

Automated, Unattended, Multi-Angle Transmission and Absolute Reflection Measurements

Using the Agilent Cary 7000 universal measurement spectrophotometer (UMS)



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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 witnessed a significant acceleration in both the production and variety of uses of glass products, predominantly due to the advent of automobiles, skyscrapers, 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 1950s.

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 that 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 an Agilent 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 a 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 move the sample between measurements. The *in situ* measurement of %T and %R from identical locations on the sample permits highly accurate absorbance ($A = 1 - T - R$) 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 collections, 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 (part number 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 in 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 collection, 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 collection was run for any user-specified angle of incidence or reflection. As shown in Figures 1 to 3, the high quality data lead 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

A 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.

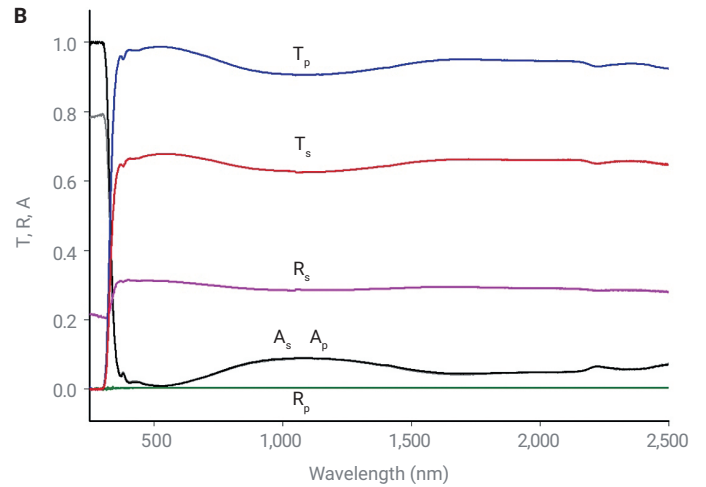


Figure 1. (A) Example of an EN 410 test report generated for an architectural glass sample. (B) Transmission, reflection, and the associated absorptance spectra ($A = 1 - T - R$) for an architectural glass sample (2 mm thick). Both s- and p-polarized spectral data were collected at 60° angle of incidence.

ISO 9050

ISO 9050 calculations:
 CIE Damage Factor, Light Reflectance, Light Transmittance,
 Skin Damage Factor, Total Solar Energy Transmittance
 (Solar Factor), UV Transmittance

A 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 0.851
 (Solar Factor)

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

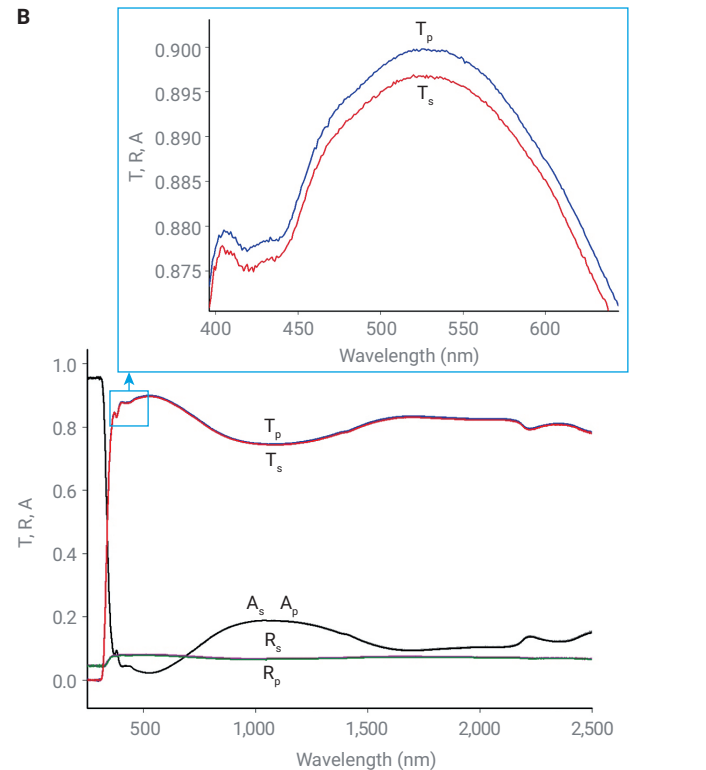


Figure 2. (A) Example of an ISO 9050 test report generated for an architectural glass sample. (B) Transmission, reflection, and the associated absorptance spectra ($A = 1 - T - R$) for an architectural glass sample (2 mm thick). Both s- and p-polarized spectral data were collected at 7° angle of incidence. 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 3. Example of an ISO 13837 test report generated for an automotive glass sample.

Conclusions

The Agilent 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.

www.agilent.com/chem/cary7000ums

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