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EXPERIMENTAL RESEARCH ON DETERMINING THE TRANSMITTANCE OF LENSES FOR VISION CORRECTION AND THE FACTORS THAT INFLUENCE IT

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ABSTRACT

The field of making optical lenses is very vast and with great applicability in several engineering fields. The research carried out in this work implied the determination of the transmittance of optical lenses of different diopters, thicknesses, with and without protection and the influence of material from which they were made. By analysing different aspects of lenses, we can better understand their impact on patients' vision and visual comfort, thus contributing to improving the quality of ophthalmic services.

KEYWORDS: transmittance, lenses, optical properties, diopters

1. Introduction

Optical lenses are essential components of many optical devices such as glasses, cameras, telescopes and microscopes. Lens manufacturing technology has developed significantly over the years, leading to improvements in precision, performance and cost.

Lenses can be made from a variety of materials, including glass, plastic, and crystal. Each material has specific optical and mechanical properties, which influence the performance and use of the lenses [1, 4].

Optical properties:

• Focusing: is their ability to focus light. Converging (convex) lenses focus parallel light to meet at a point called the focal point, while diverging (concave) lenses cause parallel light rays to spread out.

• Transmittance: refers to the proportion of light that passes through a lens and is transmitted into the optical system. A lens with a high transmittance allows more light to pass through, which can improve image clarity and brightness.

• Reflection: Lenses can suffer from unwanted reflections, which can affect the quality of images. Optical treatments, such as anti-reflective coatings, are used to reduce reflections and improve light transmission through the lens.

• Optical power: The power of a lens, is measured in diopters, and indicates the ability of the lens to focus light. Higher power lenses have a more pronounced curve, and can focus light to a smaller point.

• Aberration: Perfect lenses should focus all light rays to a single point. However, in practice, lenses can suffer from optical aberrations, which can include chromatic aberrations (differences in focus depending on colour), spherical aberrations (distortions of the image at the edge of the lens), and coma (deviations from actual focal points). The control and correction of aberrations are essential to ensure the quality of the images and the optical performance of the lenses.

• Light transmission: Lenses must be transparent to allow light to pass through with as little loss as possible. The materials used in the manufacture of lenses must be selected and processed so that they have a high optical transmission in the spectrum of interest.

• Dispersion: Dispersion refers to how the lens separates the different colours of light. Lenses with lower dispersion are preferred in many applications to minimize the effects of chromatic aberration.

• Distortions: Lenses can cause image distortions, such as pincushion or barrel distortion, which can affect the clarity and precision of images. Correcting these distortions is important in applications such as photography and medical imaging.

Transmittance is defined as the ability of a material to allow the passage of certain factors, such as light, heat or electrical signals, without significantly changing its properties. Transmittance is a measure of the degree to which a medium allows the flow or transfer of a certain characteristic or energy.

The transmittance of optical lenses refers to their ability to allow light to pass through a specific range of wavelengths. It is a measurement that tells us how much light is transmitted through the lens relative to how much is absorbed or reflected [2, 5].

The transmittance of optical lenses is influenced by:

1. Lens material: The materials used to make lenses have different optical properties. For example, glass, crystal and plastic have different optical transmittances, influenced by their molecular structure and possible impurities.

2. Lens thickness: Lens thickness can affect transmittance because some of the light can be absorbed into the lens material as it passes through it. Thicker lenses can absorb more light than thinner ones.

3. Anti-reflective coatings: Optical lenses can be coated with thin layers of materials to reduce unwanted reflections and increase transmittance. These anti-reflective coatings are designed to minimize light loss through reflection and improve lens performance.

4. Adjusting lenses with special applications: In some cases, lenses can be dissolved in certain solutions to improve transmittance, particularly in special applications or in the case of very thick lenses.

5. Optical design: Lens geometry and design can also affect transmittance. For example, lenses with less curved surfaces or manufacturing defects may have lower transmittance.

The transmittance of optical lenses is important in many applications, such as: medical optics, imaging equipment and measuring instruments. In these applications it is important to minimize light losses to obtain accurate and clear results [2, 3].

2. Research on determining the transmittance of lenses for vision correction

The research on determining the transmittance was carried out on a group of lenses of different thicknesses and diopters.

The transmittance tests were done on five lenses:

- Diopter -0.50 medium protection lenses with 1.25 mm lens thickness.
- Diopter -0.50 lenses without protection with a lens thickness of 1.20 mm.
- Diopter -0.25 medium protection lenses with 1.17 mm lens thickness.
- Diopter -0.25 lenses without protection with a lens thickness of 1.15 mm.
- Diopter -5 medium protection lens with 2.30 mm lens thickness.

The transmittance of the lenses was performed on the HACH LANGE DR5000 device with a gas-filled Tungsten lamp and a deuterium (UV) lamp and with a wavelength range between 190-1100 nm (Fig. 1).

Fig. 1. *HACH LANGE DR5000 device for determining transmittance*

The stages of making the measurements are:
- measuring the thickness of the lens (Fig. 2);
- placing the lens in the device;
- blocking the device for generating determinations;
- generating graphs for transmittance (Fig. 3);
- data transfer to a stick.

Fig. 2. *Measuring lens thickness*

The data obtained on the HACH LANGE DR5000 device for the determination of transmittance are partially presented in Table 1.

After centralizing the data in the table, we obtained the following spectra for the transmittance of the lenses shown in Fig. 4, 5.

For lenses with medium protection, we obtained a higher transmittance than the ones with -0.25 and 1.17 mm thickness because the lower thickness allows a greater flow of light to pass through.

In the unprotected lenses we obtained a higher transmittance at the -0.50 diopter lens, because it had a higher lens power, measured at one meter focal length than the -0.25 diopter lens.

We have noticed that in lenses without protection, the transmittance is less influenced by the thickness of the lens, a stronger influence of the transmittance being given by its diopter.

The comparison of transmittance spectra for both lens categories is shown in the graph in Fig. 6.

By comparing the transmittance spectra, we found that the lens thickness had the greatest influence on lenses with medium protection. At the lens taken in the study with the largest thickness, namely 2.30 mm (the -5 diopter lens), we obtained the lowest transmittance.

Fig. 3. *Generating graphs*

Table 1. *Data obtained for lens transmittance*

Wavelength	**-0.50 medium protection lens**	**-0.50 lens without protection**	**-0.25 medium protection lens**	**-0.25 lens without protection**	**Medium protection - 5 lens**
190	0.189	0.177	0.158	0.144	0.115
191	0.138	0.136	0.114	0.101	0.089
192	0.122	0.118	0.1	0.09	0.076
193	0.107	0.097	0.092	0.074	0.076
194	0.094	0.094	0.072	0.074	0.057
195	0.084	0.079	0.067	0.06	0.064
196	0.078	0.075	0.062	0.06	0.05
197	0.061	0.064	0.052	0.051	0.021
198	0.047	0.049	0.047	0.029	0.022
199	0.052	0.051	0.033	0.025	0.028
200	0.053	0.043	0.038	0.027	0.029
201	0.054	0.045	0.038	0.022	0.02
202	0.042	0.041	0.031	0.029	0.023
203	0.042	0.04	0.03	0.029	0.019
204	0.036	0.036	0.033	0.023	0.032
205	0.039	0.034	0.029	0.024	0.018
206	0.034	0.04	0.03	0.022	0.02
207	0.036	0.038	0.035	0.025	0.018
208	0.04	0.04	0.029	0.023	0.015

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209	0.035	0.035	0.025	0.018	0.018
210	0.034	0.37	0.029	0.021	0.012
211	0.033	0.03	0.025	0.021	0.02
212	0.031	0.034	0.023	0.026	0.016
213	0.035	0.033	0.024	0.023	0.023
214	0.038	0.027	0.024	0.024	0.016
215	0.036	0.03	0.026	0.024	0.01
216	0.034	0.027	0.024	0.021	0.016
217	0.033	0.027	0.025	0.021	0.015
218	0.036	0.035	0.028	0.023	0.016
219	0.029	0.027	0.027	0.024	0.018
220	0.037	0.031	0.025	0.023	0.014
221	0.031	0.03	0.024	0.023	0.02
222	0.033	0.03	0.023	0.025	0.016
223	0.04	0.031	0.023	0.023	0.015
224	0.03	0.029	0.024	0.015	0.016
225	0.037	0.034	0.025	0.02	0.017
226	0.031	0.032	0.02	0.021	0.022
227	0.032	0.034	0.02	0.016	0.02
228	0.035	0.028	0.018	0.029	0.014
229	0.034	0.027	0.024	0.019	0.017
230	0.033	0.028	0.022	0.019	0.017

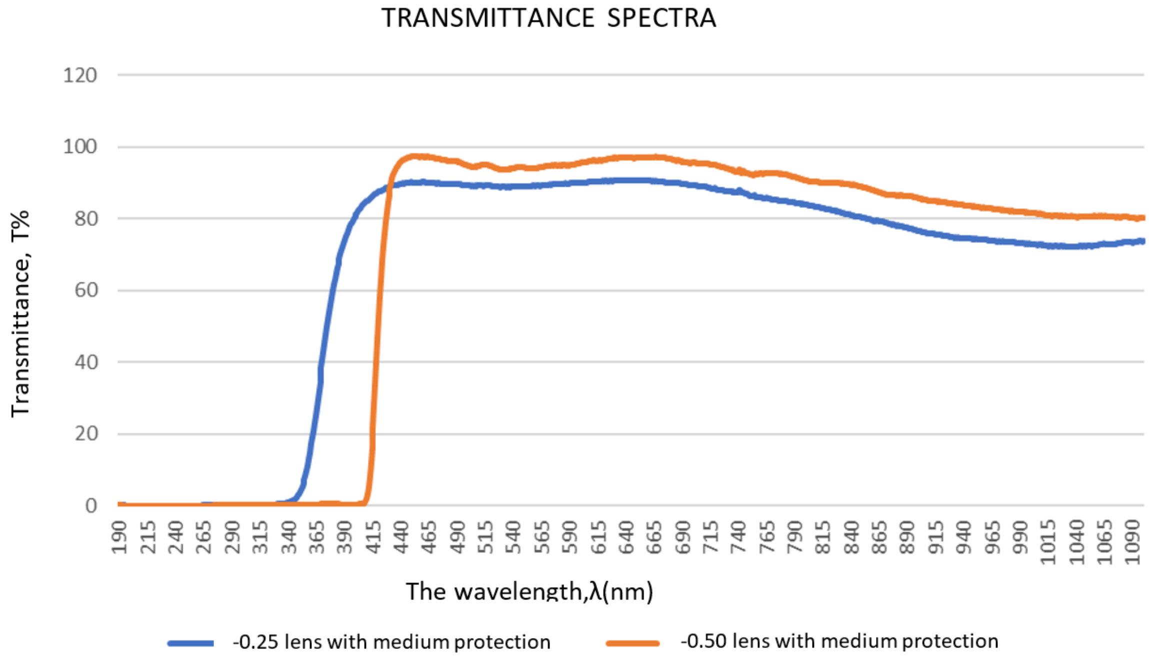

Fig. 4. *Transmittance spectrum of medium protection lenses*

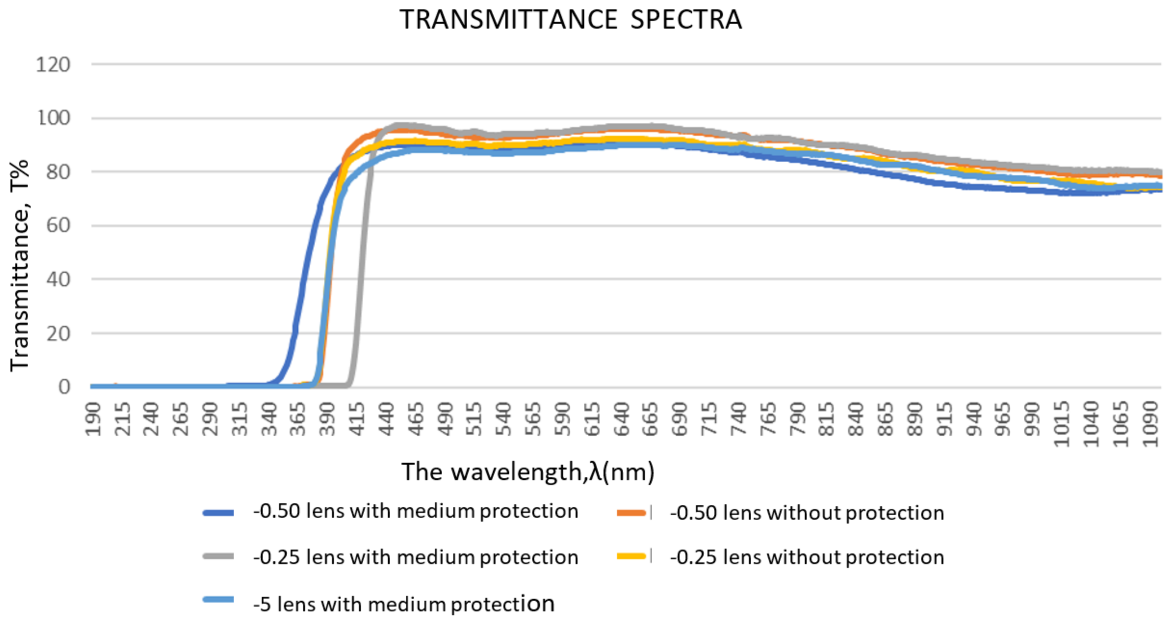

Fig. 5. *Transmittance spectrum for lenses without protection*

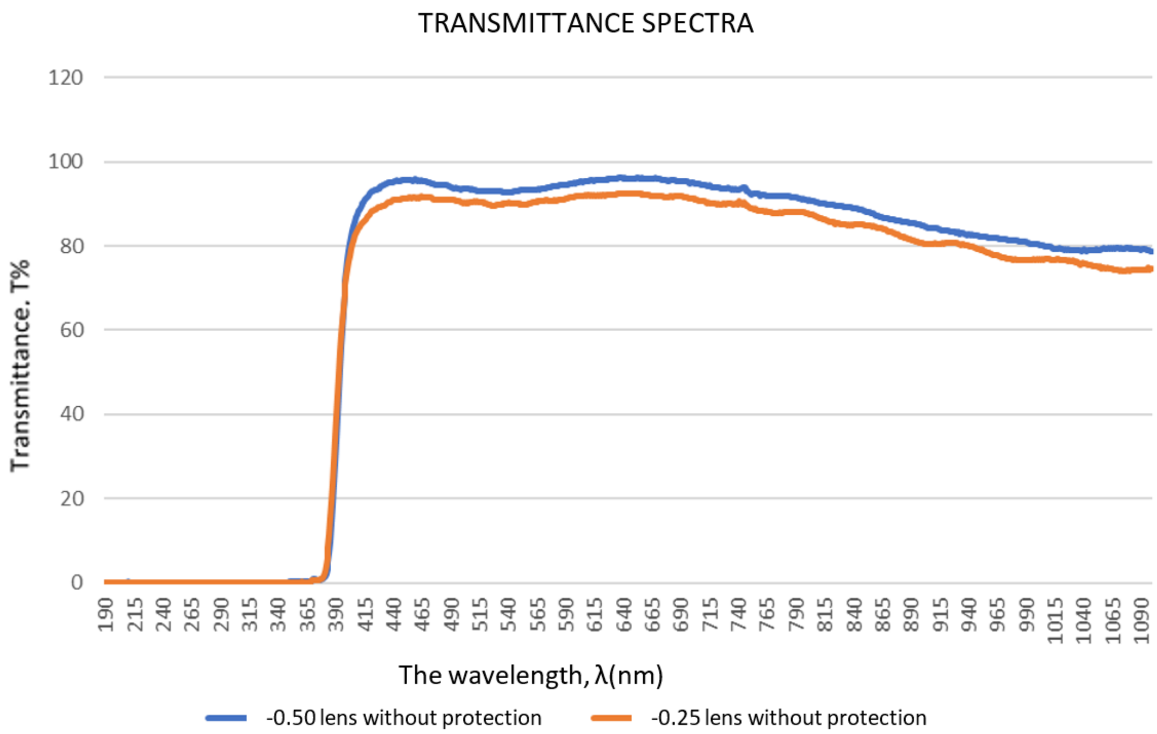

Fig. 6. *Comparison of the transmittance spectra of the both lens categories*

3. Conclusions

After the determinations made, we came to the conclusion that the transmittance of the lenses was influenced by several factors, respectively: diopters, the thickness of the lens, the protection applied to them and the material from which they were made.

At medium protection lenses with diopters of -0.50 and thickness of 1.25 mm, transmittance values were lower compared to medium protection lenses with -0.25 diopters and 1.17 mm thickness, as lens thickness influenced lens transmittance. The lowest transmittance in lenses with medium protection has been obtained in the lens with the largest thickness respectively 2.30 mm and with diopter of -5.

In the case of unprotected lenses, transmittance values were higher for lenses with -0.50 diopters compared to those with -0.25 diopters. For this type of lens, the greatest influence on the transmittance is the diopter value and not the lens thickness.

At the medium protection -5 diopter lens with 2.30 mm lens thickness, we got a lower transmittance which meant that if the diopters were very large, the lens thickness would negatively influence the transmittance.

From the point of view of the material from which the lenses are made, the PMMA polymethacrylate methacrylate lens (the -5 diopter lens) transmittance was lower than the organic glass lenses (the -0.50 and -0.50 diopter lenses -0.25).

By analysing different aspects of lenses, we can better understand their impact on patients' vision and visual comfort, thus contributing to improving the quality of ophthalmic services.

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