

# Assessing the Solar Characteristics of Building Materials by UV-Vis-NIR Spectroscopy

Simple, powerful, adaptable workflows for the Agilent Cary 5000 and 7000 spectrophotometers

## Introduction

Buildings contribute significantly to global greenhouse gas emissions through various processes such as the energy-intensive production and transportation of construction materials, and the reliance on fossil fuels for heating, cooking, and cooling. Reducing the energy consumption and emissions associated with new and existing buildings is therefore key to combating climate change and transitioning to a more sustainable built environment.<sup>1</sup>

The spectroscopic assessment of building materials is an essential aspect of design, construction, and energy efficiency. Consideration of the transmission, reflectance, and thermal emissivity properties of materials such as glazing and cladding can impact the energy efficiency of a building, as well as the comfort of its occupants.

Ultraviolet-visible-near-infrared (UV-Vis-NIR) spectroscopy is a well-understood and versatile technology that has several well-developed norms and standards for characterizing the optical properties of both thin-film layered and bulk materials.

To efficiently analyze the solar optical characteristics of diverse sample types, a high-performance instrument with a choice of flexible sample mounts and accessories is needed. Success factors of the methodology include achieving accurate and reproducible measurements. Access to calculation and reporting tools that are tailored towards the standards for measuring the solar optical characteristics of building materials is also vital.

## Optical analysis of glazing materials using UV-Vis-NIR

Agilent's Cary 5000 and 7000 spectrophotometers, and Agilent Cary WinUV software provide material scientists and engineers with a choice of powerful characterization tools. Each of the instruments can be used for the measurement of materials in compliance with the primary quality standards that are commonly used in the construction industry. The type of measurements that are required for glazing, for example, include:

- Reflectance (%R), transmission (%T), and absorbance (Abs) measurements (known as T, R, A collects) with automated sample positioning or integrated sphere attachments
- Calculation of solar reflectance index (SRI)
- In-built calculations and reporting following ASTM, ISO, and EN optical characterization standards

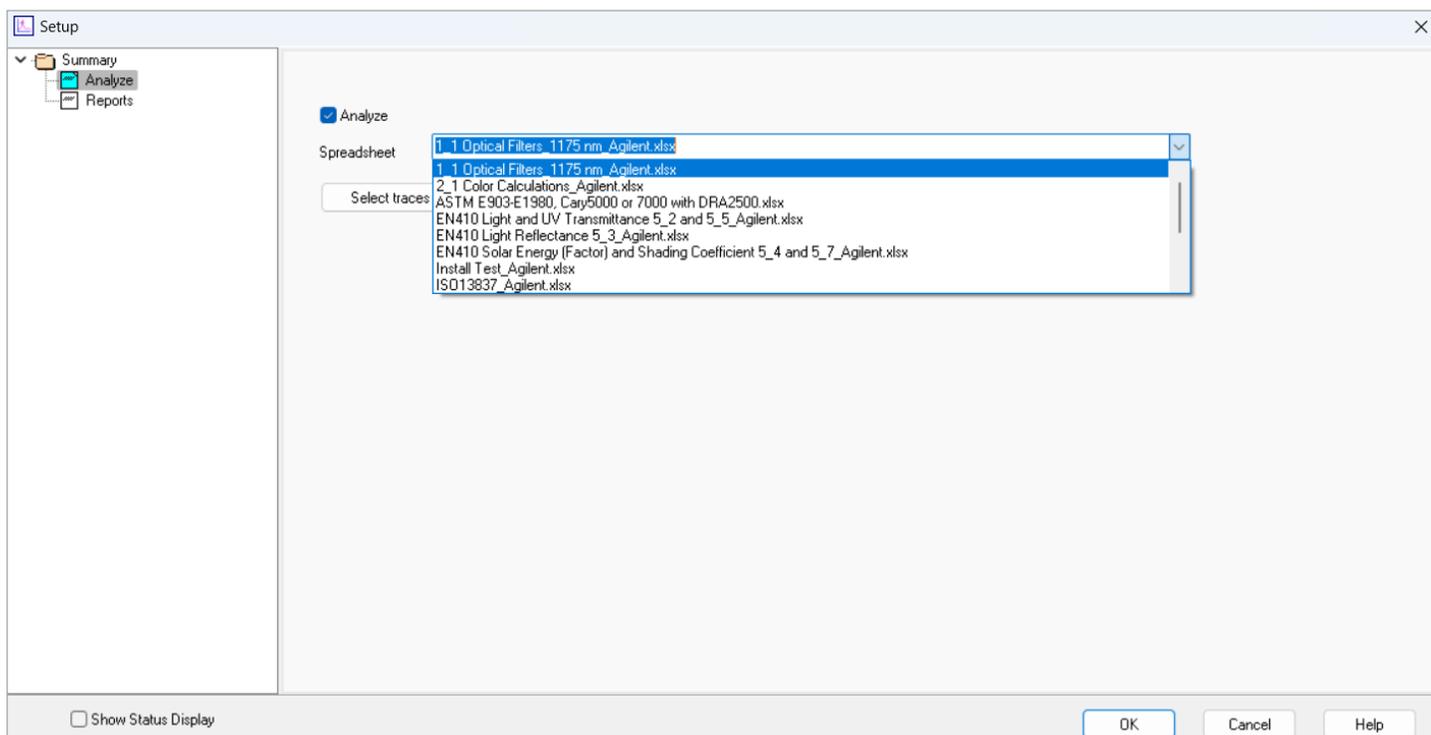
The measurement quality and flexibility of the Cary 5000 and 7000 range of instruments makes it ideal for characterizing glazing materials in compliance with multiple internationally recognized standards such as:

- **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

## Automated calculations

The Cary WinUV software (version 6 and later) provides the functionality to recalculate, format, and generate reports tailored to different quality standards using customized spreadsheets within the software. This capability is ideal for collecting, processing, and reporting data for the high throughput testing of glazing and other solar-sensitive building materials.

After collecting data with a Cary UV-Vis-NIR instrument, users can access the standard method calculations by clicking the **Recalculate** button within the Cary WinUV software. To generate a report based on the recalculated data in a specific template, users can then select **Analyze** and choose the desired spreadsheet from the available options, as shown in Figure 1. The Cary WinUV software is pre-installed with templates for ISO 9050, EN 410, E903, and ISO 13837 standards for glazing materials.



**Figure 1.** Examples of standard method-related spreadsheets that are available in Agilent Cary WinUV software for glazing materials.

## Luminous and solar characteristics of glazing

Understanding the solar optical characteristics of glazing products is important in the construction, automobile, and packaging industries, as glass coatings can vary widely in their capacity to block UV, visible, and thermal radiation. Each of these characteristics will determine whether a glazing material is suitable for the environmental conditions, lighting demands, and safety requirements of a particular application.

Typically, quality standards specify a UV-Vis-NIR methodology for the characterization of glass products. The data provide a basis for engineers to compare the effectiveness of different glazing types for a building in terms of its effect on the light, heat, and ventilation in a room.

The Agilent Cary Universal Measurement Accessory (UMA) is a powerful, automated UV-Vis-NIR system that is ideally suited to measuring the optical characteristics of different glazing products according to multiple internationally recognized standards. The standard methods may vary depending on the specific use of the glazing sample or on the required reporting criteria.

The UMA is supplied standard with the Cary 7000 and can perform multi-angle transmission and absolute reflection measurements without the need to move the sample in between measurements. This single-sequence measurement means that highly accurate calculations for %T, %R, and Abs can be made for identical locations on a sample surface.

After data collection, the Cary WinUV 6 software can apply a variety of in-built glass calculation and reporting tools to quickly generate results according to the required standard (including ISO 9050, EN 410, and ISO 13837).<sup>2</sup>

The turnkey solution provided by the Cary 7000 Universal Measurement Spectrophotometer (UMS) and WinUV 6 software is ideal for QA/QC of materials, where reliable results and efficient methodology are essential. The highly accurate data generated by the system allow for a deeper understanding of glazing products and their suitability for specific commercial applications.



**Figure 2.** Agilent Cary 7000 universal measurement spectrophotometer (UMS).

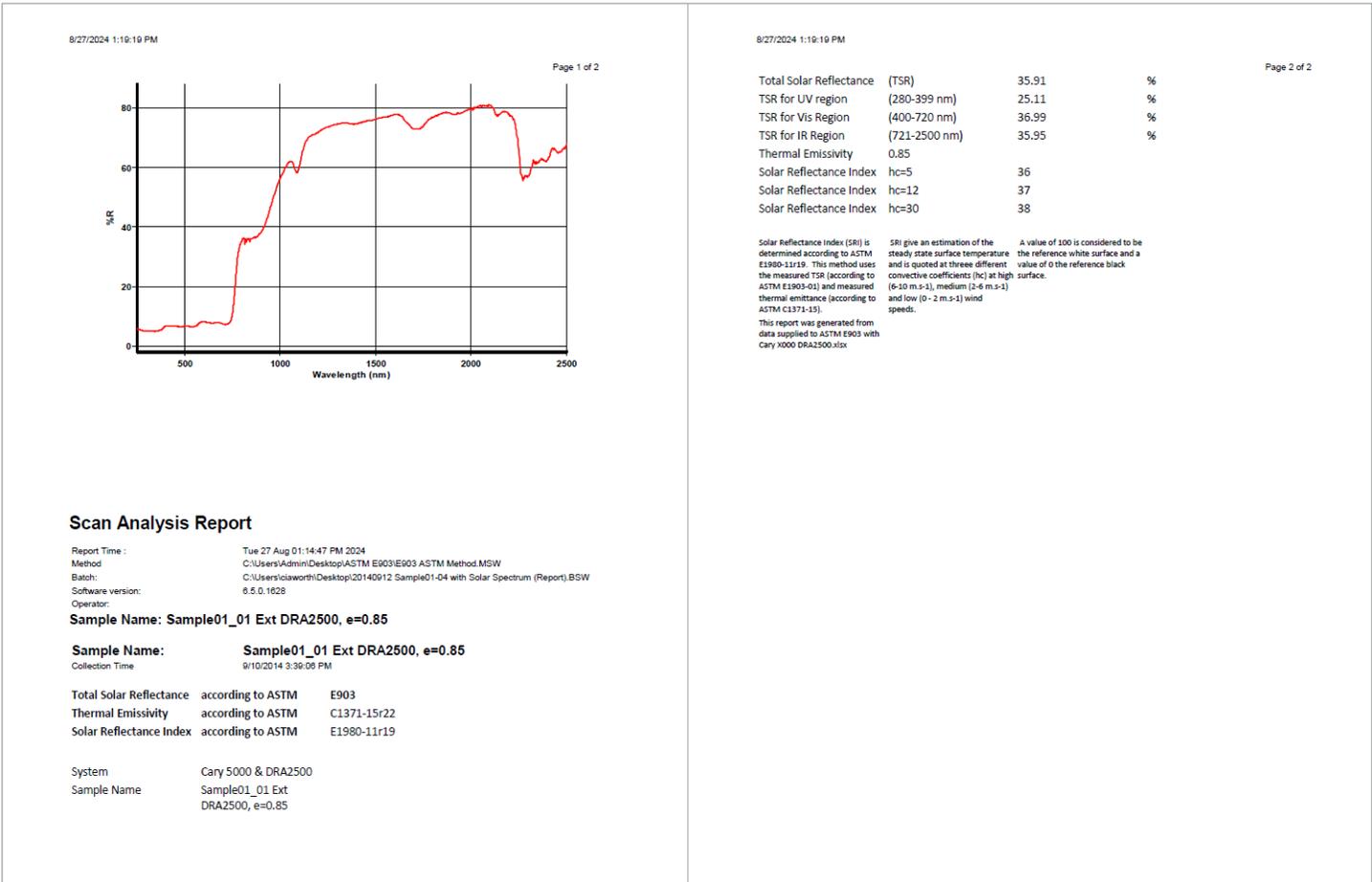
## Standard test methods with the external integrating sphere

The ASTM test method E903-20 is used to determine accurate absorbance, reflectance, and transmission measurements of materials under conditions that reflect a real-world system. The method is designed to provide reproducible results based on fixed conditions across different materials using spectrophotometers equipped with integrating spheres. When combined with the standard practice for calculating the SRI of horizontal and low-sloped opaque surfaces (ASTM E1980), the method allows for a consistent understanding of the thermal and optical properties of different materials under controlled environmental conditions.

The Cary 5000 UV-Vis-NIR spectrophotometer (Figure 3) fitted with an external Diffuse Reflectance Accessory (DRA) has been used successfully to perform these standard measurements (Figure 4).<sup>3</sup> The external DRA integrating sphere can house a wide range of sample sizes and shapes, with variable angle-center mount accessories that are suitable for multiple sample types.



**Figure 3.** Agilent Cary 5000 UV-Vis-NIR spectrophotometer fitted with an external DRA integrating sphere.



**Figure 4.** Scan analysis report following the analysis of painted aluminum coupons by the Agilent Cary 5000 UV-Vis-NIR spectrophotometer with an external DRA integrating sphere. The report is formatted according to ASTM E903 method requirements.

## References

1. Tricoire, J. World Economic Forum, Why Buildings are the Foundation of an Energy-Efficient Future, February 22, **2021**. **Buildings are the foundation of our energy-efficient future | World Economic Forum (weforum.org)** (accessed 2024-05).
2. Burt, T.; Colley, C. Automated, Unattended, Multi-Angle Transmission and Absolute Reflection Measurements Using the Agilent Cary 7000 Universal Measurement Spectrophotometer (UMS). *Agilent Technologies application note*, publication number 5991-2514EN, **2022**. <https://www.agilent.com/cs/library/applications/an-absolute-reflection-arch-auto-glass-cary-7000-ums-5991-2514en-agilent.pdf>
3. Test Methods for Solar Characteristics of Building Materials with UV-Vis NIR Spectroscopy. *Agilent Technologies application note*, publication number 5994-7538EN, **2024**.

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