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Research paper

A Study on the Functional Spectacle Lens with Photochromic, UV Blocking and Polarization

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Abstract

Background/Objectives: It is necessary to secure competitiveness through the development of functional spectacle lens due to low cost of Chinese glasses lens and sluggish domestic glasses lens industry.

Methods/Statistical analysis: A taping method was used to develop a polarized spectacle lens that partially blocks ultraviolet and blue light and has photochromic properties.

Findings: The photochromic properties of the fabricated lens showed a recovery time of about 0.5 seconds for dark reaction and about 3 seconds for dark reaction. Also, the polarization ability was about 95%. Ultraviolet rays were almost shut off and blue light was reduced by about 30%. Lenses combining photochromic, UV blocking and polarizing functions are the first attempts at researching the market for spectacle lenses in Korea.

Improvements/Applications: The developed lens can dramatically reduce glare caused by late night operation or reflected light with a functional lens. It serves as a sunglass for outdoor use with strong ultraviolet rays, and can be used as a spectacle lens at normal times.

Keywords: *spectacle lens, sun glass, polarization, UV, blue light.*

1. Introduction

We wear sunglasses a lot in summer. Sunglasses reduce the amount of light to reduce glare, but ultraviolet rays. The pupil expands and becomes vulnerable to ultraviolet rays. Therefore, blocking sunlight is one of the important factors. On the other hand, if the user wearing the water glasses is to use the sun glasses, he or she should color the glasses of the general glasses. Sunglasses reduce the amount of light to reduce glare, but ultraviolet rays. The pupil expands and becomes vulnerable to ultraviolet rays. Therefore, blocking sunlight is one of the important factors. On the other hand, if you are wearing glasses, you may use sunglasses to color your glasses. At this time, ultraviolet shielding must be dependent on the coating, which can easily be destroyed by scratches. The photochromic lens can change to black or brown upon receiving ultraviolet rays and function as a sunglass. Therefore, even if the thickness of the photochromic lens is constant and the lens material having the ultraviolet shielding function is arranged continuously, the ultraviolet ray blocking and the amount of light can be controlled without depending on the coating. If the grating direction of the polarizing film is arranged vertically, it is possible to effectively shield the horizontally polarized reflected light. In this case, it is possible to effectively prevent nighttime operation and reflected light of the road. The photochromic spectacle lens material and the UV shielding spectacle lens material can not be mixed. This is because ultraviolet rays are required for the photochromic material, while ultraviolet shielding materials must shield ultraviolet rays. Therefore, a special method is needed.

2. Lens Making Process

2.1. Photochromism

It is usually colorless and transparent, but when it receives ultraviolet light, the phenomenon that it changes to a specific color is called photochromism.The photochromic lens is manufactured using such a photochromic material. Photochromic lenses are made using such photochromic materials. The photochromic lens refers to a lens that is transparent in a room without ultraviolet rays, changes to a dark color in an outdoor environment with ultraviolet rays, and is restored to its original transparent or light color upon entering the room again. These photochromic lenses are very useful for those who wear glasses in the room for vision correction. Therefore, the photochromic lens usually performs both the functions of the vision correction and the sunglasses. Generally, a photochromic plastic lens is produced by adding a small amount of a photochromic compound to a monomer and polymerizing it. Examples of the photochromic compound include spiropyran, spiroxazine, fulguide, chromene, diazo compound, diarylethene and the like. To facilitate the photochromic behavior of such a photochromic compound, a certain amount of internal space must be secured in the polymer. Therefore, the photochromic plastic lens has a problem that the mechanical properties such as hardness are weaker than that of a general lens for correcting visual acuity. In addition, a plastic lens usually performs hard coating to strengthen the surface hardness to prevent scratches, scratches, and the like. In recent years, multi-coating is carried out to alternately deposit a low-refractive-index dielectric and a high-refractive-index dielectric thereon, thereby giving a low-reflection function. However, in the case of the photochromic lens, the surface hardness is weak and the hard coating is considerably unstable, and the multi-coating is practically impossible, and it has been difficult to manufacture the rimless glasses. In addition, attempts have been made to increase the surface hardness in the production of photochromic lenses, but when the surface hardness is increased, the production yield is greatly lowered and the photochromic life is shortened. The base material comprises 70 to 90% by weight of a monomer selected from the group consisting of diacrylate, dimethacrylate, a copolymer of acrylate and dimethacrylate, 10 to 30% by weight of dimethyloltricyclodecane di (meth) acrylate, 0.001 to 10% by weight of a photochromic compound selected from spiropyran, spirocopy, unglued, pullimide, chromene and diazo compound is used in combination. A polymerization initiator or the like is used as an additive [1-9]. Figure 1 shows an example of a photochromic raw material.

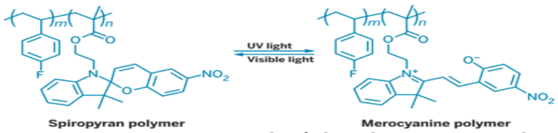

Figure 1:. Example of photochromic compound

2.2. Polarization

Polarization refers to a wave of light in which natural light vibrates only in one direction through a polarizer. Reflected and refracted natural light reflected by the natural object, it is glare when you take in natural light repeatedly. If you wear a polarizing lens, you can reduce glare. In particular, it is possible to reduce the glare by blocking the reflected light at the time of the sunrise or the sunset, and the visible distance to see the object becomes long. On the other hand, when a polarized lens is worn during operation, unnecessary light is blocked, thereby securing a wide field of view, thereby assisting safe driving. Conventional polarizing lenses are widely used in which a polarizing sheet is heated and attached to the surface of a plastic lens. However, since the polarizing film is exposed on the surface of the lens, the polarizing film is easily damaged by external impact or scratches, . In order to solve this problem, there is a method of manufacturing a polarizing lens by placing a polarizing film on the inner side of a gasket mold and injecting monomers into the mold. The method of using a gasket mold requires a certain degree of proficiency in assembling a mold and requires a working environment necessary for mold assembly, resulting in a low production efficiency. To solve this problem, a method of operating upper and lower jigs using a pneumatic device has been introduced. To pick up the polarizing lens, a lower jig and an upper jig are necessary to support the polarizing film. The lower edge of the lower edge portion is formed in a ring shape so that a portion of the inner lower side is advanced from the inner side to the outer side to form an upward inclined face and then to form an upright vertical face so as to form an obtuse angle. Therefore, even if a gasket mold is not used, a complicated lower jig and upper jig are required to support the polarizing film [10-12].

In this study, we used a method that does not require a lower jig, an upper jig, a lower support, and an upper support, does not need a notch groove in a polarizing film, and can easily manufacture a polarizing lens by preliminary polymerization and main polymerization. The polarizing film can be uniformly bonded to the lens and the polarizing film does not protrude out of the lens, so that the coating can be made uniform.

It is difficult to impart a polarizing property to the spectacle lens material and a polarizing film is applied. The heat is applied to make the curvature of the polarizing film coincide with the outer curvature of the lens, and it is positioned on the back side of the photochromic layer of about 1 mm. Inside the polarizing film, the monomer having UV blocking function is placed and the adhesion is maintained through the polymerization process.

2.3. UV Protection

Ultraviolet rays have a wavelength of 400 nm to 100 nm and are shorter than the wavelength of visible light but longer than X-rays. A gas discharge tube of an ultraviolet LED or ultraviolet laser device is the only mechanism that emits ultraviolet light. In general, exposure of the body to ultraviolet light can cause short-term or long-term skin damage such as redness, burns, wrinkles, freckles, and skin keratinocyte. Especially, exposure to ultraviolet ray A is known to weaken the immune system and cause skin cancer. Table 1 shows the range of ultra violet rays.

Table 1.: Range of ultra violet rays

Name	Wavelength	Energy/ photon
UVA	400 – 315 nm	3.10 – 3.94 eV
UVB	315 – 280 nm	3.94 – 4.43 eV
UVC	280 – 100 nm	4.43 – 12.4 eV

The cyclopentasiloxane using a high concentration of PEG-10 dimethicone is used with a dispersant of 5 to 10, and the titanium dioxide powder containing an ultraviolet screening composition is a dispersant having a high dispersion of an average particle diameter of 10 to 20 nm, The material comprises from 30 to 70% by weight of the dispersion medium and the residual amount. The dispersed material is dispersed at a speed of 800 to 1,200 RPM using a bead mill. Raw materials are the development goals of the foundation as well as the dispersion characteristics that should be used as cosmetics. In addition, the feeling of use, the biggest influence, is one of the most important development factors in selecting the dispersion medium. Thickness, spreadability, and raw materials, etc., were evaluated for maximum feelings by comparing each raw material with a maximum of 5 halftone dots by stickiness. We have developed three types of UV protection monomers. Table 2 shows the blended form of the developed monomers.

Table 2.: The types of the UV blocking monomers

Type	Materials	Portion(%)
A	1,6-diisocyanatohexane	54
	2,5-diisocyanatomethylbic	46
B	2,3-Bis(2-mercaptoethylthio)propane-1-thiol	84
	[1,4]Dithian-2-yl-methanethiol	10
	2-9[1,4]Dithian-2-ylmethylsulfanyl)-ethanelthiol	6
C	Pentaerythritoltetrakis	80
	3-Mercapto-propionic acid 3-hydroxy 2,2-bis-propylester	16
	3-Mercapto-propionic acid 3-hydroxy-2-hydroxymethyl-2-propyl ester	4

3. Performance Test of Lens

3.1. Photochromism

A sample lens was prepared using a photochromic monomer. The basic size of the spectacle lens was applied, and no reaction was observed at the red and green laser points, but the photochromism was immediately confirmed when the 405 nm laser point was injected. Figure 2 shows a photograph of a sample photochromic lens irradiated with a 405 nm laser pointer [13].

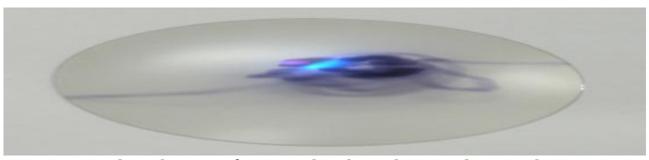

Figure 2:.Color change of a sample photochromic lens with a 405 nm laser light

The light and dark response of the sample photochromic lens was measured using ultraviolet light. Figures 4 show the light and dark response curves of the sample photochromic lens. Although the response curve is good, the rock reaction curve is expected to be improved for safety. Figure 3 shows the light and dark response curves made by sample photochromic lenses.

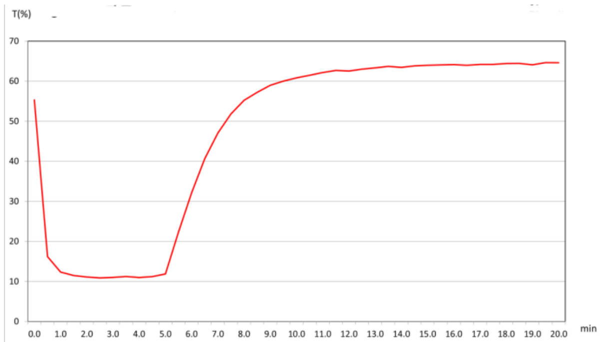

Figure 3:.Dark and light response curve of sample photochromic lens

3.2. Polarization Property

It uses Visible Linear Polarizing Laminated Film and is suitable for various microscopy, display, and imaging applications. The non-polarized light transmittance of one polarizing plate is 38%. When two polarizing plates are stacked vertically, the transmittance is reduced to 0.04%. The film is coated with cellulose triacetate to improve durability and durability, and the color is neutral gray.

0.02mm PVA polarizing films easily change the curvature of the film due to temperature and humidity, thus affecting the film distortion and quality level when manufacturing the lens. Figure 4 shows the transmittance of the polarizing film.

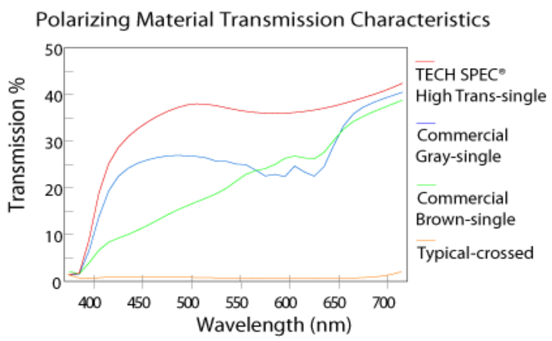

Figure4:. Transmittances of polarizing film

Sunlight oscillates in all directions, and most of the reflected light oscillates only horizontally. When the polarizer is vertically aligned, the reflected light cannot pass through it. Figure 5 depicts this principle as a picture.

Figure5.: Polarization characteristics of reflected light of sunlight and polarized glasses

3.3. UV Protection

Glass and plastic can be coated to reduce the amount of ultraviolet radiation passing through. Typical uses for such coatings include glasses and automotive windows. UV filters are used to block invisible ultraviolet radiation, which is at least slightly sensitive to most photographic sensors and films. We tested the UV410nm blocking lens with a spectrophotometer and obtained perfect protection results in the range below 410nm. 405nm laser pointer, it was confirmed that it is completely blocked [14-15]. Figures 6 and 7 show the results of UV protection by eye glass lens.

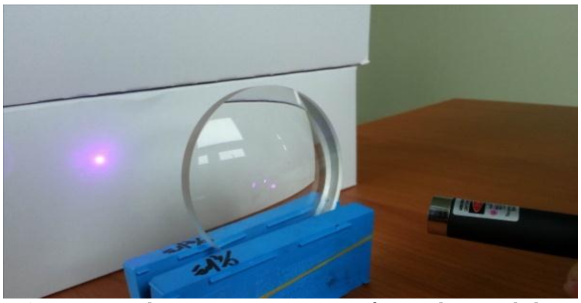

Figure 6. :Purple transmission property of general spectacle lens

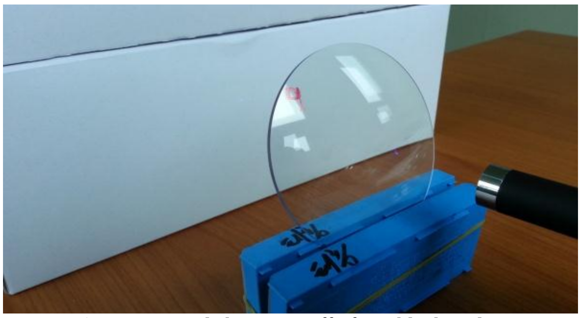

Figure 7:. Purple beam cut off of UV blocking lens

The transmittance of the specimen lens developed using ultraviolet visible spectrophotometer was measured. Figure 8 shows the transmittance of the developed specimen lens and the conventional CR39 lens. Figure 9 shows the difference in transmittance between a general UV blocking lens and a developed lens. The violet part is particularly blocked, blocking the blue light 30% as a whole.

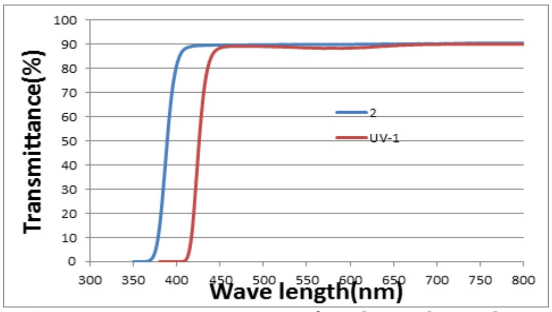

Figure8.: Comparison spectrum of 401 lens and CR39 lens

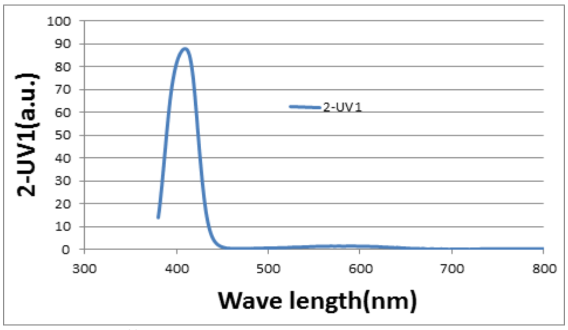

Figure 9:. Difference spectrum between 401 lens and CR39 lens

Figure 10 is a photograph of the transmittance measurement of a polarizing lens having photochromic and ultraviolet blocking functions.

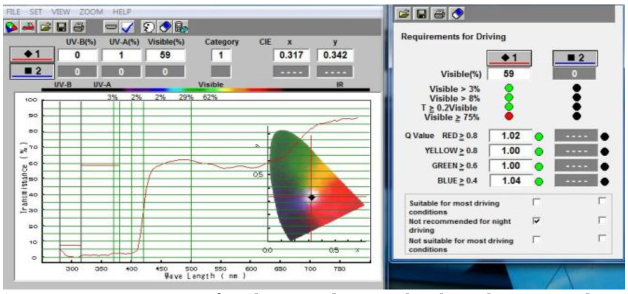

Figure 10.: Spectrum of polarizing lens with photochromic and UV blocking

4. Conclusion

The photochromic spectacle lens can condense the sunglasses. If UV protection function is added, it can be used darker in dark place, and it is widely used. In addition, the polarization function can fundamentally reduce the glare phenomenon of reflected light and the like. Photochromism and ultraviolet light blocking work opposite to ultraviolet light, so it is impossible for one monomer to be fundamental. It is the first in the world to develop an all-in-one lens by polymerization reaction by applying a monomer having different functions of photochromism and ultraviolet blocking to the polarizer. It can completely block ultraviolet rays of 410nm or less with a refractive index of 1.60 and includes a 30% blocking effect of blue light.

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