Ultraviolet (UV) Radiation Safety

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Compiled by Myung Chul Jo

Environmental Health and Safety
University of Nevada Reno

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1. UV radiation

UV radiation is invisible to the eye and it is non-ionizing form of radiation in the 100 nm to 400 nm wavelength region of the electromagnetic spectrum (see fig. 1). UV radiation is arbitrarily divided into UV-A (315 nm to 400 nm), UV-B (280 nm to 315 nm), and UV-C (100 nm to 280 nm). UV lasers are not covered in this section; please refer to the laser safety section for safety issues related to UV lasers.

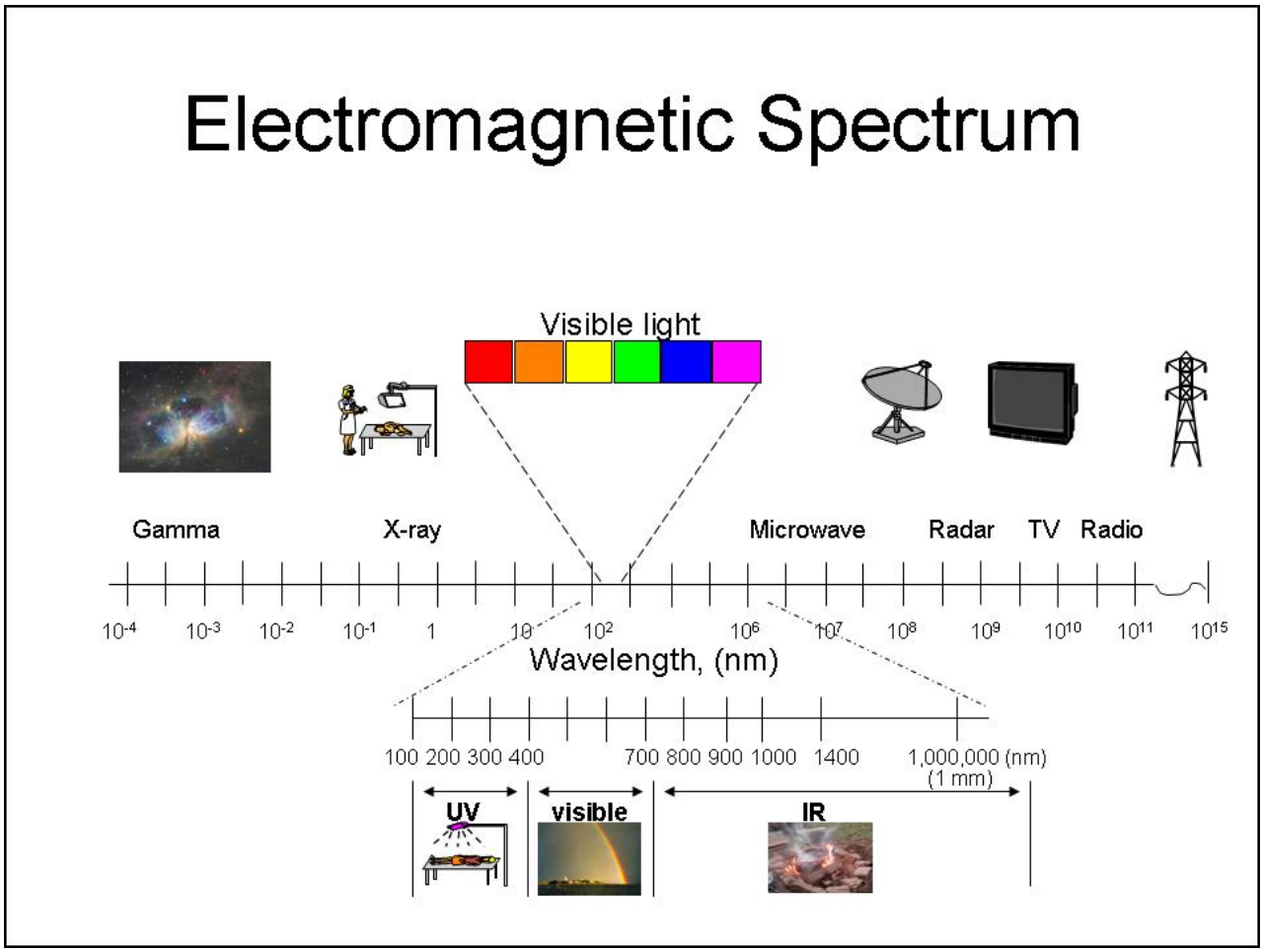


Figure 1. Electromagnetic spectrum

The ability of UV radiation to penetrate human tissue depends on wavelength. UV-A is the most penetrating among the UV groups and it can cause skin damage and cataract formation (see Fig.2). UV-B is the most destructive form of UV and it can cause erythema (sunburn) and corneal burn (see fig. 2). The UV-B erythema threshold is 1,000 times lower than the erythema threshold of the UV-A, and it is much more effective in causing damage to live tissue then UV-A. UV-C cannot penetrate the dead layer of human skin; however, it can produce corneal burn. UV-C kills bacteria and it is used in germicidal lamps.

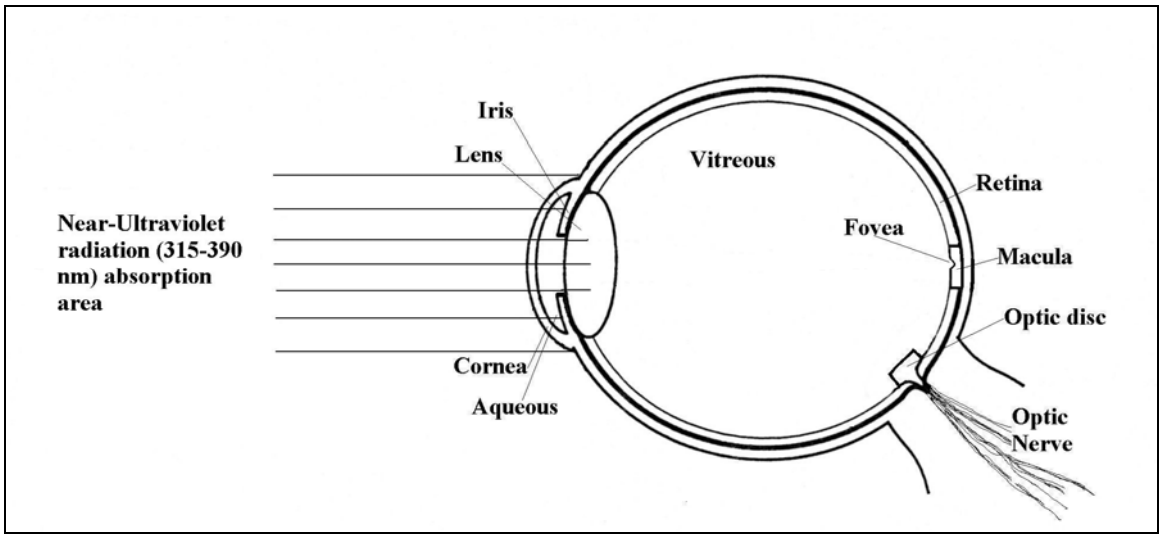


Figure 2. UV-A radiation absorption area

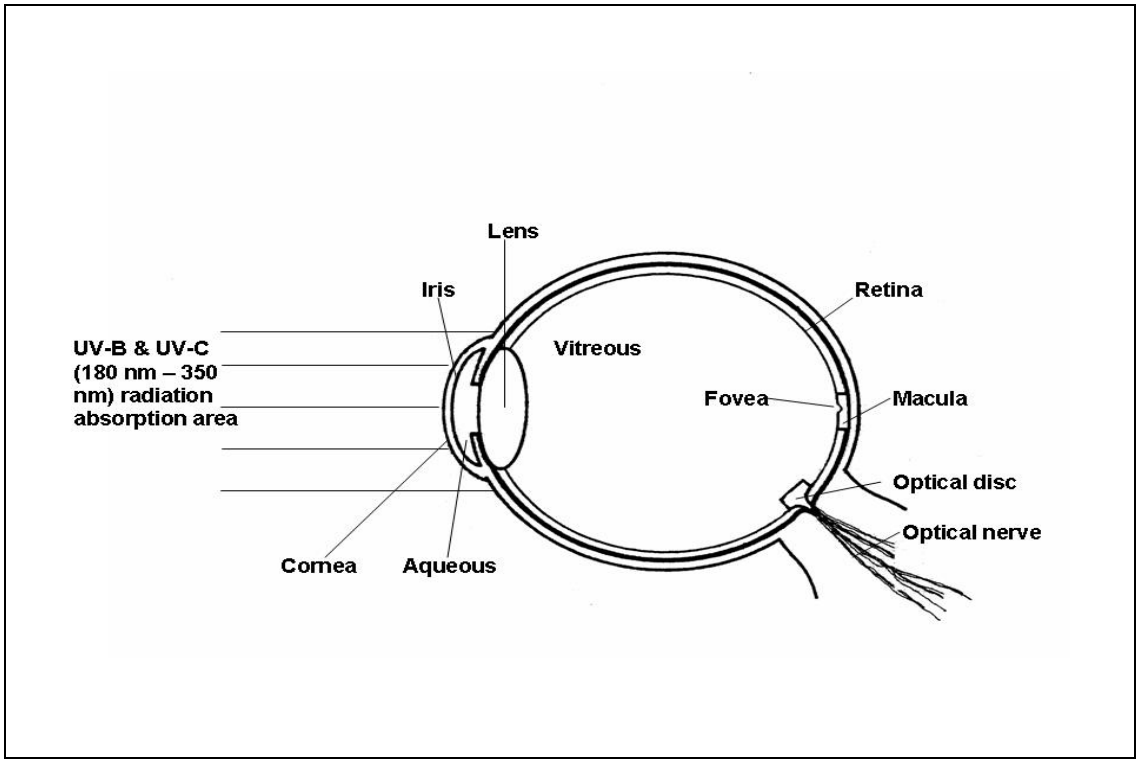
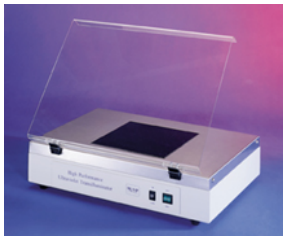


Figure 3. UV-B and UV-C radiation absorption area

2. Common sources of UV radiation in a research laboratory

Germicidal lamps, UV curing lamps, black lights, transilluminators, and crosslinkers are common UV radiation sources in laboratory environments (see fig. 4).

Crosslinker



Transilluminator

Germicidal cabinet

Figure 4. Common UV sources in laboratory

3. Hazards associated with UV radiation

The organs of the body which are affected by UV light hazards are the skin and the eye. Some drugs can enhance susceptibility to UV injury by increasing the person's photosensitivity. If a person works around UV radiation while on medications, the medication should be checked to see if it would make the person more photosensitive.

3.1. UV radiation eye hazards

The cornea and lens are the main areas of the eyes affected by UV radiation. Various components of the human eye are susceptible to damage arising from photochemical effects as a result of extended exposure to direct/reflected UV radiation. The UV wavelength is the determining factor as to which part(s) of the eye may absorb the radiation and suffer biological affects (see table 1).

Table 1. Absorption of UV wavelengths in the Human Eye

Wavelength	Cornea	Aqueous	lens	Vitreous
100 nm – 280 nm	100%	0	0	0
300 nm	92%	6%	2%	0
320 nm	45%	16%	36%	1%
340 nm	37%	14%	48%	1%
360 nm	34%	12%	52%	2%

The cornea is like the skin in that it can be "sunburned" by exposure to too much UV radiation. This is called keratoconjunctivitis (snow blindness or welders flash) and is a condition where the corneal (epithelial) cells are damaged or destroyed. This condition usually does not present until 6 to 12 hours following the UV exposure. Although very painful (often described as having sand in the eyes) this condition is usually temporary (a few days) because the corneal cells will grow back. In very severe cases, the cornea may become clouded and corneal transplants may be needed to restore vision. Exposure to UV-C and UV-B present risk to the cornea. The lens of the eye is unique in that it is formed early in human development and is not regenerated should it become damaged. For normal vision,

it is essential that the lens remains clear and transparent. Unfortunately, UV-A exposure is suspected as a cause of cataracts (clouding of the lens).

3.2. UV radiation skin hazards

UV radiation is a known carcinogen for human skin. In addition to cancer induction, erythema (sunburn), and skin aging are also known effects of ultraviolet skin exposure. Because the biological effects are dependent on the time of exposure, the specific UV wavelength, and the susceptibility of the individual exposed, it is considered prudent to prevent unnecessary skin exposure to UV sources. Elimination of unnecessary skin exposure is advisable since most individuals will receive substantial UV exposure from the sun during normal outdoor activities over a human lifetime.

4. UV radiation exposure guidelines

There are no regulatory UV radiation exposure limits. The American Conference of Governmental Industrial Hygienists (ACGIH) publishes Threshold Limit Values (TLVs), which are recommended exposure limits. The UV radiation exposure limits are wavelength dependant, ranging from 3 mJ/cm^2 to 100,000 mJ/cm^2. For UV-A (315 nm to 400 nm), the ACGIH recommends 1.0 J/cm^2 for periods lasting less than 1000 seconds, and 1.0 mW/cm^2 for periods lasting greater than 1000 seconds. For UV-B, TLV values are 3.4 mJ/cm^2 at 280 nm and 500 mJ/cm^2 at 313 nm. For UV-C, TLV values are 250 mJ/cm^2 at 180 nm and 3.1 mJ/cm^2 at 275 nm.

5. UV control measures

UV control measures in this section may not be suitable for all UV exposure circumstances. Each situation should be evaluated so that appropriate control measures can be implemented to prevent overexposure. UV control measures should be evaluated to ensure that they not creating other safety hazards.

5.1. Engineering controls

The preferred control method is the use of engineering control(s) to contain UV light. UV enclosures and interlocks supplied by the manufacturer must be used at all times. UV is easily shielded by opaque materials such as metal, wood, and cardboard. Polycarbonate material is also a good UV shield. Some types of clear glass may transmit significant amounts of UV-A radiation and should not be relied on for UV protection unless UV shielding is verified.

5.2. Administrative controls

Procedures should be developed to control and minimize UV exposure to personnel where engineering controls can not adequately protect personnel from UV exposure. UV exposure may also be minimized by limiting exposure time and

increasing the distance between personnel and the UV source. Prevent unauthorized personnel from entering the UV radiation area.

5.3. Personal protective equipment (PPE)

If engineering and administrative controls cannot protect personnel from UV exposure, PPE should be used. Commonly used PPE against UV are UV safety goggles, UV face shields, long-sleeved, tightly-woven clothing that covers much of the body, and gloves. Application of sun-screen with high sun-protection factor (>15) against UV-A and UV-B may provide some protection. However, the use of UV skin blocks is considered inadequate for protection against the high irradiance of man-made UV radiation sources.

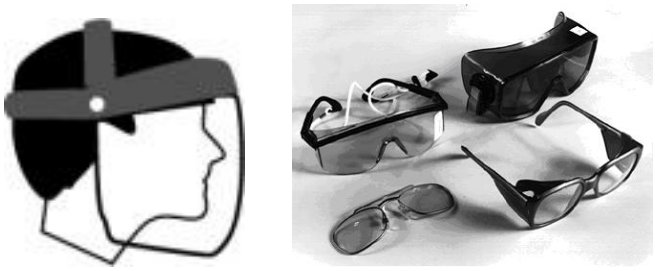


Figure 5. UV personal protective equipment

To protect the human eye from exposure to UV radiation, all that is usually needed is a pair of polycarbonate safety glasses or a polycarbonate face shield. This protective eyewear should be worn whenever there is a potential for ongoing UV radiation exposure. Contact EH&S for information and advice on appropriate UV protective eyewear.

Skin protection is not difficult, as most clothing tends to absorb UV radiation. Protection of the skin from UV radiation protection is best achieved though the use of clothing, gloves, and face shields.

5.4. Equipment and area label

Any equipment that emits UV radiation and the area where the equipment is located must have appropriate UV warning labels posted (see fig. 6). There is no standard UV warning label.

Figure 6. UV warning signs

5.5. Training

Personnel who work with UV radiation sources should receive UV safety training and they should be familiar with UV safety work practices and procedures. UV safety training can be arranged by calling EH&S at 327-5041.

5.6. UV radiation protection from the sun

Outdoor workers can minimize solar UV exposure by:

- Use of shade where practical
- Avoiding the outdoors when the sun is most intense, 11 a.m. to 4 p.m.
- Use of wide brimmed hats and long and tightly woven clothing to cover skin
- Use of sunscreen, minimum SPF 15 (sun-protection-factor)
- Use of UV blocking sunglasses

6. EHS services for UV safety

EH&S has equipment to measure UV radiation. EH&S provides, upon request, UV safety training, assistance in appropriate UV eye protection selection, appropriate warning label creation, and assistance in UV control measures Please contact EH&S at 327-5041 for more information or assistance.