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Sulfite – So what's the Story on the Most Widely Used Wine Additive?

Some call it by its full name, some call it sulfite, and still others coolly call it "meta". It is likely to be the first chemical encounter one has with winemaking. None-the-less, many people are not completely aware of what it is and how and why it is used and important to the winemaking process. So, let's first begin by looking at the chemical structures that are interchangeably referred to as "meta".

Potassium Metabisulfite

Potassium Metabisulfite, $K_2S_2O_5$, is a white crystalline powder with a pungent sulfur odor. The main use for the chemical is as an antioxidant or chemical sterilant. It is a sulfite and is chemically very similar to sodium metabisulfite, with which it is sometimes used interchangeably. Potassium metabisulfite is generally preferred out of the two as it does not contribute sodium to the diet.

Potassium Metabisulfite has a monoclinic crystal structure which decomposes at 190°C, yielding 1 K_2O (potassium monoxide), and 2 SO_2 (sulfur dioxide) molecules. The potassium monoxide is a solid salt, whereas the sulfur dioxide is a gas.

Sodium Metabisulfite

Sodium Metabisulfite or **sodium pyrosulfite** (American spelling; English spelling is **Sodium Metabisulphite** or **sodium pyrosulphite**) is an inorganic compound of chemical formula $Na_2S_2O_5$. The name is sometimes referred to as *disodium* (metabisulfite, etc). It is used as a sterilizer and antioxidant/preservative.

Usage in Wine

Despite some of the apparent similarities in function between the two forms of sulfite described above, there are some practical differences. In water, Potassium Metabisulfite inhibits harmful bacteria through the release of sulfur dioxide (SO_2), a powerful antiseptic. It can be used for sanitizing equipment and the must from which wine is to be made. For equipment, a 1% solution (10 grams dissolved in 1 liter of water) is sufficient for washing and rinsing. Note, most winemaking references will recommend a "strong" solution of upwards of 25% for sanitizing and the winemaking at juicegrape.com would concur. After using the solution, the equipment should not again be rinsed. For sanitizing the must, a 10% solution is made (100 grams dissolved in 1 liter of water). Three milliliters of this 10% solution added to a U.S. gallon of must will add approximately 45 ppm of sulfur dioxide to the must. One should wait at least 12 hours after sanitizing the must before adding the yeast. Both bottles of solution (10% and 25%) should be clearly labeled as to strength and active compound to prevent mistakes, and both may be refrigerated for upwards of a two months without effecting potency. Of course, the major concern regarding potency lies with the 10% solution, which would be used to add in the stabilization of wine in later steps of the winemaking process. This potential loss to potency is an argument for dissolving powder into solution as it is needed.

Sulfite is sold either as a white powder or in tablet form known as Campden tablets. Campden tablets come in either the Sodium Metabisulfite or Potassium Metabisulfite form. For the purposes of winemaking and through the remainder of this article, only use the Potassium form of Campden tablets. Using household measures, the powder form can be difficult to use for small batches of wine or beer. When added at the pre-fermentation stage, it inhibits the action of all yeasts; wine yeasts are just more resistant than other microorganisms. So, at a target range of approximately 30-40 ppm, the naturally occurring yeasts will be inhibited while allowing the more resistant commercial strains to proliferate. CAUTION: If too much potassium metabisulfite is added it will result in a 'stuck' fermentation. The typical amount is around 1/4 teaspoon per 5 gallons. So for batches smaller than this Campden tablets are normally used.

This sodium source of metabisulfite is not recommended because of possible flavor changes in wine. In fact, the US government currently bans the use of sodium metabisulfite in all wines made in or imported into the country due to health concerns over sodium in wine. A much better choice would be Potassium Metabisulfite.

Considering that Potassium Metabisulfite can be used for both sanitizing and stabilizing, there really is no need for Sodium Metabisulfite in the winemaker's chemical repertoire.

Packaging

Potassium Metabisulfite can be purchased in powdered form, and is also the primary ingredient in the Potassium Metabisulfite form of Campden tablets. In solid form it ranges in color from white to slightly yellow.

Chemical properties

When mixed with water, both Sodium and Potassium Metabisulfite release Sulfur Dioxide (SO_2), a pungent, unpleasant smelling gas that can also cause respiratory difficulties in some people. For this reason, it is recommended that Metabisulfite be used judiciously and occur in a well ventilated area.

Usage Choices

The most common forms of Potassium Metabisulfite for use in winemaking include powder, Campden tablets, and dilute solution (e.g. 10%). The table below lists the pros and cons of each form

Form	Pro	Con
Campden Tablet	Convenient Form 1 tablet dissolved in water added to 1 gallon of wine raises the free SO2 by 50 ppm	More costly and difficult to work with when the amount to raise free SO2 by is not 50 ppm – it means breaking tablets into pieces. Contain binders
Powder	Convenient ¼ teaspoon per 5 gallons raises the free SO2 by 50 ppm. More flexibility in using common household measures than with Campden tablets. Only use what's needed and generally a more pure form of meta than found in Campden tablets	Can still be difficult to work with when the amount needed doesn't correlate to a common household measure. This can easily be remedied by having a good gram scale that measures ideally to 1/100 of a gram.
Dilute Solution	Easy to prepare ahead of time and easy to administer using a syringe that has ml graduations.	Solution has a shelf-life of approximately 2 months. May end up with wasted solution.

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Preparation of a 10% Solution

A 10% stock sulfite solution is easy to prepare, convenient, and will store nicely up to two months in a refrigerator. Portions of the stock solution can be easily stored in a container like Portion Pro™. A container such this is graduated both on the canister and on the bulb syringe that comes as part of the canister. It makes preparing and dispensing of the solution an easy task.

To prepare a 10% solution, the ratio is 10 grams per 100ml (100 grams per 1 liter). The Portion Pro holds 350ml. So, to prepare a 10% dilute solution, the procedure would be to dissolve 35 grams of Potassium Metabisulfite into 200ml of warm water. Once dissolved, finish the solution by adding an additional 150ml of cold water, bringing the total volume up to 350ml.

Preparation of a 25% Solution

A 25% stock sulfite solution is prepared in the same fashion as the 10% - except using 250 grams per liter instead of the 100 grams that is used for a 10% solution.

SO2 Additions for Wine: Method Which Corrects for pH of the Wine

When sulfite is added to a wine, a portion of the sulfite will join with other substances in the wine. This part of the sulfite is called "bound" sulfite. Since it is bound, it is not considered to be “active”, which means it will not patrol the wine in search of substances (often those that cause spoilage) to bond to. For those sulfite molecules that do not bind, these molecules are considered to be “free” sulfite. It is the "free" sulfite which has a strong preservative effect in the wine. Free SO2 is measured in milligrams per liters, or mg/L, which is approximately equivalent to 1 ppm.

With the understanding that free SO2 is what protects wine and that it is created when sulfite is added to the wine, the next concept involves understanding that the amount of free SO2 in a wine determines how well it is protected.

There is a minimum level of free SO2, a.k.a. Molecular SO2, which is recommended at each stage of winemaking to ensure problem-free results. There are two common target values for the establishment of free SO2. The first target value is at 0.8 ppm molecular. At 0.8 ppm molecular, Malolactic bacteria will be inhibited. The second target value is 0.5 ppm molecular. At 0.5 ppm molecular, Malolactic fermentation will be permitted to proceed. However, to achieve that minimum level requires that we take into account some additional information.

The amount of sulfite that remains free after it has been added to a wine is dependent upon the pH level of the wine. A higher pH wine will experience proportionally more bound SO2 than one with a lower pH. So, for a higher pH wine, more sulfite will need to be added in order to achieve the same level of SO2 that could be achieved by adding less sulfite to a lower pH wine.

Given that the portion of molecular SO2 decreases as the pH of the must or wine increases, accurate additions require that the pH of your must or wine be factored into determination of the quantity of sulfite to be added.

The following is a guide for adding sulfite (powder, campden tablets, or 10% solution) to your wine.

1. Measure the existing SO2 in the wine. There are a couple of ways to do this. Perhaps the most common is through the use of titrets (See Appendix A). The other method is to make use of an acid test kit for the purposes of testing for free SO2. The Vinoferm brand of acid test kit comes with an optional Iodic solution for testing sulfite and can be accomplished using the same titration method that would be used for testing acid.

2. If using the 10% solution method, prepare the solution as described earlier in this document.

3. Accurately measure the pH of your wine. The measure of pH gives two indications. The first is how much free SO2 is required for adequate preservative effect. The second is how much free SO2 will remain after addition; the higher the pH the less free SO2 is yielded per addition and subsequently the more sulfite that needs to be added in order to achieve the appropriate level of free SO2.

   If you do not own a pH meter, a less accurate approach is to treat the wine as if the pH is 3.5, as you will see in some home winemaking books. Experience, as a home winemaker, leaves one uncomfortable in recommending such an assumption. pH is a critical measure and not one to make assumptions on. An incorrect assumption can spell spoilage for a wine. The best practice is to invest in a pH meter or at least some pH test strips.

From Table A below, determine the ppm free SO2 required for the pH measured in the wine. For example, if I want 0.8 ppm molecular SO2 and the pH of a wine is 3.2, 21 ppm of free SO2 would be the target measure to achieve suitable preservative effect. If the wine were of higher pH say at 3.4 then 40 ppm free SO2 would be the target value for 0.8 ppm molecular SO2. If you measured the amount of SO2 in your wine as indicated in step 1, subtract this value from the amount of free SO2 needed, which was determined from Table A. The difference is the amount you will need to add to your wine.

TABLE A Table Contains Free ppm SO2 for Target Molecular Values of:		
pH of Wine	**0.5 ppm Molecular**	**0.8 ppm Molecular (necessary to inhibit Malolactic fermentation)**
2.90	7 ppm	11 ppm
2.95	7 ppm	12 ppm
3.00	8 ppm	13 ppm
3.05	9 ppm	15 ppm
3.10	10 ppm	16 ppm
3.15	12 ppm	19 ppm
3.20	13 ppm	21 ppm
3.25	15 ppm	23 ppm
3.30	16 ppm	26 ppm
3.35	18 ppm	29 ppm
3.40	20 ppm	32 ppm
3.45	23 ppm	37 ppm
3.50	25 ppm	40 ppm
3.55	29 ppm	46 ppm
3.6	31 ppm	50 ppm
3.65	36 ppm	57 ppm
3.7	39 ppm	63 ppm
3.75	45 ppm	72 ppm
3.8	49 ppm	79 ppm
3.85	57 ppm	91 ppm
3.9	62 ppm	99 ppm
3.95	71 ppm	114 ppm
4.00	78 ppm	125 ppm

Armed with the knowledge of the ppm free SO2 that you will need to add to your wine, decide which method you will use to increase the level of free SO2 and go to Table B to find out how much free SO2 results when adding your desired form to wine per base volume unit.

Step by Step Example (for 5 gallons using 10% solution):

1. Existing free SO2 measured: 10ppm
2. Current pH measured: 3.6
3. Using Table A - Determine necessary free SO2: 50 ppm
4. Compute ppm free SO2 to add (50ppm – 10ppm): 40ppm
5. Using Table B – obtain reference data for pH 3.6: 3.8ml raises 1 gallon 43.75 ppm
6. Perform adjustment calculation:

   3.8 x 5 = 19ml to raise 5 gallons 43.75 ppm

   19ml/43.75 : x/40 – solve for x

   (19*40)/43.75 = 17.417.4ml of 10% stock solution will raise 5 gallons of wine by 40 ppm

TABLE B Table Contains Amount of Free SO2 Yielded under specific pH levels:

pH/unit volume	Free SO2 Yield (ppm)	Campden Tablet	Potassium Meta Powder	10% Stock Solution
2.9 (per 750ml)	87.5	1/5	.08 grams	.8ml
2.9 (per liter)		~1/4	.1 grams	1ml
2.9 (per gallon)		1	.38 grams	3.8ml
2.9 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.0 (per 750ml)	81.25	1/5	.08 grams	.8ml
3.0 (per liter)		~1/4	.1 grams	1ml
3.0 (per gallon)		1	.38 grams	3.8ml
3.0 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.1 (per 750ml)	75	1/5	.08 grams	.8ml
3.1 (per liter)		~1/4	.1 grams	1ml
3.1 (per gallon)		1	.38 grams	3.8ml
3.1 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.2 (per 750ml)	68.75	1/5	.08 grams	.8ml
3.2 (per liter)		~1/4	.1 grams	1ml
3.2 (per gallon)		1	.38 grams	3.8ml
3.2 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.3 (per 750ml)	62.5	1/5	.08 grams	.8ml
3.3 (per liter)		~1/4	.1 grams	1ml
3.3 (per gallon)		1	.38 grams	3.8ml
3.3 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.4 (per 750ml)	56.25	1/5	.08 grams	.8ml
3.4 (per liter)		~1/4	.1 grams	1ml
3.4 (per gallon)		1	.38 grams	3.8ml
3.4 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.5 (per 750ml)	50	1/5	.08 grams	.8ml
3.5 (per liter)		~1/4	.1 grams	1ml
3.5 (per gallon)		1	.38 grams	3.8ml
3.5 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.6 (per 750ml)	43.75	1/5	.08 grams	.8ml
3.6 (per liter)		~1/4	.1 grams	1ml
3.6 (per gallon)		1	.38 grams	3.8ml
3.6 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml

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3.7 (per 750ml)	37.5	1/5	.08 grams	.8ml
3.7 (per liter)		~1/4	.1 grams	1ml
3.7 (per gallon)		1	.38 grams	3.8ml
3.7 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.8 (per 750ml)	31.25	1/5	.08 grams	.8ml
3.8 (per liter)		~1/4	.1 grams	1ml
3.8 (per gallon)		1	.38 grams	3.8ml
3.8 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
3.9 (per 750ml)	25	1/5	.08 grams	.8ml
3.9 (per liter)		~1/4	.1 grams	1ml
3.9 (per gallon)		1	.38 grams	3.8ml
3.9 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml
4.0 (per 750ml)	18.75	1/5	.08 grams	.8ml
4.0 (per liter)		~1/4	.1 grams	1ml
4.0 (per gallon)		1	.38 grams	3.8ml
4.0 (per 5 gallon)		5	1.9 grams (1/4 teaspoon)	19ml

An added measure of security is to repeat the process once again in 1 week. If the level of free SO2 is not correct, adjust again.

Conclusion

Potassium Metabisulfite is the choice of sulfite for all winemaking tasks that require sulfite. Precise additions of sulfite require knowing pre-existing free sulfite levels and the pH of the wine to determine both the minimum free sulfite required to establish a sufficient preservative effect and the percent of free sulfite that is formed as a result of sulfite addition. Using the reference data provided in Table B, a simple calculation can be performed to arrive at the amount of powdered, tablet, or dilute solution to be added to achieve the desired results.

While this method is certainly more complicated, it is preferential to making pH assumptions and winemaker's should strive to incorporate this more accurate method of determining sulfite additions.

References

Chemical Reference information provided courtesy of:

From Wikipedia the Free Encyclopedia. [WWW Document] URL
http://en.wikipedia.org/wiki/Potassium_metabisulfite
http://en.wikipedia.org/wiki/Sodium_metabisulfite
http://en.wikipedia.org/wiki/Campden_tablets

Appendix A – Using Titrets to Measure free SO2 Concentration

CHEMetrics

CHEMetrics manufactures Ripper-method titration cells, sold under the brand name Titrets.
These titrets are to be used for measuring free SO2 concentration in the 0 to 100 mg/L range.
The titrets produce more reliable results for white wines, but can still have a margin of error of up to 10 mg/L or 10 ppm. Results are less reliable for red wines or white wines containing ascorbic acid or tannin, but they are still very adequate for home winemaking purposes.

CHEMetrics Titrets are available in packages of 10, which will be good for 10 tests. Each titret consists of an ampoule containing a reagent, iodide-iodate titrant in a phosphoric acid solution, and a starch indicator. There is also a valve assembly.

*** Note – Because the reagent is sealed under vacuum, the titration cells have an unlimited shelf life.

To measure free SO2 using Titrets:

1. Fit the valve assembly over the ampoule.
2. Snap the tip of the ampoule and allow a small sample of wine to be drawn. The wine reacts with the reagent and turns to a deep blue color.
3. Continue to draw small wine samples until the color changes to colorless for white wines, or to the color of the red wine for red wines.

*** Note - The color change is hard to notice when testing with red wines. One solution is to try viewing the ampoule with a strong light behind to determine the point of color change.

Color change detection in red wines can be improved by diluting the wine. Take your wine sample and add an equal part of distilled water. This creates a 50% solution. The test result should be adjusted accordingly to obtain the actual free SO2 reading. So, if the wine is diluted to 50 percent and a free SO2 reading of 15 mg/L is obtained, the actual concentration is 30 mg/L.

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