Automated, unattended multi-angle transmission and absolute reflection measurements on architectural and automotive glass using the Agilent Cary 7000 Universal Measurement Spectrophotometer (UMS)

Application note

Materials

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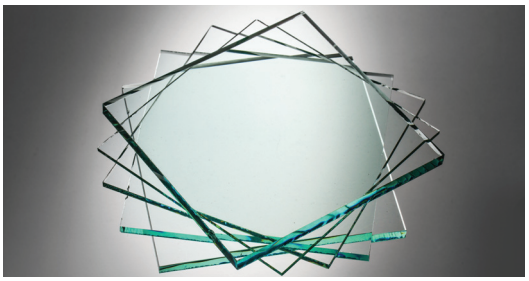


Introduction

Glass and glass-based products have been in use for thousands of years, providing form and function to people all around the world. The last century has witnessed a significant acceleration in both the production and variety of uses of glass products, predominantly due to the advent of automobiles, sky scrapers, domestic housing and consumer packaging. This increase in demand has been met by the development and refinement of high volume commercial float glass production starting in the 1950's.

More recent development in composite products and specialty coating technology has allowed glass products to be tailored to very specific functional needs, environmental conditions and lighting demands. In addition, developers and users today are equally focused on the energy efficiency of the product and the fit-for-purpose general requirements to block UV radiation, transmit visible light, repel thermal radiation (heat) in summer, and retain heat in winter.

Nationally and internationally recognized standards have been developed to ensure measurement and classification of glass products is performed in a controlled and comparable manner. The use of three such standards will be used in this application note using a Cary 7000 Universal Measurement Spectrophotometer (UMS):

- ISO 9050 (2003): Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors.
- EN 410: Glass in building — Determination of luminous and solar characteristics of glazing
- ISO 13837 (2008): Road vehicles — Safety glazing materials — Method for the determination of solar transmittance

Experimental

Samples

A variety of automotive and architectural glazing products were measured and characterized using Agilent's Cary 7000 UMS. The Cary 7000 UMS is a powerful and versatile spectral characterization tool that provides multi-angle transmission and absolute reflection measurements in a motorized, fully automated package.

The Cary 7000 UMS performs transmission and absolute reflection measurements from the same point on the sample — without having to moving the sample between measurements. The *in situ* measurement of %T and %R from identical locations on the sample permits highly accurate absorptance (A = 1–T–R) data to be calculated providing far greater insights into substrate (internal transmission) and coating properties. This capability ensures the highest quality R and T data for QA/QC operation as well as providing a better understanding for the research and development of glazing and coated glazing products.

In addition to the versatile T, R, A collects, dedicated calculations can be executed for the major international and regional glazing standards. In this application example, a complete set of transmission and reflection data was collected using standard glazing methods supplied with the Cary WinUV version 6 software. Calculations were performed using the in-built glass calculation and reporting tool. Examples of the test report, spectral data and parameters calculated are shown in the following section.

Instrumentation

- Agilent Cary 7000 Universal Measurement Spectrophotometer, P/N G6873AA

The Cary 7000 UMS is a highly automated UV-Vis-NIR spectrophotometer system. The Cary 7000 UMS performs variable angle transmission and absolute reflectance measurements. The linearly polarized beam that is incident on the sample can be used to measure transmission, and by rotating the detector assembly about an axis through the sample and perpendicular to the plane of incidence, in reflection.

Results and discussion

Each of the standards have their specific reporting parameters, which were automatically calculated and displayed in the Cary WinUV software report. Furthermore, each set of data was collected automatically and unattended, highlighting the true productivity benefit provided by the Cary 7000 UMS. After the initial configuration and baseline collect, each collection was set and executed in < 3 minutes. Testing requiring reflection and transmission measurement on the same sample required no further user interaction as the collect was run for any user-specified angle of incidence or reflection. As shown in Figures 1–3, the high quality data leads to accurate characterization of these types of samples.

EN 410

EN 410 Calculations

Color Rendering, Light Reflectance, Light Transmittance, Total Solar Energy Transmittance (Solar Factor) and Shading Coefficients, UV Transmittance

Scan Analysis Report

Report Time :	Mon 03 Jun 02:39:24 PM 2013
Method	
Batch:	C:\Documents\glass sample.BSW
Software version:	6.0.0.1547
Operator:	

Sample Name: Sample S +-60 +-180

Test Report	Determination of Luminous and Solar Characteristics of Glazing
EN410 Glass in Building	5_2 and 5_5
Light Transmittance of Glazing	
780 nm - 380 nm	**0.6767**
UV Transmittance of Glazing	
380 nm -300 nm	**0.5110**

This report was generated from data supplied to EN410 Light and UV Transmittance 5_2 and 5_5_Agilent.xlsx.

Figure 1a. Example of a EN 410 test report generated for an architectural glass sample

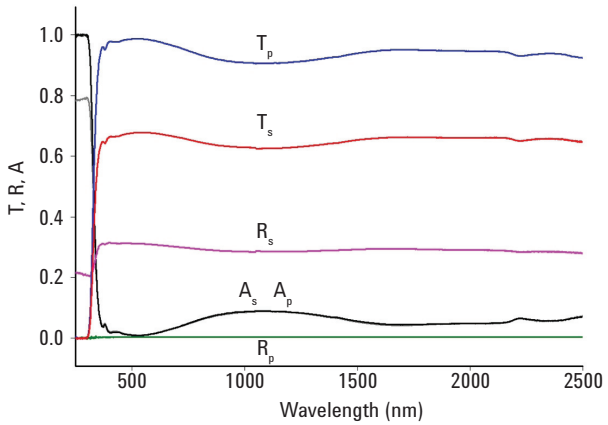


Figure 1b. Transmission, reflection and the associated absorptance spectra (A=1-T-R) for an architectural glass sample (2 mm thick). Both s- and p-polarized spectral data were collected at 60° angle of incidence

ISO 9050

ISO 9050 Calculations

CIE Damage Factor, Light Reflectance, Light Transmittance, Skin Damage Factor, Total Solar Energy Transmittance (Solar Factor), UV Transmittance

Scan Analysis Report

Report Time :	Mon 03 Jun 02:47:38 PM 2013
Method	
Batch:	C:\Documents\glass sample.BSW
Software version:	6.0.0.1547
Operator:	

Sample Name: Sample S +-7 +-14

Test Report	**Determination of Luminous and Solar Characteristics of Glazing**
ISO9050 Glass in Building	3_5
Solar direct Transmittance	0.823
Solar Direct Reflectance	0.074
Direct Solar Absorptance	0.109
Secondary Heat Transfer factor of glazing towards inside*, Single Glazing	0.028
Secondary Heat Transfer factor of glazing towards outside*, Single Glazing	0.081
Total Solar Energy of Transmittance (Solar Factor)	0.851

This report was generated from data supplied to ISO9050 Solar Energy Transmittance 3_5_Agilent.xlsx.

Figure 2a. Example of an ISO 9050 test report generated for an architectural glass sample

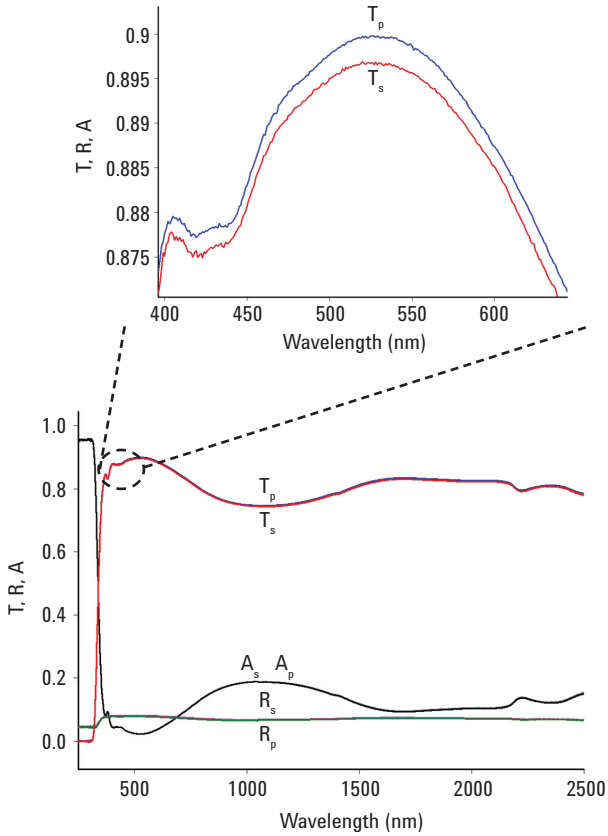
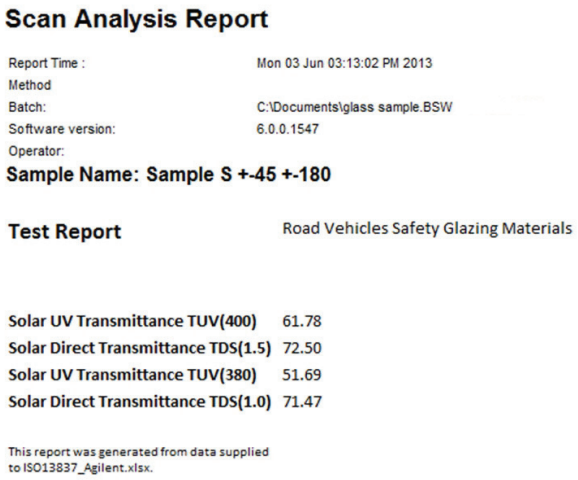


Figure 2b. Transmission, reflection and the associated absorptance spectra (A=1-T-R) for an architectural glass sample (2 mm thick). Both s- and p-polarized spectral data were collected at 7° angle of incidence. Inset: A closer look at the T_p and T_s spectra in Figure 2b reveals an expected separation of approximately 0.003 between s- and p-polarized spectra

ISO 13837

ISO 13837 Calculations
Solar UV Transmittance T_{UV}(400), Solar Direct Transmittance T_{DS}(1.5),
Solar UV Transmittance T_{UV}(380), Solar Direct Transmittance T_{DS}(1.0)



Scan Analysis Report

Report Time : Mon 03 Jun 03:13:02 PM 2013
Method
Batch: C:\Documents\glass sample.BSW
Software version: 6.0.0.1547
Operator:

Sample Name: Sample S +-45 +-180

Test Report Road Vehicles Safety Glazing Materials

Solar UV Transmittance TUV(400)	61.78
Solar Direct Transmittance TDS(1.5)	72.50
Solar UV Transmittance TUV(380)	51.69
Solar Direct Transmittance TDS(1.0)	71.47

This report was generated from data supplied to ISO13837_Agilent.xlsx.

Figure 3a. Example of a ISO 13837 test report generated for an automotive glass sample

Conclusions

The Cary 7000 UMS, standard software methods and reporting tools were used to calculate the optical properties of three different glass products used in automotive and building products. The optical properties were reported according to the regional and international glass standards, ISO 9050, ISO 13837 and EN 410. The Cary 7000 UMS is a powerful, productive and ideal turn-key solution for routine QA/QC testing, and research and development of glass and glazing products.

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