UNLOCKING BETTER DIGITAL EXPERIENCES:

TCL's NXTPAPER as a Solution to Blue Light Concerns

TCL NXTPAPER
Full-color Electronic Paper Display

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Introduction

In this whitepaper, we will explore the growing concerns associated with blue light and screen glare emanating from our digital devices. As our reliance on digital screens for work, education, and entertainment increases, the impact on our visual comfort and overall health has become a critical issue.

We offer an in-depth examination of TCL's NXTPAPER technology – a solution specifically designed to address these challenges. Focusing on harmful blue light reduction and anti-glare properties, we will delve into how the technology works, its development, and why it represents an unmatched option for individuals . With robust TÜV, SGS and Eyesafe certifications to back its quality, TCL NXTPAPER stands out as a significant innovation in screen technology.

The goal of this paper is to provide a thorough understanding of the issues related to blue light and glare, and to demonstrate how TCL NXTPAPER offers a viable solution. We will also discuss how TCL can leverage this technology in their operations or product lines. Ultimately, we aim to present a clear view of how TCL NXTPAPER can improve digital experiences, enhancing user comfort and health in our increasingly screen-dominated world.

Understanding Blue Light

Blue light is a fundamental component of the visible light spectrum, detectable by the human eye within the 380 to 500 nanometer range. It has the shortest wavelength and the highest energy among all visible light, comprising of about one-third of all visible light.

However, not all blue light is equally impactful. Certain wavelengths can significantly affect our health, particularly our vision and sleep patterns. Medical journals[1] identify that most wavelengths range.

The widespread use of digital devices has led to an increase in screen time usage, directly adding to our exposure to harmful blue light. Recent reports indicate that on average, people spend about 6 hours and 37 minutes daily in front of digital screens, with even higher averages among Gen Zs(aged 6-24).[2]

The surge in exposure to harmful blue light is associated with several health issues. Studies[3] have shown that prolonged exposure can result in digital eye strain, also known as computer vision syndrome. This syndrome is characterised by symptoms such as dry

[1] Source: Phototoxic Action Spectrum on a Retinal Pigment Epithelium Model of Age-Related Macular Degeneration Exposed to Sunlight Normalized Conditions - Published: August 23, 2013 - https://doi.org/10.1371/journal.pone.0071398

[2] Source: Screen Time Trends in The Age of COVID-19 – Published: June 8th 2021 - https://simpletexting.com/blog/screen-time-survey/

[3] Source: Prevalence of computer vision syndrome: a systematic review and meta-analysis – Published: 31 January 2023 - https://www.nature.com/articles/s41598-023-28750-6

eyes, headache, and blurred vision. More concerning, however is its potential to contribute to macular degeneration[4] a leading cause of vision loss.

As said, blue light plays a crucial role in regulating our circadian rhythm(body clock) which regulates our sleep patterns. The beneficial blue light range (455-500nm) is essential for maintaining this rhythm. However, excessive exposure to harmful blue light, especially in the evening, can disrupt our nature [5], leading to decreased sleep quality and various other health complications.

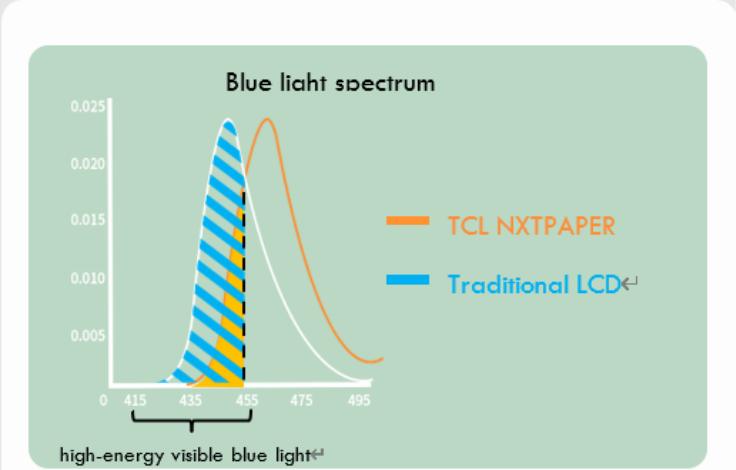
As our world becomes increasingly digital, the issue of blue light emissions and its effects on our health and well-being has emerged as a significant concern. As a result, the demand for technologies that mitigate these effects has never been more urgent This leads us to the need to development innovative solutions such as TCL's NXTPAPER technology.

TCL NXTPAPER: A Technological Response to Harmful Blue Light and Glare Issues

Addressing eye health within the realm of display technology has become imperative in today's digital world. As highlighted above, one of the most pressing challenges is exposure to blue light. There is a clear need for a technological solution that effectively manages blue light while maintaining excellent visual quality.

TCL's NXTPAPER technology steps in to meet this challenge. As a combined hardware and software solution, the TCL NXTPAPER introduces an innovative approach to managing harmful blue light emissions in electronic displays. Its goal is to enhance safety and comfort during prolonged screen use without compromising the user experience.

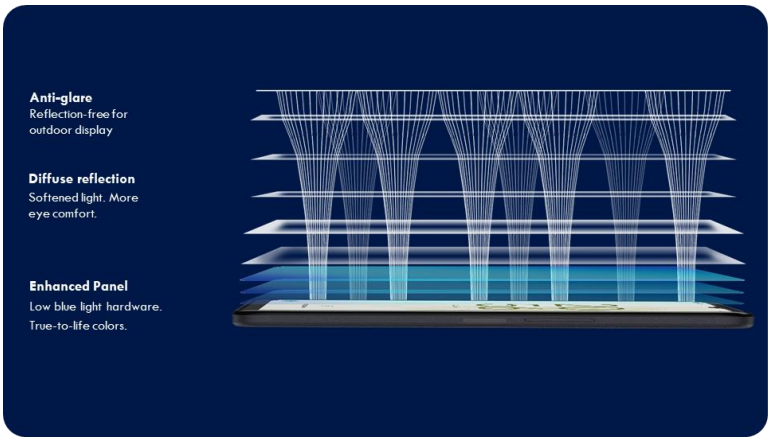
[4] Source: How blue light affects your eyes, sleep, and health – Published: AUGUST 03, 2022 - https://health.ucdavis.edu/blog/cultivating-health/blue-light-effects-on-your-eyes-sleep-and-health/2022/08
[5] Source: How Blue Light Affects Your Sleep – Published: November 16, 2022 - https://www.webmd.com/sleep-disorders/sleep-blue-light



	TCL NXTPAPER display	Traditional LCD
Hardware anti-blue-ray	√	×
Software anti-blue-ray	√	√

The core of TCL NXTPAPER technology is that it fine-tunes the LED blue light spectrum, shifting the blue light peak to the safe band of 457~462.5 nm. As shown in the ratio of the orange area to the blue area, within the harmful blue light band (415nm ~ 455 nm), the proportion of harmful blue light in TCL NXTPAPER has decreased by 61% compared to traditional LCDs[6](Liquid-Crystal Displays). This technology not only effectively avoids the ocular hazards brought by short-wave blue light (415nm ~ 455 nm) but also ensures that colors are not distorted.

More importantly, this reduction does not impact the [beneficial blue light that is essential for human circadian rhythm regulation][7], thus ensuring a balance between user safety and comfort.



6 *Testing data is from TCL's internal display lab*

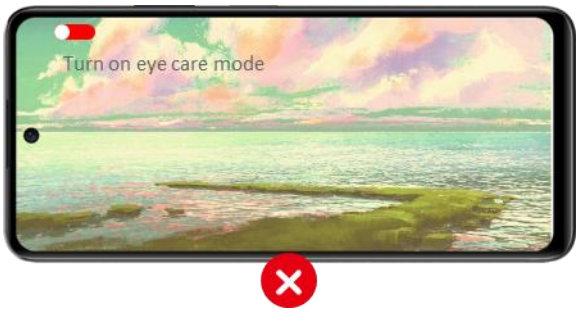
7 Source: The inner clock—Blue light sets the human rhythm – Published: 2019 Dec; 12 - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7065627

Beyond managing blue light wavelengths, TCL NXTPAPER technology also incorporates a muti-layer Eye Protection technology which ensures a comfortable viewing experience in various lighting conditions.

- Surface Layer: Anti-Glare
  This layer features an anti-glare treatment which eliminates reflections, making it ideal for reading outdoors.
- Middle Layer: Diffuse Reflection
  This layer utilizes diffuse reflection to soften light emissions, enhancing overall eye comfort.
- Bottom Layer: Enhanced Panel
  This layer introduces an enhanced panel that was specifically designed to lower blue light emissions at the hardware level; providing a safer, more comfortable viewing experience.

Besides blue light management, TCL's NXTPAPER technology also meticulously maintains the balance among the primary colors:red, blue, and green. This careful balance preserves the visual integrity of the display, preventing any shift towards a yellow hue and thus maintaining the original color temperature.

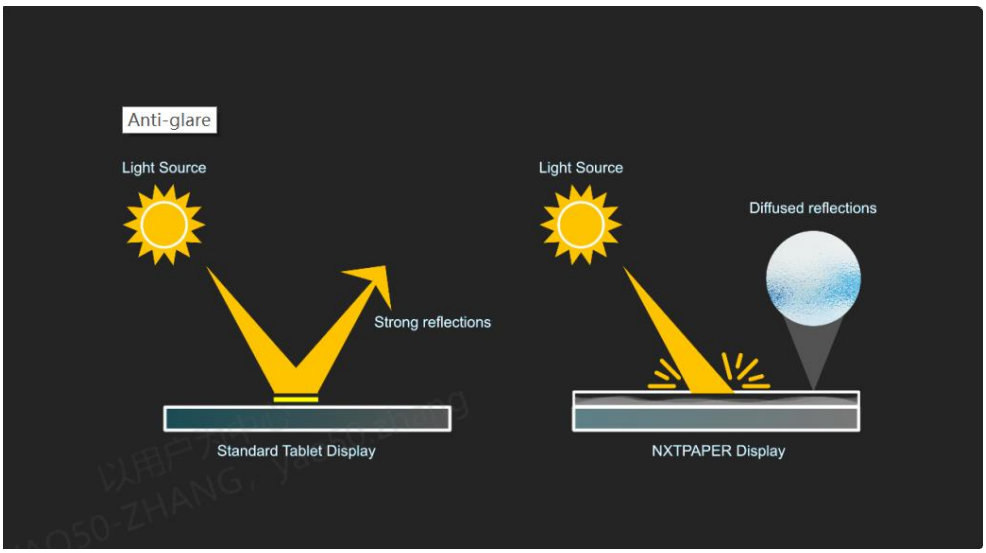
NXTPAPER display with hardware-level low blue light



Software low blue light

Anti-Glare Nano-Etching Technology

In addition to the advanced blue light management previously outlined, TCL NXTPAPER also incorporates Anti-Glare Nano-Etching Technology which produces a paper-like matte effect texture to the device and provides resistance. The Nano-Etching process scatters the internal light source and diffuses reflected light, ensuring optimal readability even under bright outdoor lighting.



Building upon its robust Anti-Glare capabilities, the TCL NXTPAPER technology excels in bright outdoor environments. This nano-level surface roughness generates a matte-like texture, akin to traditional paper, allowing the device to ensure the integrity of clear and comfortable visuals, regardless of any external environmental factors.

The further enhancement of TCL's NXTPAPER in outdoor settings is an engineered visibility enhancement technology which optimizes the display to deliver clear visuals under conditions of excessive brightness.

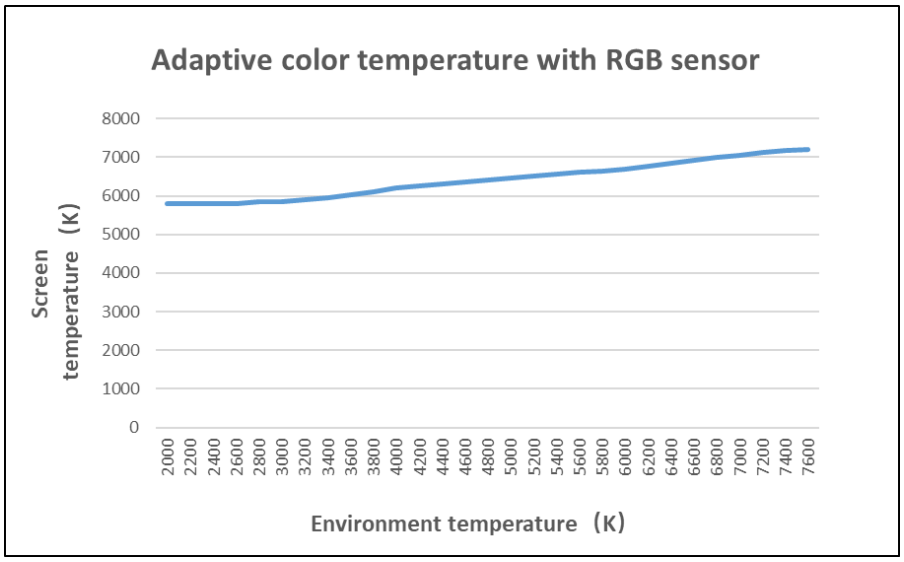
Consider this scenario: An individual is reading an e-book in a sunlit park. With conventional displays, intense sunlight would cause significant screen glare, making it difficult for the user to engage comfortably with the content. However, TCL's NXTPAPER technology adjusts the display properties to reduce this glare, thereby enabling a comfortable reading experience without undue eye strain.

Various studies[8] underscore the importance of ensuring a comfortable viewing experience across diverse lighting conditions to mitigate eye strain and related issues. The ability of TCL NXTPAPER to adapt and provide clear viewing in sunlight is therefore of profound significance.

Moreover, similar to real paper, this nano-level uneven surface increases the friction of the nib of a stylus, making the writing experience feel much more realistic. And with that surface, the NXTPAPER display delivers a matte tactile feel protecting against smudges or fingerprints.

Adaptive Color Temperature with RGB sensor

The Auto Color Temperature Adjustment 3.0 feature has been upgraded from its predecessor with enhanced hardware on tablets, including the integration of an RGB sensor. This sensor is designed to continuously capture the color temperature values of ambient lighting, using these values to adjust the color temperature of the TCL NXTPAPER in real-time. This capability allows the screen's color scheme to seamlessly blend with the surrounding environment, offering a comfortable visual experience and alleviating visual fatigue over extended periods of use.



When differences arise between the values calculated by environment and time, the colour temperature is set to the lower value for optimal viewing comfort. This unique feature, coupled with advanced anti-glare technology, enables TCL NXTPAPER to provide an exceptional viewing experience, even under bright sunlight.

Evolution of TCL NXTPAPER from 1.0 to 3.0

TCL's NXTPAPER technology has undergone significant transformations since its inception, continuously integrating advanced features to enhance user experience and

[8] Source: Effects of Paradigm Color and Screen Brightness on Visual Fatigue in Light Environment of Night Based on Eye Tracker and EEG Acquisition Equipment – Published: 2022 Jun; 22 - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9185549

environmental sustainability. The evolution from TCL NXTPAPER 1.0 to 3.0 has brought significant advancements in brightness and blue light management.

	NXTPAPER 1.0	NXTPAPER 2.0	NXTPAPER 3.0
Hardware	Low blue light: reduction by up to 61%*.	Low blue light: reduction by up to 61%*.	Low blue light: reduction by up to 61%*.
	Full color display	Full color display	Full color display
	Anti-glare (AG)	Anti-glare (AG)	Anti-glare (AG)
			Smooth and durable AF glass
		Sunlight screen	Sunlight screen with outdoor peak brightness of 650nits
			Night-friendly screen
			CPL(circularly polarized light)
			120Hz & DC dimming
Software		Adaptive color temperature	Adaptive color temperature with RGB sensor
		NXTPAPER UI	NXTPAPER UI
			NXTPAPER Wallpaper
			NXTPAPER Image filter
			TCL Eye Care Assistant
			Max Ink Mode for 7-day usage & 26-day standby
			Night light mode
			NXTPAPER Key
Accessory	Flipcase, T-Pen	Flipcase, TPU case, T-pen	Flipcase, TPU case, T-pen, Stand, Keyboard

NXTPAPER 1.0

In 2021, TCL introduced its innovative NXTPAPER technology, launching the first NXTPAPER tablet that launched a new era of eye-comfort displays. This milestone device is characterized by its low blue light emission, full color display for rich visuals, and an effective anti-glare feature, ensuring a comfortable viewing experience.

NXTPAPER 2.0

In 2023 IFA, TCL launched world's first smartphones featuring NXTPAPER technology.This iteration incorporates cutting-edge hardware developments that increased the device's display brightness by 150%, ensuring a clear and vibrant display while simultaneously introducing the adaptive colour temperature. This new feature automatically adjusted the screen's white balance to match the surrounding light environment, further enhancing visual comfort.

Importantly, the technology in TCL NXTPAPER 2.0 provides enhanced blue light reduction, surpassing standard TÜV levels. This advanced blue light management offers robust eye protection without causing any unwanted screen yellowing or distortion. Thus,

TCL NXTPAPER 2.0 delivers improved visual comfort while preserving the authenticity of the display.

NXTPAPER 3.0

Building upon that, TCL's NXTPAPER 3.0 represents a major advancement in display technology, focusing on user comfort, health features, and improved interaction.

1. Hardware

Hardware advancements in NXTPAPER 3.0 are notable. The implementation of Circularly Polarized Light (CPL) technology mimics natural light conditions, improving the screen's paper-like appearance and comfort. The RGB sensor dynamically adjusts color temperature based on ambient lighting conditions and time of day, ensuring optimal viewing comfort at all times.

2. Software

- NXTPAPER Key
  It enables users to seamlessly switch between color paper and ink paper modes, thereby improving usability. Max Ink Mode is meticulously crafted to provide you with the quintessential reading experience.
- Eye care assistant
  Software improvements in NXTPAPER 3.0 focuses extensively on eye health and user efficiency. The Eye Care Assistant monitor is a significant addition, designed to mitigate eye fatigue through various modes. The Light Reminder Mode offers subtle alerts to maintain eye health under different usage scenarios, while the Heavy Reminder Mode pauses ongoing activities to prompt a 2-minute eye relaxation video. Additional software enhancements include Posture and Environment Reminders, which encourage optimal device usage settings to safeguard vision.

- Night light mode
  Night light mode can automatically activate in darkness with a soft 10lux~30lux flashlight, compared with a normal flashlight with 90lux, ensuring no glare to others while protecting your eyes.

  The Night-friendly screen automatically detects ambient light conditions. The screen adjusts to protect users' eyes instantly once switched on, providing a constant, comfortable viewing experience.

3. Adjustable Display Technology

- Equipped with NXTPAPER 3.0 technology, the display intelligently adapts to different lighting environmentsfrom bright outdoor sunlight to dimly lit rooms, ensuring optimalvisibility and comfort.
- Compared with NXTPAPER2.0, NXTPAPER 3.0 experiences clarity like never before with a peak brightness levelof 650 nits, complemented by anti-glare technology that keepsthe screen readable in the most challenging conditions.
- Adjust the color temperature in accordance with the Circadian rhythm, ensuring it matches the natural progression of time. This dynamic adaptation offers a comfortable and natural viewing experience that evolves throughout the day.

4. Aesthetics
    - In terms of aesthetics, NXTPAPER 3.0 is a significant enhancement to the visual experience. It introduces the NXTPAPER Image Filter, which adds a distinctive paper-texture effect to images, turning regular visuals into artistic renderings. Additionally, the carefully designed NXTPAPER Wallpapers create a calming and inspiring environment, improving the overall user experience.

NXTPAPER Portfolio

TCL has been a pioneer in NXTPAPER technology, launching the first tablet of its kind in 2021 and heralding the age of eye-comfort displays. To date, the company has introduced 11 variants of NXTPAPER across multiple markets, encompassing both tablets and smartphones. This demonstrates TCL's commitment to making NXTPAPER technology more user-friendly and widely accessible through a range of innovative products.

- Tablets : TCL NXTPAPER 10S, TCL NXTPAPER 11, TCL NXTPAPER 14 ,TCL NXTPAPER 14 Pro, TCL TAB10 NXTPAPER 5G, TCL NXTPAPER 12 Pro, TCL BOOKX12 Go.

- Smartphones: TCL 40 NXTPAPER, TCL 40 NXTPAPER 5G, TCL 50XE NXTPAPER, TCL50XL NXTPAPER 5G, TCL 50 NXTPAPER 5G, TCL 50 PRO NXTPAPER 5G.

Certifications

TÜV Certifications

TÜV Rheinland, originating from late 19th-century Germany, is known for its rigorous safety and quality standards in technology, including consumer electronics. Earning its certification, a comprehensive process, ensures a product's safety, efficiency, and superior

quality. It is not merely a stamp of approval; it is a testament to a product's commitment to safety, efficiency, and superior quality. The process involves meticulous inspection and testing[9].This certification is essential for TCL NXTPAPER, proving its commitment to user safety by reducing harmful blue light emissions and effectively managing glare, while also meeting global safety standards.

TCL NXTPAPER pioneered in achieving the Low Blue Light and Reflection Free Certification from TÜV Rheinland in smartphones, highlighting its dedication to an optimal viewing experience free from reflections and glare.

Eyesafe Certification

Eyesafe is a trusted company that specializes in developing and certifying display technologies to minimize harmful blue light emissions, prioritizing user eye safety during extended screen time. Its stringent standards have established it as a leader in the digital eye health industry.

Achieving Eyesafe certification is beneficial for devices, indicating effective reduction of harmful blue light emissions without compromising visual quality. This certification ensures consumers can use their devices without worrying about potential harm to their eyes, while also enhancing brand reputation for manufacturers. TCL has obtained this certification for its NXTPAPER products, demonstrating its commitment to protecting user eyes and meeting global safety standards, which differentiates it in the competitive market.

SGS Certification

SGS, founded in 1878, a global leader in inspection, verification, testing, and certification services, offers comprehensive quality and compliance solutions. Earning an SGS certification ensures products meet high international standards, providing market access and enhancing competitiveness.

[9] Source: Product certification: Product testing and test mark as proof of quality - https://www.tuv.com/world/en/product-certification.html

TCL has obtained the SGS Paper-Display Certification for its NXTPAPER products, proving they significantly enhance eye comfort by offering paper-like display effects. This certification highlights TCL's commitment to innovation and user well-being, making its products stand out in the market.

The above awards and certifications, prestigious in digital screen safety, validate TCL NXTPAPER's eye protection measures, underscoring its commitment to user health.

Conclusion

The realm of digital display technology is experiencing significant advancements, with TCL NXTPAPER standing out as a prime example. TCL NXTPAPER presents a compelling alternative in the display technology market by integrating features typically found in separate devices into one unified product.

It specifically targets users who prioritize eye comfort without compromising on color vibrancy. By mitigating harmful blue light emissions and minimising glare, TCL NXTPAPER not only enhances user comfort but also maintains the performance capabilities essential for modern tablets and digital displays.

In conclusion, while traditional tablets and e-readers have their merits, TCL NXTPAPER stands out with its vibrant full-color electronic paper display, advanced light management features like adjustable color temperature, enhanced brightness, and adaptable display modes. These attributes place TCL NXTPAPER in a distinct league of its own.