New Studies Examine Safety of UV Curing for Fingernail Coatings

By Doug Schoon

Nail salon, professional-use only, UV artificial nail-curing lamps were recently evaluated in two independent studies and determined safe and not an actinic UV risk to skin or eyes under the conditions of use. Skin exposure is not continuous, but in short intervals (30-120 seconds), which is repeated infrequently (every two to three weeks). UV-A irradiance at skin exposure distance is very low, typically less than 1.7 µW/cm² of S(λ) weighted actinic UV. Bulbs used in nail salon lamps are spectrally different from lamps used for indoor tanning and are, therefore, different in both UV wavelengths as well as irradiance. Exposure is equivalent to receiving two extra minutes of sunlight exposure each day between salon services.

Editor's Note:

UV nail lamps are often used to cure gels. The UV gel system is an increasingly popular choice owing to its natural appearance, durability, flexibility and added high-gloss shine. In addition, the virtual lack of odor makes UV gel systems very popular in beauty salons.

In 2009, a MacFarlane-Alonso report, "Occurrence of Nonmelanoma Skin Cancers on the Hands After UV Nail Light Exposure," was published in the *Archives of Dermatology*. The report—based on an observation of two cases—noted that it may be worthy to investigate the potential health hazards of UV light applications in the beauty industry to examine if exposure to UV light may be a risk factor for the development of skin cancer. The cases involved two patients with skin cancer on their hands who had been to nail salons and had exposure to ultraviolet nail lights.

The nail salon industry recently commissioned two new studies to address concerns raised in that report. According to one of the latest studies, the MacFarlane-Alonso report was premised on an incorrect assumption that the irradiance of light produced by UV nail lamps is similar to that of tanning beds and that, in reality, UV nail lamps emit much less irradiance. In addition, the McFarlane-Alonso observations also did not take into consideration factors such as total time spent under each type of lamp; energy use versus UV exposure; and the multiple reflections of light within the tanning bed that add to UV exposure.

These new studies contend that a "fair examination of the facts supports that UV nail lamps are safe when used as directed and that brief client exposures are as safe as brief exposures to natural sunlight. Client hands are likely to be exposed to more UV light while driving their cars than they will receive from UV gel nail services." This article details some of the new studies' assertions.

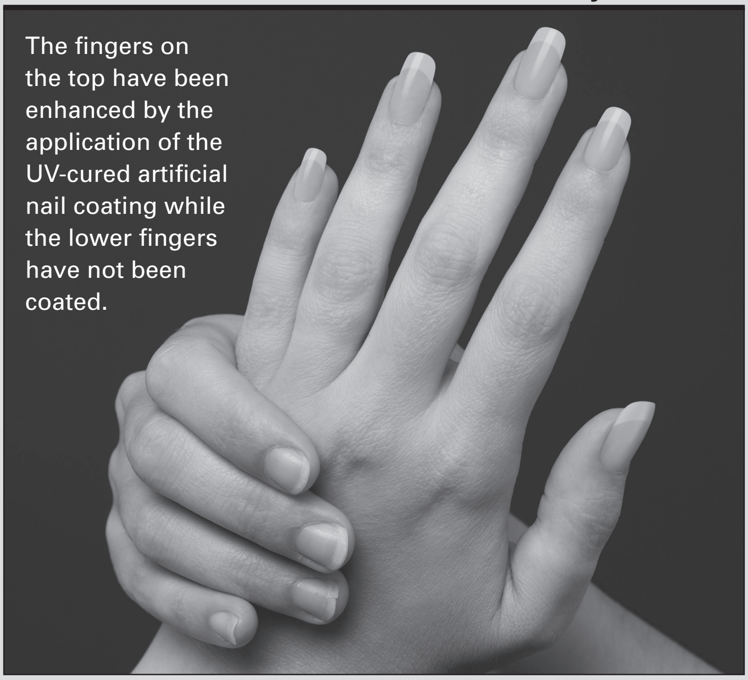
Discussion

Since the 1980s, throughout the world, UV nail lamps have been used to cure artificial nail coating formulations. Typically, three or four layers of the UV coatings are applied stepwise, using a small brush, to each finger on the hands. Each layer is cured between one to two minutes (or less) under a low-output UV nail lamp, utilizing either two, three or four nine-watt, florescent-style tubes. In some cases, these lamps utilize an array of low output, light-emitting diodes that emit in the UV-A region (UV-LED) that quickly cures each layer in about 15-30 seconds.

These nail services are performed every two or three weeks by trained professional nail technicians taught to heed manufacturers' instructions and precautions. Professionals use this coating application process to prevent the potential threat of adverse reactions due to uncured material. Each hand is exposed for less than 10 minutes per service and not continuously, but rather for one- or two-minute (or less) intervals per hand. During this time, the skin is

Figure 1

UV-cured artificial nails enhance and beautify the hands



never tanned or burned, even with regular use.

UV nail lamps have a long history of safe use and have been in use for this type of application for more than 30 years. Yet in the "Observations" section of the dermatology journal, McFarlane and Alonso raised concerns based on two patients (described below) with nonmelanoma skin cancers on their hands and suggested there could be a causative link between their conditions and exposure to UV nail lamps.

The first case involves a 55-year-old Texas woman who claimed to have had UV artificial nails applied for 15 years, twice per month. The second case involves a 48-year-old Texas woman who has a long history of "moderate recreational exposure" to sunlight and who received only eight UV nail services in one year—the total in her lifetime. The dermatologists concluded in their report that "it appears that the exposure to UV light is a risk factor for the development of skin cancer…and suggests that this observation warrants further investigation."

Flawed Calculations

Any conclusions drawn from only two patients—both who lived in sunny Texas and one who had practically no exposure to UV nail lamps—are suspect. These dermatologists erred further when they compared UV hand exposure in UV nail lamps to full body exposure in tanning beds, claiming that they were equivalent given the number and type of bulbs, as well as their wattage. Their conclusions were based mainly on the nail lamps' wattage rating, rather than on actual UV output.

These erroneous calculations caused the study authors to become needlessly alarmed and overly concerned with the safety of UV nail lamps. Had they measured the UV output in terms of wavelengths and irradiance, not wattage (a measure of bulb energy consumption), they would likely have reached an entirely different conclusion. Since the publication of their observations, no similar UV nail lamp-related cases have been reported in the literature.

In response to the McFarlane-Alonso claims, two independent scientific studies were commissioned by the Professional Beauty Association's Nail Manufacturers Council on Safety (NMC) to address these concerns as well as inaccurate information circulated by some media outlets regarding UV nail lamps (i.e., inappropriately referring to UV nail lamps as sources of "high-dose of UV-A" and/or incorrectly comparing them to UV tanning beds)—all based solely on McFarlane and Alonso's flawed calculations and erroneous comparisons.

The first study was performed by Lighting Sciences Inc. of Scottsdale, Ariz., which was asked to help put this issue in perspective by measuring the UV output of the two most widely used UV nail lamps available and comparing those UV wavelengths and irradiance to those found in natural sunlight.

The second study was performed by two internationally recognized experts in UV photobiology, Dr. Robert M. Sayre and his partner Dr. John C. Dowdy of Rapid Precision Testing Laboratories in Cordova, Tenn. Sayre and Dowdy were asked to perform a battery of tests based on the most current version of the ANSI/ISNA RP-27 standard, the "Recommended Practice for Photobiological Safety for Lamps." This standard, which has international acceptance, covers classification, labeling and informational requirements for lamps that emit energy in wavelengths ranging from 200 nm to 3,000 nm. The standard also examines and classifies sources according to their potential to create a hazard or risk for skin and eyes, as well as exposure of persons in the vicinity of the UV nail lamp.

Testing

The Lighting Sciences study used an Ocean Optics USB4000 spectrograph with a fiber-optic probe terminated by a cosine diffuser positioned to mimic the location of the upper surface of the hand while inside a UV nail lamp. With this configuration, Lighting Sciences measured the spectral irradiance in the wavelength band 250 nm to 400 nm, which encompasses both UV-A and UV-B. Two widely sold UV nail lamps were examined—one equipped with two nine-watt bulbs and the other utilizing four nine-watt bulbs.

It was previously determined that no UV emissions below 250 nm were observed; therefore, this study encompassed the entire range of UV wavelengths produced by these nail lamps. The results of this study indicate that UV nail lamps emit less UV-B than natural sunlight and no UV-C wavelengths. The amount of UV-B received during a 10-minute exposure under these UV nail lamps was approximately equivalent to spending an extra 17 to 26 seconds in natural sunlight each day. These UV nail lamps utilize special bulbs with internal coatings that filter out almost all UV-B.

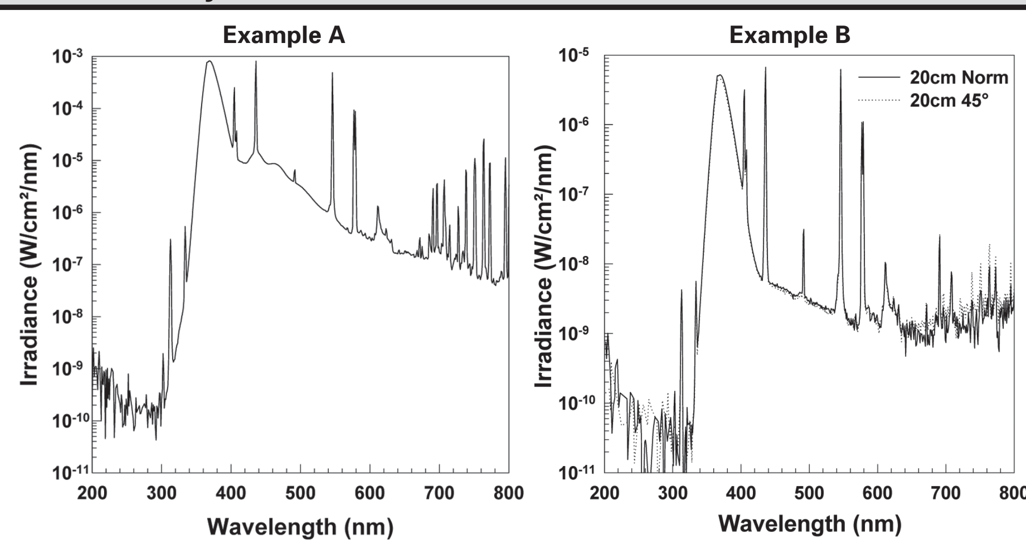
This study also determined that UV-A exposure is much lower than suggested by MacFarlane and Alonso. Lighting Sciences measurements demonstrate that UV-A exposures are approximately equal to 10-20 minutes natural sunlight, depending on whether the unit had two or four nine-watt UV bulbs. Since these exposures are not continuous and occur only twice monthly, this is akin to receiving 1.5 to 2.7 minutes of additional natural sunlight exposure each day. Unlike the sun, these lamps do not produce wavelengths below 340 nm and, therefore, have a better safety profile than natural sunlight. After obtaining this preliminary information, the NMC commissioned Sayre and Dowdy to make the necessary measurements to evaluate the photobiological safety of four widely used UV nail lamps.

Sayre and Dowdy used an Optronics Laboratory OL 756 spectral radiometer and a IL 1400A radiometer/photometer (IR meter) equipped with a thermopile or NIR detector, as appropriate, to measure energy beyond 800 nm. With this equipment and by following the ANSI/ISNA RP-27 standard, they measured the spectral output of widely used UV nail lamps. The data was used to evaluate seven risk groups associated with photo safety to include actinic UV, near UV, retinal thermal, blue light, aphakic blue light, cornea/lens, IR and low-luminance, retinal IR.

Because biological effects of UV energy are strongly wavelength-dependent, the efficiency of lamps to induce certain biological effects are best described by use of a spectral-weighting function. RP-27 utilizes a UV hazard-weighting function S(λ), which is a measurement of the combined

Figure 2

Irradiance plotted as a function of wavelength for two widely sold UV nail lamps with fluorescent-style bulbs



The background noise in these normalized spectra falling below the ninth decade is used to establish a baseline for measurements.

hazards for both skin and eye. To obtain these values, the RP-27 standard requires that a set of measurements be made at two distances—the approximate intended use distance ~1 cm (0.39 in) above the surface the fingertips rest upon directly below the UV bulb and at the 20 cm (7.87 in.) standard RP-27 required non-general light source distance from the opening of the UV lamp unit. There were 20 cm measurements made at two angles—directly in front and level with the opening (referred to as "normal" to the opening); and at 45 degrees elevated from that position to better simulate the light path in the direction of the face and eyes. This is closer than the typical maximum eye or face exposure distance of approximately 50 cm (24 in.) sitting with the arm extended.

Results

The spectra obtained when irradiance is measured at various UV wavelengths are shown in Figure 2. Example A shows two spectra typical of those obtained from UV nail lamps with nine-watt, fluorescent-style bulbs. The instrument background noise is seen in these spectra between the ninth and tenth decade. This area of the spectra is used to establish a baseline for measurements. When the semi-log scale irradiance spectra in Figure 3 are compared to the linear plot of irradiance versus wavelength (Figure 4), it is easy to see there are negligible emissions shorter than 340 nm. The background noise below the ninth decade is used to establish a baseline for measurements.

Some manufacturers use LED technology as their UV sources. In Figure 5, the semi-log scale and linear plots of irradiance versus wavelength are shown. Cure times are usually much shorter because the output from the LEDs have greater irradiance at the optimal wavelengths. Curing rates with LEDs are typically more than twice as fast when compared to fluorescent-style lamps (see Figure 6).

Table 1 outlines the actinic UV risk calculated for each lamp tested and shows how these values compared to permissible daily exposure and monthly accumulated percentage of the permissable daily exposures to UV energy. Risks are further reduced since exposure is not a daily or even weekly occurrence. The percent permissible exposure per month is an apt comparison since exposure to UV nail lamps occurs only twice per month or less. These percentages

Figure 3

Semi-log scale irradiance spectra

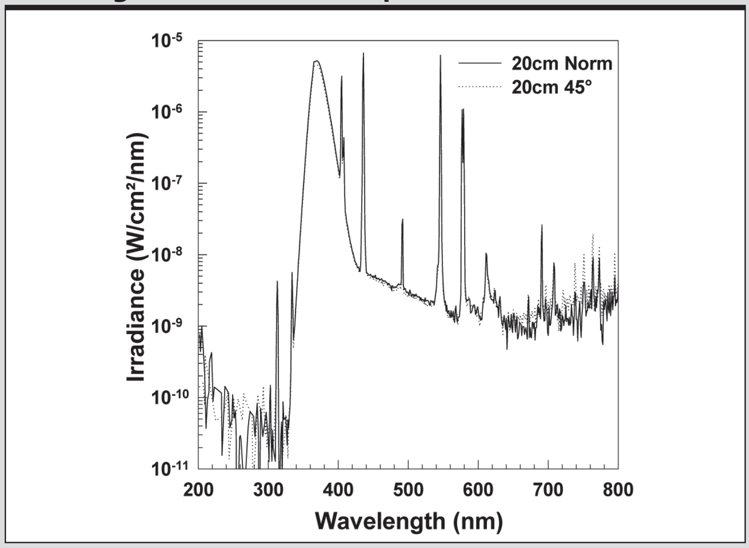


Figure 4

Linear plot of irradiance versus wavelength

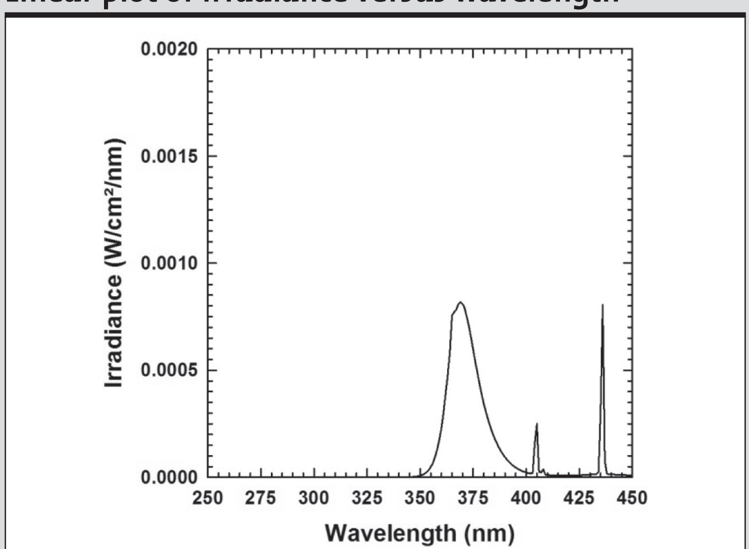
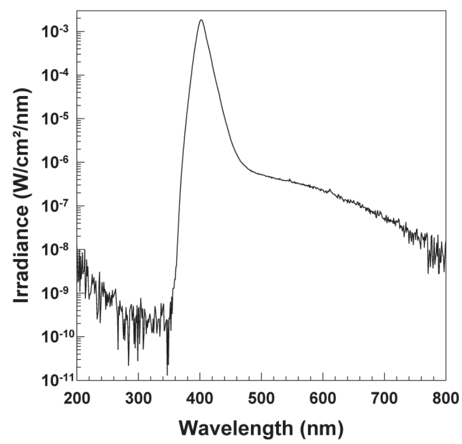


Figure 5

Irradiance plotted as a function of wavelength for a widely sold UV nail lamp with LED-style bulbs



The background noise below the eighth decade is shown to establish a baseline for measurements.

assume each hand receives 10 minutes exposure per nail service, even though exposures are typically six to eight minutes per hand (or less), depending on the manufacturers' instructions.

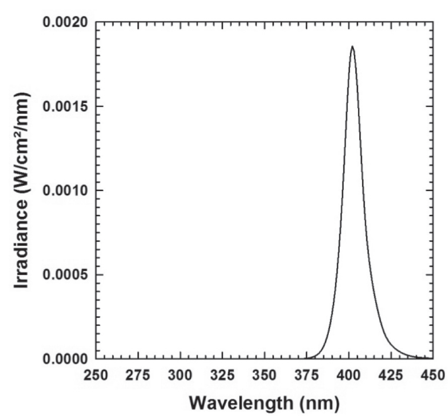
Under the ANSI/ISNA RP-27 standard, these lamps would be classified as "RG-2" or "moderate" risk, indicating that actinic UV output limits permissible exposure to 1,000 seconds or ~16.6 minutes of UV nail lamp exposure per day. RP-27 provides a suggested warning for devices in this category—"CAUTION. UV emitted from this lamp. Possible skin or eye irritation can result from exposures exceeding 15 minutes in a day. Use appropriate shielding." In the case of UV nail lamps, eyes are properly shielded from view and skin exposures do not exceed 10 minutes per day and occur only twice per month, or less.

Sayre and Dowdy also calculated several risk factors at 20 cm distance, including near UV, retinal thermal, blue light, aphakic blue light, cornea/lens, IR and low luminance, and retinal IR. In each case, the results indicate that the tested UV nail lamps properly belong in the exempt category for these potential risk factors, indicating negligible additional risks and, therefore, no additional warning required. Assessment of eye risks inside the device were not conducted, since these lamp unit assemblies are designed to prevent this type of exposure. It was noted that aphakic eye hazard (individuals implanted with non-UV blocking intraocular lenses) were also within the RP-27 exempt range. However, permissible exposure time for those with this type of unusual disability would approach the minimum for exempt category and at distances closer than 20 cm. Persons with this type of intraocular lens would be expected to enter the RG-1 (low risk) classification. In this case, simply wearing glasses or plastic eyeglasses normally produces adequate protection and eliminates the concern.

Sayre and Dowdy also commented on the Minimal Erythemal Dose (MED) and its relevance to this issue. MED is defined as the minimal amount of UV energy required to produce a erythemal response (just perceptible reddening of the skin), usually determined on the lower back after 24 hours. Interestingly, but not unexpected, skin on different parts the body become adversely affected by widely varying levels of exposures to UV energy, as shown in Table 2.[1] This data

Figure 6

Linear plot of irradiance versus wavelength for the same unit, which emits UV-A 1 energy and no emission shorter than 360 nm is detected



The background noise below the eighth decade is shown to establish a baseline for measurements.

Table 1

Actinic UV risk calculated

Risk	Lamp 1	Lamp 2	Lamp 3	Lamp 4
Actinic UV, S(λ), mW/cm^2	1.676	1.2-1.4	1.02	0.39
Percentage of permissible daily exposure	34%	28%	17.5%	7.7%
Percentage of permissible daily exposure accumulated per month	2.2%	1.9%	1.2%	0.5%

Actinic UV measured at intended use distance and shown as a percent of permissible daily and accumulated monthly UV exposure. It is important to note that exposure to UV nail lamps occurs twice monthly or less and exposures are unlikely to exceed 2.2% of the accumulated monthly exposure at permissible daily limits.

demonstrates that the back of the hand is highly insensitive to UV exposure and, therefore, the least likely part of the body to be injured when exposed to UV energy, thus providing an additional measure of safety where UV nail lamps are concerned.

As a result of this investigation, Sayre concluded that physicians are "grossly exaggerating exposures" and asserted that UV nail lamps are "safer than natural sunlight or sunlamps" and that these lamps "properly belong in the least risky of all categories." Sayre also explains that UV nail lamps used in salons have a UV-A bulb that is "vastly different from anything used for indoor tanning." UV nail lamps produce far less UV light with different ranges of wavelengths than tanning beds, so they are NOT equivalent.

Testing by Sayre and Dowdy confirms that UV nail lamps are NOT equivalent to tanning beds or indoor tanning lamps, largely because nail lamps use vastly different types of UV bulbs which produce different ranges of wavelengths with significantly lower intensities. Therefore, nail salon clients can expect that any hazard to skin or eyes from UV nail lamps under normal conditions of use is well below applicable safety limits. Of course, if nail salon clients are still concerned, they can wear SPF 15+ broad-spectrum sunscreen or cover the hand with cloth to further mitigate exposure.

Table 2

Minimal Erythemal Dose (MED)

Body Area	MED (Relative to lower back)
Abdomen	0.87
Chest	0.87
Back	1.0
Forehead	0.87
Cheek	0.87
Neck	0.91
Dorsal Arm	1.52
Dorsal Forearm	2.08
Lower Leg	3.26
Dorsum hand	3.48

The average of the MED is compared for various parts of the body relative to a 1 MED exposure to the lower back. This data demonstrates that the dorsum (back) of the hand is the least sensitive of any other part of the body to skin irritation or sunburn resulting from UV exposure.

Conclusions

Two independent scientific studies have verified that a collection of both fluorescent and LED-type UV nail lamps are safe as used in nail salons. When used appropriately and in accordance with all manufacturers' instructions, exposure to these UV nail lamps will not exceed acceptable safety levels. ◗

References

1. Olson, R. L., R. M. Sayre and M. A. Everett (1966) Effect of anatomic location and time on ultraviolet erythema. *Arch Dermatol* 93, 211-5.

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