

# PRINCIPLES OF WINE STABILIZATION

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## SULFUR DIOXIDE

### History

Greeks and Romans knew about sulfur, but the main uses of this chemical were not a part of their grape growing and winemaking practices. In the 14<sup>th</sup> century, many differed in their opinion on the suitability and usefulness of sulfur.

### Importance

1. Advantages: Sulfur dioxide in solution is unique, because it has both antimicrobial and antioxidative properties.
  - a. As an antioxidant, sulfur dioxide protects musts and wines from browning by inhibiting enzymic and nonenzymic oxidation. Also, this chemical protects wines from oxidation by reducing the amount of available oxygen.
  - b. The antiseptic activity of sulfur dioxide prevents microbial spoilage in wines. It is known that certain spoilage microorganisms such as acetic acid bacteria, lactic acid bacteria, molds, and wild yeasts are inhibited by sulfur dioxide.
  - c. At certain levels, sulfur dioxide may promote a rapid and complete clarification of musts and wines.
2. Disadvantages: Although sulfur dioxide is necessary in preventing undesirable change in wines, excessive amounts may cause an incomplete fermentation, bleaching of color, and cause an objectionable, pungent odor.

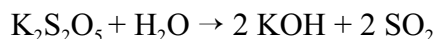
### Source

For a small winery operation, the most convenient method for adding sulfur dioxide is to treat musts and wines with potassium metabisulfite ( $K_2S_2O_5$ ).

### Chemistry

Since potassium metabisulfite ( $K_2S_2O_5$ ) does not contain 100% sulfur dioxide ( $SO_2$ ), it is essential to know the percentage of  $SO_2$  in this salt.

1. Chemical reaction:



2. Molecular weight:

Atomic wt. of K = 40

Atomic wt. of S = 32

Atomic wt. of O = 16

Molecular wt. of  $K_2S_2O_5 = 222$

Molecular wt. of  $SO_2 = 64 \times 2 = 128$

3. Percentage of  $SO_2$  in  $K_2S_2O_5$ :

$$\% SO_2 \text{ in } K_2S_2O_5 = \frac{128}{222} \times 100 = 58\%$$

or

$$1 \text{ gm of } K_2S_2O_5 = 0.58 \text{ gm of } SO_2$$

4. Conversion: grams of  $SO_2$  to grams of  $K_2S_2O_5$ :

$$\frac{1}{0.58} = \frac{\text{wt. of } K_2S_2O_5}{\text{wt. of } SO_2}$$

$$\frac{1.72}{1} = \frac{\text{wt. of } K_2S_2O_5}{\text{wt. of } SO_2}$$

$$\text{Wt. of } K_2S_2O_5 = 1.72 \times \text{wt. of } SO_2$$

## pH

1. Importance: Acid levels, tartaric and malic acid, significantly influence must and wine pH. This factor is important to both color and keeping quality of wines. Problems with spoilage are likely to occur as pH values increase. Another reason for improved stability as the pH is lowered is the increased effectiveness of  $SO_2$  as an antimicrobial agent.

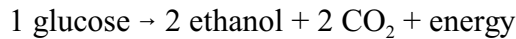
2. Definition:

- a. pH refers to a numerical scale for expressing degrees of acidity or alkalinity.
- b.  $\text{pH} = -\log [\text{H}^+ \text{ conc.}]$
- c.  $\text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^-$  ( $\text{H}^+ \text{ conc.} = 10^{-7}$ )

<u>Reaction</u>	<u>gms. of H<sup>+</sup> per liter</u>		<u>Log</u>	<u>pH</u>
acidic	.01	(10 <sup>-2</sup> )	- 2	2
neutral	.0000001	(10 <sup>-7</sup> )	- 7	7
alkaline	.00000000001	(10 <sup>-10</sup> )	-10	10

**Alcoholic Fermentation**

- 1. Equation: For the alcoholic fermentation, the overall process can be represented by the following equation:



- 2. By-Products: Although ethanol is the major product of this process, many minor constituents are also produced during alcoholic fermentation. In addition to their importance in wine quality (aroma and flavor), some have a high affinity to sulfur dioxide; thus, forming complexes.

**Forms and pH Influence**

- 1. Forms: When sulfur dioxide is added to musts and wines, the following reactions occur in equilibrium:



All forms of SO<sub>2</sub> (molecular, bisulfite and sulfite) that are not chemically bound to other wine constituents are called "Free SO<sub>2</sub>". The molecular form is almost entirely in the "Free" form. Furthermore, the "Free" unionized form (molecular) is the SO<sub>2</sub> form which prevents oxidation and spoilage.

Those SO<sub>2</sub> forms that combine with other constituents are termed "Bound SO<sub>2</sub>". "Total SO<sub>2</sub>" refers to the amount of "Free" plus "Bound" SO<sub>2</sub>.

- 2. pH Influence: The amount of each SO<sub>2</sub> form in musts and wines depends upon the pH

value. The following data indicate that as the pH decreases, the amount of molecular SO<sub>2</sub> increases (more antiseptic activity).

<u>pH</u>	<u>%SO<sub>2</sub> (molecular)</u>	<u>% HSO<sub>3</sub><sup>-</sup></u>	<u>% SO<sub>3</sub><sup>=</sup></u>
3.0	6.1	93.9	0.012
3.2	3.9	96.1	0.019
3.4	2.5	97.5	0.030
3.6	1.6	98.4	0.048
3.8	1.0	98.9	0.077

### Weight and Volume

1. Weight:

$$1 \text{ lb} = 16 \text{ ozs} = 454 \text{ gms}$$

2. Volume:

$$1 \text{ gal} = 3.8 \text{ liters} = 3790 \text{ ml}$$

3. Measure:

$$1 \text{ gal of wine} = 8.2 \text{ lbs} = 132 \text{ ozs} = 3723 \text{ gms}$$

$$1 \text{ gal of wine} = 3.8 \text{ liters} = 3790 \text{ ml}$$

$$1 \text{ gal of juice (crushed grapes)} = 9.0 \text{ lbs} = 144 \text{ oz}$$

### Conversions

<u>ppm</u>	<u>%</u>	<u>mg/L</u>	<u>Multiplication factor</u>
100,000	10	100,000	.1
10,000	1	10,000	.01
100	.01	100	.0001
10	.001	10	.00001

Example: 100 ppm of 1000 gallons of wine

By Volume:

$$100 \text{ ppm} = .01\%$$

$$1000 \text{ gal} \times .0001 \text{ (factor)} = \underline{.1 \text{ gallon}} = 380 \text{ ml}$$

By Weight:

$$1000 \text{ gal} \times 8.2 \text{ lbs/gal} = 8,200 \text{ lbs}$$

$$8200 \text{ lbs} \times .0001 \text{ (factor)} = \underline{.82 \text{ lbs}} \times 454 \text{ g/gal} = 372.3 \text{ gms}$$

### Dosage

1. Crushed Grapes: Condition of grapes, temperature, and pH are important factors in determining the amount of SO<sub>2</sub> to be added to the crushed grapes or musts. In general, sound grapes without spoilage, cool, and low pH require about 50 ppm SO<sub>2</sub>.

- a. Estimate weight of crushed grapes (9.0 lbs per gallon).
- b. Determine the ppm of SO<sub>2</sub> to be added to the crushed grapes.
- c. Equation:

$$\text{Wt. of K}_2\text{S}_2\text{O}_5 = Y \times Z \times 1.72$$

Where: Y = weight of crushed grapes

Z = multiplication factor of desired ppm SO<sub>2</sub>

1.72 = Conversion factor to change SO<sub>2</sub> to K<sub>2</sub>S<sub>2</sub>O<sub>5</sub>

- d. Example: for a 50 ppm SO<sub>2</sub> treatment, calculate the weight of K<sub>2</sub>S<sub>2</sub>O<sub>5</sub> to be added to 2000 lbs (ton) of crushed grapes

$$\begin{aligned} \text{Wt. of K}_2\text{S}_2\text{O}_5 &= 2000 \text{ lbs (Y)} \times .00005 \text{ (Z)} \times 1.72 \\ &= \underline{.172 \text{ lbs}} = \underline{2.8 \text{ ozs}} \end{aligned}$$

2. Wine Storage: Immediately after alcoholic fermentation, the amount of free SO<sub>2</sub> is relatively low in the wines. Also during wine storage, SO<sub>2</sub> is constantly being lost due to such factors as oxidation and volatilization. Therefore, it is essential to treat wines with additional amounts of SO<sub>2</sub> at regular storage intervals. Under most conditions, maintaining 20 to 40 ppm of free SO<sub>2</sub> will protect wines against oxidation and spoilage.

- a. Estimate volume of wine in storage (3.8 liters per gallon).
- b. Determine the ppm (mg/liter) of SO<sub>2</sub> to be added to the wine.
- c. Equation:

$$\text{Wt. of K}_2\text{S}_2\text{O}_5 = \frac{Y \times 3.8 \times 1.72 \times Z}{1000}$$

Where: Y = Volume of wine in gallons

3.8 = Conversion factor to change gallons to liters (L/gal)

1.72 = Conversion factor to change SO<sub>2</sub> to K<sub>2</sub>S<sub>2</sub>O<sub>5</sub>

1000 = Conversion mg/L to gms/L

- d. Example: for a 20 ppm SO<sub>2</sub> treatment, calculate the weight of K<sub>2</sub>S<sub>2</sub>O<sub>5</sub> to be added to 500 gallons of wine.

$$\text{Wt. of K}_2\text{S}_2\text{O}_5 = \frac{500 \times 3.8 \text{ L/gal} \times 1.72 \times 20 \text{ mg/L}}{1000}$$

$$= 65.4 \text{ gms or } .14 \text{ lbs or } 2.3 \text{ ozs}$$

3. Bottling: It is important to inhibit spoilage yeast and bacteria in the bottle. Therefore, winemakers always adjust the free SO<sub>2</sub> level of their wines at the time of bottling. In

general, a molecular SO<sub>2</sub> level of 0.8 ppm has been reported to be an acceptable concentration for most wines. The table below offers those free SO<sub>2</sub> levels to obtain 0.8 ppm molecular SO<sub>2</sub> at various pH values.

<u>pH</u>	Free SO <sub>2</sub> to obtain 0.8 ppm molecular SO <sub>2</sub> ___	<u>pH</u>	Free SO <sub>2</sub> to to obtain 0.8 ppm molecular SO <sub>2</sub> ___
2.9	11	3.5	40
3.0	13	3.6	50
3.1	16	3.7	63
3.2	21	3.8	79
3.3	26	3.9	99
3.4	32	4.0	125

Source: C. Smith, Enology Briefs, Feb/March, 1982, Univ. of Calif., Davis.

### **BATF Consideration**

The finished wine shall contain not more than 350 ppm of total sulfur dioxide.