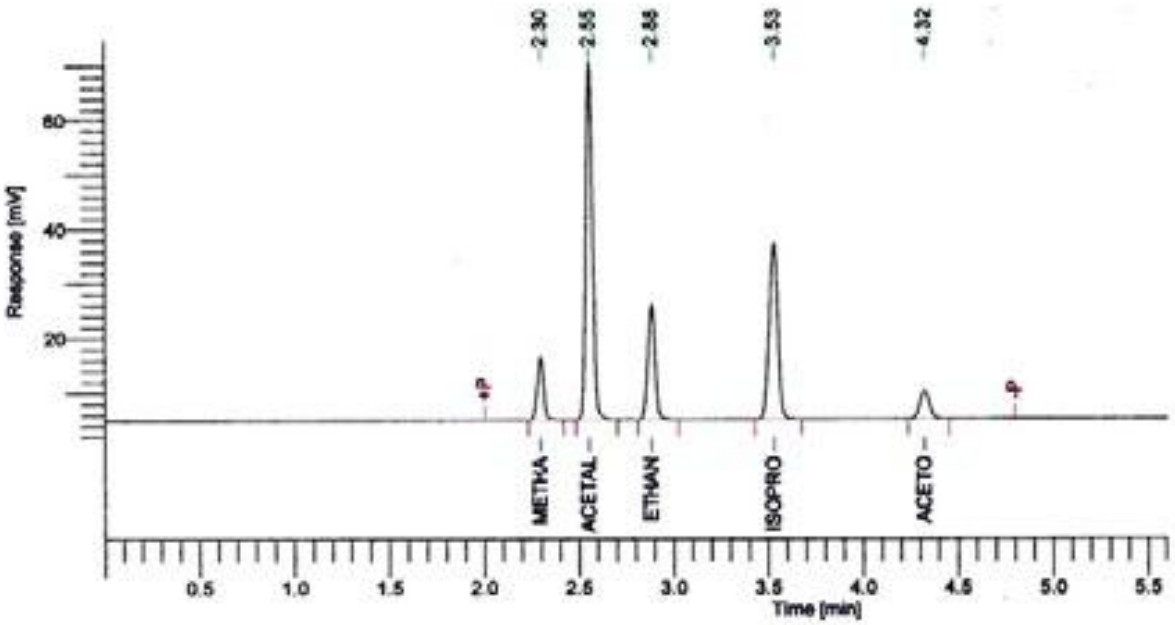
Analysis time: 30 minutes

Accuracy: ± 0.1 % v/v

Hazards: Proper storage and handling of compressed gas is required; also, the GC oven, injection port and detector get very hot, and can cause burns if touched.

Cost: $30,000+ for initial GC-FID purchase; approximately $20 per analysis for expendables

Theory and Practice: Wines are diluted and injected into the GC, where the sample is rapidly heated, vaporizing volatile components (including ethanol) which are then carried through the column in order of their molecular weight and polarity. Because ethanol is present in relatively high quantities and separates well from other compounds, it is very easy to identify and quantify via GC-FID. This method can also be used to measure methanol and some fusel alcohols.



A GC chromatogram.
http://www.laboratoryequipment.com/uploadedImages/Chromatography_Techniques/Magazine/Gas_Chromatography/ct06a_parker_Fig5.jpg