

NICHIA Corporation  
White Paper

# Dynasolis™ Lighting Solution



# Nichia Dynasolis™ White Paper

## Dynasolis™ as a True Human Centric Lighting Solution

NICHIA CORPORATION

### Abstract

As more attention is being paid today to human centric lighting (HCL), many lighting manufacturers are looking into the functions of HCL in an effort to perfect circadian lighting designs. This paper provides important basic concepts of HCL as well as the effects of cyan light on human health and wellbeing. It explains distinct features of Nichia's Dynasolis™ and the study results for cognitive and physiological effects of Dynasolis™ lighting solution by Fraunhofer Institute for Building Physics.

### Effects of Cyan Light on Human Health and Human Centric Lighting (HCL)

Light has a significant influence on the human body. It is commonly known that exposure to blue light at night can be disruptive to sleep, due to suppression of melatonin production, a sleep hormone produced from serotonin in a region of the brain called the pineal body. Suppression of melatonin occurs when intrinsically photosensitive retinal ganglion cells (ipRGCs) in the human eye are exposed to shorter wavelength light, and it affects the human wake/sleep cycle.

While exposure to blue light can be harmful at bedtime, light in blue wavelengths, more specifically cyan light, is in fact beneficial at other times of the day when suppression of the sleep hormone is valuable, such as during office work, study, housework, etc. Being exposed to cyan light makes people more alert and attentive, improving concentration and productivity.

In the natural daily lighting cycle, the sun provides bright blue light in the morning, which stimulates the ipRGCs with its high content of cyan light. The daylight also has a high correlated color temperature (CCT) in the range of 5500-5800K, and the CCT gradually decreases through the afternoon, until it reaches approximately 2700K at sunset, where longer wavelengths (yellow-red) become dominant. ipRGCs are not sensitive to these wavelengths and thus are less stimulated as the sky gets dark in the natural lighting cycle. This lighting cycle has a great effect on human circadian rhythms, affecting

people's health and wellbeing.

Human centric lighting (HCL), also known as circadian lighting, mimics this natural daily lighting cycle to regulate the circadian rhythms. The visual element of color temperature tuning does play a major role in replicating the natural light cycle; however, as ipRGCs are stimulated by exposure to short wavelengths around the cyan region within light, tuning of a non-visual element, melanopic illuminance, is also crucial to design HCL that truly benefits circadian rhythms. In other words, good circadian lighting should be made up of both visual color temperature tuning that corresponds with the natural light cycle and non-visual melanopic illuminance tuning that can enhance ipRGC stimulation when and where it is needed. The key to create such circadian lighting lies in the spectral light distribution as it determines the proportion of cyan in the light as well as the CCT.



## Nichia's Dynasolis™ Lighting Solution

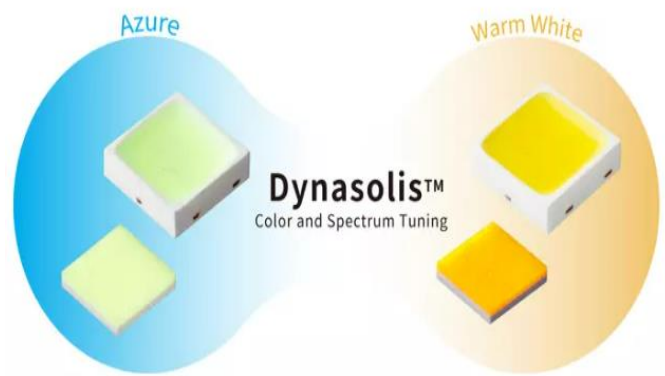
Nichia's Dynasolis™ is a completely new LED tuning solution that regulates human circadian rhythms by simultaneously adjusting melanopic illuminance and color temperature while maintaining the critical characteristics valued by the lighting industry, high CRI and high efficacy. The melanopic illuminance unit quantitatively captures the brightness affecting circadian rhythms. The higher ratio of melanopic light contributes to more secretion of serotonin, the "happy hormone" responsible for regulating the human body's internal clock.

Most existing human centric lighting systems mainly work by varying CCTs, but Nichia also focuses on the non-visual effect of light, the effect of the Melanopic Equal-energy Efficacy Ratio (MEER) on circadian rhythms.

The WELL Building Standard™ defines the requirements for equivalent melanopic lux (EML) of circadian light fixtures, as the product of the visual lux and MEER. The high MEER of Dynasolis™ helps circadian lighting designers meet those requirements and obtain a better score in this standard.

The Dynasolis™ lighting solution uses two separate LEDs: an azure-color LED with increased output at 480nm for an energizing effect and a warm white LED for a calming atmosphere. By tuning the color and melanopic illuminance of light using these two LEDs, Dynasolis™ provides the optimal color temperature and appropriate ipRGC stimulation from the morning to the evening.

One of the distinct features of the Dynasolis™ lighting solution is the high output of the azure-color LED at 480nm, which contributes to the high MEER of this lighting solution, even better than the standard light source (Figure 1). The 480nm light stimulates the secretion of serotonin and activates the human body and mind. When humans get sunshine, serotonin is secreted within the cerebrum, bringing many benefits such as proactivity, stable mental outlook and peace of mind, quick and flexible thinking, strengthened intuition, improved work efficiency, and reduced



errors. It also helps to reduce the reactive oxygen species in the body that leads to aging. The more serotonin secreted in the morning, the more melatonin, the sleep hormone, is secreted 14-16 hours later, using it as a source, contributing to a good night sleep. Thus, 480nm light is considered very important by having a twofold significance.

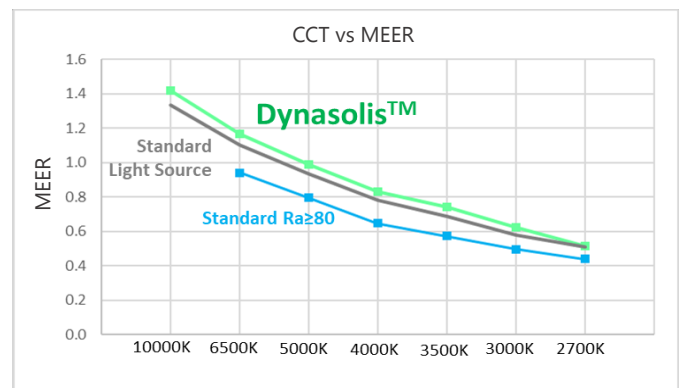


Figure 1: MEER of Dynasolis™ vs. Standard Light Source/CRI 80 LED

Figure 2 compares the spectrum of the Dynasolis™ lighting solution with a conventional color tuning solution. It demonstrates a significant difference in the 480nm area at the peak of the melanopic sensitivity curve between Dynasolis™ and the conventional solution at 6500K, as well as showing the wider tunable color range of the Dynasolis™ solution.

In addition to the abundant cyan light, Nichia's Dynasolis™ delivers light with both high CRI and high efficacy. Typically, these two features are in a tradeoff relationship, even though both are required for human centric lighting. Dynasolis™ has a CRI rating of 90 or greater while its IpW performance is almost equivalent to that of a CRI 80 LED. A balanced human centric lighting system is achieved with simply no loss in efficacy.

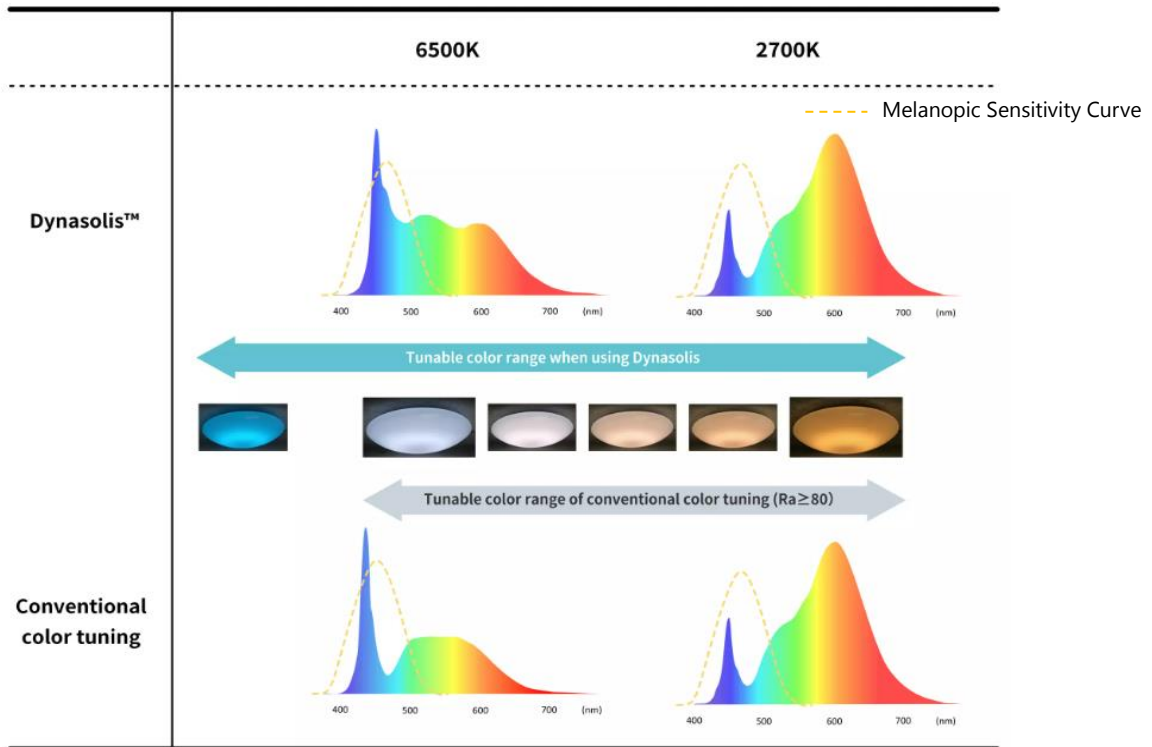


Figure 2: Spectrum Comparison between Dynasolis™ and Conventional Tunable Light

### Fraunhofer IBP Study on Cognitive/ Psychological Effects of the Dynasolis™ Solution

The Fraunhofer Institute for Building Physics (IBP), a research institute for building physics in Germany, carried out comparative tests between standard LEDs (2700K, 4000K, and 6000K, each with CRI 83+) and the Dynasolis™ solution at color temperatures of 2700K, 6000K, and 10000K. The tests were designed to analyze the cognitive and psychological effects of different light color temperatures and spectrum on approximately 35

test subjects per test series, which included evaluating how the light can impact alertness, attention, and relaxation. The subjects' alertness was assessed with an AuReTim test, in which subjects were asked to press a button when they heard a beep from the headphones they wore during each test light. For attention evaluation, a Stroop test, a commonly used attention task, was used to evaluate the subjects' concentration, and a PANAS (Positive and Negative Affect Schedule) test to determine their stress level. Figure 3 shows the sequence of each test series and lighting conditions.

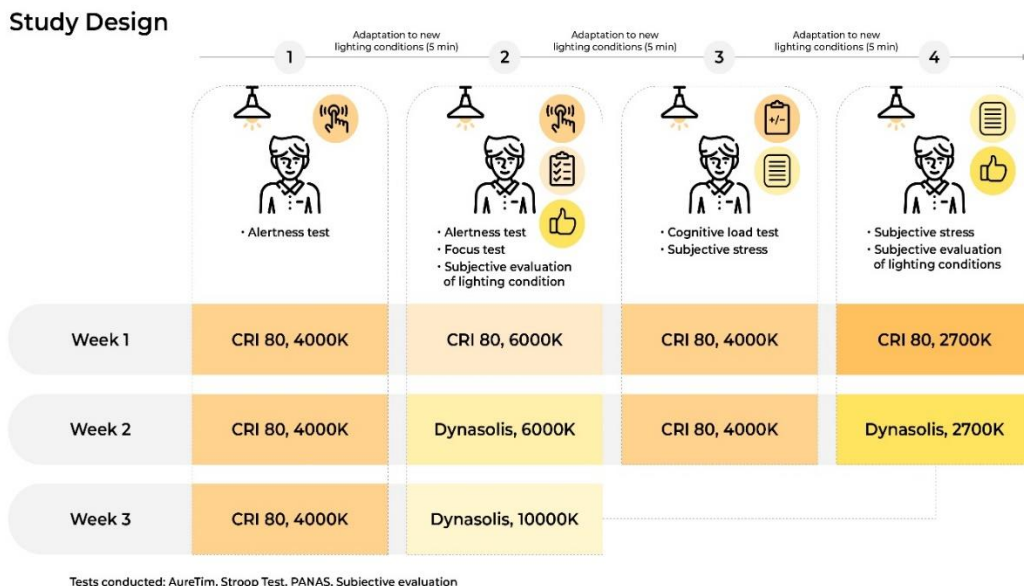


Figure 3: Fraunhofer IBP Study Design



The Stroop test was carried out to evaluate the different effects on attention between the standard LEDs and the Dynasolis™ solution. Here, the subjects were asked to read for example the word “green” but written in red (subjects are supposed to say “red” in this case). The test revealed significantly shorter reaction times of the subjects when conducted under the Dynasolis™ 6000K solution when compared to the standard LED with no cyan at the same color temperature (Figure 4).

There were also clear differences between the Dynasolis™ variations with an increase of cyan, with subjects responding faster under Dynasolis™ 10000K than Dynasolis™ 6000K. These results suggest a clear advantage of Dynasolis™ solutions over the standard CRI 80 LED in enhancing people’s attention as well as the great impact of cyan light on attention.

In the alertness test, the study established that alertness is directly impacted by the color temperature, regardless of whether it is the standard LED or Dynasolis™ solution. The test subjects were more alert when exposed to a color temperature of 6000K when compared with exposure to a color temperature of 4000K.

To test relaxation potentials, subjects were first placed in a room with standard 4000K LED, where they were allowed to acclimate to the light for five minutes. They were then placed under stress for 7 minutes with a cognitive task (mathematical test). The stress level was determined with a PANAS test, which was followed by a five-minute

relaxation phase under new lighting conditions (standard 2700K LED in the first test series and Dynasolis™ 2700K in the second test series) with stress levels then being determined again by the PANAS test. The results showed that the subjects were more relaxed under 2700K than under 4000K regardless of the standard LED or Dynasolis™ solution and that they were as relaxed under 2700K Dynasolis™ as they were under the 2700K standard LED with no cyan. The subjects' subjective assessments of factors such as comfort, attractiveness, or suitability for work were also comparable. This is presumably due to the reduction in 480nm output in the Dynasolis™ solution when it is not needed at the low CCT.

The results of the Fraunhofer IBP tests clearly show the advantages of the Dynasolis™ solution. The tunable Dynasolis™ can provide equal or better results in the different phases of human lighting needs than a variety of standard LEDs. This is due to the color temperature tunability and melanopic illuminance tunability which is unique to Dynasolis™. In particular, the attention tests revealed significant improvements in reaction times of the subjects under Dynasolis™. The good performance with regards to relaxation enables Dynasolis™ for a full spectrum of applications. For example, in hospitality applications, guests can find anything from a good place to work to a place to recover after a long day. With Dynasolis™, it is possible to install circadian lighting that has the optimized color temperature and spectrum as applicable to the setting.

### Stroop test: line color/word conflict

Friedman test,  $p < 0.0001$

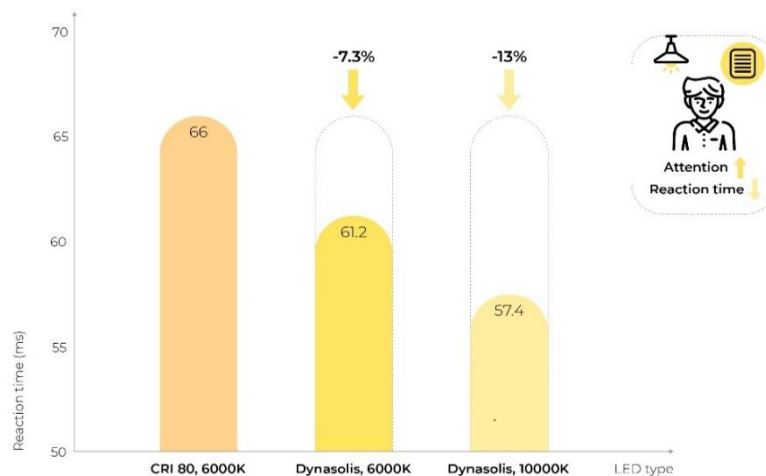


Figure 4: Results for Attention (Stroop Test)

## Why do we need Dynasolis™?

As more and more people are aware of health and wellbeing in today's society, it may not be so far away for human centric lighting to become the mainstream of the lighting industry.

Dynasolis™ checks off all the requirements for human centric lighting: color temperature and melanopic illuminance tuning, high MEER, high CRI, and high efficacy.

A unique feature of Dynasolis™ is to support the optimization of circadian rhythms by adjusting both the color temperature and the amount of azure-colored light that vitalizes humans.

Waking up with an azure color and being exposed to plenty of light with 480nm energy, which is abundant in the morning sun, stimulates the secretion of serotonin and leads to the normalization of the circadian rhythm. Later, during daytime activity hours, the color temperature is lowered to deliver light in CCTs of natural daylight to improve alertness and maintain concentration. From the late afternoon, the light is gradually changed to a warmer CCT, which is calmer and more relaxing, allowing people to relax, feel more comfortable, and sleep more smoothly (Figure 5).

Nichia believes that Dynasolis™ is the true human centric lighting solution that can support people's health and wellbeing and expects it to be used to meet the society's needs for such a solution.

### References

NICHIA Corporation (2022), *Fraunhofer IBP study confirms the performance of Dynasolis human centric lighting solution*, [Press release]

Menno Schakel (2020), *ipRGC sensitivity optimized LED spectrum and its application in colour temperature tunable solutions*

Menno Schakel (2022), *Improve alertness, focus and comfort with biologically effective light*

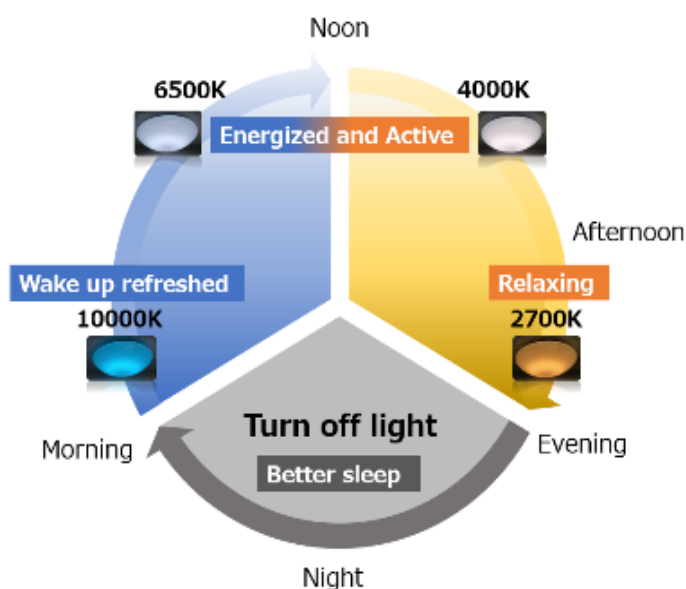


Figure 5: Dynasolis™ Color Tuning in a Day