

Measuring the cover and shade protection factors of synthetic shadecloth

Application Note

Author

Zafira Bilimis
Agilent Technologies, Inc.
Mulgrave, Victoria 3170,
Australia

Introduction

The ozone layer acts as a filter for dangerous ultraviolet radiation (UVR) from the sun, reducing its impact at the earth's surface. As this ozone layer thins, the effectiveness of this filter is reduced significantly, resulting in skin cancer (e.g. Melanoma), whose incidence increases around the world. The UVR exposures of the population could be significantly reduced by implementing behavioural changes, such as using hats and sunglasses along with protective clothing and shade. Traditionally, shadecloth has been used in the nursery and horticultural industries to provide optimum growing conditions for a variety of plants. In recent years, due to the severe problems associated with the depletion of the ozone layer, shadecloth is being widely used as an architectural medium providing cool shaded outdoor spaces¹. Some examples of the use of shadecloth are:

Horticultural shadehouses

- Fern gardens (ferneries)
- Livestock protection
- Shade structures at public swimming pools
- Shade structures in parks and gardens

This paper focuses on how to assess the amount of UVR protection provided by synthetic shadecloth. The cover and shade protection of two shadecloth samples with variable construction (woven and knitted) were determined using a spectrophotometric method.



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Equipment

- Cary 1/3E UV-Vis Spectrophotometer
- Labsphere DRA-CA-30 Diffuse Reflectance Accessory
- Schott UG 11 filter
- Shadecloth Easy Menu software package

Results and discussion

Method for the determination of the Cover Factor of shadecloth.

This method requires five pieces of each shadecloth sample to be cut from the sample roll and tested according to the following procedure².

1. Insert UG 11 filter in sample slot and zero the instrument.
2. Insert the shadecloth and UG 11 filter in the sample slot.

Note: Ensure that the shadecloth is fixed closely against a UG 11 filter which is fixed very closely to the entrance port of the sphere. The light from the instrument is firstly transmitted through the shadecloth, then through the UG 11 filter and into the integrating sphere. This arrangement ensures the elimination of the effects of fluorescence from the fluorescent whitening agents (FWAs) that may be present in the shadecloth.

3. Record the reading at 350 nm.
4. Repeat (1) to (3), having rotated the sample 90° before insertion into the sample slot.
5. Repeat steps (1) to (4) for the remaining four samples. The cover factor for each of the shadecloth samples was calculated according to the following formula:

$$\text{Cover factor} = 100 - \%T_{av}$$

Where $\%T_{av}$ is the average of the 10 readings measured as described in the above procedure.

The Australian standard for synthetic shadecloth (AS4174-1994), also requires:

- The designation of the shadecloth according to the calculated cover factor, (see Table 1).

Note: The cover factor ranges displayed in Table 1 are not continuous. This means that any shadecloth which has a cover factor outside of these ranges does not comply with the Australian standard for synthetic shadecloth (AS 4174-1994).

- A trim colored according to the designation color code shown in Table 1 shall be knitted, woven or attached to the edge of the shadecloth.

Table 1. Designation and color code according to cover factor range

Type of Shadecloth	Designation of Shadecloth	Cover Factor Range	Color Code
Knitted	Extra-light	26-34	Dark Green
	Light	50-56	Red/Orange
	Medium	64-70	Blue
	Heavy	74-80	White
	Extra-heavy	84-90	Lime Green
Woven	Extra-light	25-30	Dark Green
	Light	50-55	Red/Orange
	Medium	67-73	Blue
	Heavy	77-83	White
	Extra-heavy	87-93	Lime Green

The Shadecloth Easy menu software enables all the measurements and calculations to be performed automatically. This software also allows one to use a standard woven stainless steel mesh (e.g. BS410 British Standard Sieve) of known cover protection factor (CPF) rating to ensure validation of the shadecloth apparatus. Also, there is an instrument test option which allows the operator to validate the wavelength accuracy of the UV-VIS spectrophotometer.

Table 2 summarizes the results for the two shade cloth samples which were measured.

Table 2. Shade cloth measurement results

Shade cloth details	%T AV	Cover Factor (%T)	Designation of Shade cloth	Color Code
Green woven	12.7	87.3	Extra-heavy	Lime
White knitted	48.7	51.3	Light	Red or Orange

Figure 1 shows an example of a report generated by the Shade cloth Easy Menu software package for the cover factor calculations.

Sample Name : Shade Cloth 1
 Operator : Zafira Bilimis
 Client : Agilent Technologies Australia
 Batch : 92678
 Comment : Green shade cloth
 Shade cloth Type: Woven
 Date : 8 July 1994
 Instrument : Cary UV-Vis
 Wavelength : 350.00 nm

Pass	Reading 1 (%T)	Reading 2 (%T)	Average (%T)
1	13.45	13.14	13.30
2	12.64	14.63	13.64
3	14.93	11.69	13.31
4	11.64	12.04	11.84
5	11.03	11.81	11.42

%Tav (350 nm) = 12.70 %T

Cover factor = 100 - %Tave
 = 87.30 %T

Designation of shade cloth: Extra Heavy

A Lime green trim should be knitted, woven or attached to the edge of the shade cloth.

Reference: AS 4174

Figure 1. Report generated by Shade cloth Easy Menu software package

Method for the determination of the UV-Visible transmission of shade cloth.

This test requires that 10 pieces of shade cloth are cut from the sample roll and tested according to the following procedure³:

1. Mount the sample at the sample port of the sphere.
2. Record the UV-Vis transmission of the sample from 290 to 770 nm.
3. Repeat steps (1) and (2) for each of the remaining 9 samples.

The shade cloth Easy menu software performs the following calculations automatically:

- a. The 10 readings which are collected are averaged (%Tav).
- b. The shade factor is calculated using the following formula:

$$\text{Shade Factor} = 100 - \%T_{av}$$

Note: %Tav is the average of the 10 readings over the wavelength range 290 to 770 nm.

- c. Using the average transmission data from (a) the following parameters are calculated:
 - i. Average % UVR transmission data from 290 to 400 nm
 $\%UVR \text{ block} = 100 - \%UVR_{av}$.
 - ii. Average % Photosynthetically Active Radiation (PAR) transmission from 400 to 700 nm.

Ultraviolet radiation can produce biological damage such as sunburn, hence an accurate assessment of the amount of protection provided by various shade cloth requires the calculation of the %UVR block over the wavelength range 290 to 400 nm, (or 280-390 nm) which includes both the UVB (280 to 315 nm) and the UVA (315-380 nm) regions. This calculation is specifically important when the shade cloth is used as an architectural medium, providing shaded outdoor spaces.

For horticultural use, a certain amount of PAR must reach the plants to provide optimum growing conditions. The %PAR transmission calculated over the wavelength range 400 to 700 nm indicates the effectiveness of the shadecloth for the horticultural industry. Table 3 summarizes the results for the two shadecloth samples which were measured using the method described in Appendix B of the Australian standard for synthetic shadecloth.

Table 3. Results of shadecloth sample measurements

Shadecloth Details	%T AV 290-770	Shade Factor	% PARav 400-700	%T UVRav 290-400	%T UVR Block
Green woven	16.54	83.46	18.09	11.33	88.67
White knitted	58.88	41.12	62.62	48.71	51.29

Figure 2 shows an example of a report generated by the Shadecloth Easy Menu software package for the transmission of shadecloth calculations.

Sample name : Shade Cloth 1
 Operator : Zafira Bilimis
 Client : Agilent Technologies
 Batch # : 92678
 Comment : Green shadecloth
 Date : 8 July 1994
 Instrument : Cary UV-Vis
 Wavelength range : 290.00-770.00 nm
 SBW : 4.0 nm
 Scan Speed : 900.000 nm/min
 Number of scans : 10

Type	Scan 1	Scan 2	Scan 3	Scan 4	Scan 5	Scan 6	Scan 7	Scan 8	Scan 9	Scan 10
Shade	16.02	15.30	16.50	17.08	17.44	16.54	16.31	16.02	17.56	16.63
PAR	17.71	16.78	18.16	18.60	18.89	18.05	17.76	17.71	18.99	18.28
UVR	11.43	11.29	11.97	12.97	13.51	12.46	12.37	11.44	13.69	12.16

$$\begin{aligned} \%T_{av} (290-770 \text{ nm}) &= 16.54 \%T \\ \text{Shade factor} &= 100 - \%T_{ave} \\ &= 83.46 \%T \\ \%PAR_{av} (400-700 \text{ nm}) &= 18.09 \%T \\ \%UVR_{av} (290-400 \text{ nm}) &= 11.33 \%T \\ \%UVR \text{ block} &= 100 - \%UVR_{av} \\ &= 88.67 \%T \end{aligned}$$

Reference: AS 4174

Figure 2. Report generated by Shadecloth Easy Menu software package

The Shadecloth Easy Menu displays the wavelength scans, as the shadecloth is being measured, and allows the operator to obtain a printout of the graphics at the end of the run.

Figure 3 shows the spectral transmittance of the white and green shadecloth samples.

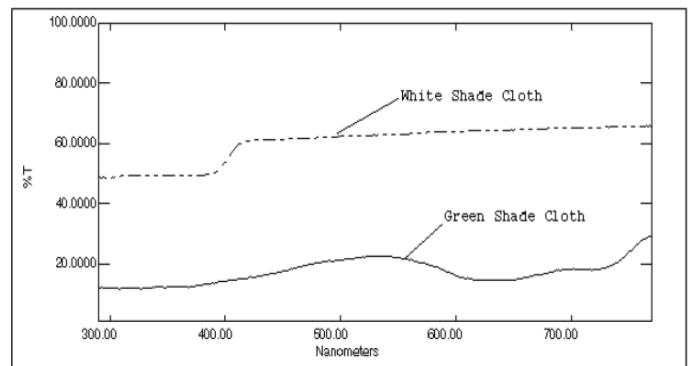


Figure 3. The spectral transmittance of white and green shadecloth samples

Conclusion

The Cary 1E spectrophotometer, in conjunction with the Labsphere DRA-CA-30 and the Shadecloth Easy Menu software, provides users with a user friendly, highly productive solution. This shadecloth analyzer enables the most novice user to perform shadecloth measurements because the Shadecloth Easy menu software automatically performs all calculations.

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References

1. Pailthorpe, M.T. and Auer, P.D., 1991, *On the %UV shade provided by shade cloth*, Australasian Textiles, 11(6):35.
2. Australian standard for synthetic shade cloth (AS 4174-1994), Appendix A.
3. Australian standard for synthetic shade cloth (AS 4174-1994), Appendix B.

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