Don Newsome
UV SYSTEMS, Inc.
16605 127th Ave. S. E.
Renton, WA 98058

Phone (425) 228-9988

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Ultraviolet Lights for use with Fluorescent Minerals

by Don Newsome

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Understanding Ultraviolet Lights: A Rockhound's Guide to UV Equipment

INTRODUCTION

Ultraviolet light assemblies ("lights") provide the invisible ultraviolet (UV) light that causes fluorescent minerals to glow. Some background information about ultraviolet light will help the new collector understand the different types of UV lights.

Ultraviolet light has wavelengths shorter than visible light, while infrared has wavelengths longer than visible light. Ultraviolet wavelengths are usually divided into three groups: UV-A from 400 nanometers (nm) to 315 nm, UV-B from 315 nm to 280 nm, and UV-C from 280 nm to about 160 nm. Long wave UV is in the UV-A range and has been incorrectly labeled "Blacklight." If it were truly black, it would have no effect, since black is the absence of any light. Short wave UV is in the UV-C range.

When UV energy of some specific wavelength hits some mineral specimens they will fluoresce, giving off colored visible light. There are at least five accepted theories explaining the mechanism of fluorescence in minerals. I will not go into detail on any of these, other than to say that in general when UV rays hit the electrons of an atom it causes them to gain energy, and when they return to their normal state they give off energy in the form of light. This light is usually longer than the excitation energy (the UV light) and is usually in the visible spectrum. That "glow" is what we call "fluorescence." If the electrons take a significant amount of time to return to normal, then the light given off (after the UV energy is stopped) is called "phosphorescence." Phosphorescence can last from fractions of a second to minutes, hours, or weeks.

UV LIGHT ASSEMBLIES ("LIGHTS")

UV lights are made up of: (1) some type of power supply and/or ballast; (2) a bulb (lamp); (3) a filter; and (4) something to hold the bulb and filter together (and sometimes the batteries to operate the light). Of these, this article will discuss only (3) and (4), bulbs and filters.

Short wave UV lights are the most commonly used by fluorescent mineral collections, since about 80% to 90% of all fluorescent minerals will fluoresce brighter under short wave (SW) than under long wave (LW). However, a few minerals will show up better under LW. There are also some specimens that will show up better under medium wave UV (explained later in this article). That is because these specimens are made up of two minerals (or more). One mineral shows up best under LW, the other shows up best under SW and the medium wave causes both to fluoresce.

UV lights come in several models or styles. Some are large expensive display lights for display cases or museums, such as the SW Raytech SW-218CB or the UVP UVGD-68. Some are hand-held 115VAC models that are designed to used at home such as the SW Raytech 88CB or UVP UVG-54. Some are small low powered hand-held battery models primarily for beginning collectors, such as the SW Raytech PP-FS or UVP UVG-4. Some are battery powered with rechargeable batteries in the lights such as the SW Raytech R5-FS or UVP UVS-26P. Another is the UV SYSTEMS SuperBright 2000SW and, when used with its external rechargeable battery pack, is the lightest weight, most powerful hand-held SW light available. The SuperBright can also be used for a small display since it also operates with 115VAC, is "instant start" and has no extra switches or starters to turn "on" the light. The SuperBright lights are available in either SW (2000SW) or LW (2010LW) models.

People sometimes confuse electrical wattage with UV output when trying to determine which UV light is the most powerful. Electrical wattage is <u>NOT</u> related to UV output. How an SW germicidal bulb (tube) is powered and designed (i.e., frequency, wave form, arc current, bulb material, bulb wall temperature, etc.) will determine how much SW UV is developed, and it is not related how much electrical power (watts) it takes to operate the bulb. The SuperBright 2000SW –because of its "U" shaped quartz bulb, high frequency inverter/ballast, and high efficiency reflector –produces more SW UV output than any other hand-held light.

UV FILTERS

It is very important to note that <u>no present UV source emits just invisible UV light</u>; all the sources emit some visible light. To have a successful UV light assembly you must have some sort of filter between the bulb and the fluorescent mineral. The filter is designed to transmit as much UV as possible but absorb as much visible light as possible (both of which are being generated by the bulb). No perfect filter exists; all UV filters absorb some of the UV they are designed to transmit and transmit some of the visible that they are designed to absorb. See Figure 1 for a typical SW filter transmission and Figure 2 for a typical LW filter transmission. Note that wavelengths longer than about 400 nm are visible to the eye.

Almost any material that will transmit SW UV will deteriorate when exposed to SW UV. This deterioration is called "solarization." Solarization reduces the amount of SW that your UV light transmits which results in your minerals not fluorescing as bright as before. While there was a breakthrough improvement in the life of SW filters about 16 years ago, all SW filters are susceptible to solarization. Present SW filters may last about 900 hours to 3500 hours of use (arbitrarily defined as when their transmission drops to approximately 25%), depending on the light assembly and application. However, there is no such thing as an SW filter that will "last a life time." In 1991 the Fluorescent Mineral Society, Inc., published the results of a three year study of the solarization effects of different manufacturers of SW filters. SW filters also will absorb moisture from high humidity in the air. This moisture will form a white film coating on the filter that affects its transmission. Even if the coating is cleaned off, damage most likely will have already occurred inside the glass. Keep your SW lights in a dry area when you are not using them. SW filters must be periodically replaced because of solarization and damage from long exposure to humidity. LW filters (in a LW UV light) will not solarize and should never need to be replaced.

The special glass in SW germicidal bulbs (tubes) will also solarize (as will the quartz in the SuperBright light). However, the solarization rate of germicidal bulbs is only a fraction of the SW filters' rate. And quartz is the longest lasting, being about five times more resistant to solarization than the special glass in germicidal bulbs and maybe fifty to hundred times more resistant than SW filters. The glass in the LW tubes will not solarize; however, the LW phosphor in the tube will deteriorate and lose its effectiveness long before the tube itself will fail. If your SW light makes your fluorescent minerals look dull, then it is time to replace your filter and maybe your bulb. If your LW light makes your fluorescent minerals look dull or weak, it is time to replace your LW tubes.

Figure 1 shows that a new, polished filter at an SW wavelength of 254 nm has only about a 70% transmission (while the more common non-polished filters have only about 57% to 65% transmission), while the peak transmission of the filter is about 90% at 300 nm to 320 nm. Because the SW filter curve is so steep at 254 nm, it is very difficult to manufacture a filter with a high 254 nm transmission. Because the SW filters are made by a special process with expensive materials, the filters are very expensive, often about 25 times more expensive than LW filters.

BULBS (LAMPS)

There are three common sources of LW UV: the high pressure mercury arc bulb (lamp) (usually 100W to 175W or higher), which has a monochromatic wavelength at exactly 365 nm ("monochromatic" meaning that almost all the UV energy is at the one 365 nm wavelength), and two fluorescent bulbs or tubes that have LW fluorescent phosphors that emit primarily in the UV-A LW region. One of these two tubes has a phosphor that peaks at about 351 nm while the other has a phosphor that peaks at about 368 nm. These LW fluorescent tubes are called low pressure mercury arc lamps. Figure 2 shows their phosphor spectral distributions (the amount of energy emitted versus wavelength). In addition, the 351 nm and 368 nm bulbs are manufactured both with and without integral LW filters in the glass bulb. Tubes called "Blacklight Blue" by the lamp industry (or just "BLB" lamps) are LW fluorescent tubes that have an integral filter in the bulb envelope. They appear to look black when they are turned "off" and a deep blue when turned "on." Another type of fluorescent tube is the "Blacklight" or "BL" lamp. These do not have an integral filter in the bulb and appear white when "off" and bright blue-white when "on."

Although BLB tubes are sometimes used in some UV fixtures for fluorescent minerals, they are usually not recommended. This is because the visible light transmitted through the filter reflects off the specimen and mixes with the emitted fluorescent light of the mineral, giving you a false color for that specimen. This happens because the integral filters in the tubes are so thin that they are not dense enough to filter out most of the deep blue visible light (that's why they look deep blue when "on": you are seeing the visible light transmitted through the filter). If those BLB tubes are ONLY used for blue fluorescing minerals such as fluorite, then there is usually not a problem. However, if the minerals are ones that fluoresce red, yellow, or orange, the visual effect will be totally different and misleading under BLB tubes. For example, orange fluorescing sodalite, variety hackmanite, will have a <u>false pink color</u> under a BLB tube, but will look orange under a BL tube with an external LW filter (and orange is the correct fluorescent color). The visible deep blue light transmitted through the thin filter will reflect off the hackmanite and mix with the fluorescent orange, and the result is that your eyes see a false pink color.

Many collectors who set up fluorescent mineral displays know about the BLB tube problem, but not everyone does. *It is <u>not</u> recommended to use bare BLB tubes in a first class LW fluorescent display!*

Fortunately, you cannot get confused with SW UV light assemblies since they are all at a monochromatic 253.7 nm wavelength. The SW wavelength is often rounded out to just 254 nm. Because they have no phosphor on the inside of the tube, the SW tubes are clear when "off." They look blue when "on" but be careful not to glance at them for more than a split second (this is explained in more detail below). Although these common SW tubes are called germicidal tubes (lamps) and are primarily used for sterilization applications, these tubes are also used in most SW UV light assemblies. Almost all glass will absorb all SW 254 nm wavelengths, however, the germicidal tubes are made with a special glass that transmits about **65%** of the 254 nm wavelength. Except for a few exceptions, most SW UV light assemblies use the germicidal tubes. One exception is the UV SYSTEMS SuperBright 2000SW. It uses a "U"-shaped quartz bulb that transmits about **90%** of the SW wavelength (which is one of the reasons why the light is so powerful). While there are other sources (such as lasers, deuterium lamps, sun lamps, open arc, etc.) that produce SW UV, none of these are economically practical for use with fluorescent minerals.

It is very important to protect your eyes and skin from SW UV. Even brief exposure to SW UV can do temporary, but very painful, harm to your eyes. Never look directly into an SW light. Eye glasses will absorb the 254 nm wavelength and will give pretty good protection; however, for very powerful SW lights, UV goggles with side protection are suggested to prevent UV from entering by the side. LW light presents a different, harmless situation; it will cause your eye lens to fluoresce, which may seem uncomfortable, but no damage to your eyes or skin can occur from normal occasional LW UV exposure.

UV LIGHT

While there are several different wavelengths available in UV lamps, only a few are used for viewing fluorescent minerals. The UV lights as used for fluorescent minerals were once thought of as just two types of UV light, or two different wavelengths: –SW or LW. That is no longer true. There are at least three different LW or "Blacklight" wavelengths (as mentioned above), and several medium or midwave wavelengths. However, there is still only one practical SW wavelength.

About 4 years ago, some Fluorescent Mineral Society, Inc. (FMS) collectors discovered that the 351 nm peak LW phosphors in the some BL tubes will cause a different response in some minerals when compared to the 368 nm peak BL tube phosphors. This difference is not apparent for most minerals, but is quite dramatic in a few. The clear cleavage calcite rhombohedrons that come from Múzquiz, Coahuila, (sometimes labeled as from Nuevo Leon or Challenger Cave, Monterrey) Mexico, will fluoresce a bright blue SW with a very bright phosphorescence (you can almost read a newspaper from the afterglow). This is very similar to the calcite from Terlingua, TX. And under the 351 nm OR 368 nm LW tubes, the better specimens of Terlingua calcite will fluoresce the same color pink. While the Múzquiz, Mexico, calcite will also fluoresce pink under the 368 nm wavelength, it will fluoresce a distinctly different pale straw-white color under the 351 nm wavelength. The difference between these two fluorescent colors (pink and straw-white) is very distinct. The color photos show three Múzquiz, Mexico calcite specimens under: daylight; 368 nm LW (pink color); 351 nm LW (straw-white color); 312 nm MW (slight bluish-white color); and 254 nm SW (blue color). Figure 2 shows the relative difference in the spectral distribution of the 351 nm and 368 nm phosphors in the tubes and the monochromatic 365 nm wavelength of a high pressure mercury arc lamp.

Agrellite from Canada or Russia will fluoresce a unique magenta type color under SW, and will also fluoresce the same color under the 351 nm. However, under 368 nm it is almost non-fluorescent. These differences are also noted in hardystonite from Franklin, NJ. Under SW and 351 nm LW it will fluoresce deep blue, but under 368 nm it is very dull or almost non-fluorescent. There are many other specimens where the LW fluorescent color difference has been noted, but usually not as dramatic an effect as the Múzquiz, Mexico, calcite.

The Fluorescent Mineral Society is planning a research project to come up with some type of standard nomenclature that is hoped would be used by the major UV light manufacturers (e.g., Raytech Industries, UVP, Inc., and UV SYSTEMS) so that when a customer buys a LW UV light he or she will know if it has a 351 nm or 368 nm phosphor in the light's tube. The FMS research project is in the organizational stages now. Any such standard would, of course, have to be accepted by all the UV light manufacturers, so it may take some time before it becomes a reality.

The last UV wavelengths that will be discussed do not even have a uniform name [let along a uniform source (bulb or tube)]. Some wavelengths in the UV-B range are called medium wave or midwave (MW). The MW tubes (bulbs) are always fluorescent tubes that have a phosphor that peaks at about 312 nm (see Figure 1), 306 nm, or other wavelengths between 295 nm and 315 nm. These MW tubes are so new that there is no uniform phosphor wavelength being used for fluorescent minerals. Many of these MW tubes are used for special applications and, to be competitive, the different lamp manufacturers have developed different phosphors for MW. Making matters more complicated, some of the lamp manufactures blend different phosphors together to form a new spectral distribution. As many as 20 different phosphor combinations might be able to be used for a MW UV light! An MW UV light always requires an SW filter, and the MW bulb is costly, so MW light assemblies are not inexpensive. Figure 1 shows the UV SYSTEMS 15W replacement tube (model LMW-15) spectral distribution of the phosphor with a peak at 312 nm (this may or may not be typical of other 312 nm peak tubes). Some minerals will fluoresce a slightly different hue under one of the MW wavelengths than under 254 nm SW. One specimen that does show well under some MW lights is the new material coming out of the Purple Passion mine near Wickenburg, AZ. The MW light causes the calcite and willemite to fluoresce red and green, and it also causes the fluorite in the specimen to fluoresce blue-violet, making for a very striking three-color specimen.

CONCLUSION

UV lights for fluorescent mineral collectors are not the same anymore. New wavelengths such as medium wave and the available of new, more powerful lights make it important to think about whether you might want to upgrade your UV lights so your collection will be viewed and shown at it greatest potential.

OTHER READING AND INFORMATION

Fluorescent Mineral Society, Inc. is an international society with over 350 members in 43 states and 19 other countries. For more information contact the:

Fluorescent Mineral Society
P. O. Box 572694
Tarzana, CA 91357
or by e-mail at: DMitchell@compuserve.com

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