

# Bringing the Daylight Inside with Lighting Recipes

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## ABSTRACT

Our daily biological rhythm is synchronized to the 24-hour day on Earth, full of sunlight in the daytime and dark at night. Now that we are spending 90% of our time indoors, indoor lighting needs to adequately mimic sunlight to help maintain circadian rhythms, in addition to providing sufficient light for visual needs. Scientists have shown that light is a key signal for our body to function optimally and set our circadian clock to 24 hours to have a regular rhythm. Proper lighting indoors can help maintain this regular rhythm. Circadian lighting indoors should have the appropriate color temperature, spectral composition, brightness at the right time of day. There needs to be sufficient light stimulus during the daytime and a low level of light exposure in the evening and nighttime. Currently, the amount and type of light indoors in industrialized countries may be too low as reported by the International Commission on Illumination.

**Keywords:** Spectral composition; Nano-lit's circadian lighting; Light-Emitting Diodes (LED)

## INTRODUCTION

The spectrum of the light is also an important consideration as our circadian rhythm is most sensitive to the short wavelengths [1]. The brightness outside during the day is around 25,000 lux in full daylight, however light intensity in standard office lighting is ~50 times lower at ~500 lux [2]. Getting a sufficiently low amount of light at night is very important for our circadian rhythm and sleep, especially light with blue spectrum components. This is because our receptors are very sensitive to blue light in the evening and night-time hours, and even low levels of blue light can influence our clock by changing our melatonin levels (a night-time hormone that's produced when it's dark and prepares our body for sleep). At night, blue light between 440 nm to 480 nm is most effective for suppressing melatonin [3]. Light around 479 nm is most effective at stimulating melanopsin [4] and thus stopping production of a night-time hormone melatonin, which normally prepares us for sleep [5]. Blue light is a strong signal to our brain to heighten alertness, and increase our heart rate [6]. Even a small amount of the wrong type of light at night is strong enough to shift our rhythm and delay sleep. Light from LED screens block melatonin production at night [6]. Using a backlit e-reader 4 hours before bed compared to paper books increased the time to fall asleep, had less deep sleep, shifted the circadian rhythm resulting in the subjects feeling sleepy and not alerts the next morning [7]. Light in the evening can also lead to less deep sleep by changing the types of sleep you get during the night [8]. Screened devices used in the evening that emit 460 nm light

resulted in subjects going to bed later and lower melatonin levels in the evening [9]. Getting daylight during the day is associated with getting more sleep at night [10], having better quality sleep [10,11] and falling asleep faster [12]. Getting more blue light during the day protects from nighttime light-induced melatonin suppression [13]. Blue-enriched white light during the day leads to an earlier sleep time and faster time to fall asleep as compared to white light in subjects in Antarctica [14]. Getting daylight during the day is beneficial for sleep and circadian rhythms, and in turn better health and performance. It's important to note that the sun's light spectra are fairly broad in distribution. While artificial light allows us to light up the inside and appear white, the underlying spectral densities that compose the light are different and affect the circadian clock as well.

## LITERATURE REVIEW

### Nano-lit smart diffuser circadian lighting recipes

Nano-lit's lighting system allows us to improve our health, alertness and performance in our day to day lives. The lighting recipe has been developed in consultation with circadian lighting researchers and the circadian lighting industry experts. The dynamic lighting has a preprogrammed circadian recipe that changes the color temperature, brightness and the right type of light (correct wavelengths) at the right times of day over 24 hours. This ensures that there is sufficient light during the day, less light at night and that the wavelengths are tunes to the time of day (Figure 1).

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### Morning

Simulating the dawn colours in the early morning, the light becomes cool white and gradually gets brighter.

### Daytime

During the day from the morning to the late afternoon, the light is white and at the brightest point of the day. The light during peaks in brightness level and has a blue component in its spectra, to which our body is sensitive to and plays an important role in circadian clock regulation.

### Evening and night time

At dusk, the sun sets and the light gradually become redder. When it gets darker, the body makes the melatonin hormone in preparation for sleep. In the evening and towards the night, the light simulates sunset becomes a warmer white and less bright, with more orange-red components of the spectra and less of the stimulating blue light. During the night, the lights are a warm white, reddish color and dimmed to a low level. If the light needs to be turned on at night, the amount of blue light, that our body is so sensitive to, is very low (10% of the lights output bluecyan in the 2,500 K to 3,000 K colour temperature range in the evening) such that we are not disturbing our circadian rhythms in the middle of the night.

### Nano-lit lighting system light recipes

Nano-lit’s lighting system is flexible, allowing us to create different lighting recipes in many environments. Our lighting system is diverse, and can be used in a variety of environments including corporate offices, learning institutions such as schools

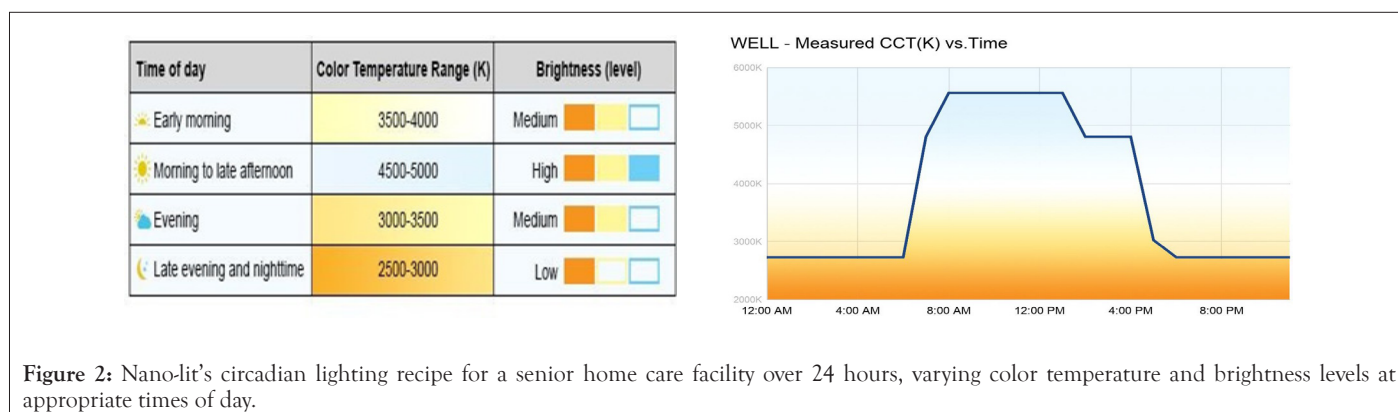
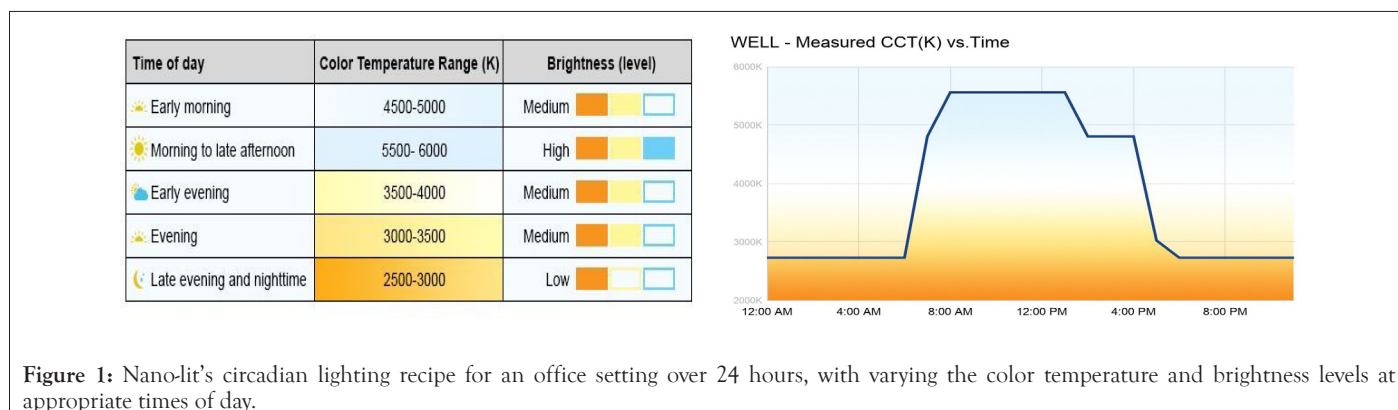
and universities, home care facilities, healthcare and hospitals.

### Home care facility

We have designed a lighting recipe for a home care facility in Figure 2. Older adults are more likely to have disrupted circadian rhythm due to deterioration affecting the circadian clock [15]. Improving lighting quality can help maintain circadian rhythms. Increasing daytime light levels in home care facilities for older adults has been associated with more daytime activity and better sleep quality [16,17], improved mood [16,18,] and agitation in dementia patients [16]. Improved lighting can also delay cognitive deterioration in patients with Alzheimer’s, with bright light reduced cognitive decline by 5% and depression symptoms by almost a fifth [18]. Getting bright light therapy can improve sleep and cognitive performance in elderly who do not have dementia or Alzheimer’s as well [19]. Improving quality of lighting in care homes for the elderly can strongly impact their health, sleep, cognitive performance, and overall well-being. The elderly often suffer from poor sleep which is then associated with a cognitive decline, worse physical and mental health and aggressive behaviour, improved lighting can help improve many of these factors [20,21].

### Health and sports facilities

Using tailored light recipes, health and sports clubs can give their clients an energy boost by having brighter lights in the evening extending the daylight hours to accommodate members working out in the late evening. The appropriate lighting can be achieved by extending the “daytime” settings of daylight color temperatures and high brightness levels later into the evening time.



## Shift workers

Different careers may require working on shifts throughout the 24-hour day. For example, corporate offices that often work with colleagues overseas on different time zones can have a recipe that matches the working hours of their overseas counterparts. This would mean having more bright light earlier in the day or later depending on the time zone shift needed. Individuals who work evening or night shift work such as factory workers, physicians, nurses, can have lighting recipes better suited to their “day”. If the shift starts in the late evening, the lights can be on a flipped schedule, having a “morning” brightness and color temperature setting when they start their shift and simulate day as it progresses while it’s night outside. This would create a schedule that provides the most light when the employee needs to be most alert and productive, and can help them adjust their day and sleep when they get home from work, even though it might be bright outside.

## DISCUSSION

### Longer dark evening environments

Those living in regions with dark evenings in the winter, have been using bright lamps at 2500 lux or more to suppress melatonin in the evening, given that we are a lot more sensitive to blue light, suggests that we can use blue light in the evening instead of just bright light for more effective treatment [5]. Our lighting system can be programmed to increase extended daylight and brightness to help extend daylight indoors aiming to reduce symptoms of seasonal affective disorder.

## CONCLUSION

Nano-lit’s lighting system allows to develop new lighting science-based recipes. Our lighting recipe is developed by researchers, based on the latest peer-reviewed scientific literature in the field of lighting and circadian rhythms. We actively collaborate with researchers from North America and Europe to validate our circadian lighting recipes and develop new ones in the field and in the lab, as our lighting system allows us to easily program new recipes as needed. Our light recipe meets industry-backed circadian lighting standards, we are WELL certified, and meet the daytime circadian UL standards as well.

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