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Spectral Transmittance of Soft Contact Lenses Following One Month of Eyedrop Application: An In Vitro Investigation

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This study investigated the spectral transmittance of six different types of soft contact lenses after exposure to normal eyedrops use over one month. The normal eyedrops were only meant to be instil into the eyes without contact lenses. The objective of this lab study was to look at the effect of the eyedrops on the spectral transmittance of all contact lenses.

The two types of eyedrops for dry eye (eyedrop A) and eye irritation (eyedrop B) were applied to the surface of each contact lens (two drops each) at 2-hour intervals (n = 15), following which the lenses were immediately immersed in saline solution. This process was repeated four times daily (eight hours for Eyedrop A) and five times daily (10 hours for Eyedrops B), with the lenses subsequently soaked in Optifree disinfecting solution overnight. This constituted one complete cycle, which was repeated daily for 30 consecutive days. The control group underwent a similar procedure but used a saline solution instead of a disinfecting solution.

Spectral transmittance measurements were conducted on Day 0 and Day 30 for both the experimental and control groups. The results were analysed to determine the average of spectral transmittance values, and the absolute differences between the measurements were calculated. All recorded values fell within the tolerance limits outlined in ISO 18369.

This study concluded that neither type of eyedrop induced significant changes in spectral transmittance after 30 days of daily use as recommended by the manufacturer. All tested lenses (in the FDA categories) exhibited consistent spectral transmittance values throughout the study. Therefore, the eyedrops evaluated in this trial were deemed not to affect the spectral transmittance of any soft contact lens types.

Keywords: *Spectral transmittance, contact lenses, ophthalmic solutions, ISO, Eyedrop*

Introduction

Spectral transmittance in soft contact lenses denotes the lens's capacity to permit specific wavelengths of visible light to pass through while obstructing others. This value characterises the extent to which light of different wavelengths can penetrate the lens material and reach the eye.

Soft contact lenses are typically crafted from various polymer materials with distinct optical properties, which influence how the lenses interact with light, impacting factors such as visual clarity, comfort, and colour perception.[1] Spectral transmittance plays a critical role in determining the overall optical performance of the lens.

Different colours of light correspond to different wavelengths within the electromagnetic spectrum, and the human eye is sensitive to a range of these wavelengths, collectively constituting the visible spectrum.[2] A soft contact lens with standard range of spectral transmittance should facilitate a balanced and accurate representation of these visible wavelengths, ensuring clear vision and preserving natural colour perception.

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Contact lens manufacturers often assess and specify the spectral transmittance of their lenses to ensure compliance with specific optical standards and to provide wearers with optimal visual experiences. Consistent and accurate spectral transmittance properties are essential for contact lenses to avoid issues such as color distortion, diminished visual acuity, or discomfort resulting from improper light filtration. Thus, this study is significant as it evaluates the lens's optical performance when used with eyedrops daily.

Many contact lens wearers overlook the importance of verifying if the eyedrops they use are compatible with their lenses. Consequently, they may assume that the eyedrops are safe and will not alter the quality of the lens material, potentially affecting their vision quality.

Optishine® Eye Drops for Dry Eye Relief and Optishine® Eye Drops for Irritation & Discomfort Relief are two types of eyedrops commercially available in Malaysia, manufactured by Y S P Industries (M) Sdn Bhd. These products are registered under the Medical Device Act 2012 (Act 737). These two eyedrops were randomly chosen as it is commonly used and easily found in the market. These two eyedrops were meant to be used on eyes without contact lenses.

Optishine® Eye Drops for Dry Eye Relief (Eyedrops A) contains hydroxypropyl methylcellulose (3 mg) and are recommended for use 3-4 times daily, or as needed. Optishine® Eye Drops for Irritation & Discomfort Relief (Eyedrops B) contain Sodium Chloride (4.4 mg) and Potassium Chloride (0.8 mg), and are recommended for use 5-6 times daily, or as needed. Presently, both eyedrops are recommended for use on eyes without contact lenses. The objective of this study was to assess the spectral transmittance changes of six different types of soft contact lenses after using these two different eyedrops in vitro. The parameters examined in this study include spectral transmittance, with the accepted measurement range based on the guidelines outlined in ISO 18369-3:2017.[3-7]

This study builds on previous investigations into the optical properties of contact lenses by focusing specifically on the potential impact of prolonged eyedrop use on spectral transmittance. While earlier research has evaluated changes in contact lens parameters after exposure to cleaning solutions or manufacturing processes, this study uniquely explores the interaction between eyedrops designed for use without lenses and different types of soft contact lenses over an extended period. It is the first study to systematically assess whether common commercial eyedrops for dry eye and irritation affect the spectral transmittance of contact lenses across FDA categories, using ISO standards as benchmarks. By confirming that these eyedrops induce no significant changes in transmittance after 30 days, the study fills an important gap in understanding the compatibility of eyedrops with contact lenses, offering reassurance about their safe use.

Material & Methods

Contact Lenses & Solutions

The contact lenses that were selected were soft lenses which were readily available in the Malaysian market and the most preferred by contact lens wearers (Table I). These lenses were chosen to represent the FDA lens classification category. The brands and materials are as listed below:

Table I. The FDA classification is based on the lens brands and material used in this study.

Brands	Material	FDA Lens Classification
Bausch & Lomb, **Softlens 38**	Polymacon	Type 1
FreshKon 58	Etafilcon A	Type 4
Bausch & Lomb, **Pure Vision 2**	Balafilcon A	Type 5A
Alcon, **Total 30**	Lehfilcon A	Type 5B
CooperVision, **Biofinity**	Comfilcon A	Type 5C
Maxvue **ColourVue** (Sparkle Black Olive)	Hydrogel Terpolymer	Coloured Lens

The lenses used are with a power of -3.00DS, with base curve range of 8.6-8.7mm and diameter range of 14-14.5mm (as labelled on its blisters by the manufacturers). All lenses were of monthly wear modality and can be commonly found in the market. Fifteen lenses (of each category) were tested with Eyedrop A and Eyedrop B, and ten lenses (of each category) were used in the control group.

Soaking solution used for overnight soaking is a multipurpose Opti-Free disinfecting solution. Standard saline (0.9% NaCl) was used to simulate tears in the eye during daytime. All solution was recorded of its lot number and the expiry date was noted. Autoclaved phosphate buffered saline at pH 7.4 ± 0.1 and nominal osmolarity of 310 ± 5mOsm was used throughout the lab test.

Lens preparation

All contact lenses underwent an equilibration process for eight hours in a standard saline solution, followed by an additional 16-hour soaking period in a solution designated for overnight use, resulting in a total conditioning time of 24 hours.[3-7] This protocol ensured that the contact lens parameters remained constant before measurements were taken on Day 0.

Approximately 5 ml of saline solution was utilised to soak the lenses, and the temperature of both the saline solution and the room environment was maintained at a standard range of 23-24 degrees Celsius at all times.[2]

Test procedures

After a 24-hour equilibration period, measurements were taken on Day 0. To ensure thoroughness, two consecutive days were allotted for the completion of measurements for all 150 lenses by respective operators. For the instillation of the daily drops, we had assigned different unmasked operators to be in charged for a month, however, the operator that measured the spectral transmittance was one masked individual. Each contact lens was individually placed in a casing soaked with standard saline solution (0.9% NaCl) for eight hours, commencing at 8 am.

While the lenses remained in their casing, a plastic-padded forceps was used to gently lift the lens slightly to expose its surface. Two drops of Eyedrop A were applied to the contact lens every two hours. Immediately after the drops were applied, the lens was placed back into the same casing filled with saline solution. This process was repeated four times for Eyedrop A and five times for Eyedrop B. The number of drops were in accordance with the manufacturer's recommendation. Total drops instilled were eight drops and ten drops for Eyedrop A and B consecutively.

At 4 pm, the saline was drained from its casing and replaced with 5 ml of Opti-Free disinfecting solution, which was left in the casing for 16 hours until the following day at 8 am. This completed one full cycle. This cycle was repeated consecutively for 30 days.

Measurements were again carried out on Day 30. The schedules were pre-established to allow operators sufficient time to complete the measurements within a two-day period.

The study's methodology, which mimics real life conditions through daily application cycles over an extended period, provides a practical framework for future research and regulatory testing. It underscores the importance of balancing product efficacy and safety while addressing consumer needs and regulatory expectations, ultimately improving the overall experience for contact lens wearers.

Measurements

Spectrophotometry serves as a crucial technique employed to assess how different wavelengths of light interact with specific substances. In the context of contact lenses, spectrophotometry is utilised to analyse the optical properties of the lenses, including their transmission and absorption characteristics across various wavelengths of light.[8]

The spectrophotometer utilised in this study is the Shimadzu UV-Vis Spectrophotometer UV-1800 (Double beam optics), Japan, which incorporates a cuvette made of quartz glass (dimensions: 12.5x12.5x45mm). This instrument enables the evaluation of contact lens performance by measuring their transmittance and reflectance properties. By emitting light across a spectrum of wavelengths, the spectrophotometer determines how contact lenses interact with light, allowing for optimisation of clarity, colour perception, UV protection, and other desired optical attributes.

During the analysis, the contact lens and saline solution are placed within the cuvette, ensuring proper positioning to accurately measure the transmission of the central optic zone. All handling from the lens casing into the cuvett was done using a padded plastic forceps. The spectrophotometer then measures the transmittance of the spectrum ranging from 400 to 800 nanometers (nm).

The contact lens was placed in the cuvette at a position where the light passes through the centre of the lens as shown in the side view diagram (Figure I). During spectral transmittance measuring, the lens does not move as it is held in position by the walls of cuvette as shown in the top-view diagram.

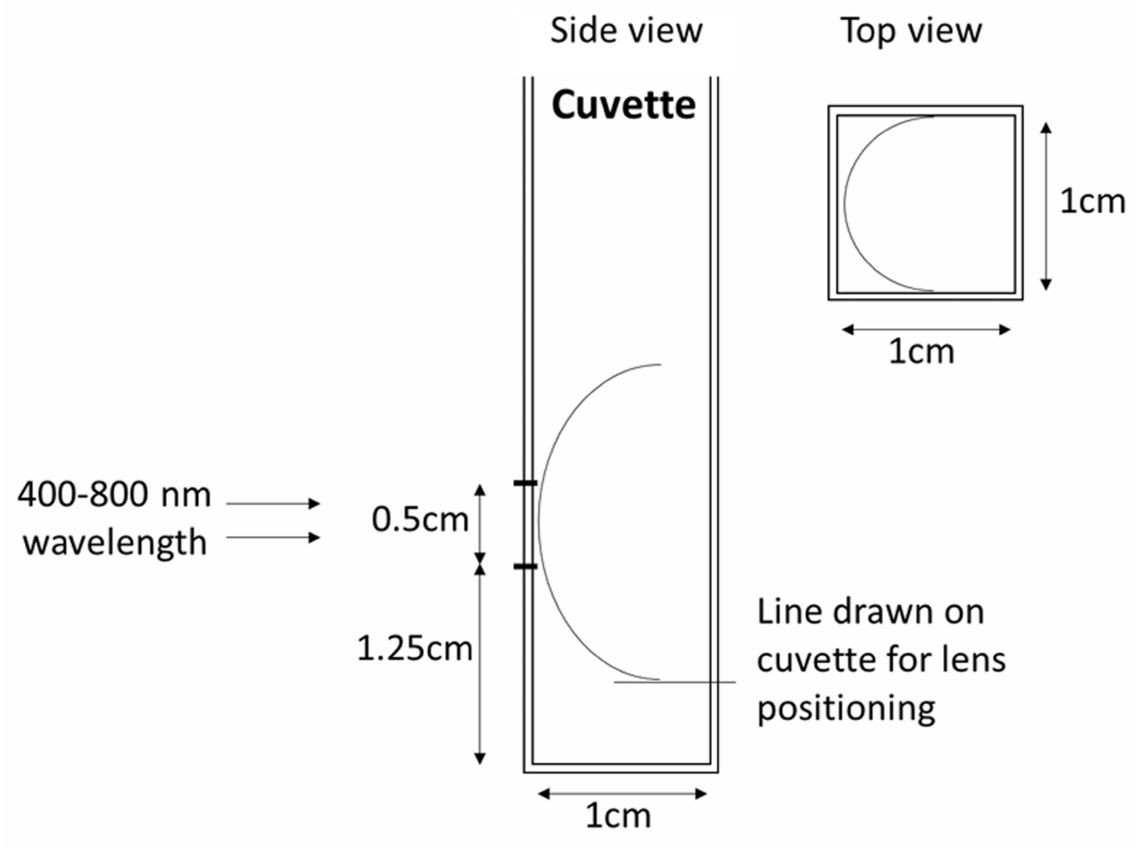

Figure I. The schematic diagram on how a piece of contact lens is being placed in the cuvette before measurements were taken.

All data collected for this study were analysed using SPSS version 26. Statistical comparisons of spectral transmittance value and after laboratory procedures were conducted accordingly. Furthermore, all results were compared to the ISO 18369-3:2017 standards, where the acceptable range of spectral transmittance in the visible region (400nm to 800nm) is within ± 5% absolute.[2]

The absolute difference refers to the numerical difference in the transmittance values between Day 0 and Day 30. It was calculated as:

Absolute Difference=$|T_{day0}(\lambda)-T_{day30}(\lambda)|$

This measure highlights the magnitude of the difference in light transmission characteristics without considering the direction (whether one is higher or lower). This is particularly useful in optical comparisons for quantifying deviations in transparency or filtering properties between samples.

Results

The measurements were conducted in a randomised fashion for each of the lenses on Day 0 and Day 30 (refer to Table II). The differences between pre- and post-readings were calculated in absolute values. It is important to note that the tolerance limits, as per ISO standards, are within ± 5% absolute.

Table II. The spectral transmittance values of six types of contact lenses at Day 0 and Day 30.

EYEDROP A		Type 1 (n = 15)	Type IV (n = 15)	Type 5A (n = 15)	Type 5B (n = 15)	Type 5C (n = 14[a])	Colour (n = 15)
Spectral transmittance	Day 0	98.2941	98.5353	97.5041	91.8274	98.5809	84.6842
	Day 30	97.6029	96.8952	96.8782	89.4983	96.458	85.7778
Differences		-0.6912	-1.6401	-0.6259	-2.3291	-2.1229	1.0936
Absolute Differences in %		-0.70%	-1.66%	-0.64%	-2.54%	-2.15%	1.29%

EYEDROP B		Type 1 (n = 15)	Type IV (n = 15)	Type 5A (n = 15)	Type 5B (n = 15)	Type 5C (n = 14[a])	Colour (n = 15)
Spectral transmittance	Day 0	98.1941	98.4905	97.3779	91.7187	98.4672	84.4692
	Day 30	97.6919	97.3823	96.3618	89.2392	97.3148	85.6188
Differences		-0.5022	-1.1082	-1.0161	-2.4795	-1.1524	1.1496
Absolute Differences in %		-0.51%	-1.13%	-1.04%	-2.70%	-1.17%	1.36%

CONTROL		Type 1 (n = 10)	Type IV (n = 10)	Type 5A (n = 10)	Type 5B (n = 10)	Type 5C (n = 10)	Colour (n = 10)
Spectral transmittance	Day 0	98.2046	98.4759	97.1947	91.7502	98.2778	85.0327
	Day 30	97.4626	97.3313	96.4279	89.0915	96.7726	85.7574
Differences		-0.742	-1.1446	-0.7668	-2.6587	-1.5052	0.7247
Absolute Differences in %		-0.76%	-1.16%	-0.79%	-2.90%	-1.53%	0.85%

[a] *lens damage*

The data obtained revealed no significant changes in the spectral transmittance value of the lenses after 30 days of using Eyedrops A and B on separate lens groups. This demonstrates that the drops do not compromise the lenses' high optical standards and ensuring optimal vision correction. Measurements were scrutinised for any notable alterations and found to fall within the tolerance limits for all six types of contact lenses in both the Eyedrop A and B groups. In fact, both groups exhibited less than ± 5% absolute differences, further supporting the conclusion that the eyedrops have negligible impact on the lenses' optical performance.

Discussion

A total of 300 lenses from six categories of soft contact lenses were divided into two groups: Eyedrop A (15 lenses for each lens type) and Eyedrop B (15 lenses for each lens type) in the study group, while the control group (10 lenses for each lens type) maintained spectral transmittance values within the acceptance range specified by ISO18369-3:2017 after 30 days of continuous use of eyedrops.

Eyedrops A and B, both consisting of simple chemical compositions but not mentioned of its suitability with contact lens wear were demonstrated to have no significant changes in the parameters of the contact lenses. All values observed after 30 days fell within the tolerance limits, indicating that both eyedrops had no adverse effects on the evaluated lenses.

Variations in spectral transmittance of contact lenses can be attributed to several factors, including lens material, manufacturing processes, coatings, and additional treatments. The molecular structure and composition of lens materials, categorised into hydrogels, silicone hydrogels, and colour tints in this study, influence their interaction with light, affecting spectral transmittance. Tinted or coloured lenses containing dyes or pigments exhibit lower spectral transmittance due to selective absorption or reflection of certain wavelengths of light, serving cosmetic or visual enhancement purposes. Spectral transmittance values were observed to be lower in tinted lenses compared to clear lenses.

To minimise confounding factors, parameters such as curvature, thickness, and design of contact lenses were standardised to a constant back-vertex power (-3.00DS). However, variations within each lens category may still occur due to differences in manufacturing processes and lens coatings. Coatings, while enhancing certain properties like UV protection or scratch resistance, can influence spectral transmittance, particularly over time as they age and potentially thin out.

Consistency in laboratory conditions, including temperature, humidity, and measurement instruments, was maintained throughout the study to mitigate variability introduced during the manufacturing process and lens handling.[1] Despite diligent handling procedures, minor variances may still contribute to differences in spectral transmittance values among lens categories.

Overall, the spectral transmittance measurements focused solely on differences between Day 0 and Day 30 after instillation of drops, providing insights into the impact of eyedrop use on the optical properties of contact lenses.

The findings of this study, which demonstrate that neither of the tested eyedrops significantly altered the spectral transmittance of soft contact lenses after 30 days of exposure, have important implications for consumer safety, regulatory standards, and product development. The compatibility of ophthalmic solutions with contact lenses is a topic of growing interest, especially as the prevalence of contact lens wear continues to rise globally. This research builds on earlier investigations into the interactions between contact lenses and external agents, such as cleaning solutions and environmental factors, by specifically evaluating eyedrops that were not originally intended for use with lenses.

Previous studies have highlighted potential risks associated with the interaction between contact lenses and external agents. For example, Ogbuehi *et al*, examined the transmittance properties of contact lens multipurpose solutions, revealing that some solutions can cause measurable changes in lens material properties, including reduced transmittance.[2] Similarly, Mutalib and Lee reported parameter changes in soft contact lenses exposed to automated cleaning machines.[1] These findings underscore the importance of evaluating how commonly used ophthalmic solutions, such as eyedrops, might impact lens properties over time.

The current study is unique in its focus on two commercially available eyedrops containing hydroxypropyl methylcellulose and sodium/potassium chloride. Unlike earlier research that concentrated on cleaning solutions, this study examined products primarily intended for ocular surface relief rather than lens maintenance. The results showed no significant changes in spectral transmittance across various lens types and materials, even for coloured lenses, which typically exhibit lower transmittance due to dye incorporation. This consistency with ISO 18369 standards suggests that the tested eyedrops are safe for use with contact lenses, aligning with the broader aim of ensuring compatibility and maintaining optical performance.

Moreover, the study's method of simulating real life usage by applying eyedrops at prescribed intervals and immersing lenses in saline solution parallels practical conditions, enhancing its applicability. This contrasts with studies like those of Turki *et al*, which often focused on isolated laboratory parameters without simulating daily wear cycles.[2]

The findings could inform updates to product labelling, specifically allowing manufacturers to indicate compatibility with contact lenses. For instance, adding statements such as "Safe for use with soft contact lenses" to packaging could alleviate consumer concerns and promote informed decision-making. This is particularly relevant given that a significant proportion of contact lens wearers may use eyedrops to alleviate dry eye symptoms or irritation.

From a regulatory perspective, the study underscores the need for standardised testing of ophthalmic solutions with contact lenses. Regulatory bodies, such as the International Organization for Standardization (ISO) or the US Food and Drug Administration (FDA), could incorporate protocols similar to those employed in this study as part of the approval process for ophthalmic products. Including spectral transmittance testing in these guidelines would enhance the safety and reliability of products intended for use alongside contact lenses.

This study also highlights the importance of consumer education regarding the compatibility of ophthalmic products with contact lenses. Many wearers are unaware of the potential for eyedrops to interact with their lenses. Educational campaigns could use the study's findings to reassure consumers about the safety of certain products, potentially encouraging adherence to recommended usage guidelines and reducing misuse.

Limitations

While the current study provides robust evidence for the short-term compatibility of specific eyedrops with soft contact lenses, further research is necessary to expand the scope and real-world relevance of the findings. Future investigations should consider extending the study duration beyond 30 days – such as over 90 days or more – to assess whether cumulative effects emerge with prolonged exposure. Additionally, examining a broader range of ophthalmic solutions, including those containing preservatives (eg, benzalkonium chloride), antibiotics, or anti-allergic agents, would offer a more comprehensive evaluation of chemical interactions with lens materials. Beyond optical transmittance, future studies should also assess post-use mechanical properties of contact lenses, such as tensile strength, elasticity, and oxygen permeability, as these are essential to overall lens performance and wearer comfort. Moreover, in vivo studies are crucial to capture physiological variables like tear film interactions, blinking dynamics, and the impact of protein or lipid deposits – factors that cannot be fully replicated in vitro. Incorporating these elements into future research will strengthen the scientific foundation for developing safer, more compatible ophthalmic products and inform clinical practices and regulatory policies.

Conclusion

This in vitro study offers valuable insights into the chemical resilience of modern soft contact lenses when exposed to non-lens-specific ophthalmic solutions. The evidence suggests no clinically significant degradation in spectral transmittance, even in coloured lenses. These findings support more flexible usage recommendations, potential product label updates, and informed clinical guidance. They also point toward a broader regulatory and product development shift where compatibility testing could enhance both consumer safety and product transparency.

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