IALD: Lighting Design and GUV Technology

As we navigate into a “new normal” and get a better grip on what business operations in a world transformed by COVID-19 look like, there are lots of questions and discussions on how to modify buildings and buildings systems to mitigate virus transmission and protect building occupants. One item that is being discussed with a great deal of interest is Germicidal Ultraviolet Lighting (GUV).

Listen to our leading experts, **Darcie Chinnis, IALD**, HLB Lighting Design; Dr. Robert Karlicek, Jr., LESA Center, Rensselaer Polytechnic Institute; and Dave Pfund, The Lighting Quotient, answer key questions about GUV technology, what the latest research says, the concerns/issues lighting designers need to consider, and what lighting designers should discuss with manufacturers and/or their clients.

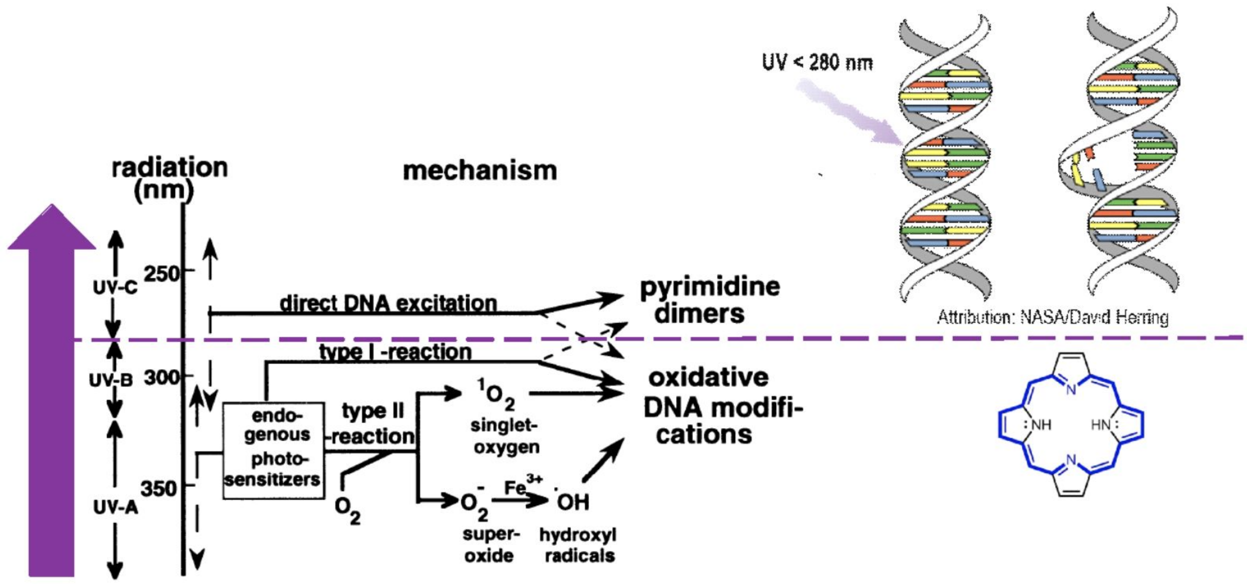
Q: How can the lighting design community participate in the GUV discussion?

A: CHINNIS The lighting design community is really focused on three main things: educating our clients so they can educate theirs, following the current research (which honestly gets updated it seems almost daily), and learning about the types of products and applications that have been traditionally used and what is rapidly emerging.

Q: How does GUV impact the virus from reproducing?

A: KARLICEK Let’s look at some of the molecular reasons for why UVC radiation is regarded as germicidal, and the lesser role in germicidal action for UVA and UVB portions of the UV spectrum.

Now this is a somewhat complex slide – but it helps show how UV radiation (and 405 nm light, which is almost UV radiation) perform various germicidal roles.



On the far left, you see the UVA, UVB, and UVC bands stacked vertically, with a purple horizontal dividing line between UVB and UVC radiation. Let's focus on the UVC part first: called direct DNA excitation. On the top right, you can see what happens when UVC energy is absorbed by DNA (or RNA). The radiation is energetic enough to break the bonds of the DNA, and those bond ends promptly loop into dimers—rendering the DNA unable to reproduce properly. **This essentially disables the microbe or virus from reproducing.**

Now lower energy UVB, UVA and 405 nm radiation can still be germicidal, but only when chemically assisted by reactive oxygen generating compounds that absorb the light to generate reactive oxygen compounds, which in turn attach proteins in the microbe to kill it. I say microbe, because all cellular pathogens contain compounds that absorb 405, UVA and UVB radiation to generate reactive oxygen species. Note that viruses are so simple a structure, that they do not contain ROS generating compounds, and thus are largely unaffected by 405, UVA or UVB radiation.

Simply stated, practical germicidal systems require UVC radiation—it is fast and effective. Other ROS mediated processes with 405, UVA and UVB are slow and not worth considering for viruses.

Q: How do we know it will work?

A: DAVE PFUND OF THE LIGHTING QUOTIENT That's an understandable question considering that we are used to flipping a switch and seeing a lighting effect, but with UV-C we cannot see what's happening, in fact if the source output is truly limited to UV-C radiation you can't even tell that the source is "ON."

But of course, it will work… because Bob Karlicek told us so when he said: "If a high enough dose is delivered to the DNA or RNA, UVC radiation will kill all pathogens." All kidding aside, this is, in fact, true.

And when it comes to COVID-19, we are talking about SARS-CoV-2 which is a coronavirus—an enveloped, positive-sense, single-stranded RNA virus nearly identical to the better-known SARS-CoV-1 virus. Early predictions based on genome suggested that there is less than a 1.5% difference in UV-C susceptibility between SARS-CoV-2 and SARS-CoV-1 and subsequent findings are confirming a close correlation.

Q: Can you comment on any existing research on the effectiveness of UV-C LEDs? For example, the IES has classified them as an experimental source.

A: KARLICEK The use of UVC LEDs as effective germicidal sources of UVC radiation is well established, and they are no longer properly regarded as only experimental devices. They have been shown to be effective against a wide variety of pathogens, including SARS CoV 2, and are finding their way into a variety of commercial disinfection products. The efficiency of UVC LEDs today remains at only about 25% of more commonly used Hg lamps operating at 254 nm, but their reliability is about the same as Hg lamps (typically at L70 of 10,000 hours). While they are still a more expensive UVC source than Hg lamps, their solid-state form makes them suitable for a much wider range of germicidal applications. Continuing research on the fabrication of UVC LEDs will continue to improve efficiency, lifetime and cost effectiveness, but they are already well established in the peer reviewed research literature for use in disinfection systems (particularly water disinfection systems) when part of a properly design UVC LED disinfection solution.

Q: What do designers need to move forward with designs and specifications?

A: DAVE PFUND OF THE LIGHTING QUOTIENT What is necessary for product assessment and application is much the same as you would require to execute a lighting design: a verified UV spectral characterization or UV spectral radiant flux report, and a corresponding UV radiant intensity report. The UV radiant intensity report typically consists of a polar plot and a database of intensity values in an .ies file format where intensity is reported in milliwatts per steradian. Together, like the spectral power distribution and photometric reports associated with luminaires, these provide the basis for design.

The UV spectral radiant flux report will confirm that the unit does produce UV-C (which tells us that it is capable of deactivating the virus), how much of the energy is delivered in the UV-C range, and what the peak wavelength is. And, like a photometric report, the UV radiant intensity report will tell you the intensity distribution so you can calculate the irradiance delivered to specific points much as you would calculate footcandles or lux. However, standard lighting design software typically only works with lumens which are related to the sensitivity of the human eye and will not work with irradiance power data. So, you will need to use a different calculation software—there are a few software programs available and more soon to come—or, you might need to rely on your manufacturer for calculations, at least for now.

Q: The GUV product landscape is new to most lighting designers. What should designers be looking for?

A: DAVE PFUND OF THE LIGHTING QUOTIENT Focus on trusted manufacturers that have done their homework and can help you navigate through the misinformation circulating in the market. In addition to their products and technology, they should also understand the design and application side of the equation. Choose a manufacturer known not only for performance, but also for quality and reliability—quality and reliability are part of the safety aspect. Often high quality and reliability come in part from the manufacturer working with suppliers that demonstrate the same high level of quality and reliability.

Q: Where are we likely to see GUV in use already?

A: CHINNIS Infection control, in general, can be thought of as the concerted effort to reduce pathogens in our environment. In today's COVID climate, we're often seeing infection control focused around disinfection of surfaces, everything from handrails to PPE. But many of the applications of UV have been based on other specific ways of applying UV that have been developed, tested and used for over a century.

The first known use of UV for water disinfection dates back over a hundred years, making it the most established application of this technology for killing pathogens. Upper air GUV was first deployed in the 1950s in hospital settings and was quite effective. But we saw it phase out around the 1970s as effective antibiotics became cheaper and more widely available.

Another tried and true application to note is integrating UVC lights into HVAC units to treat the air as it is being conditioned. We see this application typically as UV-C sources integrated at the cooling coils to help sterilize the air with the added benefit of reducing the buildup of bacteria and mold on the coils.

Q: What are considerations when bringing in GUV to new applications?

A: CHINNIS UV for disinfection is clearly not a new application. But in today's COVID climate, we're seeing UV touted as an option for helping to speed up our return to school, work, and the rest of pre-pandemic life. Lighting designers are often getting asked "How do I *DO* UV lighting?" even though we know it's not really light. As a design community, we're finding ourselves to be the resource for our clients who are trying to get a grasp on the technology—what is it, what does it take to do, what do I need to be careful of, and, basically, how do I do this?

So before leaping headlong into a UV application, there are two fundamental questions that a designer needs to ask that will help guide the application of UV: First, what type of pathogen needs to be controlled? And second, what actually needs to be disinfected?

Q: What are some of the promising new applications of GUV technology?

A: CHINNIS Some of these promising emerging applications for UV are essentially bringing those more traditional applications into new spaces types. Upper air GUV is a time-tested, tried-and-true method for air disinfection. It has historically been relegated to clinical settings like operating rooms, or congregate settings like homeless shelters.

Many of the discussions recently have been about other applications where upper air GUV would be a great fit. Places like gyms where you typically have a higher amount of air circulating in the space to keep people cool and reduce odors are already primed for upper air GUV. Places like airports or arenas, with large congregations of people, could also use upper air GUV as a method for controlling the risk of terror attack via microorganism—things like the use of weaponized anthrax.

Secondly, we're seeing full-time disinfection using 405 moving out of the clinical setting, where it's generally been relegated. Now the discussion is about integrating 405 into all sorts of non-clinical settings, like office spaces and schools.

Thirdly, the emergence of 222, or far UVC, as a full time disinfection source in all sorts of spaces is a very promising application.

Finally, we're seeing a very quick rush to market with devices that bring that 222 down closer to the surface it's disinfecting—things like portals or wands that can provide a higher dosing level by being closer to the object they're disinfecting.

But with this rush to market, there are some important safety issues to keep in mind, some of which Bob Karlicek addresses in the next response.

Q: We are all hyper-focused on GUV as a solution to COVID-19, but how effective would a wide GUV implementation be in combating seasonal flus and colds? Is it worth pursuing as a wider health initiative to reduce pathogens in our environment and ultimately reduce costs and burdens on the healthcare systems worldwide?

A: KARLICEK I believe that this will be a complex topic, because three considerations need to be balanced: (1) Risks and costs of GUV versus possible gains in reducing human illness due to microbes and virus, (2) Issues related to damage to the built environment with long term exposure to GUV radiation, with the possible generation of added particulate matter as organic materials in furniture and carpeting sustain UVC damage over long periods of exposure, and (3) indiscriminate damage to the microbiome that lives all around (and in) us and offsetting health issues related to that damage. Perhaps the biggest risk is that we use GUV technology indiscriminately without more research on some of these unintended consequences as opposed to doing a careful technical risk assessment and form and evidence-based strategy for the proper use and deployment of this powerful germicidal technology platform.

Q: Is there any public and/or private funding available for further development and research for GUV?

A: DAVE PFUND OF THE LIGHTING QUOTIENT During the early stages of the pandemic, The National Science Foundation began funding university research related to the rapid disinfection and reuse of N95 respirators. This was followed by funding for university research related to UV-emitting chemistries for germicidal/antimicrobial surfaces and airborne pathogens. Unfortunately, government funding for GUV research is extremely limited and many universities are struggling to sustain operations during the pandemic. Still, we continue to explore opportunities to participate in NSF funded university research.

View the full GUV webinar on IALD's YouTube channel

View the GUV presentation.