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Application News

UV-Vis Spectroscopy

No. SCA-100-022

Evaluating Polarizing Sunglasses with UV-3600plus and the Depolarizer Accessory

Color, UV protection and polarization effects

▪ Introduction

Sunglasses protect our eyes against the bright sunlight and especially dangerous ultraviolet radiation. Most sunglasses nowadays bear the „UV400“ label, indicating 0% transmission at wavelengths below 400 nm.

Some companies also offer polarizing glasses. These are recommended to use during outdoor activities in water and snow environments. The reason is, that normally unpolarized sunlight is polarized by reflection on the water or snow surface.

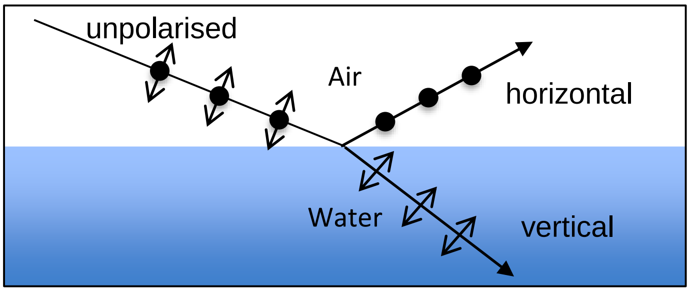

Figure 1: Polarization by reflection on a surface.

At the air/water interface, the light interacts with the water molecules. Depending on the incident angle, the reflected light is predominately polarized horizontal to the water surface, while the diffracted light is predominately polarized vertical. Because of this effect, sunglasses for watersports or similar applications are fitted with polarizing filters optimized for blocking light with horizontal polarization. This suppresses the glare from the reflecting water surface, enhances the contrast and leads to a better visibility of objects under the water surface.

A quick check can be done by looking at a liquid crystal display while wearing the sunglasses, because such a display also emits polarized light. If they are outfitted with polarizing filters, the display will appear black and the picture is only visible if the head is tilted into the correct position.

In this application, four different sunglasses were measured with the UV-3600plus UV-Vis spectrometer and different optics. Two samples were sunglasses with polarizing filters.

Figure 2: From top left to bottom right: Samples A, B, C, D.

The spectra were measured in direct transmission without any additional optics, with a polarizer and with a depolarizer. A measurement with depolarized light is important to check the attenuation of the sunglasses under realistic conditions, while the measurements with polarized light will proof the quality of the polarization filter.

▪ Depolarizer Attachment

The depolarizer attachment is described in detail in specification note SCA-100s-076. Briefly described, it is an optic that – correctly adjusted – compensates the polarization of the sample beam that is caused to some degree by optics like the diffraction grating of the instrument.

The depolarizer crystal is mounted in a rotating mount. For this application, it is mounted on the film holder baseplate and adjusted with a polarizer. The depolarizer is turned and the transmission of the polarizer in 0º and 90º orientation is compared until both intensities are the same. At 20º rotation angle of the depolarizer, the best degree of depolarization is reached and the polarizer is removed for the measurement.

The same polarizer is used for the measurements.

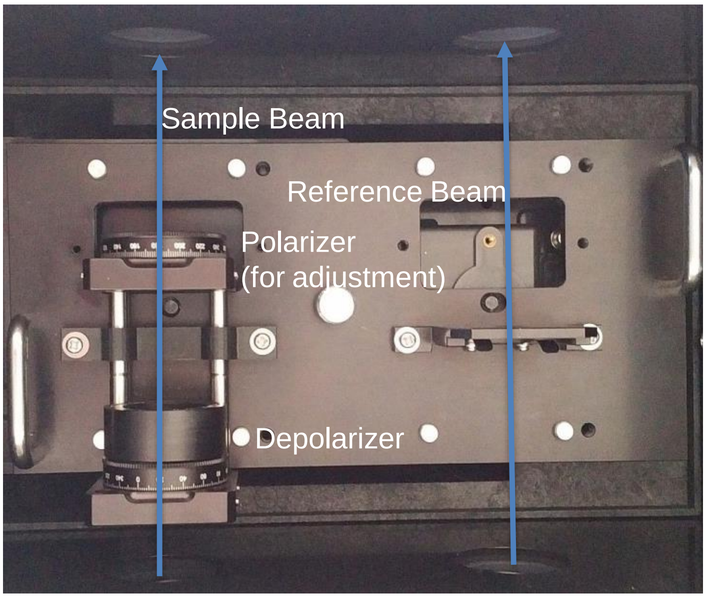

Figure 3: Depolarizer and polarizer mounted in the UV-3600plus during adjustment procedure.

▪ Check for UV400 Label

All samples are labelled with the UV400 mark. To check the credibility of that mark, UV-Vis spectra are measured with a scan range of 800 – 200 nm.

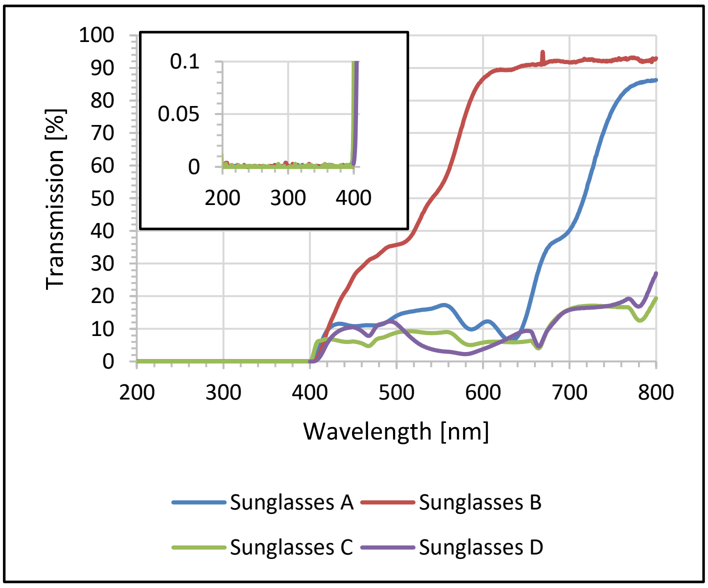

Figure 4: UV-Vis transmission spectra of all samples. Inset: Zoom to the "UV400" region.

All spectra show a cutoff wavelength at 400 nm and 0 % transmission at lower wavelengths. In the visible region, the spectra of sunglasses C and D look similar, while the spectra of sunglasses A and B are very different.

Sunglasses B show the highest transmission over the whole spectral range, as expected from the high transparency seen in Figure 2.

▪ Color Analysis

A color analysis of the spectra shows how the transmission spectra are correlated to the green color of sunglasses A and C and the yellow color of sunglasses C. The color analysis of sunglasses D fails, which is most likely correlated to the multicolor reflecting coating as seen in Figure 2.

Illuminant D65 (that simulates the spectrum of daylight) and an observation angle of 10º are used for the calculation of the color coordinates. The x-y-plot is shown on the left side of Figure 5, the a*-b*-plot is shown on the right side of Figure 5. The results shown here are from the spectra measured in the range 800 – 400 nm with depolarized light to better reflect the color under normal conditions.

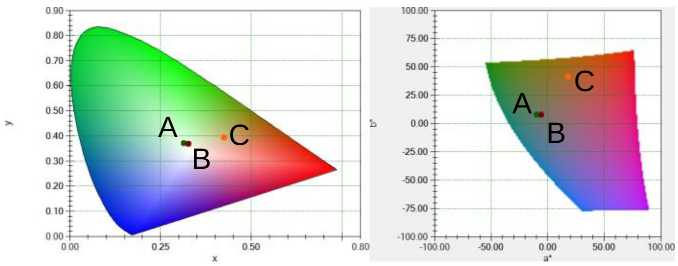

Figure 5: Color Plots of sunglasses A, B and C

SMP	x	y	L*	a*	b*
A	0.3	0.4	43.9	-10.1	7.8
B	0.4	0.4	81.3	17.6	41.5
C	0.3	0.4	40.4	-5.8	8.1

Table 1: Color coordinates of sunglasses A, B and C.

▪ Measurements

All sunglasses are measured from 700 – 400 nm
- without any optics
- with polarizer in 0º (vertical polarized light)
- polarizer in 90º (horizontal polarized light)
- with unpolarized light (with depolarizer)

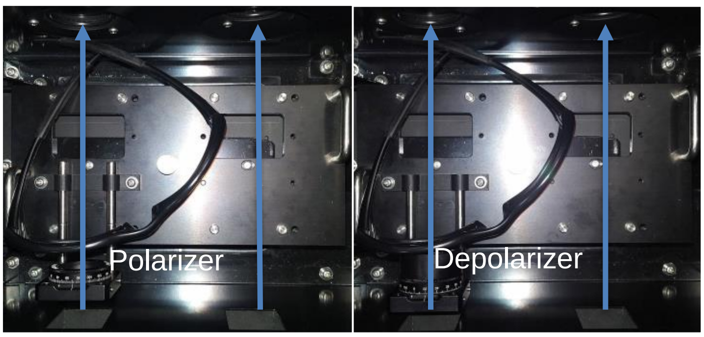

Figure 6: Measurement configuration with polarizer (left) and depolarizer (right). The sunglasses are positioned carefully to not block the sample or reference beam.

▪ Sunglasses without Polarization Filter

Figure 7 shows the transmission spectra of sunglasses A in all four configurations, Figure 8 shows the spectra of sunglasses B. No difference is noticed between the spectra, since light of all polarization directions is absorbed equally by the coating of these sunglasses.

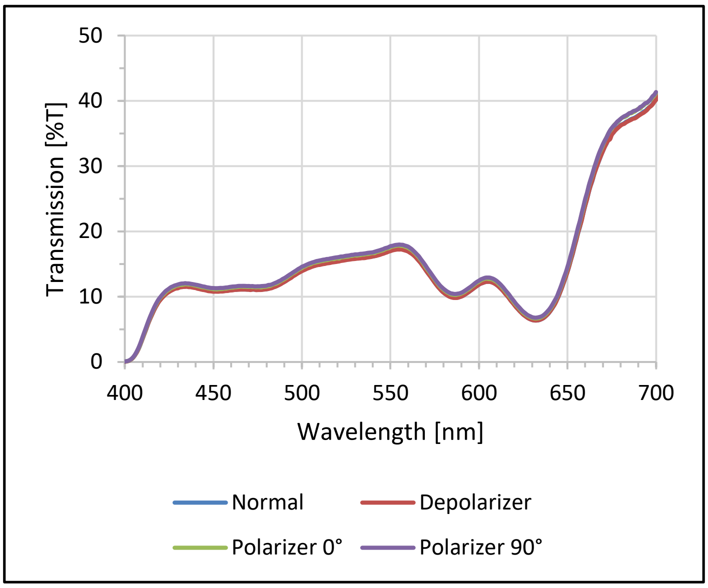

Figure 7: Transmission spectra of sunglasses A.

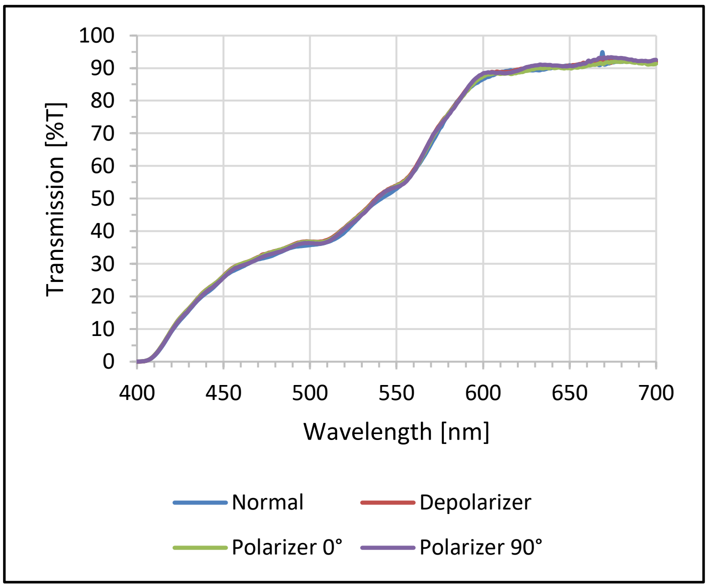

Figure 8: Transmission spectra of sunglasses B.

The transmission of sunglasses A is lower over the whole visible spectral range, especially in the region of 400 – 650 nm. Yellow and orange sunglasses like sample B are known for enhancing the contrast and are commonly used in sports, while green and brown sunglasses like sample A and C block bright light with little color distortion.

▪ Sunglasses with Polarization Filter

Figure 9 shows the transmission spectra of sunglasses C in all measurement configurations. As expected, the transmission depends on the polarization of the sample beam.

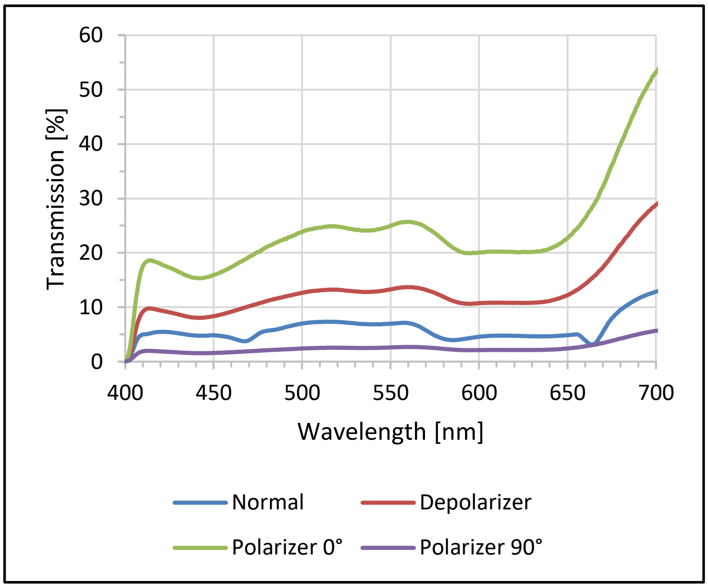

Figure 9: Transmission spectra of sunglasses C.

The lowest transmission is observed with horizontal polarized light (polarizer in 90º orientation), as expected. Without additional optics, the transmission is higher, but still below the transmission observed with completely depolarized light. This shows, that the sample beam is vertical polarized to some degree.

The highest transmission is observed with the polarizer in 0º orientation (vertical), since this is the same orientation as the polarizing film of the sunglasses.

In the transmission spectrum without additional optics, the absorption peaks of the polarizing film are observed at 470, 580, 660 and 780 nm.

The transmission spectra with vertical polarized or completely depolarized light are similar to the spectra of sunglasses A, as expected from the similar glass color. The difference is, that sunglasses C nearly completely suppress horizontal polarized light that is reflected from surfaces like water or snow, but also block the light from liquid crystal displays.

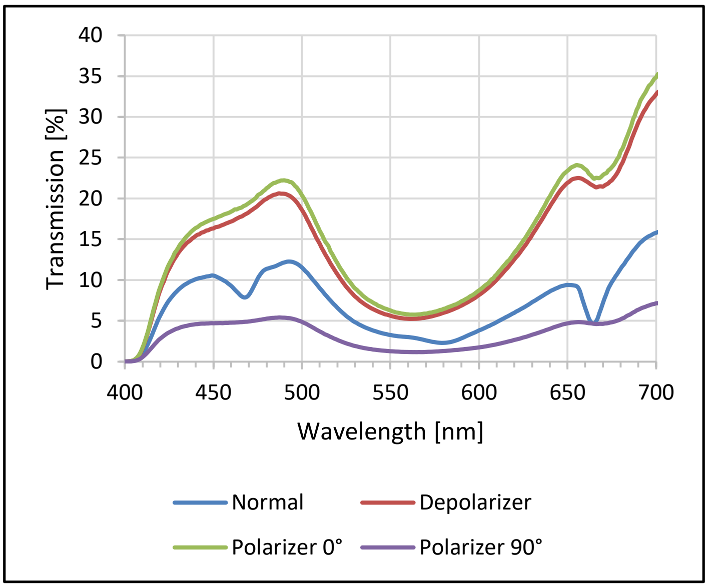

Figure 10: Transmission spectra of sunglasses D.

For sunglasses D, the transmission spectra with vertical polarized or completely unpolarized light are nearly the same. Like with sunglasses C, the transmission drops significantly without depolarizer and with the polarizer in 90º orientation. The difference is smaller though which underlines the assumption that the polarizing filter is not as strong as in sunglasses C.

The measurement might be biased by the highly reflective coating of sunglasses D, which was not present on any of the other samples.

Discussion and Conclusion

The UV/Vis spectra different sunglasses with and without polarization filter were measured with different measurement configurations.

All tested sunglasses offer complete UV-protection as indicated by the UV400 label, the color coordinates of the glass color was determined by a color analysis of the spectra measured with unpolarized light.

As expected, the two samples without polarization filters show no dependency on the polarization of the measurement light. The transmission spectra of the two samples with polarization filters are different for each measurement configuration.

To obtain unbiased transmission spectra, measurements with completely unpolarized light are required. The measured transmission values are always too low without use of a depolarizer and might differ between spectrophotometers with a different optical setup, because of the small polarization of the sample beam at each optical element (mirror, grating…). For both polarizing samples in this application, the transmission values measured without depolarizer are around half of the values with unpolarized light.

The polarization filters were checked by measurements with polarized light. Both tested sunglasses are optimized for blocking horizontal polarized light like that reflected from a water surface. The transmission for horizontal polarized visible light is below 5 % for sunglasses C and D, while the transmission for vertical polarized light is around the same value (20 – 30 %) as for sunglasses A.

Instrument and Measurement Parameters

Instrument:	UV-3600plus
Accessories:	Rotating film holder, depolarizer
Photometry:	% Transmission
Scan range:	800 – 200 nm (check for UV-400)
	800 – 400 nm (with (de)polarizer)
Scan speed:	Fast
Data interval:	1 nm