Evaluation of Ultraviolet Filtration by Glazing and Display Case Materials

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Aim

UV-filtration properties of 24 glazing and display case products are evaluated. Types of products examined:

- Acrylic, glass, polycarbonate, and polystyrene
- Sheets in various thicknesses
- "UV-filtering" or "museum grade" products are compared to similar materials not advertized as "UV-filtering."

Two methods for measuring UV filtration are compared:

- UV/Vis (Elsec) Monitor
- Spectrophotometer

Background

Ultraviolet light (320 - 400 nm) filtration and white distortion are two important concerns in the selection of glazing and display case materials.

- The ideal UV filter should stop transmission of all radiation below 400 nm. Radiation of shorter wavelengths has a higher potential to damage light-sensitive materials and it does not contribute to our ability to see (the human eye has limited sensitivity below this point).
- For least white distortion, the glazing should not cut off transmission above 400 nm, as this may result in a yellow cast.

Glazing and display case products available today range widely in UV filtering capacity. Many are marketed as "museum grade" or "UV-filtering."

- Most manufacturers provide the percentage of UV radiation filtered. Comparing products based on this information is problematic because the upper limit of filtering in the UV is not specified between 380 - 400 nm. Additionally, the percentages provide no information on the product's visual properties.
- What methods are available for the conservator or curator to independently evaluate the filtering capacity?

Experiment

Products Tested

Material Type	Product	Manufacturer
Standard acrylic	Acrylite FF	Evonik Cyro, LLC
	Optium Acrylic	Tru Vue, Inc.
Non-reflective acrylic	Acrylite AR P99	Evonik Cyro, LLC
UV-filtering acrylic	Acrylite OP-2	Evonik Cyro, LLC
	Acrylite OP-3	Evonik Cyro, LLC
	Lucite Lux Museum Grade Acrylic	Lucite International
	Optix UVF Acrylic	Plaskolite, Inc.
UV-filtering, non-reflective acrylic	Optium Museum Acrylic (3 mm)	Tru Vue, Inc.
	Optium Museum Acrylic (4.5 mm)	Tru Vue, Inc.
	Optium Museum Acrylic (6 mm)	Tru Vue, Inc.
	Spartech UF-3 Acrylic	Spartech Polycast
	Spartech UF-4 Acrylic	Spartech Polycast
UV-filtering, abrasion-resistant polycarbonate	Makrolon AR1 (3 mm)	Bayer Material Science
	Makrolon AR1 (4.5 mm)	
	Makrolon AR1 (6 mm)	
Polystyrene	Clear Styrene	Plaskolite, Inc.
UV-filtering, non-glare polystyrene	Optix UVF Clear Styrene	Plaskolite, Inc.
Non-reflective glass	Anti-Reflective Laminated Glass	Tru Vue, Inc.
	Luxar Coated Glass	Glas Trösch AG
UV-filtering glass	Conservation Clear Glass	Tru Vue, Inc.
	Museum Glass	Tru Vue, Inc.
UV-filtering, non-reflective glass	Conservation Reflection Control Glass	Tru Vue, Inc.
	Luxar Laminated Glass (4 mm)	Glas Trösch AG
	Luxar Laminated Glass (7 mm)	Glas Trösch AG

Test Lamp

Solux tungsten-halogen lamp

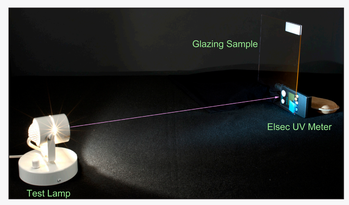
- Lamp is UV-rich and has a continuous spectrum.
- Unfiltered UV content: 305 µW/lm
- Color Temperature: 4700 ºK

Evaluation Method 1

Proportion of UV to Visible Light

Instrument: Elsec 764 UV meter

Output: Microwatts per lumen (µW/lm)



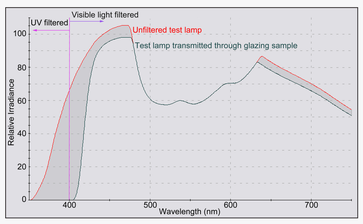
- Quickly and conveniently measures the proportion of UV to visible light, providing a single value for comparison to museum guidelines.
- Some visible light is measured as UV because meter sensitivity peaks around 380 nm.

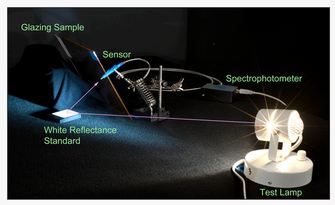
Evaluation Method 2

Relative Irradiance of the Transmitted Beam

Instrument: Ocean Optics UV-visible spectrophotometer

Output: Spectral power distribution (transmission curve)





- Provides wavelength-specific information in UV and visible ranges (which wavelengths are filtered and to what degree).
- Shows how the filter affects transmission in the visible range, determining white distortion.

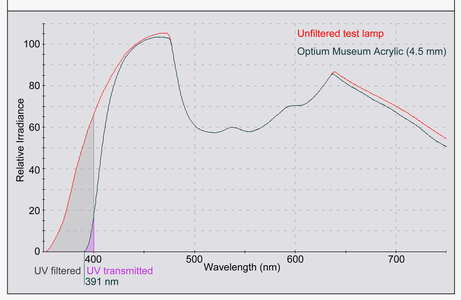
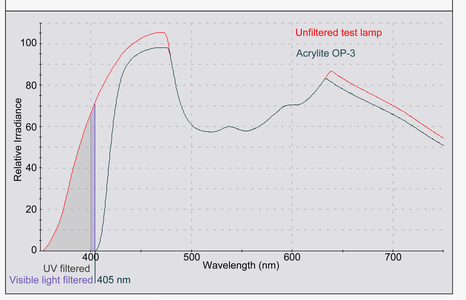
Results

The evaluation methods concur on the degree of UV filtration achieved by each product.

Evaluation	Product	UV Content Transmitted (µw/lm) Measured with UV Meter	Percentage UV Filtered Calculated relative to baseline of UV content in the unfiltered beam	Relative Irradiance Transmitted at 400 nm Measured with Spectrophotometer
Excellent UV Filtration	Acrylite OP-3	0	100.0%	0
	Lucite Lux Museum Grade Acrylic	0	100.0%	0
	Acrylite OP-2	1	99.7%	0
Elsec Meter: <10 µW/lm transmitted	Optix UVF Acrylic	1	99.7%	0
	Makrolon AR1 (4.5 mm)	1	99.7%	0
Ocean Optics: Zero relative irradiance transmitted below 400 nm	Makrolon AR1 (6 mm)	1	99.7%	0
	Spartech UF-3 Acrylic	4	98.5%	2
	Makrolon AR1 (3 mm)	5	98.4%	1
Good UV Filtration	Spartech UF-4 Acrylic	18	93.9%	13
	Optium Museum Acrylic (4.5 mm)	25	91.8%	17
Elsec Meter: 10-75 µW/lm transmitted	Tru Vue Conservation Clear Glass	34	88.9%	17
	Tru Vue Museum Glass	35	88.4%	17
Ocean Optics: <40% relative irradiance transmitted at 400 nm	Conservation Reflection Control Glass	37	87.9%	17
	Optium Museum Acrylic (3 mm)	47	84.6%	33
	Luxar Laminated Glass (7mm)	49	83.9%	33
Poor UV Filtration	Optium Museum Acrylic (6 mm)	84	72.5%	44
	Tru Vue Anti-Reflective Laminated Glass	85	72.0%	43
Elsec Meter: >75 µW/lm transmitted	Luxar Laminated Glass (4mm)	88	71.1%	43
	Optix UVF Clear Styrene	111	63.6%	46
Ocean Optics: >40% relative irradiance transmitted at 400 nm	Optium Acrylic	153	49.8%	57
	Acrylite FF	167	45.1%	57
	Acrylite AR P99	198	35.1%	57
	Luxar Coated Glass	240	21.3%	59
	Clear Styrene	285	6.6%	59

Discussion

The UV meter provides a basic rating of the percentage of UV radiation filtered, whereas the spectrophotometer gives information about the visual properties of the product.
Compare the results for Optium Museum Acrylic and Acrylite OP-3:

Product	Optium Museum Acrylic (4.5mm)	Acrylite OP-3
UV Content Measured with Elsec UV Meter	25 µw/lm	0 µw/lm
Transmission Curve Measured with Ocean Optics Spectrophotometer		

The Elsec results suggest these products provide good to excellent UV filtration, since both values are below 75 µw/lm. By comparing their transmission curves, however, it is possible to predict that Acrylite OP-3 will have a significantly more yellow cast. The difference in visual properties is striking.

Optium Museum Acrylic (4.5mm)

Acrylite OP-3

Conclusion

- Both methods can be used to evaluate UV filtration properties.
- The Elsec UV meter gives a simple numeric value that is easier for relative comparisons of efficiency.
- A transmission curve (spectral power distribution) is of greater utility to the museum community because it allows prediction of UV filtration and white distortion.
- The products tested in this study included standard products with low filtering capacity and high-level products with a maximum of UV filtration and minimum yellowing.
- All of the "standard" products fall in the lowest tier of filters. If UV filtration is a requirement, the additional cost of a product designated "UV-filtering" is likely warranted.
- In any glazing choice, a compromise must be made between exposure to short wavelength radiation (and its damage potential) and the impact on the viewing experience. Filtration should be used in combination with control of light levels, light sources, and total exposure time, to minimize damage and extend the life of light-sensitive objects.

References: Commission International de l'Eclairage (CIE). *Control of Damage to Museum Objects by Optical Radiation.* CIE Technical Report 157. Prepared by CIE Technical Committee 3-22 of Division 3, "Interior Environment and Lighting Design." 2004.
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Acknowledgements: FAIC George Stout grant, Margaret Holben Ellis, Jennifer Perry, Hugh Phibbs, Bayer Material Science, Evonik Cyro LLC, Glas Trösch AG, Lucite International, Plaskolite, Inc., Spartech Polycast, and Tru Vue, Inc.

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