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Essential Laboratory Analyses

Part 10: Monitoring Winery Sanitation

by Richard Carey

Many small and medium-sized wineries do not have a suitable sterile area for their bottling line, even though this is one of the critical components of a winery. The lack of a sterile bottling line area represents a significant risk of contamination of a bottling, even if all procedures for bottling line preparation are followed. However, a new system for the removal of yeast, bacteria, mold and volatile organic compounds has been developed that could be of great benefit to small wineries. KES Science and Technology, Inc., is now producing the AiroCide PPT (Perishables Preservation Technology) air sanitizer/sterilizer, a small rectangular device that measures 16" by 24" by 4" (see Figure 1) and attaches either to the wall or the ceiling of the space to be kept clean. This size unit is rated to cover 85 m^3. Other units range in size from 708 m^3 for the ACS-50 PPT to the largest unit, the ACS-100 PPT, which is rated to cover 1,416 m^3. Even larger spaces can be covered by mounting several units in the space to be sanitized.

Similar in function to a HEPA (High Efficiency Particulate Air) filter used in wineries, surgery centers and other areas where the air must be sanitized, the AiroCide unit kills or removes 99.999987% of bacteria, fungi (yeasts) and viruses, a factor 10,000 times greater than the standard for HEPA classification of 99.97% removal of potentially harmful organisms. It also has the additional benefit of being able to break down volatile organic compounds with no harmful by-products such as ozone. The only items going "into" an AiroCide are electrons and the winery's ambient air, and only CO_2 and water come out.

How the AiroCide Unit Works

The AiroCide unit uses photocatalytic destruction of microorganisms and volatile organic compounds (VOCs) as the key mechanism of action. The most critical of the VOCs that are removed is TCA. Other compounds are less noxious to the wine, but are still not good to have in the ambient air of either the winery or the bottling room. The catalyst is titanium dioxide (TiO_2) and the energy to activate the catalyst is provided by UV light at 390nm. A small fan brings winery air into the unit and forces it over a TiO_2 bed in the presence of UV light. This air movement activates the electron energies of the TiO_2 compound to such a degree that anything organic and small is vaporized on contact with the catalyst. The UV light imparts a 3.2 electron volt activation energy between the outer electron shell of the catalyst and the "hole" in the lower electron shell from which the electron came (see Figure 2). This energy is the source of the microorganism and VOC destruction. There is a dramatic increase in redox energy that oxidizes the organic compounds and reduces the free radicals of the hydroxyl ions which destroy microorganisms.

Figure 1: *An AiroCide ACS-25 PPT unit mounted on a wall. (Photo courtesy of KES Science and Technology, Inc.)*

Figure 3 shows a flow diagram of a reaction bed. It is in the reaction bed that the titanium dioxide catalyst is coated on glass tubes inside the unit. The fan directs the ambient air over the catalyst coated glass tubes. The AiroCide unit has interlock safety devices to prevent anyone from looking inside the unit during its operation.

Testing the AiroCide Unit

KES provided one of their ACS-25 PPT units for trial in the Tamanend Winery facility and an experiment was set up to test the unit in this real winery environment. Subsequently the unit was tested in other winery environments to duplicate the results.

Prior to testing, typical plate count agar Petri plates were placed in each

quadrant of the winery building and opened for a 30-second time frame. This represented the baseline of the environment in which the ACS-25 was to be placed. Plates similar to the one in Figure 4 were observed in this initial trial. Although not exactly able to be extrapolated to a true volume-based analyzer, I have estimated that the approximate cfu's (colony forming units) found on the agar plates should be over 2000 cfu per m^3.

An ACS-25 was then mounted on the wall in one quadrant of the winery and the unit turned on. No special cleaning of the winery facility was conducted after the unit began operation. A similar technique of preparation and exposure was used as on the baseline sample agar plates to collect samples at 24, 48, 96 hours and at 1 week. There was a dramatic 50% drop of airborne microorganisms in the first 24-hour period and by 96 hours there were virtually no airborne organisms present.

The effect of the AiroCide unit on microorganisms is shown in Figures 5A and 5B. *Bacillus subtilis* passing through the system (Figure 5A) is reduced to cell fragments (Figure 5B).

Advantages of the Unit

An important benefit of the AiroCide installation was the smell (or better put, the lack of off aromas) of the air in the winery. Also, it is possible that a less aromatic cellar may attract fewer fruit flies than a highly aromatic cellar.

Another advantage to the AiroCide unit is its very low maintenance cost. An occasional rinsing of the dust filter mesh is necessary, and the only other maintenance task is to replace the UV lamps on an annual basis. In order to operate properly and accurately, the AiroCide unit must have sufficient UV light intensity at a wavelength of 390nm. There are many manufacturers of UV lamps that can fit in the unit, but not all have the predictable intensity of UV light at that critical wavelength. It is therefore important to follow the manufacturer's recommendations for the UV lights to be sure both that the unit is receiving the correct intensity and that the winery gets the expected longevity of the UV lamps. I have been assured that if a winery follows the company's recommendations and the lamps are replaced annually, the system will continue to kill microorganisms and remove volatile organic compounds for years.

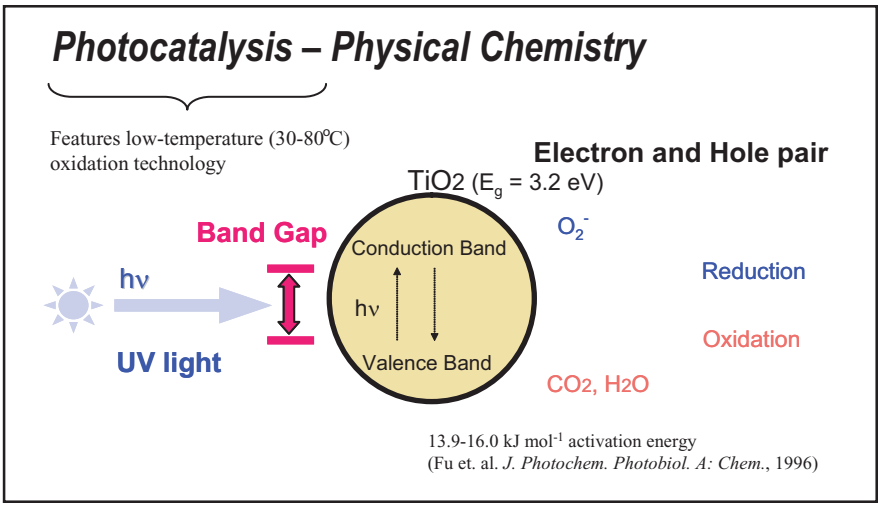

Figure 2: *This diagram illustrates the two processes that activated TiO_2 uses to destroy biologically active compounds, organisms and volatile organic compounds. Electrons can be excited by light energy. Each compound absorbs specific wavelengths of light (in this case 390nm light). The UV light excites an electron into an outer shell of the compound and correspondingly creates a "hole" in the lower shell from which it came. In the presence of volatile organic compounds, organisms and/or biologically active compounds, the energy stored in the catalyst via the excited electron is transferred to those moieties when contact is made. In the process of transferring the energy, any VOCs are oxidized and the biologically active compounds are reduced with the transfer of the excited electron back to its original state. The UV light then re-excites the electrons to repeat the process on the next moiety that comes into contact with the catalyst. (M. E. Zorn, D. T. Tompkins, W. A. Zeltner, and M. A. Anderson, "Catalytic and photocatalytic oxidation of ethylene on titania-based thin-films,"* Environmental Science & Technology, *34:24, 5206–5210, 2000).*

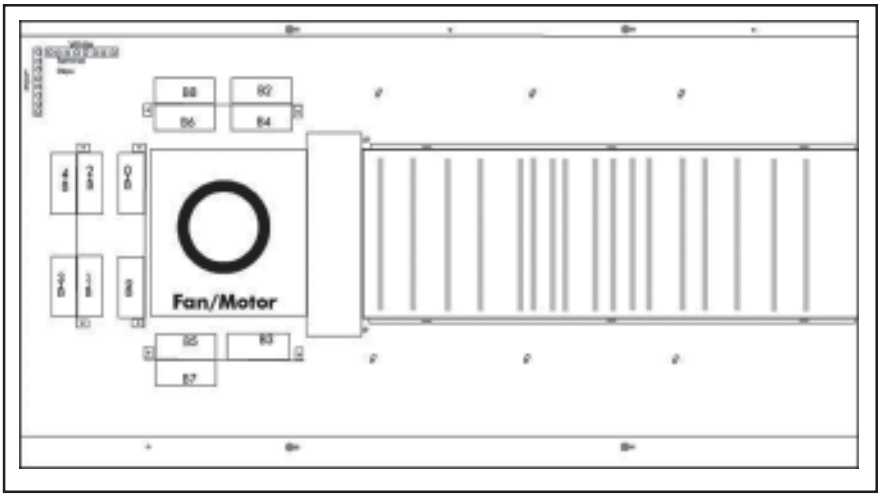

Figure 3: *Flow diagram of an AiroCide unit. (Used with permission of KES Science and Technology, Inc.)*

Other Uses

A winemaker will find uses for the AiroCide unit in many places inside

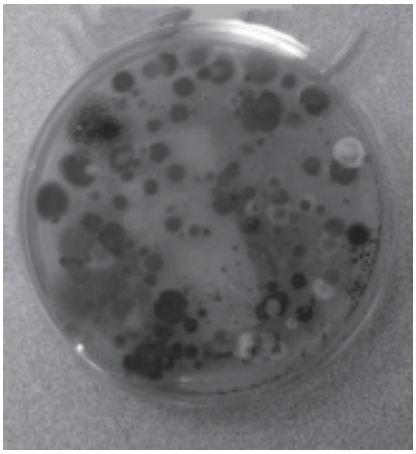

Figure 4: *Sample air contamination plate with a 30-second exposure in the winery. (Photo by Richard Carey)*

a winery. The bottling line area may be the most important location because of the critical nature of the bottling function. Whether the winery cannot afford the luxury of a sanitary room for bottling or is simply relying on a temporary HEPA filtered room to help protect the bottling of its wine, the AiroCide unit will give the winemaker the additional comfort of knowing that the probability has been reduced to a reasonablelevel that the bottling environment will not be the cause of spoiled wines. HEPA filters are good, but expensive, systems that help a well-prepared bottling line produce sanitary bottlings, but at the cost of more maintenance and the lack of volatile organic compound removal (unless there is also an added activated carbon filter in the HEPA system). If a winery with such a system does not maintain the filters on a regular schedule, the air will not be cleaned properly and the wine being bottled will be at risk for contamination.

Other valuable locations for an AiroCide unit are the general wine cellar and barrel rooms. Because of AiroCide's function of microorganism removal, installation in both cellar and barrel rooms will reduce cross contamination of airborne microorganisms from lot to lot of wine.

AiroCide units can also be used in places where people are sensitive to molds and fungi. Since these "bugs" are continuously removed by the unit, there would be less of an adverse effect on people's systems.

Conclusion

In general, I have found that the more sanitary manner in which a winery is maintained, the higher the probability it will make consistent and higher quality wine. I believe that at this time AiroCide is the simplest and, in the long run, the least expensive solution available for small wineries to clean ambient air in the bottling room, cellar and barrel rooms.

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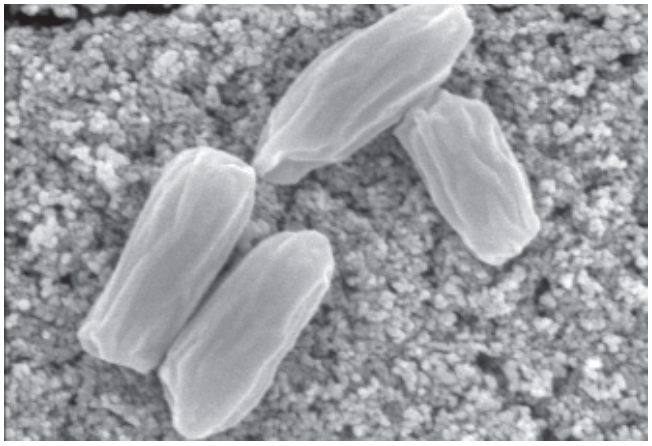

Figure 5A: *Electron microscopy photo of a live* Bacillus subtilis *before contact with the AiroCide unit. (Prepared by the University of Florida and used with permission of Dr. D. Yogi Goswami)*

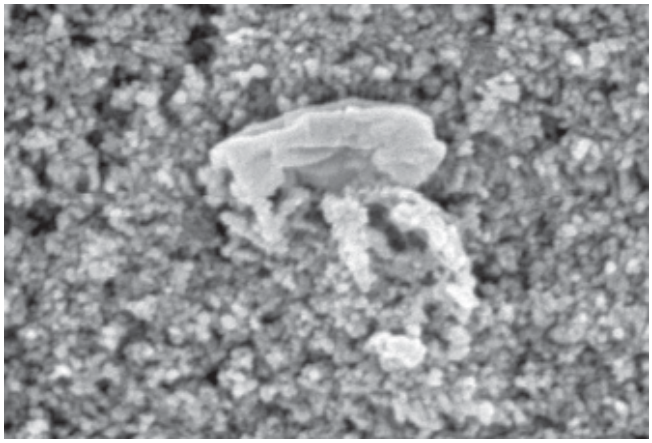

Figure 5B: *Electron microscopy photo of the* Bacillus subtilis *after the photocatalytic process used by the AiroCide unit. (Prepared by the University of Florida and used with permission of Dr. D. Yogi Goswami)*