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Are U Vulnerable to UV radiation?

What type of material, coating and thickness
gives best protection against UV radiation for ophthalmic lenses?

WHAT TYPE OF MATERIAL, COATING AND THICKNESS GIVES PROTECTION AGAINST UV RADIATION FOR OPHTHALMIC LENSES

Abstract

This project intends to investigate what type of material, coating and thickness gives the best protection against UV radiation for ophthalmic lenses. The experiment involved the experimentation of different types of material (glass, polycarbonate and CR-39), different types of coating (non coating, UV coating, and both UV & Multicoating, and different thicknesses (-4, 0 and +4 diopters is used to determine the different thickness; as different diopters give different thickness). The method involved the testing of various ophthalmic lenses using an ultraviolet detector to measure the amount of UV transmission that passed through the lens. The results showed that the thicker the lens, and the higher the diopter, the better it is at protecting against UV radiation. Polycarbonate is the best material for ophthalmic lenses as it blocked 100% of UV radiation regardless of diopter or coating. Additionally, the UV coating is sufficient enough to give UV protection in CR-39 lenses. The addition of Multicoating to the UV coating did not make a significant change in the UV protection, as the effectiveness of both coatings depended on the diopter of the lens.

Introduction

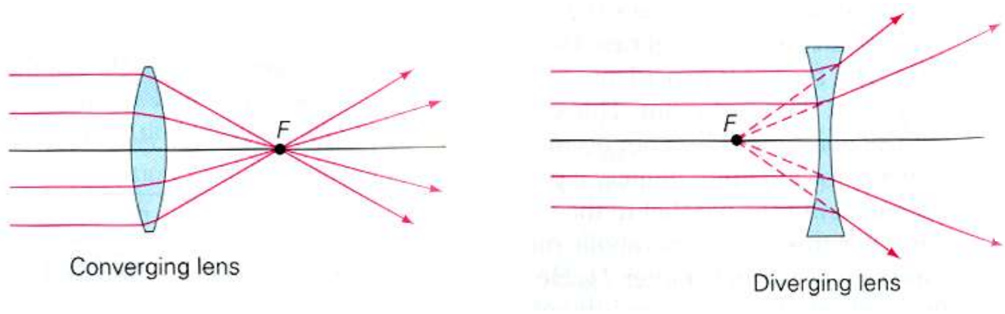
U are Vulnerable to UV damage all times of the day, all year round. When we buy a new pair of glasses, we tend to spend the most time on the frame's appearance and brand. However, we often forget to take into consideration how effective the lenses are in protecting against ultraviolet radiation. I became interested in exploring what material, thickness and coating of lenses would best protect my eyes from the Sun's ultraviolet radiation, as I am myopic and have worn glasses since Year 3. My eyesight has become progressively deteriorated every year, and I noticed that my ophthalmic lenses are getting thicker. My optometrist tried to explain the different ophthalmic lens materials and coatings to me, which sparked my interest. I was curious to know which combination of material and coating would be best for my diopter (thickness). By investigating this issue, I was able to determine what factors would create the ophthalmic lens that would best absorb ultraviolet radiation.

Research

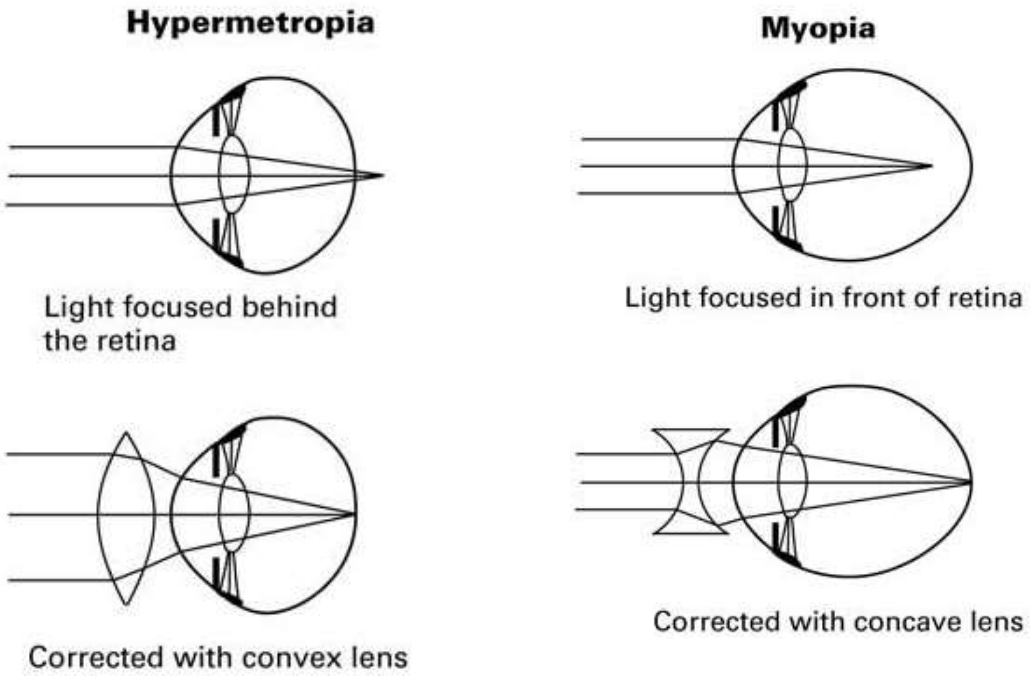
WHAT ARE DIOPTERS?

A diopter is a unit of measurement of the optical power of a lens which is equal to the reciprocal of the focal length measured in metres. The unit is used by opticians to measure the strength of the ophthalmic lenses. Ophthalmic lenses are graded in steps of 0.25 diopters.

Convex lenses are used to correct hyperopia (long-sightedness, also known as hypermetropia) through its positive dioptric values, whilst concave lenses that are used to correct myopia (short-sightedness) through negative dioptric values. As diopter increases, the lens becomes thicker, the curvature becomes greater and the power becomes greater. The units are measured in the abbreviation ‘D’.



Many Faces of Light: As Newton Saw it, with Some Magic Tricks. 2013. *Lenses*. [ONLINE] Available at:http://newton.physics.uiowa.edu/~umallik/adventure/geo-optics/lightnw.htm. [Accessed 23 June 2013].



Refraction and Refractive Errors | Doctor | Patient.co.uk. 2013.*Refraction and Refractive Errors | Doctor | Patient.co.uk*. [ONLINE] Available at: http://www.patient.co.uk/doctor/Refraction-and-Refractive-Errors.htm. [Accessed 23 June 2013].

DIFFERENT MATERIALS USED IN OPHTHALMIC LENSES

The three most commonly used ophthalmic lens materials are CR-39, polycarbonate and ophthalmic crown glass.

CR-39 is the most widely used of the three types, and is less commonly known by its chemical name, allyl diglycol carbonate, which is a plastic polymer. Its abbreviation comes from Columbia Resin #39 as it was the 39th formula of thermosetting plastic developed by the project by which the plastic is named. It has the highest abrasion/scratch resistance of any other type of uncoated plastic and is almost half the weight of its glass counterpart. The refractive index of a transparent medium is a measure of the "optical resistance" of the material to light, and CR-39 has a low refractive index of approximately 1.5.

Polycarbonate is light and impact resistant and the material is naturally UVR resistant. It has a refractive index of 1.6. Polycarbonate lenses are ten times more impact resistant than plastic lenses, and up to 35% lighter and thinner than standard plastic lenses. It is primarily used for industrial safety spectacles, sports eyeglasses and for kids and policemen.

Glass ophthalmic lenses have excellent optical quality and are scratch resistant, but tend to be heavier and more likely to shatter on impact. Ophthalmic crown glass has a refractive index of 1.5-1.6.

Glass was initially, the most common and preferred material for ophthalmic lens but has been superseded by both polycarbonate and CR-39 due to its weight and safety issues. Additionally, consumer interest in thinner, more attractive ophthalmic lenses led to the development of special lens materials that bent light differently than conventional plastic lenses which were called ‘high-index’. Of these, polycarbonate has become the most popular and in high demand.

DIFFERENT COATINGS USED IN OPHTHALMIC LENSES

The three main options available in regards to coatings are non coating, UV coating, and Multicoating and UV coating.

UV coating The invisible UV coating is easy to apply to any lens and can prevent cataracts, retinal damage, and other serious eye conditions attributed to the sun’s rays.

Multicoating can only be applied on top of the UV coating. The purpose of multicoating is to reduce the reflections off the lenses. It is made of a very hard thin film that is layered on the lens, and the material that has an index of refraction that is between that of air and of glass. This causes the intensity of the light reflected from the inner surface and the light reflected from the outer surface of the film to be nearly equal. When applied in a thickness of about a quarter of the light’s wavelength, the two reflections from each side of the film effectively cancel each other out through destructive interference and thus minimise the glare.

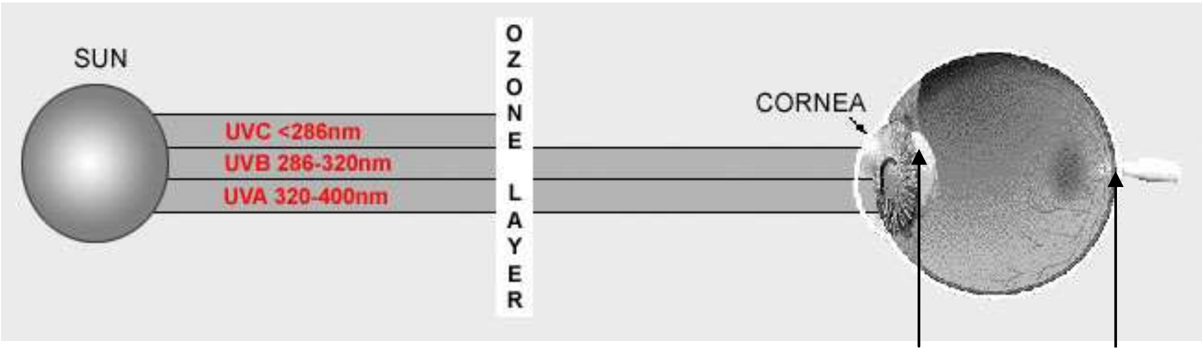
WHAT IS ULTRAVIOLET RADIATION

On the electromagnetic spectrum, the wavelength of UV rays is shorter than the violet end of the visible spectrum but longer than the X-ray. The sunlight is the main source of UV rays, since the sun emits ten percent of its total power in the form of UV radiation.

UV light can be categorised by three different types; Ultraviolet A (UVA), Ultraviolet B (UVB) and Ultraviolet C (UVC).

- UVA has longer wavelengths of (320-400 nm) and passes through glass easily. Although UVA is the weakest form of ultraviolet light, it advances age-related macular degeneration (ARMD) and skin cancer.
- UVB rays are the most dangerous as their wavelength is much shorter than those of the UVA’s (286-320 nm). UVB can cloud the eye cells and contribute to cataracts.

- Normally UVC (<286 NM) is absorbed in the ozone layer. However thinning ozone and penetrating UVC has an undetermined effect on vision.



AMDF: American Macular Degeneration Foundation - Ultra-violet and Blue Light. 2013. *AMDF: American Macular Degeneration Foundation - Ultra-violet and Blue Light*. [ONLINE] Available at:http://www.macular.org/bluelite.html. [Accessed 23 June 2013].

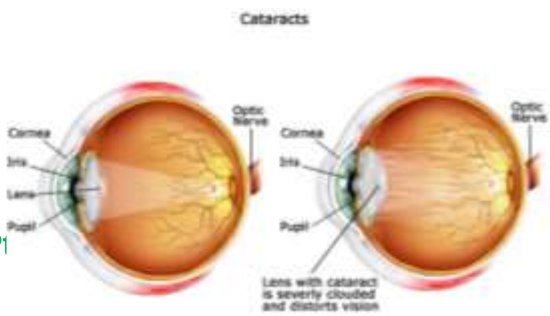
HAZARDS OF UV RADIATION

Repeated exposure of the eyes to UV radiation causes both short-term eye complaints and permanent eye damage. Short-term complaints include mild irritations such as excessive blinking, swelling, or difficulty looking at strong light. Exposure to UV radiation over long periods can result in more serious damage to the eyes. According to Cains (1992) in ‘the Royal Australian College of Ophthalmologists Policy Statement on Sunglasses’, the most prevalent diseases and damages include cataracts (cloudiness of the lens); pterygium (an overgrowth of the conjunctiva on to the cornea); solar keratopathy (cloudiness of the cornea); macular degeneration (destroying of the macula and impairment of central vision); and skin cancer of the eyelids and around eyes.

It has been estimated that 10% of cataracts are potentially due to UVB radiation exposure to the eye. Around 160,000 cataracts are treated in Australia each year at a cost of $320 million. According to Sharma (2006) ‘almost half of the 8600 cases of pterygium treated annually in Australia are also caused by sun exposure.’

DIAGRAMS

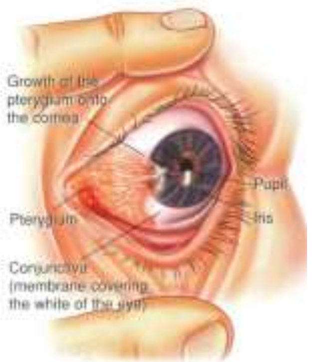
Cataracts



Cataracts. 2013. *Cataracts*. [ONLINE] Available at:http://www.murdocheye.com.au/cataracts/. [Accessed 23 June 2013].

La Palma Eye Care Center - Eye Conditions. 2013. *La Palma Eye Care Center - Eye Conditions*. [ONLINE] Available at:http://www.lapalmaeye.com/cataract.html. [Accessed 23 June 2013].

Pterygium



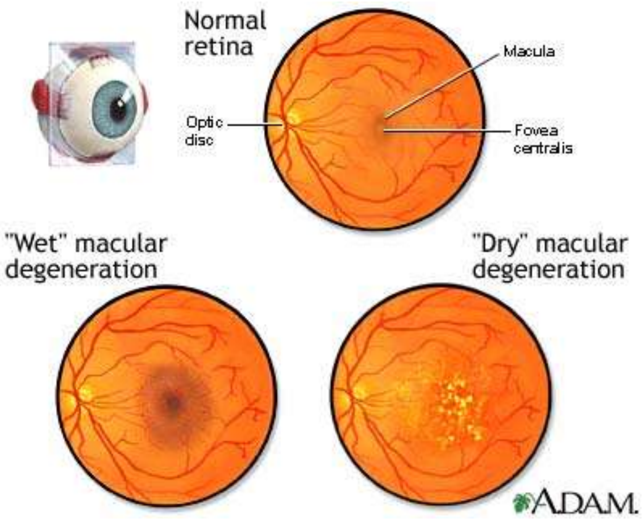
A pterygium may grow large enough to obstruct vision.

Doctors Gates: Photo description of Pterygium of the eye. 2013. *Doctors Gates: Photo description of Pterygium of the eye*. [ONLINE] Available at:http://doctorsgates.blogspot.com.au/2011/05/photo-description-of-pterygium-of-eye.html. [Accessed 23 June 2013].

Solar keratopathy

Keratitis Photos & Images - Download Free Keratitis Photos. 2013.*Keratitis Photos & Images - Download Free Keratitis Photos*. [ONLINE] Available at: http://foter.com/Keratitis/. [Accessed 23 June 2013].

‘Wet’ and ‘dry’ macular degeneration macular degeneration



Macular degeneration - age-related. 2013. *Macular degeneration - age-related*. [ONLINE] Available at: http://printer-friendly.adam.com/content.aspx?productId=117&pid=1&gid=001000&c_custid=758. [Accessed 23 June 2013].

Wet

Dry

Aim: To determine which type of material, thickness and coating gives ultimate protection against ultraviolet radiation for ophthalmic lenses.

Hypothesis:

1. The thicker the lens and thus the higher the diopter, the better it is at absorbing ultraviolet radiation.

2. Polycarbonate would be the best lens material to protect against ultraviolet radiation.

3. The lenses with both Multicoating & UV coating would be better at absorbing ultraviolet radiation, than those with only UV coating or non coating.

Equipment:

- 2 x uncut glass lenses with -4 diopter, UV coated & multi-coated
- 2 x uncut glass lenses with no prescription (0 diopter), UV coated & multi-coated
- 2 x uncut glass lenses with +4 diopter, UV coated & multi-coated
- 2 x uncut CR-39 lenses with -4 diopter, UV coated & multi-coated
- 2 x uncut CR-39 lenses with no prescription (0 diopter), UV coated & multi-coated
- 2x uncut CR-39 lenses with +4 diopter, UV coated & multi-coated
- 2 x uncut polycarbonate lenses with -4 diopter, with UV coated & multi-coated
- 2 x uncut polycarbonate lenses with no prescription (0 diopter), with UV coated & multi-coated
- 2 x uncut polycarbonate lenses with +4 diopter, with UV coated & multi-coated
- 2 x uncut glass lenses with -4 diopter, only UV coated
- 2 x uncut glass lenses with no prescription (0 diopter), only UV coated
- 2 x uncut glass lenses with +4 diopter, only UV coated
- 2 x uncut CR-39 lenses with -4 diopter, only UV coated
- 2 x uncut CR-39 lenses with no prescription (0 diopter), only UV coated
- 2 x uncut CR-39 lenses with +4 diopter, only UV coated
- 2 x uncut polycarbonate lenses with -4 diopter, only UV coated

- 2 x uncut polycarbonate lenses with no prescription (0 diopter), only UV coated
- 2 x uncut polycarbonate lenses with +4 diopter, only UV coated
- 2 x uncut glass lenses with -4 diopter, non coated
- 2 x uncut glass lenses with no prescription (0 diopter), non coated
- 2 x uncut glass lenses with +4 diopter, non coated
- 2x uncut CR-39 lenses with -4 diopter, non coated
- 2 x uncut CR-39 lenses with no prescription (0 diopter), non coated
- 2 x uncut CR-39 lenses with +4 diopter, non coated
- 2 x uncut polycarbonate lenses with -4 diopter, non coated
- 2 x uncut polycarbonate lenses with no prescription (0 diopter), non coated
- 2 x uncut polycarbonate lenses with +4 diopter, non coated
- 1 x UV Light Detector (Model: UV-340A from Digital Instruments- online purchase)
- 1 x red pen
- 1 x safety glasses
- 1 x scissors
- 1 x compass
- 1 x ruler
- 1 x calculator
- 1 x microfiber lens wiping cloth
- 1x A4 thick cardboard
- 1 x cylindrical cardboard tube (recycled from badminton shuttlecock tube)
- 1 x table

Method

1. A lens platform was constructed by first cutting out a disc of white cardboard with diameter 75 mm, as shown in Figure 1. This circle was then created into an annulus, with the inner circle diameter measuring 65 mm. The inner circle was removed and discarded, and using a red pen, a circle was drawn with diameter 70 mm to create concentric circles. This red line indicated where the lens would sit on this platform, as in Figure 2.

2. The cylindrical cardboard tube was cut such that the height would be fractionally taller than that of the sensor’s as in Figure 3.

3. An opening was cut out on the side of the cylindrical tube, in order to accommodate for the handle of the sensor. This was then attached to the cut-out cardboard disc, as shown in Figure 4.

4. This completed platform was placed on the outdoor table.

5. The UV detector was placed directly underneath the platform and measured the amount of UV rays without any lenses, as the control (see Figure 5 and 6).

6. The -4 diopter, UV & Multicoated glass lens was cleaned with the microfiber lens wiping cloth by holding the lens by the rim, to remove any dust and fingerprints which may block UV rays (see Figure 7).

7. The glass lens was placed on top of the platform, and aligned with the circle marked in red pen, and the amount of UV rays passing through the lens was measured by the sensor in microwatts per square centimetres. This was exposed to the UV rays of the sun for five seconds, before recording. (see Figure 8)

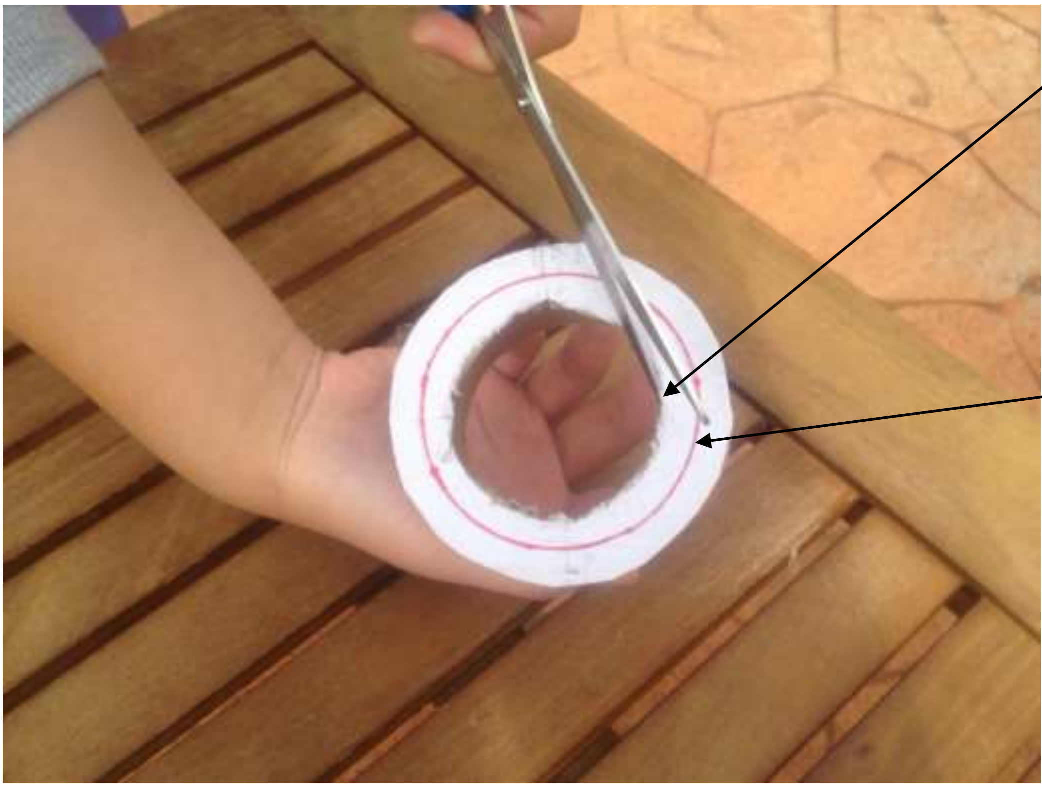
8. Steps 6 and 7 were repeated, using all the types of lenses. The measurements were observed and recorded. This raw data was tabulated and put into graphs.

9. Steps 5 to 8 were repeated on ten different days

Figure 1

A disc of white cardboard with diameter 75 mm was cut out

Figure 2



Annulus was created by cutting out the inner circle

Concentric circle drawn in red pen, with diameter 70 mm indicates where the lens will sit on the platform.

Figure 3

The cylindrical cardboard tube was cut so the height is fractionally higher than the sensor.

Figure 4

An opening was cut out on the side of the

Figure 5

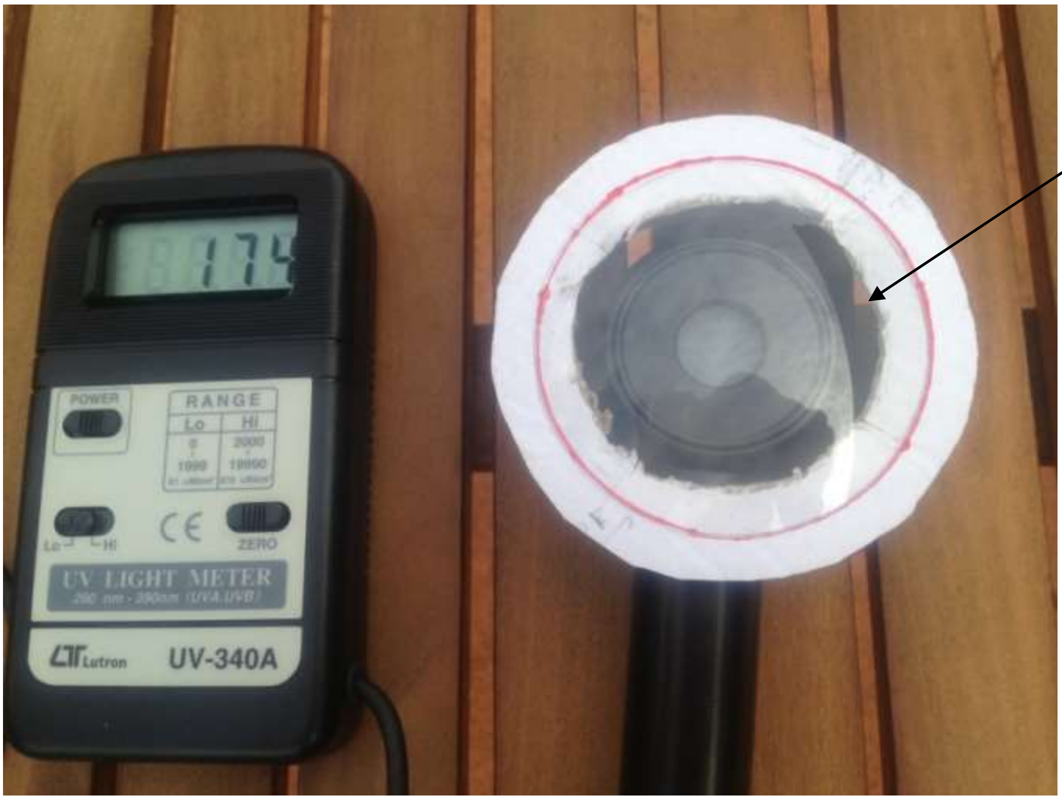
The UV detector was placed directly underneath the platform and measured the amount of UV rays without any lenses, as the control.

Figure 6

Figure 7

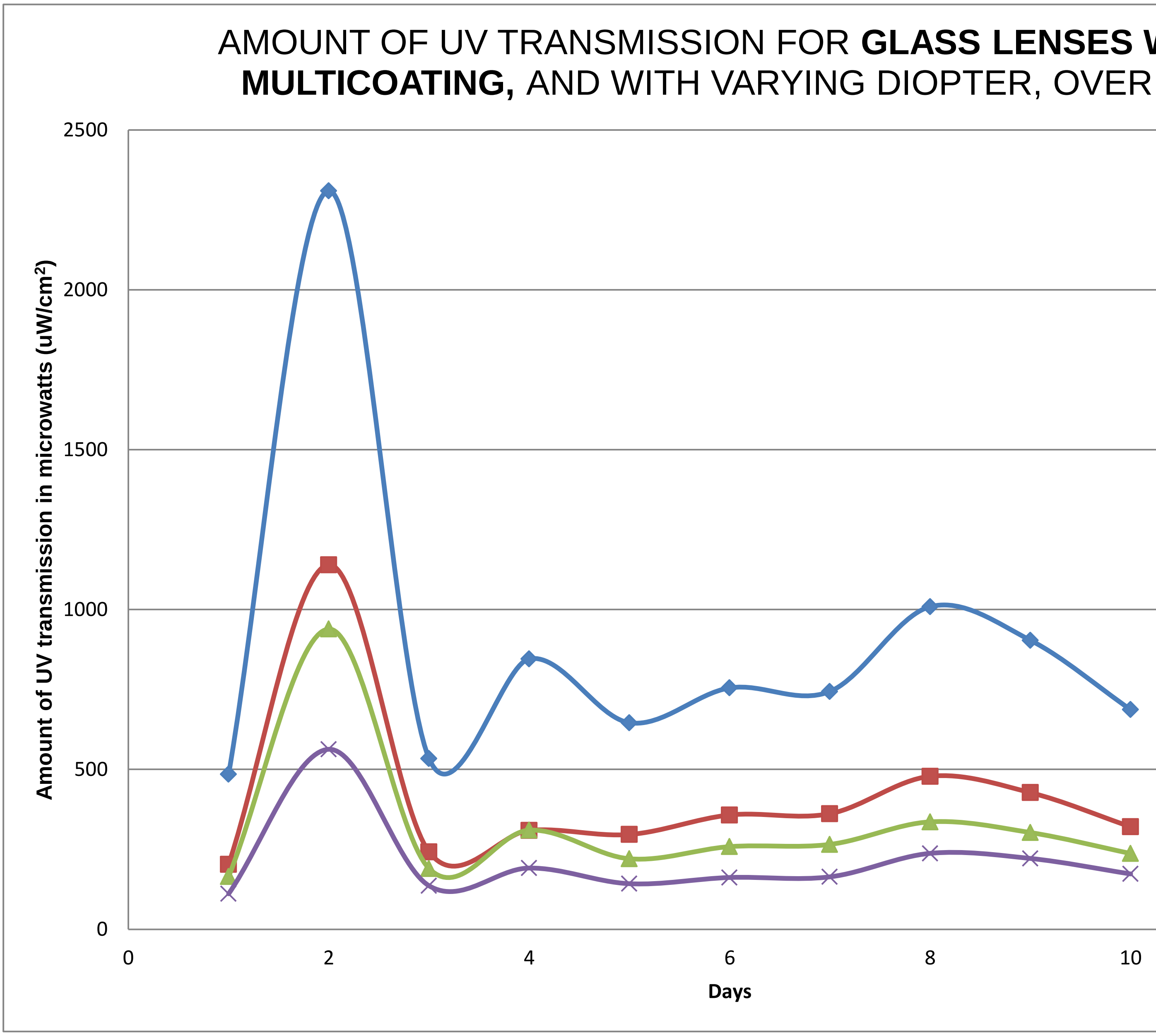
Lens was cleaned with the microfiber lens wiping cloth by holding the lens by the rim, to remove any dust and fingerprints which may block UV rays

Figure 8



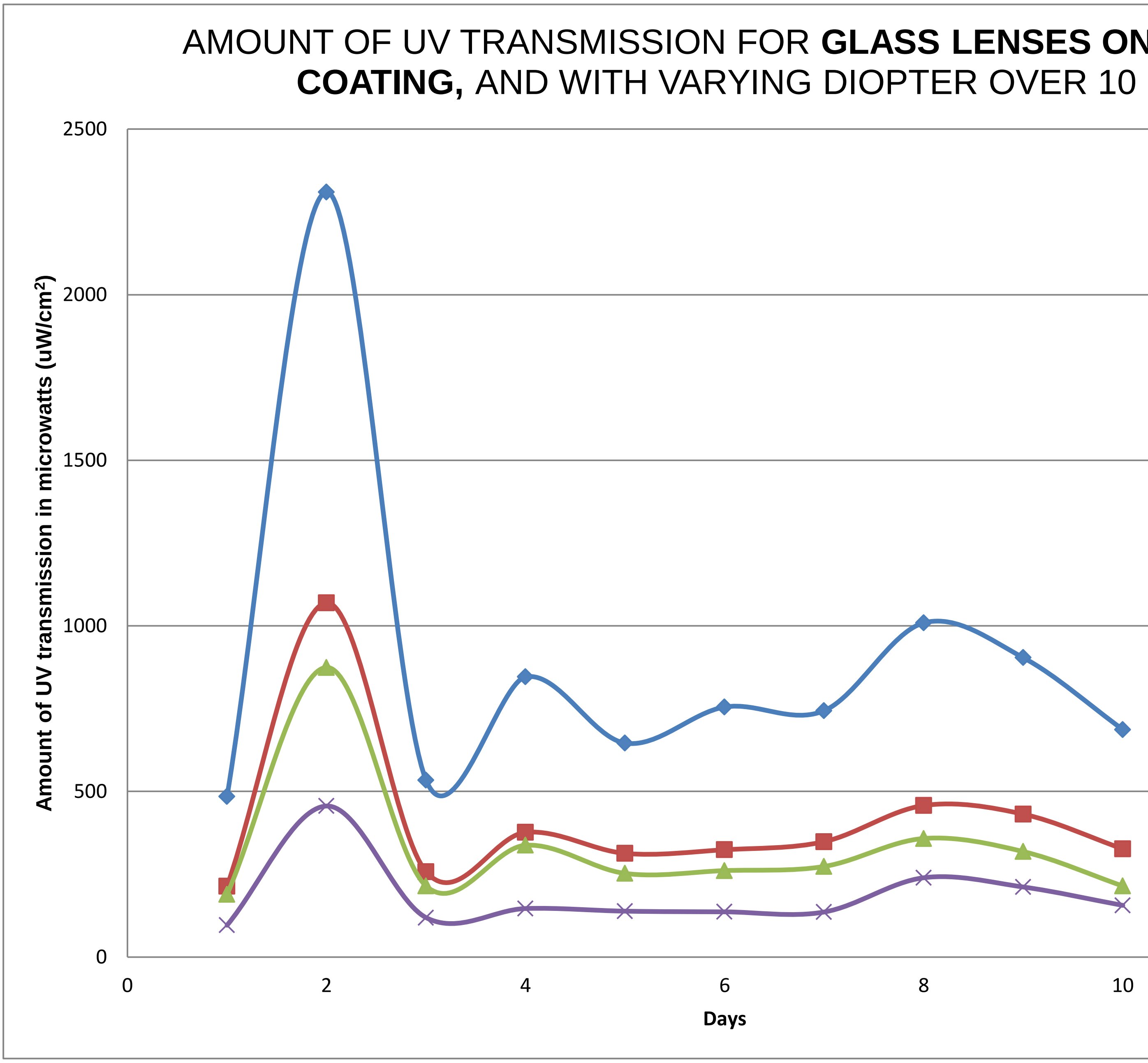
The glass lens was placed on top of the platform, and aligned with the circle marked in red pen. This was exposed to the UV rays of the sun for five seconds, before recording the measurement.

GRAPH 1



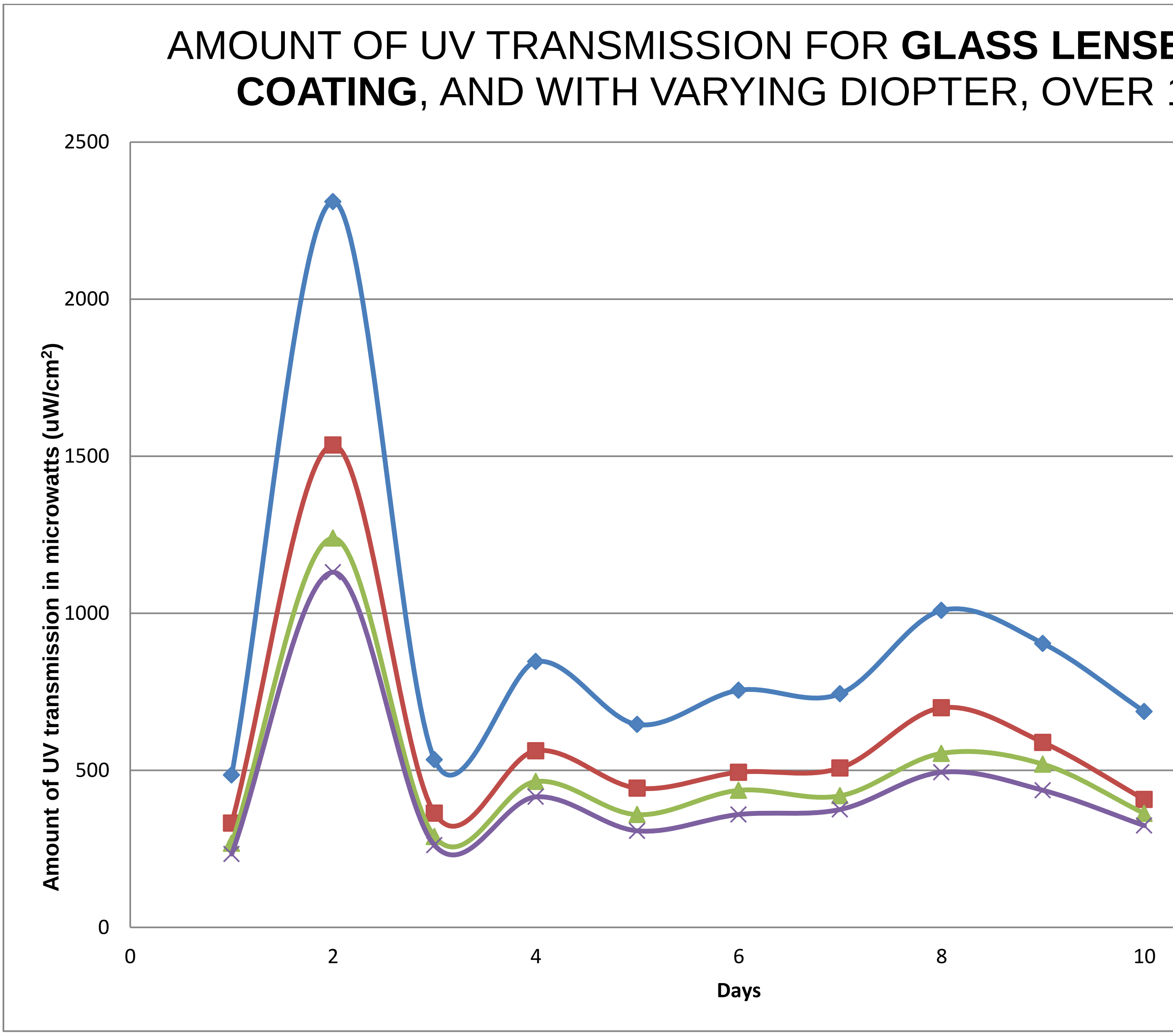
AMOUNT OF UV TRANSMISSION FOR GLASS LENSES W
MULTICOATING, AND WITH VARYING DIOPTER, OVER
Amount of UV transmission in microwatts (uW/cm²)
2500
2000
1500
1000
500
0
0
2
4
6
8
10
Days

GRAPH 2



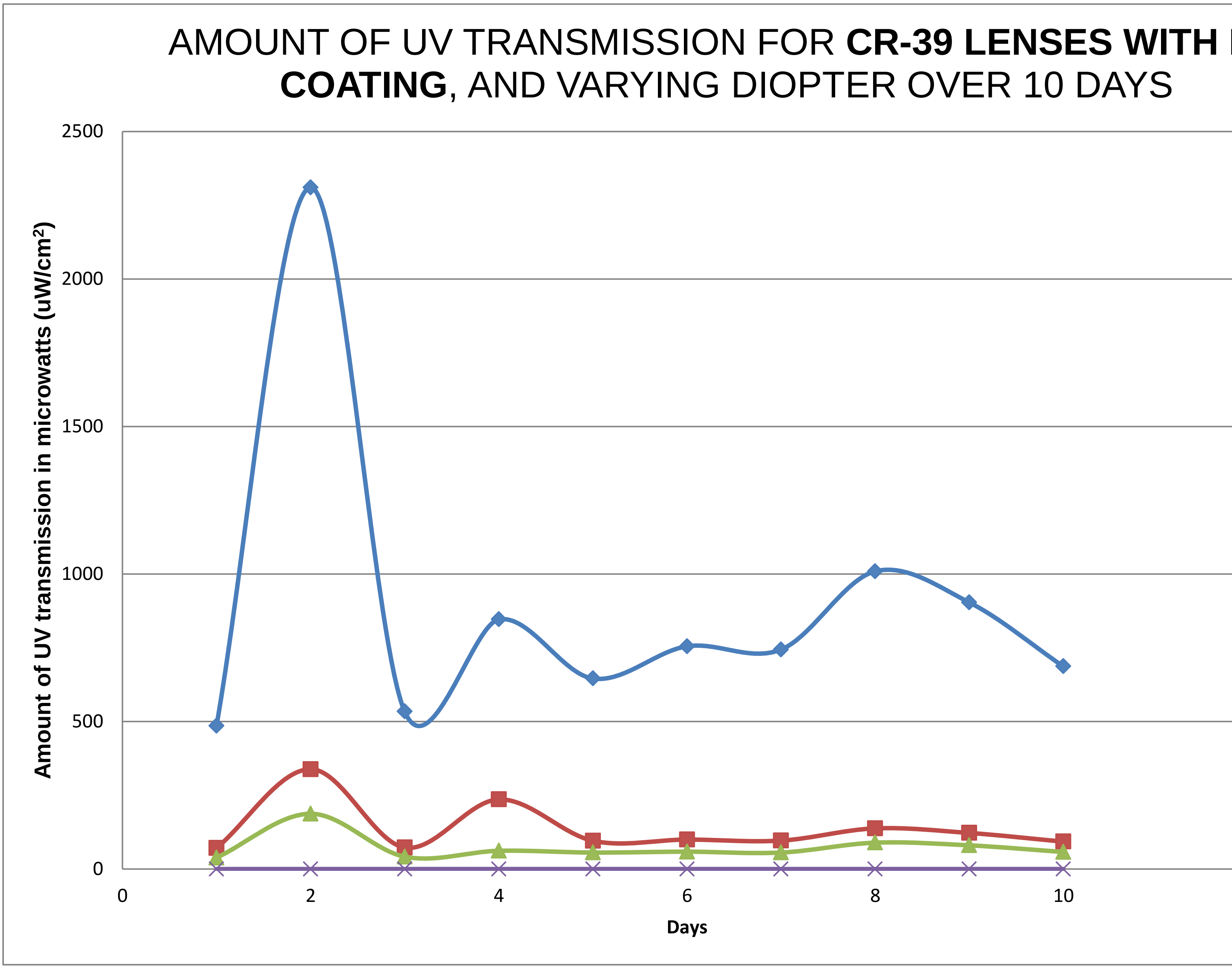
AMOUNT OF UV TRANSMISSION FOR **GLASS LENSES ON**
COATING, AND WITH VARYING DIOPTER OVER 10
2500
2000
1500
1000
500
0
Amount of UV transmission in microwatts (uW/cm²)
0
2
4
6
8
10
Days

GRAPH 3



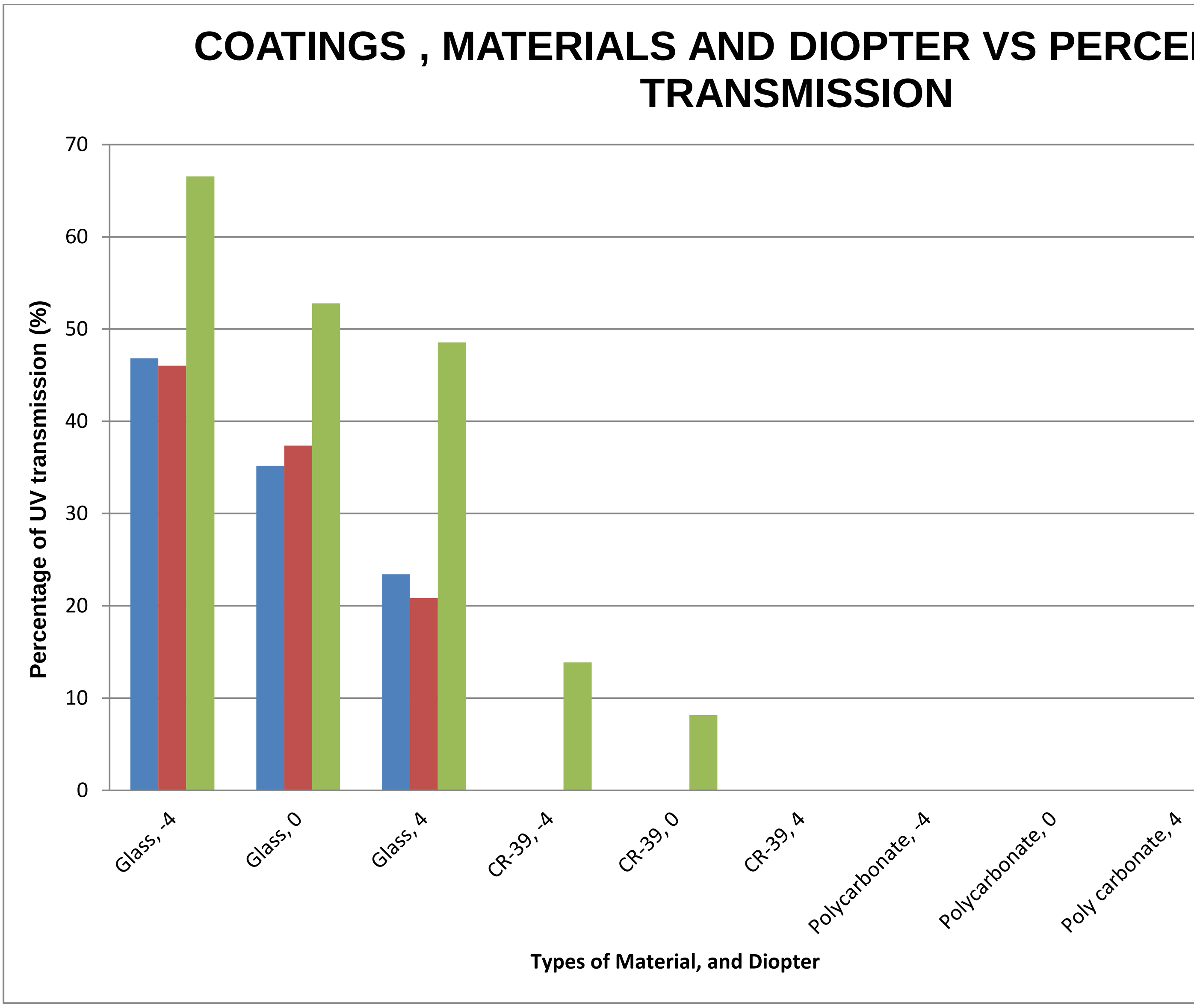
AMOUNT OF UV TRANSMISSION FOR **GLASS LENSE**
COATING, AND WITH VARYING DIOPTER, OVER 1
Amount of UV transmission in microwatts (uW/cm²)
2500
2000
1500
1000
500
0
0
2
4
6
8
10
Days

GRAPH 4

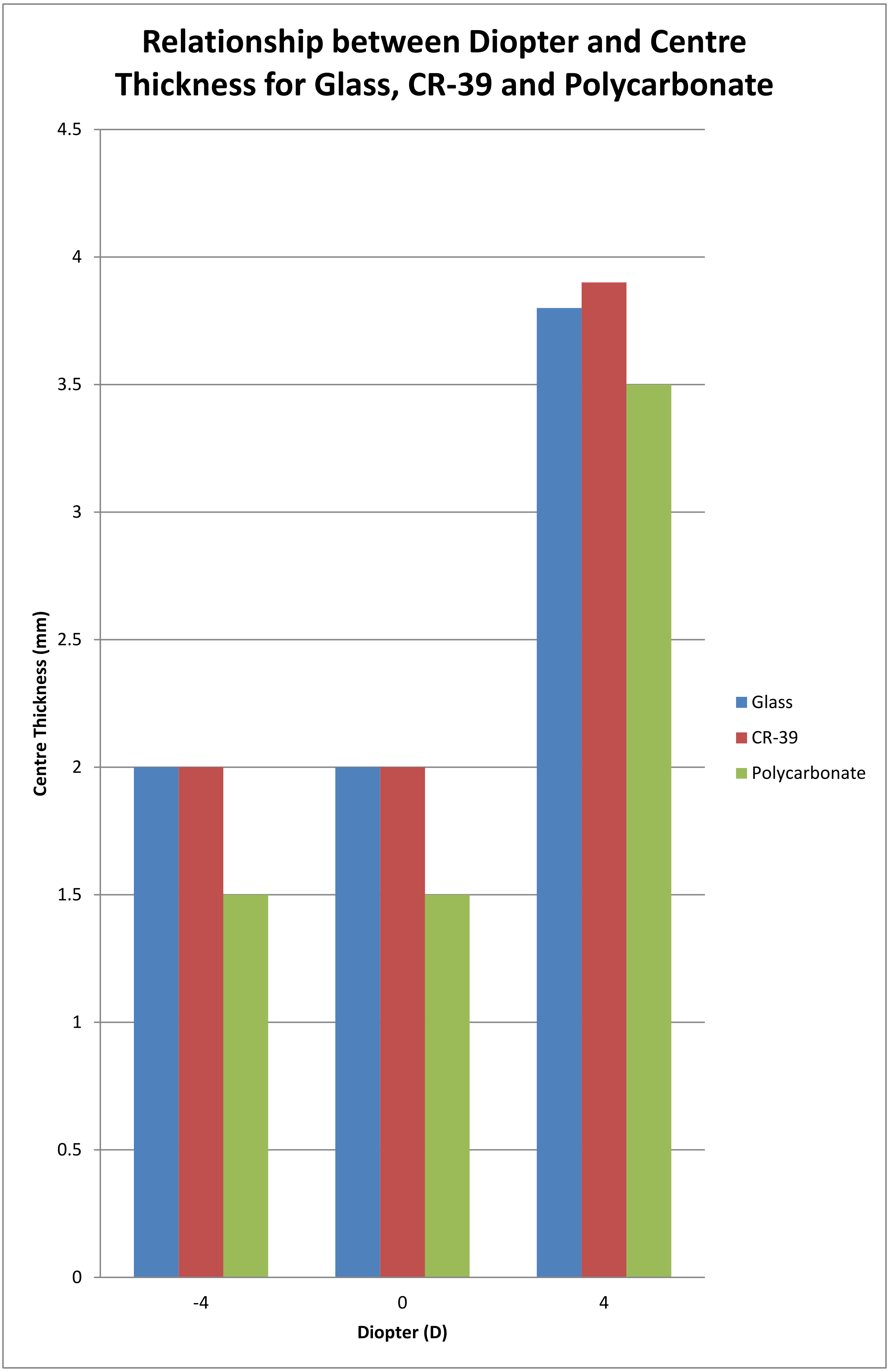


AMOUNT OF UV TRANSMISSION FOR CR-39 LENSES WITH
COATING, AND VARYING DIOPTER OVER 10 DAYS
Amount of UV transmission in microwatts (uW/cm²)
2500
2000
1500
1000
500
0
0
2
4
6
8
10
Days

GRAPH 6


COATINGS , MATERIALS AND DIOPTER VS PERCE
TRANSMISSION
Percentage of UV transmission (%)
70
60
50
40
30
20
10
0
Glass, -4
Glass, 0
Glass, 4
CR-39, -4
CR-39, 0
CR-39, 4
Polycarbonate, -4
Polycarbonate, 0
Poly carbonate, 4
Types of Material, and Diopter

Graph 5



Relationship between Diopter and Centre Thickness for Glass, CR-39 and Polycarbonate
Centre Thickness (mm)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-4
0
4
Diopter (D)
Glass
CR-39
Polycarbonate

Discussion

Hypothesis 1: The thicker the lens and thus the higher the diopter, the better it is at absorbing ultraviolet radiation

Hypothesis 1 was true as the higher the diopter, the less UV transmission would pass through the lens. In Graph 1, it is shown how for glass lenses with both UV & Multicoating, it is the +4 diopter that allowed the least transmission through. This is then followed by the lenses with 0 diopter, and then by -4 diopter. It suggests that the higher the diopter, the less UV rays it will transmit. Since the control UV in Day 2 was higher than the other days, it is able to effectively compare the UV absorbing abilities for each diopter. The -4 diopter was able to transmit more 1140uW/cm^2 than the lens with 0 diopter, which supports the hypothesis.

Graph 4 is unlike the other graphs, in that it shows how in non coated CR-39, the +4 diopter lenses allowed for zero transmission, whilst those with -4 or 0 diopters, allowed for transmission below 15%. This suggests that the increased thickness in the CR positive diopters enabled for increased absorption.

Graph 5 depicts the relationship between the diopter and centre thickness of the lenses of different materials. This graph was created to take in account for the different shapes of the lens- negative diopter lenses are concave and positive diopter lenses are convex. Graph 5 supports and correlates with the raw data and shows that in -4 and 0 diopters, the glass and the CR-39's centre thickness was the same, but for +4 diopter, CR-39's centre thickness was thicker than the other materials. This then suggests that CR-39 was able to block UV radiation completely for +4 diopter due to its centre thickness being thicker.

Thus the results supported Hypothesis 1

Hypothesis 2: Polycarbonate would be the best lens material to protect against ultraviolet radiation

Table 1, 2 and 3 (raw data) depicts how lenses made of the **polycarbonate** material allowed zero transmission of the UV rays regardless of diopters or coatings, which supported the Hypothesis 2. **CR-39**, on the other hand, enabled zero transmission for both UV & Multicoating, regardless of the diopters, but for the CR non coated lenses, it did allow UV rays to pass through for positive diopters. **Glass** was unable to prevent the transmission of UV radiation completely for any diopter and any coating, suggesting it is the worst material of the three.

Thus the results supported Hypothesis 2

Hypothesis 3: The lenses with both UV & Multicoating would be better at absorbing ultraviolet radiation, than those with only UV coating or non coating.

In Graph 2, it is shown how each of the measurements is lower than that of Graph 1. When comparing both UV & Multicoated **glass lenses** (Graph 1) with the only UV coated glass lenses of relative diopters (Graph 2), it can be concluded that there is only a marginal difference between the two, suggesting that the added Multicoating has little effect in preventing against UV radiation. There are some anomalies that should be noted, such as the fact that the UV coated, +4 diopter glass lenses was lower than the UV & Multicoated, -4 diopter glass lens. Thus, the effectiveness of the Multicoating varies with the material used, and in some cases will increase the UV transmission as opposed to those just UV coated (comparing the UV coated & multicoated glass lenses with -4 diopter & those that are only UV coated), and in others will decrease UV transmission (comparing the UV coated &multicoated glass lenses with 0 diopter & those that are only UV coated).

However, when juxtaposing the results of the UV-coated glass lens (Graph 2), with the non-coated glass lens (Graph 3), it is clear that there is a dramatic increase in the percentage of UV rays that has transmitted. For example, UV coated, -4 diopter glass lens was 466uW/cm^2 lower than the non coated, -4 diopter glass lens. This suggests that the UV coating is sufficient enough to block the transmission of UV rays, and can prevent UV rays from harming the eye.

Thus the results neither supported or unsubstantiated Hypothesis 3 as the Multicoating's effectiveness in protecting against UV radiation varied depending on the diopter.

Finally, Graph 6 was able to combine all the data together, and highlighted a number of concluding results. Firstly, polycarbonate would prevent all UV radiation regardless of diopter or coating. Secondly, having non coated lenses would increase the UV transmission significantly, as opposed to the same lenses being UV coated or UV & Multicoated. Thirdly, the CR-39 material would block all UV transmission, except the non coated lenses with negative diopters or zero diopters. Lastly when comparing the blue and red columns of the glass lenses with the three different diopters, it is clear that the Multicoating's ability to prevent UV transmission is variable to diopter and does not consistently lower or raise the UV transmission.

VALIDITY, ACCURACY AND RELIABILITY

To ensure validity of the method, the measurements of the UV radiation were written in the appropriate units of microwatts per squared centimetre. The experiment incorporates suitable equipment such as the UV detector and various types of lenses, and appropriate measuring procedures were taken as shown in the method.

The method included repetition which made the experiment more reliable, and variables such as the weather, time of day, location, length of exposure under the sun, company of the lenses, and brand of UV detector were controlled. Upon repeating the experiment, the results were similar and within an acceptable margin of error. Each lens was tested twice, and the averages of the measurements were used in the results to make the processed data accurate. However, the experiment's reproducibility is limited by the fact that the controls (amount of UV radiation without any lens) may be subject to change, depending on the weather and the atmosphere.

The results are also accurate as they are close to the true value of the amount of UV radiation, although the accuracy and sensitivity of the UV detector is limited to ±(4% FS). FS stands for full scale which is the maximum amplitude the UV detector can present.

Due to the number of lenses that needed testing, the results may be subject to error as it was impossible to test them all at exactly the same time and weather condition. Additionally, the possibility of human error must be taken into account.

IMPROVEMENTS

It would have been preferable to test every single diopter (eg. From -10 to 10, in 0.25 steps) however this would be impractical and time consuming. Additionally, CR-39 lenses with higher dioptres such as 10 and -10 are not commercially available on the market as they are too thick and unappealing to consumers.

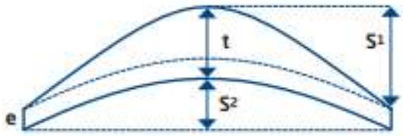
Further improvements could be achieved by testing to find what diopter is the first to allow for UV transmission of zero, for CR-39, as the results were only able to support that +4 diopters in CR-39 material prevented UV radiation completely.

Another area for further testing involves investigating the properties of CR-39. The results have shown that with CR-39 material for +4 diopters, the centre thickness is 3.9 mm (see table 1). Therefore, it would be interesting to investigate if lens with negative dioptres and a centre thickness of 3.9mm or more, would also allow zero transmission of UV radiation.

The edge and centre thicknesses can be calculated by using a formula. However, for the purposes of practicality and efficiency, an online commercial lens thickness calculator was used.

Formula to calculate centre thickness

Meniscus lens



From Figure 1 (above)

$t + s^2 = e + s^1$

so

$t = e + s^1 - s^2$ where s^1 = sag of F_1

s^2 = sag of F_2

APPLICATION

Currently, many franchised budget eyewear stores often sell glasses with non coating CR-39 as these are cheaper to sell as a packaged deal. These may be suitable for use if the wearers require a positive diopter. Although polycarbonate is ideal for protection against UV radiation, people still opt to use glass or CR-39 as these are usually cheaper. The results have shown that glass lenses are not only heavy and likely to break, they provide the least UV protection. However, it is suitable for people with extreme myopic or hyperopic vision as it will be thinner than its CR-39 and polycarbonate counterparts or those who prefer better visual clarity and a material that is less likely to be scratched.

Conclusion

The thicker the lens and the higher the diopter, the better it is at protecting against UV radiation. Polycarbonate is the best material to use as it blocks 100% of UV radiation regardless of diopter or coatings. Thus Hypothesis 1 and 2 were supported to be true, but Hypothesis 3 is neither true nor false as the effectiveness of the Multicoating depended on the diopters.

Glossary

Allyl diglycol carbonate (CR-39)- the most common ophthalmic lens material which is lighter than glass lenses, more impact resistant and more prone to scratching.

Concave- a type of lens that curves inward and causes light rays to diverge

Convex- a type of lens that bulges outward and causes light rays to converge

Crown glass- an inexpensive ophthalmic lens material with excellent optical properties and a reasonable scratch-resistant quality

Diopter (D)- a unit of measurement of the optical power of a lens.

Hyperopia/ Hypermetropia (long-sightedness) – a condition in which the optical components of the eye are not strong enough, resulting in the light not being focussed on the retina. People with hyperopic vision are able to see objects in the distance reasonably well, but their vision becomes blurred when doing near work.

Microwatts per squared centimetres (uW/cm^2)- measures the exposure levels of radio-frequency radiation (which includes UV radiation). One uW is a millionth of a watt.

Multicoating- a treatment used to reduce reflections from the lens surfaces and increase the amount of light that passes through the lens.

Myopia (short-sightedness) - a condition where the light is focussed in front of the retina, resulting in blurred vision. People with myopic vision are able to see objects in short distances reasonably clearly, but will not see distant objects clearly.

Polycarbonate- a thin, light and highly impact resistant ophthalmic lens material

Refractive index- a measure of the speed of light passing through a material. The higher the index number, the thinner (and generally more expensive) the lens and the more durable it is as the material is denser.

Ultraviolet-A (UVA) – a type of ultraviolet radiation that has a long wavelength, passes through glass easily and is the weakest form of ultraviolet light

Ultraviolet-B (UVB) – a type of ultraviolet radiation that is most dangerous but does not pass through glass.

Ultraviolet-C (UVC) – a type of ultraviolet radiation which is usually absorbed in the ozone layer.

UV coating- a treatment used to reduce transmission of light in the ultraviolet spectrum.

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