Journal of Physical Chemistry and Functional Materials

Home Page of Journal: https://dergipark.org.tr/jphcfum

Investigation of Spectral and Optical Properties of Color Polarization Lenses

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ABSTRACT

Polarized lenses are recommended because exposure to intense sunlight damages cellular function and photoreceptor structures in the eyes. Polarized lenses filter all wavelengths of UV radiation and most of the reflected glare due to strong reflections depending on the angle of incidence of sunlight and environmental factors. The wavelength of mineral glass in the horizontal and vertical direction (~550nm) is 16.64% for (CF1) and 13.21% for (CF2). There is a sudden drop of 27.87 at 729nm in CF2 and a sudden increase to 58.80 at 730nm in CF1. Absorbance values at 730nm are 0.21 with a decrease in AF1 and 0.54 with an increase in AF2. CF2 is polarized. To determine how the structure of the lens material affects light transmittance and absorbance, the light transmittances of smoked mineral and organic lenses of the same color are 16.64 for the mineral lens and 22.47 for the organic lens at (~550nm) wavelength. Maximum transmittance is 81.25 for mineral lens and 85.73 for organic lens. For night vision, at (~507nm) wavelength, it is 19.35 for mineral lens and 25.00 for organic lens. At (~550nm) wavelength, absorbance values are 0.78 for mineral lens and 0.62 for organic smoked lens. In the study, the effect of color factor on the light transmittance and absorption of organic smoked, brown and green polarized lenses was investigated. Light transmittance at 550 nm wavelength is 22.47 in smoked, 13.48 in brown and 14.32 in green. Absorbance at 550 nm wavelength is 0.62 in smoked, 0.94 in brown and 0.82 in green lens. Since dark lenses do not allow high light transmission, smoked color should be chosen for good vision in the visible light region. Brown color should be preferred if dark glasses should be used in situations where bright light is intense. In the 507nm wavelength of color polarized lenses, smoked is 25.00, brown is 11.45 and green is 16.94. Smoked should be chosen for night vision.

ARTICLE INFO

Keywords:

Color Polarization Lenses
UV radiation
Light transmittance
Eye health

Received: 2023-07-09
Accepted: 2023-10-06
ISSN: 2651-3080
DOI: 10.54565/jphcfum.1324779

1. INTRODUCTION

Ultraviolet radiation is a non-ionizing radiation with wavelengths ranging from (100-400 nm) [1].The ultraviolet spectrum is divided into three bands; UV-A (315-400 nm), UV-B region (280-315 nm) and UV-C (100-280 nm) wavelengths [2]. In the electromagnetic spectrum, the wavelength to which the human eye is most sensitive is visible light (400-700 nm) [3].Sunlight reaches the Earth's surface after being absorbed by 30% of the atmosphere. The atmosphere absorbs UV-C wavelengths by filtering radiation below 290 nm before it reaches the earth's surface. Recent global atmospheric changes have depleted the ozone layer and increased the level of UV radiation, resulting in increased exposure of eye and skin tissue to UV light [4, 5].The effect of radiation on the eye depends on the wavelength of the incident light and the duration of exposure [6,7].Exposure to intense sunlight damages cellular functions and photoreceptor structures in the eye[8].Protective goggles are recommended to protect the eyes from solar radiation[9].

The eye functions as a receiver and transducer of light from the environment [10]. The human eye contains photoreceptor cells in the retina that are stimulated by sunlight [9].The quality of the image on the retina depends on the light passing through the ocular structures of the eye [11]. UV radiation damage to the retina has been reported [22]. Unlike the skin, the natural defense mechanisms of the eye are the eye sockets, eyelids, natural reflex and adjustment of the amount of light in high intensity environments and darkness [12]. However, environmental conditions and improper selection of glasses cause more harm than not wearing glasses at all. The eye reflexively narrows in bright light outdoors and widens in dim light. Because the lenses create a dim environment, they weaken the natural reflex action of the eye, causing the pupil to dilate and expose it to harmful radiation [4,13]. For complete protection from radiation, properly selected glasses that will block UV radiation 100% up to 400nm are recommended, especially in bright sunlight outdoors[12].When light falls on wet, icy roads, car windshields, snowy environments and bright and reflective environments, it reflects off the surface with different reflection angles and causes glare. The angle of incidence of the reflection depends on Fresnel's Law of Reflection. Glare is annoying, especially for skiers, drivers and fishermen. When the sun is overhead, a body of water reflects about 2% of UVR upwards [14].When the sun is low in the sky, most of the incoming light is reflected, at low sun angles, strong reflections from the water create uncomfortable glare. Since reflections from water are strongly polarized and atmospheric scattering also polarizes light, a polarized lens can selectively filter out most of the reflected glare [15]. Light vibrates in the entire electrical plane, both as a particle and as a wave. Polarization is the cessation of vibration at some angles and the continuation of vibration at other angles. Polarization occurs in transverse waves. When unpolarized sunlight and artificial lights are reflected on shiny surfaces, full polarization occurs in the horizontal plane [16].This is prevented by vertical polarization of the lenses. People wearing polarized glasses are not bothered by reflections and glare on shiny surfaces and their clarity of vision is improved. Polarized sun lenses absorb 75% of incoming light and 100% of UV [17]. In recent years, photochromotic polarized lenses have been produced. Photochromotic polarized lenses are 100% UV-A and UV-B protected [18].

In this study, the light transmittance and absorbance of a mineral smoked lens in both horizontal and vertical directions were measured using UV/VIS spectrophotometry to show in which direction polarization occurs. In addition, the absorption and transmittance of organic smoked, brown and green polarization lenses were measured using UV/VIS spectrophotometer to explain the effect of color factor on the absorption and transmittance of photochromotic polarization lenses. The data of transmittance and absorption spectra were plotted using OriginPro-8 software. Since the thickness of the lenses affects absorbance and light transmittance, their thickness was measured with the help of a center thickness gauge. The aim of this study is to increase the level of social awareness and contribute to the literature by expressing which lenses should be preferred when choosing glasses, especially outdoors, and how color factors affect them.

2. MATERIAL AND METHOD

When light passes through any transparent medium, depending on the density and other properties of the medium, light reflection, absorption and light attenuation are observed. The polarization filter filters the wavelengths of the rays moving in the undesired direction, allowing them to pass through only one plane (Segre, 2003.78) [19].Today, there are many models according to the purpose of glasses used as accessories as well as eye diseases. Especially skiers, pilots, sailors prefer polarized filtered lenses. Accordingly, Jasco V-730 UV/VIS Dual Beam Spectrophotometer at Şırnak University Technology and Research Central Laboratory was used for absorption and transmittance measurements of organic and mineral polarized lenses, including the visible region. When an electromagnetic wave in the UV or visible region passing through the material is analyzed by UV/VIS spectroscopy, the wavelength corresponding to the rays absorbed by the material will be different for each atom and molecule, and the values obtained provide important information about the structure of the material under investigation [20].To see how polarization behaves on the horizontal axis and the vertical axis, the transmittance versus wavelength of the mineral smoked lens passing through both the horizontal and vertical axes is shown in Figure 1 and plotted using OriginPro-8 software.

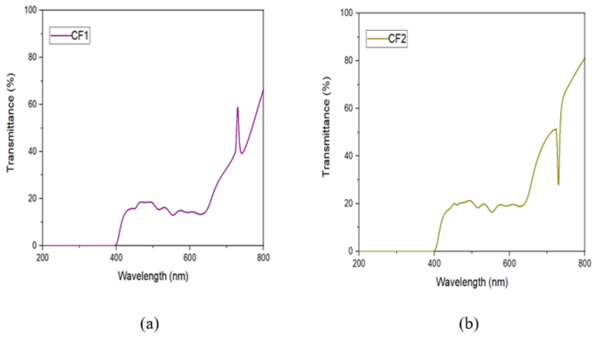

Figure 1 (a) Graph of light transmittance on the horizontal axis and (b) light transmittance on the vertical axis versus wavelength of mineral smoked lens

In the graphs in Figure 1, it can be seen that the smoked mineral lens exhibits the characteristics of polarizing lenses that do not transmit wavelengths in the UV radiation region both in the horizontal axis and in the vertical axis. In both lenses, starting from 1% at the wavelength to which the human eye is most sensitive (~550nm) [20] up to 400nm, it is 16.64% in the horizontal position (CF1) and 13.21% in the vertical position (CF2). Polarized lenses show a sudden drop of 27.87 at 729nm at CF2 and a sudden rise to 58.80 at 730nm CF1. The properties of the polarized lens are demonstrated at these wavelengths. The clearest wavelength for night vision is 507 nm. At these wavelengths the lenses should show maximum light transmission and brightness reduction [21] of 19.35 for CF1 and 16.44 for CF2. The maximum transmittance is 66.44 for CF1 and 81.25 for CF2.

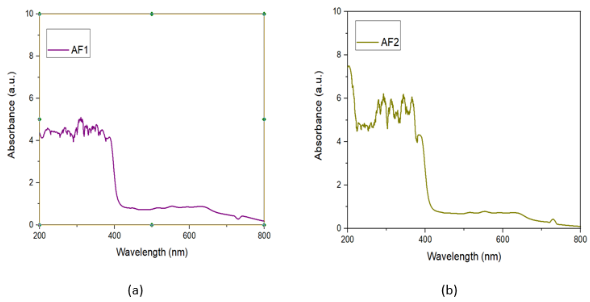

Figure 2 (a) Absorbance plot of Mineral Smoked lens versus wavelength on the horizontal axis, (b) absorbance plot on the vertical axis

In the absorbance graphs on the horizontal and vertical axes of the mineral lens shown in Figure 2, AF1 on the horizontal axis and AF2 on the vertical axis at the same wavelength 730nm, AF1 decreases by 0.21 and AF2 increases by 0.54. At 550nm wavelength it is 0.88 for AF1 and 0.7 for AF2. In the wavelength range of UV radiation, AF2 was the highest. The polarizing phenomenon is most clearly seen for AF2.

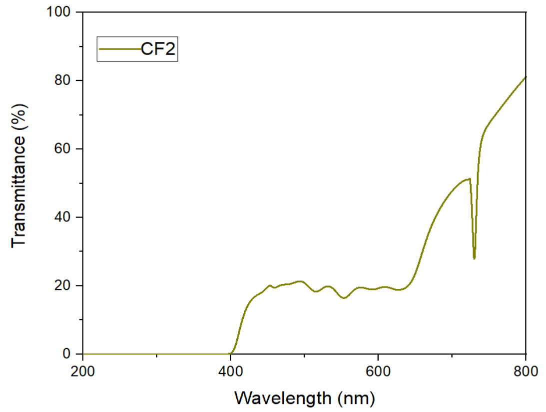

Figure 3 Wavelength versus light transmittance plot of smoked mineral lens

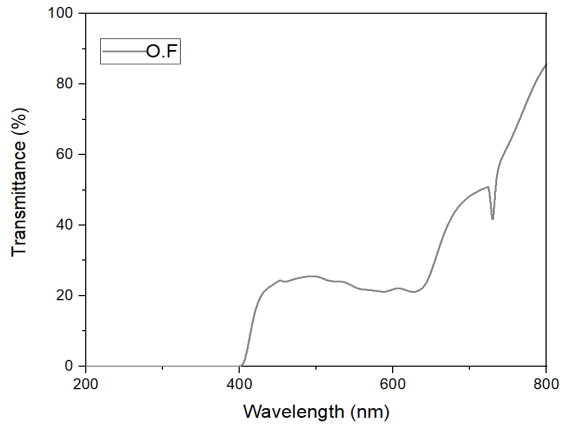

Figure 4 Light transmittance versus wavelength plot of smoked organic lens

To compare the light transmittance of Mineral and Organic lenses by wavelength, the same color was chosen for both lenses. The graphs in Figure 3 and Figure 4 show that polarized lenses provide full protection over the UV wavelength range. The wavelength at which the polarizing feature is most prominent is 41.66 at 729nm in mineral lens and 27.87 at 729nm in organic lens. At (~550nm) the light transmittances of mineral lens and organic lens are 16.64, 22.47. The maximum transmittances are 81.25 in mineral lens and 85.73 in organic lens. At the clear vision wavelength (~507nm) for night vision against glare is 19.35 in mineral smoked lens and 25.00 in organic smoked lens.

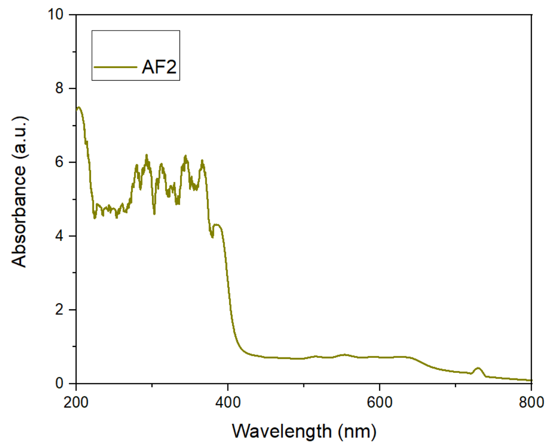

Figure 5 Absorption versus wavelength of smoked mineral lens

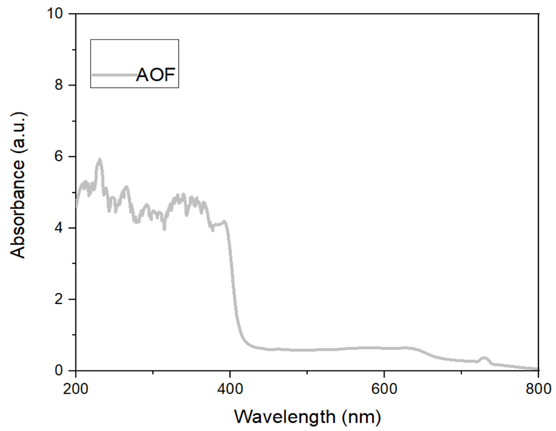

Figure 6 Absorption versus wavelength of smoked organic lens

The polarized lenses given in Figure 5 and Figure 6 are expected to have very good absorption in the UV radiation region and low absorption in the visible region. Looking at the graphical values, the absorption values in the transmission regions are below ~1, the absorption value at 729nm wavelength of the transmittance value where the polarization is most prominent in the mineral lens is 0.54 and 0.44 in the organic lens. Light transmittance is low and absorption value is high. Absorption at wavelength (~550nm) is 0.78 for mineral smoked lens and 0.62 for organic smoked lens. Maximum absorption values are 5.44 at 215nm for mineral smoked lens and 5.52 at 241nm for organic smoked lens. The thickness of mineral smoked lens is 1.9 and organic smoked lens is 1.8. As the thickness of the lens increases, absorption increases and light transmittance decreases [22], it can be said that mineral smoked lenses absorb better than organic lenses.

In recent years, photochromotic polarized lenses have been produced. Photochromotic polarized lenses are 100% UV-A and UV-B protected [18]. Since the color and material type of the lens will significantly contribute to the transmission and absorption of optical radiation, when we look at the transmittance and absorption of the colors we used in our study in the literature, smoked colors transmit visible rays very well, brown lenses absorb the blue-green band more than the orange-red band, while the green color absorbs the orange-red band more than the blue-green band [23].The light transmittances of organic green, brown and smoked lenses with photochromotic polarization are shown in Figure 7, Figure 8 and Figure 9.

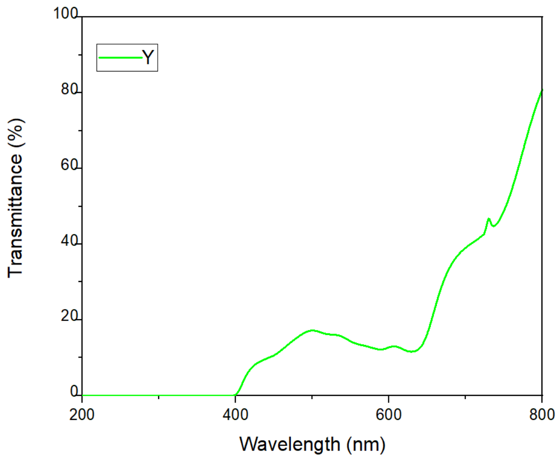

Figure 7 Light transmittance versus wavelength of organic green lens

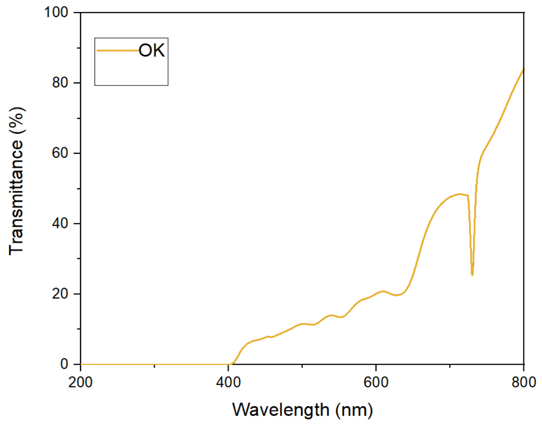

Figure 8 Light transmittance versus wavelength of organic brown lens

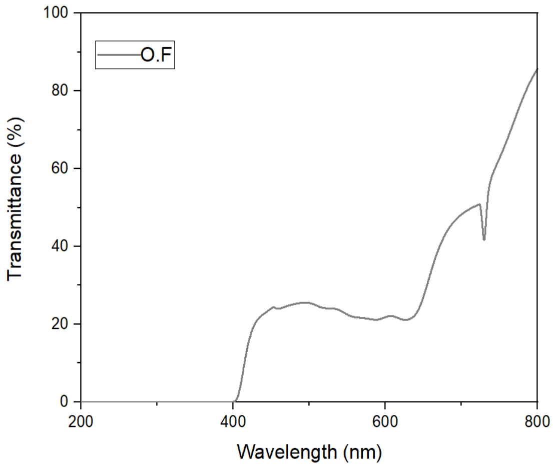

Figure 9 Light transmittance versus wavelength of organic smoked lens

The wavelength vs. wavelength graphs of the organic polarized lenses given in Figure 7, Figure 8 and Figure 9 show that there is no light transmittance in the UV radiation regions. At 550nm, which is the eye's photosensitive range, the light transmittances are 22.47 for fume, 13.48 for brown and 14.32 for green. Smoked color should be chosen for good vision in the visible light region. As the color of the lens darkens, the light transmittance decreases, so dark colored lenses should be preferred in situations where bright light is intense in outdoor environments. The light transmittance of colored polarized lenses selected for night vision to reduce the disturbance caused by brightness is 25.00 in smoked, 11.45 in brown and 16.94 in green at 507nm wavelength. Since all three lenses are polarized for night vision, smoked should be chosen for clear vision. In the visible light region, the polarization phenomenon is between (725-730nm) wavelengths for the smoked lens and there is a 7% decrease in light transmittance, for the brown lens there is a 20% decrease between (724-734nm) wavelengths and for the green lens there is a 1% decrease between (734-738nm) wavelengths. The polarized feature is seen in the visible region in organic colored lenses in the brown lens. This is also explained by the fact that darker lenses absorb more light.

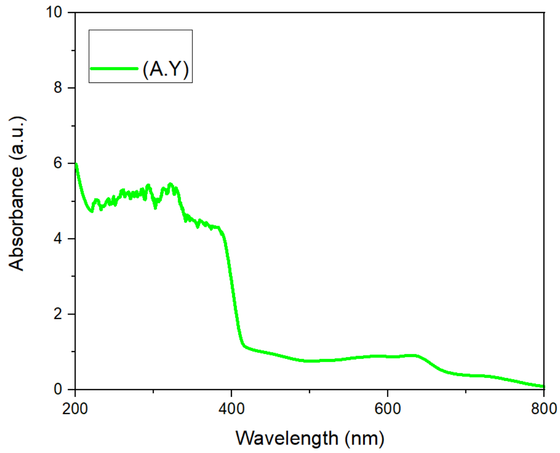

Figure 10 Absorption versus wavelength of organic green lens

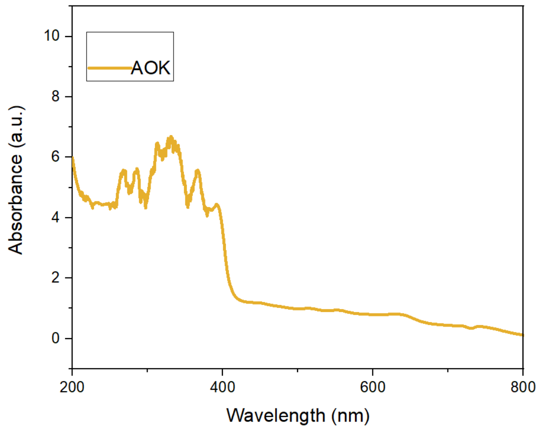

Figure 11 Absorption versus wavelength of organic brown lens

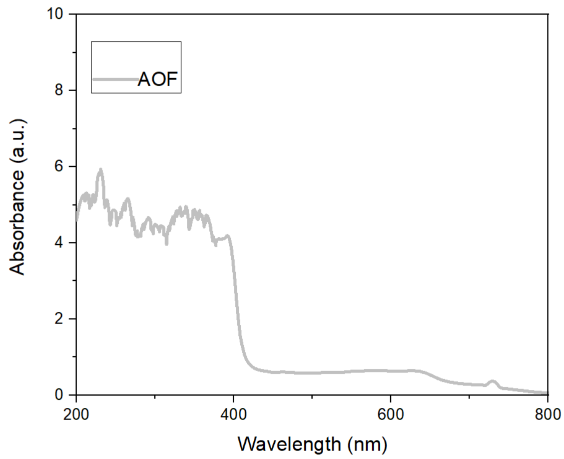

Figure 12 Absorption versus wavelength of organic smoked lens

In the absorption versus wavelength graphs of organic polarized spectacle lenses given in Figure 10, Figure 11 and Figure 12, it is necessary to have low light transmittance and high absorbance in the UV radiation wavelength range. When polarized lenses absorb 100% of UV radiation wavelengths, it is approximately 4% in all three lenses. It is 5.23 at 364nm wavelength in smoked lens, 5.42 at 211nm wavelength in brown lens and 5.31 at 265nm wavelength in green lens. Although the absorbance is approximately the same in all three lenses, it is higher in the brown lens. Since the thickness of the lens also affects the absorbance, as the thickness of the lens increases, absorption increases and light transmittance decreases [22], looking at the thicknesses of the lenses, the thicknesses of the organic brown and green lenses are the same (1.75), but the brown lens absorbs more, which shows that color is important in absorption. In the visible light region, the absorbance is well below 1%. At 550 nm it is 0.62 for smoked lens, 0.94 for brown lens and 0.82 for green lens. The light transmittance of the smoked lens is higher.

3. DISCUSSION

Protective eyewear is recommended to protect the eyes from UV radiation from the sun, as exposure to intense sunlight damages cellular functions and photoreceptor structures in the eyes. Polarized lenses filter all wavelengths of UV radiation and most of the reflected glare due to strong reflections depending on the angle of incidence of sunlight and environmental factors. Polarization filtered lenses filter the wavelengths of the rays moving in the unwanted direction and allow them to pass through only one plane. In this direction, when the light transmittance and absorbance of the mineral smoked lens are measured by UV-VIS spectrometer in both horizontal and vertical axis, the light transmittances are 16.64% (CF1) and 13.21% (CF2) at wavelength (~550nm). CF2 shows a sudden drop of 27.87 at 729nm and CF1 shows a sudden increase to 58.80 at 730nm...When we look at the absorbance values, AF1 at 730nm decreases by 0.21 and AF2 increases by 0.54. Looking at the values, CF2 shows the polarization feature in the vertical direction and the passage of unwanted light is filtered. In order to determine how the structure of the lens material affects the light transmittance and absorbance and which material should be preferred, the wavelength at which the polarized properties are most pronounced is a decrease of 41.66 at 729nm in the mineral lens and a decrease of 27.87 at 729nm in the organic lens. The light transmittances of mineral lens and organic lens at (~550nm) are 16.64, 22.47. The maximum transmittances are 81.25 for mineral lens and 85.73 for organic lens. For night vision against glare, the clear vision wavelength (~507nm) is 19.35 for mineral smoked lens and 25.00 for organic smoked lens. Absorbance value at 729nm wavelength is 0.54 in mineral lens and 0.44 in organic lens. Absorbance at wavelength (~550nm) is 0.78 for mineral smoked lens and 0.62 for organic smoked lens. While both lens types provide full protection in the UV radiation wavelength range, it shows that organic lenses should be preferred over mineral lenses for good vision and night vision against glare.

The eye reflexively constricts the pupil in bright light outdoors and dilates in dim light. Since spectacle lenses create a dim environment, they weaken the natural reflex action of the eye and cause the pupil to remain dilated, exposing it to harmful radiation. In addition, the pupil response is most sensitive to visible light. The glasses allow pupil dilation in proportion to the darkness of the glasses. These glasses can cause a lack of light in the eye and consequently increase eye defects caused by the lack of light. In our study, we investigated the effect of color factor on the light transmittance and absorption of organic smoked, brown and green polarized lenses with UV-VIS spectrometer. The light transmittance at 550nm wavelength where the eye is sensitive to light is 22.47 for smoked, 13.48 for brown and 14.32 for green. Absorbance values at 550 nm are 0.62 for smoked glass, 0.94 for brown glass and 0.82 for green glass. For good visibility in the visible light region, smoked color should be chosen, as dark colored glass does not allow high light transmission. However, brown color should be preferred if dark glasses should be used especially in outdoor environments where bright light is intense. In the 507nm wavelength of colored polarized lenses, smoked is 25.00, brown is 11.45 and green is 16.94. Since all three lenses are polarized for night vision, smoked should be chosen for clear vision. Since polarized lenses absorb 100% of the UV radiation wavelengths, it is approximately 4% in all three lenses, with a higher percentage in the brown lens. Since the thickness of the lenses also affects the absorbance, although the thicknesses of the organic brown and green lenses are the same (1.75), the brown lens absorbs more, which shows that color is important in absorbance and the absorbance decreases as the color of the lens gets darker.

Acknowledgement: We would like to thank Şırnak University for enabling the use of the Technology and Research Central Laboratory in the spectral analysis of the examined of Color Polarization Lenses in this study with the UV/VIS Spectrophotometer. This article is an extended version of the paper presented at the 6th International Conference on Physical Chemistry & Functional Materials on 14 June 2023.

Competing interests

The authors declare that they have no competing interests.

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