SPECTRA OF THE MONTH

COMPARING UV TRANSMITTANCE: UV-PROTECTIVE ATHLETIC VS. REGULAR CLOTHING

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INTRO

BACKGROUND OF APPLICATION

The start of a new year often comes with New Years Resolutions, many of which pertain to fitness. Advances in health and exercise sciences have only increased our access to healthier, more active lifestyles, including regimented nutrition plans, personalized workout routines, and athletic wear that is designed to protect our body during physical activity. These can include sweat wicking technology, more breathable fabrics, and UV-protective treatments of clothing. UV protection is graded in terms of SPF (sun protection factor) and is given on a number scale that quantifies how many times more effective a covering is at protecting human skin from a sunburn compared to without the product. For example, is human skin starts to sunburn after 10 minutes, a product with an SPF rating of 30 would protect against sunburns for 300 minutes. Many UV-protective clothing lines are rated as SPF50 or higher, providing significant UV protection. Besides advances in UV-coatings, the choice of fabric can be critical in providing UV protection, with materials like cotton providing less protection compared to polyester or nylon.

This experiment aims to determine how effective UV-protective athletic clothing is in blocking UV light compared to clothing with no additional UV-protective coating. A swimming shirt treated with a UV-protective coating was exposed to a UV light, and the opposite side of the fabric was measured to see how much UV light passed through. The resulting spectra were compared to the standalone UV light source to quantify the amount of UV light blocked by the fabric. To determine how much more effective this clothing type is compared to regular clothing, two additional articles of clothing (one 50% cotton/50% polyester blend, one 100% polyester) underwent the same testing procedure to quantify their UV protective capabilities (Figure 1).

FIGURE #1: Clothing samples used for this experiment (from left to right: 50% cotton/50% polyester shirt, 100% polyester shirt, 100% polyester shirt with UV protective coating).

DESCRIPTION OF SPECTROSCOPY SETUP

The setup for this experiment (Figure 2) utilized our AvaSpec-NEXOS™ more commonly known as the Nexos. This compact instrument is the next-generation photonics backbone spectrometer, designed to empower a wide range of applications in various industries. This device is built using our new semi-automated manufacturing technique that ensures higher levels of consistency and reproducibility unit-to-unit. The Nexos offers USB2.0 communication as well as RS232 and SPI communication protocols, a CMOS linear array detector, ultra-low stray light as low as 0.1%, and a signal/noise ratio of 375:1. Furthermore, this spectrometer can be customized with a wide range of gratings (13 total available) and the replaceable slit option is now standard for non-OEM units, which provides even more flexibility for a variety of application needs. The unit used in this experiment was optimized for the UV range with a 200-450 nm wavelength range.

FIGURE #2 Experimental setup for clothing sample measurements. The clothing sample is placed directly on top of the integrating sphere sample port as the sample is exposed to UV light. The light source is controlled by the spectrometer via the interface cable.

The light source used for this experiment was the AvaLight-XE-HP, a high-powered pulsed xenon light source. This light source comes in a compact housing, making it well-suited for integration into customer systems. Compared to the AvaLight-XE, which has a maximum power of 2 W, the AvaLight-XE-HP provides significantly more power (6 W). When connected to an AvaSpec spectrometer via our custom interface cable, the number of flashes per scan can be set in our AvaSoft software, and the flashes are synchronized with the data collected by the spectrometer.

Other accessories used for this experiment included our AvaSphere-50 integrating sphere, a custom 0.5-meter, 600-micron core fiber optic cable to connect the integrating sphere to the spectrometer, our TR-Stage to mount the integrating sphere and AvaLight-XE-HP, a direct-attach collimating lens to focus the xenon light into the integrating sphere sample port, and a custom interface cable to connect the AvaLight-XE-HP to the AvaSpec-NEXOS™ to control flashes per scan and to power the light source. This interface cable was designed by our engineering team and highlights some of the custom build options that can be assembled for our customers.

DESCRIPTION OF METHODOLOGY

The UV-protective clothing sample used for this experiment was a swimming shirt rated at SPF50. The other two clothing samples were shirts, one 50% cotton/50% polyester and the other 100% polyester, purchased at a local clothing store. None of the samples underwent any preparation or cleaning before the measurement process, as this could affect their UV blocking properties.

For data analysis, we used the Transmittance mode in AvaSoft, our exclusive custom software package. This mode is specifically designed for transmission applications, where the reference measurement will report 100% transmittance and the dark measurement will report 0% transmittance. In this experiment, the xenon light shining directly into the integrating sphere port with no fabric in place was used as the reference. This same setup with the light source off was used for the dark measurement to account for any ambient light in the measurements. We used an integration time of approximately 4 seconds, which can be adjusted to increase or decrease the amount of light being measured at one time and affects the overall magnitude of the reported spectrum. This high integration time was necessary due to measuring a limited amount of UV light in free space. We set averaging to 1, meaning each measurement corresponded to one scan. While higher averages are usually preferred, the high integration time limited the amount of averaging that could be used.

TEST DATA AND RESULTS

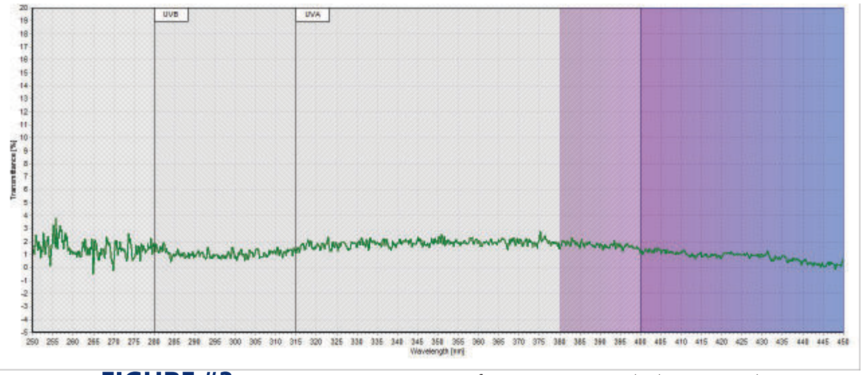

FIGURE #3: Transmission spectrum of UV-protective clothing sample.

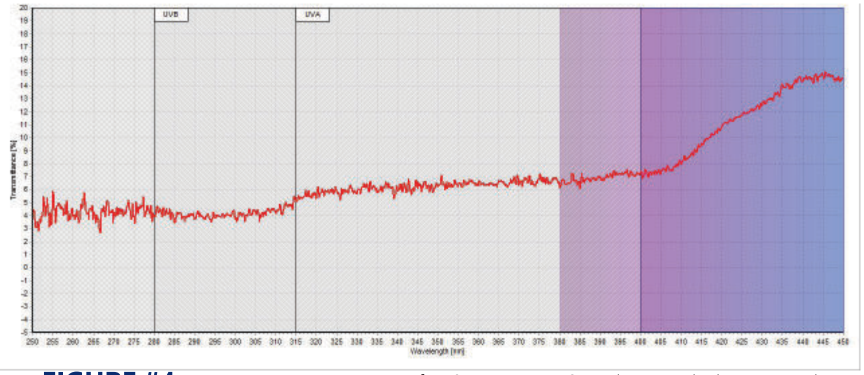

FIGURE #4: Transmission spectrum of 50% cotton/50% polyester clothing sample.

TEST DATA AND RESULTS

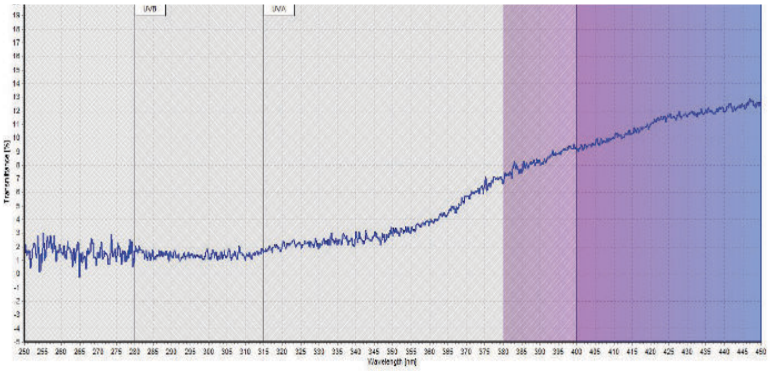

FIGURE #5: Transmission spectrum of 100% polyester clothing sample.

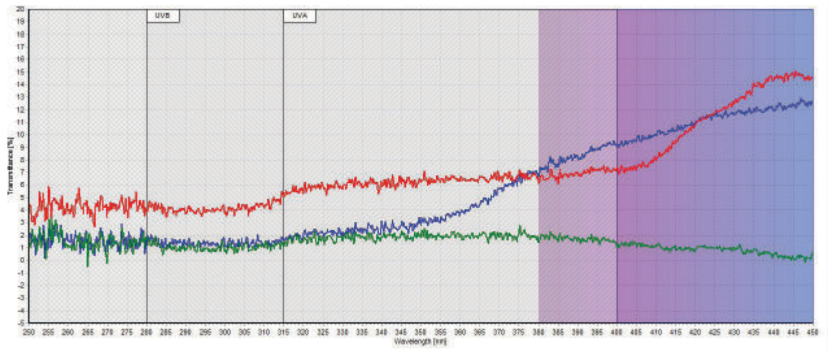

FIGURE #6: Spectra of UV-protective (green), 50% cotton/50% polyester (red), and 100% polyester (blue) clothing samples, shown together for comparison.

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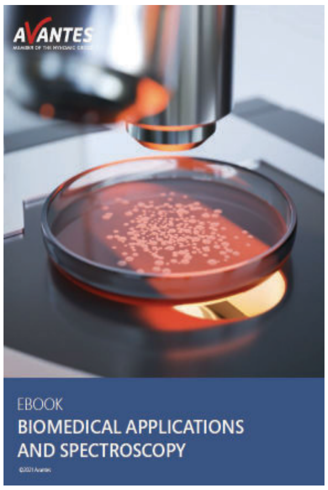

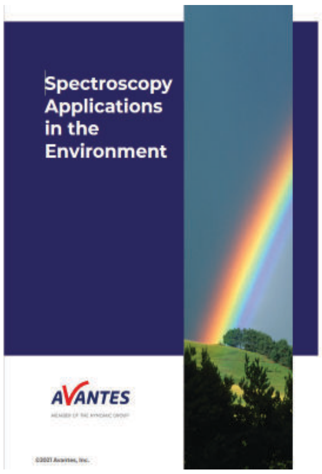

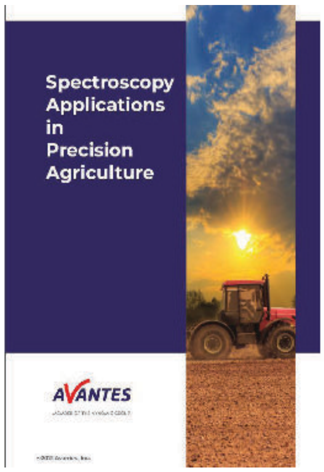

ANALYSIS

While offering varying levels of UV protective capabilities, all three clothing samples demonstrated significantly less UV transmittance than air alone, which allowed around 100% transmittance as the reference measurement. As expected, the UV-protective swimming shirt provided exceptional UV protection, with only around 1% transmittance in the UVB region, around 2% transmittance in the UVA region, and less than 1% transmittance in the lower visible region (Figure 3). The cotton/polyester blend shirt allowed significantly higher UV transmittance in all areas, with around 4% transmittance in the UVB region, 6% in the UVA region, and from 7-15% transmittance in the lower visible region (Figure 4). The 100% polyester shirt with no added UV-protective coating still provided strong UV protection, though only for a portion of the UV range, with around 1% transmittance in the UVB region, anywhere from 2-9% in the UVA region, and 9-12% in the lower visible region (Figure 5). A graph of all the spectra together is included for comparison of all samples (Figure 6).

Comparing the three samples, it is clear that the UV-protective shirt provides the least amount of UV transmittance through the fabric. Interestingly, the regular 100% polyester shirt is almost as effective as the UV-protective version in the UVB region and the lower part of the UVA region, demonstrating how important material selection can be even when disregarding additional UV-protective coatings. The cotton/polyester blend shirt clearly provides the least UV protection across all regions, though is still significantly more protective than no clothing.

CONCLUSION

In conclusion, the present experiment highlights the use of spectroscopic analysis in determining the UV blocking capabilities of UV-protective clothing versus regular clothing. Comparison of the amount of UV light that passed through each sample was used to determine the difference in UV protection for the clothing samples. While the data presented here only analyzes the transmittance of UV light through each fabric, further quantification could be utilized to potentially link these transmittance percentages to SPF ratings. The AvaSpec-PCT2048CL is an ideal solution for OEM applications or for any measurements where a smaller instrument is preferred. The AvaLight-XE-HP is a xenon light source that is well-suited for applications where high power is needed or compact form factor is a must. The custom interface cable highlights the capabilities of our engineering team to provide custom assemblies and solutions for customer needs. Please contact Avantes for more information on the configuration that is best suited for your data collection.

CONTACT

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