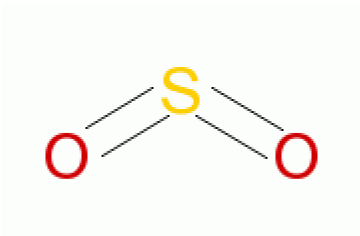
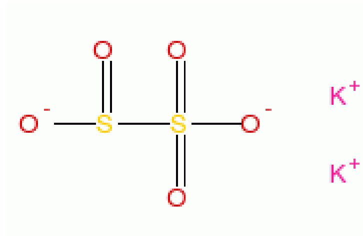
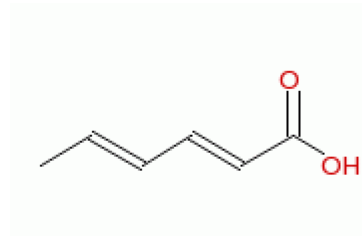
Basic Winemaking and Enology – 3

Chemical Additives. Most additives to wine, such as fining agents, are removed before bottling. The only additives remaining in the wine are antioxidants and preservatives; SO2, ascorbic acid, sorbic acid and fumaric acid. Chemical structure is:

SO_2 Sulfur Dioxide	$K_2S_2O_5$ Potassium Meta-bisulfite (KMS)	CH3CH:CHCH:CHCOOH Sorbic Acid
		

SO_2 is a normal constituent in wine. Yeast metabolism has been shown to produce 12 to 65 mg/l. Burning elemental sulfur has been used for vessel fumigation since Roman times.

Up to 60 mg/l can be picked by wine from SO2 in fumigated barrel. This was the primary method of SO_2 addition to wine until the 20th Century.

KMS reacts with grape acids to release SO_2. Large wineries add SO_2 gas, smaller use KMS or Sodium bisulfite ($NaHSO_3$).

SO_2 serves many roles. There are four reasons why people have used sulfur to protect wine for hundreds of years; anti- oxidant, anti-browning enzyme, anti- microbial and aldehyde binding activities.

Bisulfite salts rapidly ionize under the acidic conditions of must or wine, releasing gaseous sulfur dioxide.

$$SO_2 + H_2O \Leftrightarrow H_2SO_3 \Leftrightarrow HSO_3^- + H+ \Leftrightarrow SO_3^{2-} + 2H^+$$

In wine, sulfur dioxide can exist in a variety of free and bound states. A very small % exists as free SO_2 gas (about 2% of total sulfur dioxide). A small fraction also exists as free sulfate ions (SO_3^{2-}). Most of the free ionic sulfur dioxide exists as bisulfite ions (HSO_3^-) and the reminder of free sulfur dioxide exists as undissociated sulfurous acid (H_2SO_3). This is highly dependent on pH as well as on the concentration of binding compounds.

SO_2 binds with carbonyl compounds (aldehydes, aldose sugars, pyruvic acids, etc.), unsaturated aliphatic (straight chains, no rings) compounds, proteins and other compounds and is oxidized by oxygen. The

binding of SO_2 greatly reduces the active (free) concentration of SO_2. In bound form it is less toxic and less effective as an anti-oxidant. In oxidized form, as sulfate, SO_4^{2-}, it's inert.

The portion of SO_2 not bound or fixed is the "free sulfur dioxide", the FSO_2. The combination of the FSO_2 and the bound SO_2 is the "total sulfur dioxide", the TSO_2. Analysis is normally done for F/TSO_2. The TSO_2 permitted in the US in wine is 350 ppm. In Europe, only 160 ppm of TSO2 is permitted for red wines and 210 ppm for whites and roses.

The lower the alcohol and TA and higher the pH, more SO_2 is required. It can reduce oxidative aromas, improve color in red wines and retard bacterial growth.

SO_2 is an antioxidant in inhibiting enzyme-catalyzed oxidative discoloration and nonenzymatic browning during fermentation, aging and storage. With aeration during fermentation the acetaldehyde increases during the end of fermentation. It is important to keep the SO_2 levels low and maintain anaerobic fermentation. As stated before, 50 ppm SO_2 added prior to fermentation results in approximately double the level of acetaldehyde vs. that no SO_2 addition fermented wines.

Wines produced by oxidation of phenolic substrate materials at the juice stage are rendered more oxidatively stable than wine made with SO_2 protection. During white grape processing, SO_2 free juice browns rapidly. It looks like coffee with lots of cream added. SO_2 added to juice retains straw and green tints. Following completion of cold settling of the SO_2 free juice, the juice changed color to straw and green tints as the brown pigments settle out in the juice lees.

During fermentation, some SO_2 is oxidized to sulfate (SO_3^{2-}) (perhaps by enzymes). Active fermentation soon binds the FSO_2 because acetaldehyde is an intermediate in ethanol production. SO_2 does stimulate the production of acetaldehyde during fermentation. Acetaldehyde is the main "binding partner" for FSO_2 (50% to 80% of all FSO_2), with the sugars being next in line. After fermentation enough SO_2 should be added to combine completely with any residual acetaldehyde.

It is best to try to keep FSO_2 at 20 ppm in wine of pH 3.2. That is certainly true when clean and complete fermentations have occurred. At bottling, FSO_2 at 30 ppm is safe. SO_2 kills many bacteria like Acetobacter. Acetobacter can oxidize EtOH to HAc. Also, 25 ppm FSO_2 can inhibit MLF. The antiseptic qualities come from the small portion of dissolved SO_2 gas. SO_2 has wide-spectrum antimicrobial activity. About 1.5 mg/l is generally sufficient to inhibit most spoilage yeast and bacteria.

At pH 2.8, 20% of the FSO_2 is in this dissolved gas stage, while at pH 3.8, the concentration drops to 1%. This is one reason why high pH wines have a tendency to spoil. Yeasts are sensitive to SO_2, especially in the presence of alcohol. High FSO_2 levels can interfere with good secondary fermentations of sparkling wine. Many studies have shown that delaying SO_2 addition until after fermentation reduces total phenolics and produces wines with better color as compared to addition of SO_2 at crush.

Pigments of red wines loosely bind SO_2. This makes FSO_2 analysis difficult in red wines. SO_2 does help dissolve red pigments. Red wine with SO_2 retains color better than those without SO_2. But, excess SO_2 can bleach pigments.

SO_2 has minor effect in retarding natural yeast growth. It has been shown that SO_2 of 100 ppm does not necessarily prevent growth of indigenous non-*Saccharomyces* species, especially in red wines. Yeast follow a successor pattern of growth. In the first few days, species of *Kloeckera*, *Hanseniaspora, Candida* and *Hansenula* frequently grow. They are soon dominated by a *Saccharomyces* and fermentations are completed by *S. cerevisiae*. It is known that *S. cerevisiae* is the most sensitive to SO_2.

Not only is sulfur dioxide the most important antimicrobial and antioxidant additive in wine, it is also the primary sterilant of winery equipment. Care must be taken when used because of its corrosive nature. Sulfur dioxide can solubilize metal ion from unprotected surfaces.

Sulfur dioxide may also react with oak and form lignosulfurous acid. It has been proposed that, after decomposition, lignosulfurous acid may release hydrogen sulfide that reacts with pyrazines in wood. This could form must-smelling thiopyrazines. This could get in the wine.

At FSO_2 levels between 15 to 40 mg/l, most people can detect a distinctive burnt-match odor. This can be missed due to habituation. Healthy individuals can consume up to 400 mg/l of TSO_2 per day. Although SO_2 can precipitate asthma attacks in sensitive individuals, most wine does not have enough FSO_2 to induce an attack. For a small portion of asthmatics, all forms of sulfur dioxide are potentially allergenic. Sulfur dioxide absorbed by the blood from the digestive tract can be translocated to the lung. An asthma attack may occur.

Few winemakers use <u>ascorbic acid</u> (Vitamin C) and erythorbic acids. Both are anti-oxidants. When air contacts wine, certain phenolic compounds are converted to very strong oxidizing agents, which can oxidize EtOH to acetaldehyde and other unwanted compounds. SO_2 itself does not react fast enough to prevent these rxns. Ascorbic acid does increase the ability of SO_2 to absorb oxygen and is most effective when added just before racking or filtering. It is generally not needed

<u>Sorbic acid</u> has been used to preserve sweet wines and prevent second fermentation from taking place in the bottle. Usually 150 to 200 ppm is effective. 1,000 ppm is legal in the U.S. With bottle age, these wines can smell like butter, oxidized fat or geraniums when lactic acid bacteria metabolize sorbic acid. Sorbic acids, or sorbates, have been widely used in inexpensive wines.

<u>Fumaric acid</u> at 500 ppm can prevent MLF. It is not totally successful and can produce gassiness and off odors in bottled reds. Some winemakers use it.

<u>Clarifying agents</u>. Fining consists of adding to a wine a clarifying product capable of coagulating and making large particles which precipitate in the form of floccules that carry down the particles of cloudiness and clarify the wine, improve the color, flavor and stability.

The agents are grouped according to natural categories:

1. **Earth; bentonite, kaolin**
2. **Proteins: gelatin, isinglass, casein, albumen, ox blood**
3. **Polysaccharides: agars**
4. **Carbons**
5. **Synthetic polymers: PVPP, nylon**
6. **Kieselsol (silicon dioxide)**

7. Others, including metal chelators, enzymes, etc.

Many fining agents contain an electrical charge. If this charge is the opposite of the particles in suspension, then neutralization and absorption may occur.

(Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or, more rarely, a liquid (adsorbent), forming a molecular or atomic film (the adsorbate). It is different from absorption, in which a substance diffuses into a liquid or solid to form a solution. The term *sorption* encompasses both processes, while desorption is the reverse process.)

In a fining operation, small particles of suspended solids are induced to coalesce so that they form larger particles which, because of their density relative to that of the wine or juice, settle from solution. In most cases, the fining agent adsorbs suspended material and exerts some clarifying action by virtue of formation of particles of high density, thus increasing filterability.

The effectiveness of fining is dependent upon the agent, the method of preparation and addition, the quantity employed, the pH, the metal content, the temperature, the age of the wine, and previous treatments. Fining is a surface action performed by the agent (adsorption); therefore, the method of hydration and addition of the agent is of extreme importance.

Four common methods of adding fining agents are:

1) uniformly and slowly through a 'Y' on the suction side of a positive displacement pump while transferring or mixing;
2) uniformly and slowly through an 'in line' proportioning pump;
3) uniformly and slowly through a 'T' into a Guth-type tank mixer; or
4) added slowly in slurry form to a barrel using a dowel to stir in a figure-8 motion through the bung hole.

The main clarifying agents are generally positively charged proteins; their coagulation is carried under the influence of the tannins and sometimes solely by the wines acidity. Negatively charged earth products are also used.

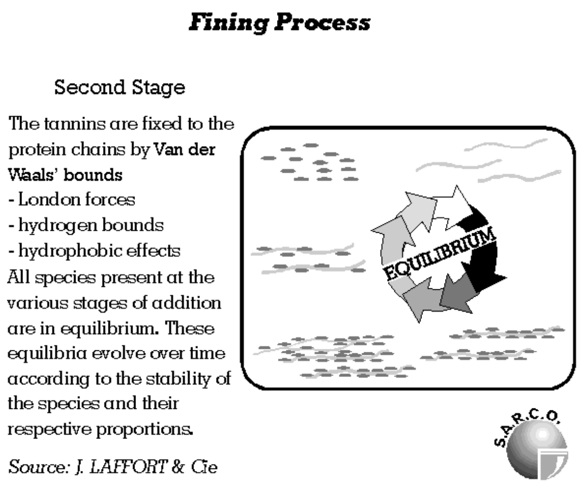
Years back, things like milk, egg-white and ox-blood were most widely used. Now, the most commonly used agents are gelatin, albumens and casein, as well as bentonite.

When a solution of a fining agent (say gelatin) is mixed with a white wine, after a few minutes cloudiness is seen to appear which slowly becomes denser. The clouds become floccules, coagulate and slowly sink, leaving the wine more clear. In red wines, after the addition of a clarifying agent, the appearance of cloudiness is immediate and floccules begin to form in a few minutes. They grow rapidly and appear more and more colored; they form a meshwork that shrinks and falls to the bottom of the tank. Their first fall still leaves the wine cloudy with little floccules. The floccules continue to slowly form and settle.

This progresses until, over time, precipitation and clarification is achieved, and after a few days, the wine becomes clear. Clarification carries down the particles of suspension, which might or might not settle on their own over a very long time. It also fixes the colloidal coloring matter and carries away the tannins, which are more or less polymerized and cause astringency. Two stages of fining occur; the rxn of the agent and the ppt of the flocculate.

Reaction of tannin and agents. A colloidal rxn, not chemical, between the tannins and agents occur. The levels of fining agents to add vary. Trial taste tests in the lab must be done. The polyphenols of acidic wines (with low pH) are easily precipitated. The lowering of the temperature of the fined wine increases the agent's ability to react with and precipitate tannins.

The fining mechanism is illustrated below:



The proteins used in fining are colloids with positive charges.

Colloids are special types of liquid mixture or suspension in which the particles of suspended liquid or solid are present in very finely divided but not molecular or dissolved form. Unlike ordinary suspensions, colloids do not exhibit the phenomenon of settling because of their exceedingly high ratio of surface area to volume.

The tannins and particles creating turbidity are negatively charged. When brought together, attraction, then flocculation and finally settling occurs. The tannin "denatures" the protein. It transforms them from lyophilic colloids (in stable state of suspension) into lyophobic colloids (no affinity for the medium they're in), which are coagulated by the salts of wine. It must be remembered that fining can only function in the presence of mineral matter; Ca, Mg, K salts and ferric salts.

Role of salts in fining. The action of salts has been known since ancient times when NaCl was added directly to wine to increase clarity. Ferric (Fe^{+++}) salts are the most important. If gelatin is used to fine white wines lacking in ferric iron, flocculation is delayed or impeded. By aerating wine, ferric salts are

formed from ferrous (Fe^{++}) salts. Clarification can be improved. Fining succeeds better on aerated wines. That is why it often recommended to fine after racking a wine.

Effect of temperature. Protein fining is poor at high temperatures. Fining in winter at 10 °C (50 °F) is considerably faster in flocculation and settling than in summer at 25 °C (77 °F).

Overfining. It is important that protein agents added to wine are completely coagulated. They must not remain in solution in the wine. The clarity of overfined wines is not stable. They can later become cloudy with temperature change or blending or contact with wood or cork tannin. Red wines are generally never overfined. Overfining whites with proteins, especially gelatin, can be common. Red wines can sometimes throw brown deposits that cover the whole inside of a bottle. Some of the protein-tannin rxn products don't instantly ppt. Further polymerization with more tannins or pigments takes place and causes this ppt in the bottle.

To detect overfining, in the lab add to your wine sample 0.5 g of commercial tannin per liter. After 24 hours, cloudiness will appear in an overfined wine.

Fining tests. Before any cellar fining takes place it should always be tested in the lab. Each clarifying agent reacts differently depending on the wine style, composition, colloidal structure and suspended particles nature. Each wine coagulates differently. Fining tests can be done in the lab in 375-ml bottles. Various levels of a given agent can be tested against a control sample of the wine. Remember that mixing in a 375-ml bottle is easier and more thorough than in a barrel or large tank. Besides tasting the fining results, the sample bottles will also speed up the flocculation and ppt., clarity obtained by each agent and compactness of lees.

Bentonite. A clay flocculable in wine is empowered with high adsorbent and stabilizing properties. It is a natural mineral substance of the clay family, a hydrated aluminum silicate. Bentonite clay can swell considerably and fix as much as 10 times its weight in water, which allows slurries to be prepared. The negative charges its particles possess afford it potent adsorbent power of the positively charged protein molecules. For use with wine, sodium bentonite activated with sodium carbonate is generally used. It is called an alkaline rxn. The best known bentonite comes from Wyoming. The bentonite properties are defined by the colloidal structure, not by the chemical makeup.

It is estimated that a gram of bentonite in an aqueous suspension presents a surface area of about 750 m^2. Say you have a 3,000 gallon tank of Chardonnay. Your lab tests showed that 2-1/2 #/m of Bentonite would make it heat stable. That's 1,135 grams/m or 3,405 grams of Bentonite for the whole tank. That bentonite has about 630 acres of surface area upon which to absorb protein.

If a white wine is heated, cloudiness appears when the wine cools again. The proteins have been "denatured" by heat. That transforms the lyophilic colloids into lypophobic (flocculable) colloids. The proteins then ppt. In a wine of this protein mix and pH, the protein cloudiness may naturally ppt right away or over a prolonged period. So, as lab test is needed to prevent these possibilities.

Several different lab tests exist. One method is to add bentonite slurry in the lab at various levels (C-1-2-3-4-5 #/m). Shake the bottle and then vacuum filter in the lab and collect filtrate in 25 ml screw capped

culture tubes. Put the tubes in boiling water for 17 minutes. Let cool and examine with a light beam for cloudiness. When no haze appears, the needed bentonite is known.

The bentonite needs change easily so always check for heat stability just before bottling. Low pH wines need less bentonite than high pH wines. Normally, all red wines are naturally heat stable because of extra grape tannins. Whites and rosés both can give problems.

Wine proteins are derived primarily from grapes and autolyzed yeast. They consist of several (protein) fractions which appear to be the subunits of denatured grape enzymes. Their molecular weight varies from 20,000 to 40,000 Daltons (used to be called molecular weight). The polypeptides with molecular weights of less than 10,000 are mostly derived from yeast autolysis. The isoelectric point (pI) of wine protein fractions have been reported to be in the range of 2.5 - 8.7.

Wine proteins occasionally cause cloudiness or haze in white wine. Haze formation is poorly correlated with total protein content since only certain unstable protein fractions cause haze. When stabilizing a wine for protein, it is not necessary to remove all proteins, but only those fractions that are unstable and thus contribute to cloudiness.

A bentonite treatment is often used to remove unstable proteins from a wine. Bentonite is a negatively charged colloid which adsorbs positively charged protein and removes it from the wine. Proteins with the greatest positive charge are removed first.

The pH influences protein stability in two ways:
1. it affects protein solubility, and
2. it influences the charge (positive or negative) on the protein molecule.

To understand the role of pH one needs to understand the isoionic or isoelectric properties of proteins.

<u>Protein solubility</u>
Proteins can be either positively (cation) or negatively (anion) charged based on pH conditions. When the positive and negative charges on protein are equal, the net charge is zero. The characteristic pH of a solution at which the net charge on protein is zero (positive and negative charges are equal) is defined as the isoelectric point (pH). The isoelectric point of a protein is an important property because it is at this point that the protein is least soluble, and therefore unstable. It should be noted that both below and above the isoelectric point (isoelectric pH) the protein will be soluble.

To understand the implication of pH, let us consider an example. Suppose we have a white wine with a pH of 3.30 and a protein fraction with a pH of 3.2. After blending with another wine, the pH of the new blend is changed to 3.2. Notice that the pH of the blend and the pH of the protein are now the same. Since the protein is in a pH solution similar to its pH value, it will become insoluble and thus unstable. The blend could therefore be protein unstable even though the wine was stable before blending.

<u>pH and the charge on protein</u>

We have just noted above that protein can be positive or negative based on the pH of the solution. The important point to remember is that in a pH condition below its isoelectric point, the protein will carry net positive charge and behave like a cation. In a pH condition above its isoelectric point, the protein will carry a net negative charge and act as an anion.

In the example used above (wine with a pH of 3.3), the protein with an isoelectric point of 3.2 will carry a net negative charge. If this wine is fined with bentonite, the bentonite will not remove this protein fraction. This is because both the protein and bentonite carry a negative charge and we know that like charges repel. After blending, the pH will change to 3.2. The shift in pH will change the charge on the protein from negative to neutral which will make the protein insoluble because the pH is similar to the pI.

From these examples it should be clear that pH affects protein stability and that any change in pH, as often occurs after blending, can lead to the problem of insolubility. Therefore, it is a sound practice to stabilize a wine after blending, before it is bottled.
Ref. Dr. Murli Dharmadhikari

Preparation of bentonite for use is done by hydration of its particles in hot water for at least several hours, and preferably for a day. The recommended slurry concentration is 6% weight/volume. If you have at least 25,000 gallons of white and pink wine, assume the average addition will be 2 #/m. That would take 50 lb of bentonite. Bentonite can be purchased in 50 lb sacks. If you have smaller lots you can prepare the exact amount of bentonite to be used the day before.
Inspect the bentonite to ensure it is clean, dry and has no off odors. Put 100 gallons of water in a container with a low speed mixer installed. If you don't have a mixer a low volume pump can be used for circulation of the slurry. Raise the water temperature to 120° F. (Not greater, or off odors may occur.) With the mixer turning, slowly add the bentonite powder. Mix until uniform and smooth and avoid clumping. Beginning the next day, this bentonite slurry can be used. Each gallon of slurry has about ½ gallon of bentonite. Add to tank with a mixing valve or other methods as noted before.

<u>Gelatin</u> is obtained by vacuum pan cooking of bones, tendons, gristle and skin. It must have little color or flavor. It has both adsorbent and flocculent powers. Gelatin has a positive charge in wine and hence precipitates after binding with negatively charged tannins. The fining power of gelatin is expressed as Bloom units (100 to 200) and viscosity (30 to 60 millipoise). The molecular weight of the fractions that are used vary from 15,000 to 140,000.

Gelatin is sold in sheets, pearls or powder. Sheet gel is the finest form. It is more expensive, is purer and readily dissolves. Gelatin dissolves in hot water, not boiling. After dissolving, cool the mixture slightly and mix the wine while slowly adding the gelatin mixture. Gelatin is good at reducing bitterness in young red wines. Levels of ½ to 2 #/m are generally adequate. Turbid wines can generally be made clear at ¼ to ½ #/m. Gelatin can be too harsh for older wines. It also is often used to help settle bentonite. After adding and mixing bentonite in a tank, 1/8 #/m of gelatin is often added to white or rosé wines. Before adding any fining agent, taste test series must be done in the lab.

<u>Isinglass</u> is removed from the air bladder of a sturgeon. It appears as practically transparent chips or cut into "vermicelli". The latter is much easier to prepare. To prepare, take a kg (2.2 lb) of isinglass and add 100 liters of water diluted with 100 g of tartaric acid plus 40 g as KMS as a preservative. The isinglass swells rapidly and in a few hours forms a jelly. Constantly stir to keep it uniform.

After a few days, the jelly can be poured through a wire sieve. It can be smelly. It can be used at 1/16 to ¼ #/m on all wines. The lees sometimes floats, may cling to the tank walls, clog filters and they always create a large volume of lees. It's a pain, but is very powerful and gives good brilliance. Overfining with isinglass is rare.

Egg albumen or egg white is soluble in cold water, with a touch of salt (in the U.S. we use KCl) added. Egg white contains 12% proteinaceous substances suitable for fining. Each egg white has 3 to 4 g of active agent. Generally, red wines are fined (especially in France) with between 5 and 8 egg whites per 60 gallon barrel. Fine red wines can take as much as 30#/m of egg white. Egg whites are not used on white wines.

It is the most delicate fining agent for red wines and is generally used only on the best wines. It can be prepared fresh, but is more often (in the U.S.) purchased in the frozen form. Work tags will note to "positive add 20 #/m FEW". When adding to the wine, avoid foam and aeration. Coagulating foam floats to the wine surface and does no fining. Beat the eggs gently to mix and then mix with about ten times their volume of the wine to be fined. This mixture is then added to the tank. Add about 1 oz of KCl to each lb of egg white to maximize fining. Remember the role of salt in fining.

Casein. Casein is a major protein found in milk. It is a positively charged macromolecule with a molecular weight of approximately 375,000. A liter of milk contains 30 g of casein. In association with sodium and potassium ions, it forms a soluble caseinate salt that easily dissolves in wine. In wine, the salt dissociates and insoluble caseinate is released. The caseinate adsorbs and removes negatively charged particles as it settles.

It is mainly used to remove oxidized color from white wine, remove off odors and aid in clarification. The agent is commonly sold as potassium caseinate in a powder form. To prepare, make a 2% (20 g/l) solution of potassium caseinate in warm water and gently stir. Leave overnight and stir again until it is completely dissolved. The solution is good for a couple days. Each ml contains 20 mg of agent. Doses range from 50 to 250 mg/l of potassium caseinate. When added to wine it should be well mixed. After solution preparation and then adding to wine, a drop in pH occurs, causing the casein to flocculate, ppt, adsorb and settle.

Carbon. Activated carbon adsorbents are used to decolorize and deodorize wine and spirits. It is made of small particles, with extremely high surface area, which range from 500 to 1,000 m^2/g (that's up to ¼ acre of surface area per gram of carbon). To activate carbon, it is heated to 900 °C (1,652° F) to get proper pore alignment. It bonds with weakly polar molecules, especially those containing benzene rings or their derivatives. Phenolic compounds generally exist as ring structures, so they are removed by carbon additions.

The carbon pores are very small, so larger molecules (bigger than flavonoid dimers) are not adsorbed. Recommended levels range from 1/8 to 2 #/m. The adsorption on the carbon surface is very fast, so results are noticed immediately. Activated carbon contains a great amount of oxygen in the pores and should be removed after addition. Due to its adsorption capability, carbon will also adsorb positive aroma and flavor components, reducing their concentration in the wine, so care must be taken when carbon is used. It works best on low pH wines and at higher temperatures.

The carbon type most suitable for decolorizing is marked KBB, and the deodorizing type is marked AAA. Examples:
Norit's DARCO KB-B carbon is best suited for decolonization (adsorption of higher molecular weight molecules).

Norit's DARCO S-51 is best suited for odor reduction (adsorption of smaller molecular weight molecules).

Both carbons are extremely pure, have excellent adsorptive capacities, and are routinely used in food applications.

Polyvinlypolypyrrolidone. PVPP is a resinous polymer not soluble in any solvent and leaves no residue in wines. It is sold in granular form with mean particle size of 100 μ (1 μ is 10^{-4} cm). PVPP is obtained by the polymerization of vinylpyrrolidone. The final product is a network of macromolecules.
PVPP acts by adsorption. The amide bonds of PVPP form hydrogen bonds with the hydroxyl groups of polyphenols.

PVPP is used in:
~The treatment of maderization and browning of white wines:
Phenolic compounds play an important role in the color and taste of white wine, in particular during oxidation phenomena (phenol acids, catechins, and leucoanthocyans).
~Mellowing red wines:
Treatment with PVPP has little effect on anthocyanins and the color of wine, but leads to a considerable reduction of tannins and lowers the phenol value.
~ PVPP preferentially binds astringent tannins.

Treatment with PVPP offers the following advantages:
- A noticeable reduction in the optical density of the wine. White wines are less yellow. In conjunction with carbon, it can be very effective in color reduction.
- A reduction in catechins and leucoanthocyans, which are responsible for browning and binding of free SO2.
- Sensorially, a reduction of bitterness and improved freshness and aroma. This specificity of action of PVPP is a complement to that obtained by treating with casein and with bentonite. It is recommended to treat the must or wine with PVPP after eliminating impurities and microorganisms in order to avoid uselessly saturating the active sites of PVPP.

The dosage for use varies depending on the gustatory effect sought, to be predetermined by prior lab trials and tasting. Dose range in white wines is 100-700 mg/l and in red wines 100-200 mg/l.

After doing lab tests, weigh the PVPP needed for your tank and suspend 250 g/L of wine for 30 minutes in a small container. Use the wine to be clarified. The mixture is then added to the wine. Mix for 30 to 45 minutes by mixing or pumping over. It is not necessary to fine in order to eliminate the product after treatment, but it is useful to allow it to settle for several hours before carrying out filtration. Addition of PVPP can be done at any stage of production, from must to pre-bottling.
In the United States, 21CFR173.50 states that the addition rate shall not exceed 60lbs/1,000 gallons.

Silica-gel. This is also sold commercially as kieselsol, baykisol and klebsol and is a milky aqueous solution of silicon dioxide. It generally is sold as a 30% (by weight) suspension of SiO_2. It is available in both negatively and positively charge forms, and can therefore adsorb and remove both negatively and positively charged colloidal material. It is commonly used for removing bitter tastes from white wines. It

does not produce large amounts of lees and when used on red wine, removes little color. The negatively charged particles interact with positively charged proteins, the same as bentonite or as tannin do.

It is a very clean fining agent. When using it on white wines, the use ranges from 0.1 to 0.25 ml/l (30% soln.). Coagulation and separation from the wine begins in a very short time after addition. If using in conjunction with bentonite, add the bentonite first. This agent works well on cloudy *botrytised* wines.

Ref. Ron S. Jackson Wine Science Principles, Practices, Perception 2nd edition