



SOURCE: LED Luks, European Manufacturer of Commercial, Architectural, and Industrial LED Luminaires

Creating a Healthier Indoor Environment Through Natural Spectrum LED Lighting

Lighting designers now have an LED light source that closely mimics the spectrum of natural sunlight

Since the development of artificial light sources, architectural lighting designers have sought to replicate the qualities of natural sunlight for indoor environments. As electric lighting sources evolve to include LED technology, lighting designers are focused on creating a light source that not only provides basic illumination, but also enhances human health and well-being. Part of this effort includes research involving the effects of LED lighting on human circadian rhythms through studies on how the brightness, duration, directionality, and spectral output impacts the way humans interact with light, and the measurement of these effects on them. Many of these studies indicate that properly-specified advanced LED lighting has similar effects on human circadian rhythms as natural sunlight.

Circadian Rhythms and the Effects of Blue Light

Human circadian rhythms function as an internal clock that governs the body's hormone levels and other biological processes, based on a 24-hour cycle. Over the course of evolution, human circadian rhythms have become aligned with the light and dark patterns associated with natural sunlight, typically stimulating activity during daylight, and sleep during darkness. The advent of artificial indoor lighting has disrupted the cycle of natural light by extending the hours of light exposure, and, in turn, has led to an increase in the observable effects that this disruption has on human circadian rhythms.

To minimize these effects, it is important to ensure that indoor light sources produce natural spectrum light that provides beneficial support for circadian rhythms – a term that is now known as “human-centric lighting.”

However, all human-centric light sources are created equal. For example, even if different sources of white light look identical to the naked eye, they may contain different levels of the crucial wavelength in the blue spectrum that triggers the body's hormonal response. The mechanism for this response is found in the eye's non-visual photoreceptors, which have been shown to influence human circadian rhythms. These intrinsically-photosensitive retinal ganglion cells (ipRGCs) respond to the blue wavelengths of the spectrum, and control hormonal balance, specifically the release of melatonin, serotonin, and cortisol – all of which are hormones responsible for the human “wake/sleep” cycle.

Thus, a truly human-centric lighting source must not only closely match the spectrum of natural sunlight, but it also must have the correct level of blue-wavelength light for the time of day. Specifically, exposure to bright residential indoor lighting sources with excessively high peaks of blue-wavelength light has been correlated to disruption in circadian rhythms, which can involve shorter sleep times, reduced sleep quality, and excessive drowsiness during daytime hours.

SunLike Series Natural Spectrum LEDs Enable Human Centric Lighting Design

In response to the need for truly human centric lighting, Seoul Semiconductor developed the SunLike Series natural spectrum LEDs – the first LED light source that closely matches the spectrum of natural sunlight. By lowering the blue-wavelength light “peak” typically used in conventional LED technology to achieve white light, SunLike Series LEDs have a spectral output similar to sunlight.

Introduced in June 2017, the SunLike Series natural spectrum LEDs represent an advance in LED lighting by combining the latest optical and compound semiconductor technology of Seoul Semiconductor with Toshiba Materials’ TRI-R® technology to produce light that closely matches the spectrum of natural sunlight. The SunLike Series LEDs have also achieved the highest level of eye safety certification from the International Commission on Illumination and RG-1 light source with no photo-biological risk.

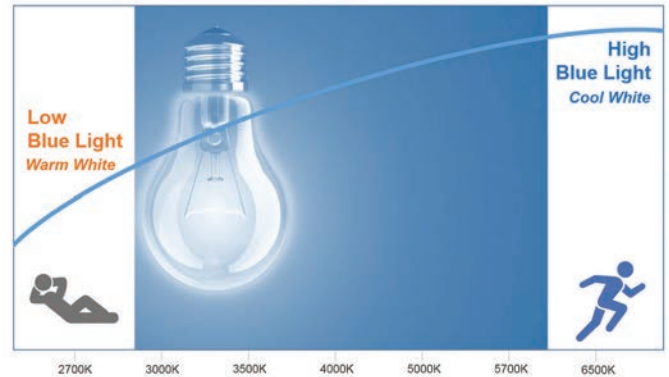
SunLike Series LEDs Selected for Light Quality in Special Illumination Projects

SunLike Series natural spectrum LEDs are optimized to the natural light spectra of the sun (CRI-100) with a color rendering index of CRI-97, which is significantly higher than the CRI-80 of conventional LEDs. This provides lighting designers with a light source that delivers vivid color rendering, texture contrast, and a more homogeneous quality of light.

Most artificial lights, such as fluorescent lights and conventional LEDs, exhibit light with a different spectrum from natural sunlight. The light output of those devices typically has a higher peak of blue light when compared to sunlight. Even conventional LEDs with a high CRI (Color Rendering Index) of 90 have a significantly lower color quality than natural sunlight. This oversaturation of blue light produces a scattering effect, causing distortion in the color of objects and making it difficult to accurately identify their contrasts.

SunLike LED technology, on the other hand, produces light with superior color quality compared with conventional LEDs, because the spectrum of SunLike LEDs closely matches that of natural sunlight. Conventional artificial lighting has applied the CRI that evaluates color quality based on fluorescent lamps. However, as LED technology advances, it has exceeded the color quality of fluorescent lamps. As a result, new standards of color quality scales (CQS) are being used. In particular, if the existing CRI was based on the mechanical measurement of color, CQS is characterized by the expression of natural colors that the human eye can perceive.

In the case of conventional LEDs, color rendering is high, but CQS is low. However, light produced by SunLike LEDs can achieve the best color quality in both color standards, such as color rendering and CQS because it has a 95%+ rating for both CRI and CQS.



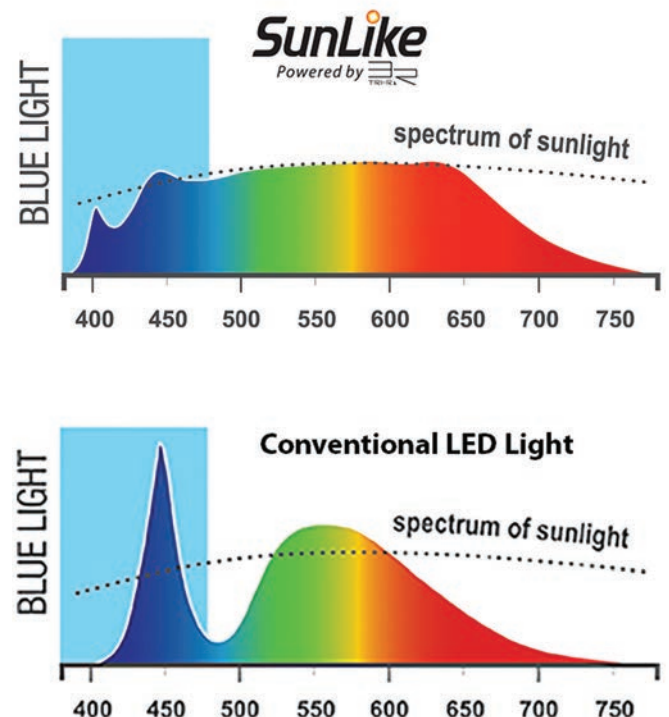
Effects of different concentrations of blue light on humans

Cold light with a high percentage of blue light has a vitalizing effect and promotes the release of serotonin and cortisol, while at the same time reducing melatonin. Physical fitness, mental performance, and vigilance are significantly increased.

Warm light with a very low percentage of blue [and a high percentage of red] does not suppress the release of melatonin, thus encouraging relaxation and regeneration.

Reference: "Healthy Light - LED Technology for Health and Care Applications," LED Professional, May 27, 2019

SunLike Series natural spectrum LEDs more closely match the spectrum of sunlight than conventional LED technology





SunLike Series natural spectrum LEDs illuminate wax figures in the Grevin Museum of Paris

The light output by the SunLike Series LEDs also reduces the light scattering, reflection, and glare common with conventional LED lighting, resulting in more accurate color and texture rendering of objects, similar to how they would appear in natural sunlight.

Illumination of Wax Figures in the Grevin Museum of Paris

Seoul Semiconductor's SunLike Series LEDs were adopted by French LED lighting manufacturer RAMO for downlight fixtures used to illuminate wax figures in the Grevin Museum of Paris. Since 1882, the Grevin Museum Paris has been a leading tourist attraction featuring exhibits of more than 200 wax figures, including movie stars, celebrities, historic figures, and politicians.

These downlight fixtures, with color temperatures of neutral white (3000K) and warm white (4000K), are designed to bring out the natural color tones of objects that are particularly color-sensitive, making the wax figure exhibits appear more lifelike to visitors, with vivid color, detail contrast, and uniform quality of light. Because the SunLike Series LEDs feature a lower blue light peak, their light output is similar to the spectral curve of natural sunlight with reduced reflection and glare.

Lighting for the Restored Murals in the Ancient Ruins of Pompeii

SunLike Series natural spectrum LEDs have also been adopted for a lighting project to illuminate the restored murals of the Casa dei Vettii in the ruins of

the ancient city of Pompeii, Italy. Because their light output closely matches natural sunlight, the SunLike Series LEDs convey the colors and textures of the restored murals accurately – as they would appear in natural light – providing a superior sense of depth based on high contrast ratio.

The lighting of the restored murals was undertaken by the premium lighting company Lumen Center Italia (LCI) technical lighting division, as part of the world heritage site restoration of the Pompeii ruins.

With the SunLike Series natural spectrum LEDs, Seoul Semiconductor provides the optimal selection of LED lighting for museums, art galleries, hospitals, and commercial spaces.

Recent Studies Show the Beneficial Effects of Natural Spectrum Lighting on Human Health and Well-being

There has been a significant increase in research activity on the relationship between light and human bio-functions, including a recent scientific study focused on the effects of light spectrum on sleep quality, visual comfort, overall well-being, and daytime alertness; encompassing the interaction of both visual and non-visual light on humans. The relatively new concept of human centric lighting encourages lighting designs that balance visual, emotional, and biological benefits.

Recent developments in evaluating buildings, such as the WELL Building Standard, assess these non-visual effects of indoor lighting in terms of

“melanopic stimulus,” which goes beyond conventional visual measurements of photometry and colorimetry. Melanopic stimulus measures the non-visual effects of lighting on the production of melatonin in humans.

Melanopic Stimulus Study Demonstrates the Benefits of SunLike Series LEDs

A recent study on non-visual melanopic stimulus of LED light sources conducted by Dr. Octavio Perez, adjunct researcher in Integrative Lighting at Mount Sinai Hospital in New York City, demonstrated that SunLike Series natural spectrum LEDs have beneficial effects on human health and well-being. The study results showed that the SunLike Series LEDs provided up to 21% higher melanopic stimulus than conventional LED lighting at color temperatures of 4000K. These non-visual effects are related to sleep quality, wakefulness, alertness, circadian rhythms, task performance, and mood.

Reference: “Become an Expert in Melanopic Stimulus Measurement & Improvement,” presented by Dr. Octavio Perez at Lightfair 2019.

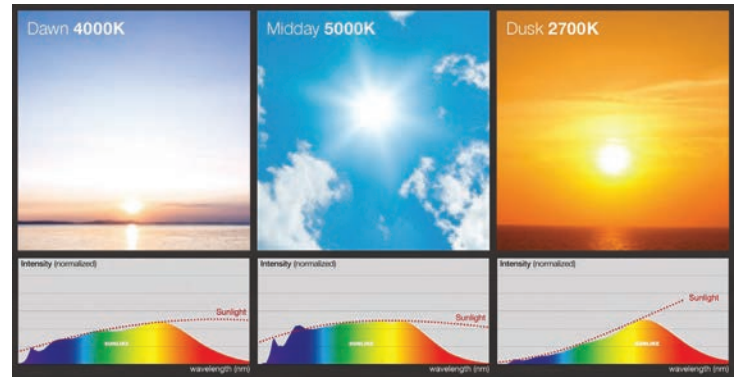
Natural Spectrum LED Study Shows Holistic Beneficial Effects on Human Well-being

Based on the results of a comprehensive sleep study conducted by Professor Christian Cajochen and his colleagues at the University of Basel in Switzerland, SunLike Series natural spectrum LEDs have been identified as a key light source for promoting human well-being. The study, published in the Journal of Lighting & Research Technology on March 24, 2019, found “evidence that a daylight [natural spectrum] LED solution has beneficial effects on visual comfort, daytime alertness, mood, and sleep intensity in healthy volunteers.”

According to Cajochen’s study, LED light sources with the same measured intensity and correlated color temperature (CCT), but different spectral output, can have different effects on human behavior and physiology. Moreover, study participants exposed to LED light sources with a spectral output close to natural sunlight experienced better visual comfort, more alertness, and improved moods in the morning compared to those

participants exposed to conventional LED lighting. The research study evaluated subjects’ visual comfort, circadian physiology, daytime alertness, overall mood, cognitive performance, and sleep quality after exposure to both conventional LED light and natural spectrum LED light for 49 hours in a laboratory setting.

Reference: “Effect of daylight LED on visual comfort, melatonin, mood, waking performance, and sleep,” by Professor Christina Cajochen, et al, The University of Basel, published in the Journal of Lighting & Research Tech, March 24, 2019



SunLike Series natural spectrum LED solutions follow the sunlight spectrum at different times during the day

By providing the same spectrum as natural sunlight in the visible light range, the SunLike Series LEDs deliver benefits to human health and well-being, consistent with biological mechanisms that impact both visual and non-visual aspects of the eyes, including control of circadian rhythms. While the qualities of artificial light sources have previously been characterized primarily in terms of color rendering index and light intensity, SunLike Series LEDs have expanded this characterization to include light spectrum as an important factor in determining overall light quality.

Seoul Semiconductor’s SunLike Series natural spectrum LEDs will enable a new architectural paradigm for human centric lighting for indoor design, with a light source that delivers the spectrum of natural sunlight to provide beneficial effects for human health and well-being.

**Natural Spectrum LED
for Human-Centric Lighting**



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