Measuring the reflective properties of architectural glass using the Agilent Cary 630 FTIR with 10 degree Specular Reflectance Accessory

Application note

Materials

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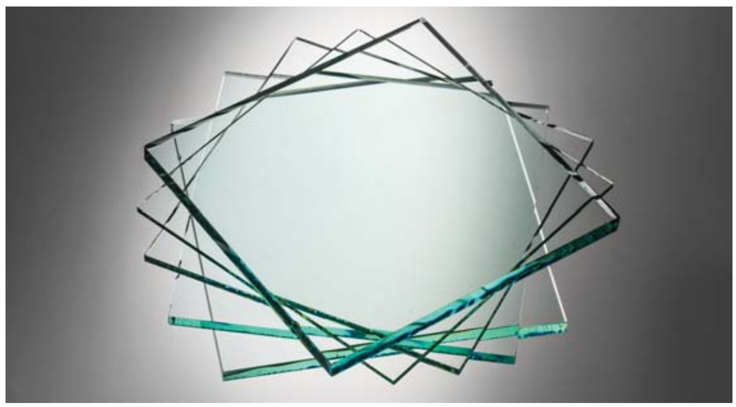

Introduction

Buildings around the world are striving to become greener and more energy efficient. While there are many aspects to building construction that enable 'green' capabilities, one area of consideration is the amount of natural heat that enters a building from the outside. As external walls are insulated, it is the windows on the external glass that have a big influence on how a building heats up and cools down. To control this level of heating, thin film coatings are placed on the architectural glass to (a) enable IR light to enter the building to heat up in colder climates or (b) reflect IR light to keep the building cooler in warmer climates. The optical properties of the thin film needs to balance the amount of IR light entering the building, and the angle at which the sunlight hits the glass and its coatings can have a significant effect on the behavioral characteristics of the coating.

FTIR spectroscopy can be used to measure the characteristics of the thin films across the IR spectral range. These measurements complement similar UV-Vis-NIR measurements and the ability to collect both types of data allows for a more complete characterization of the coating. Agilent offers solutions for both the FTIR and UV-Vis-NIR measurements.

In this paper we will demonstrate how the Agilent Cary 630 FTIR can be used to measure the properties of coatings on glass at 10° (near-normal) using a 10 degree Specular Reflectance Accessory. Here we measure 4 different glass samples, 3 with a coating and one bare sheet of glass as a reference. The objective is to determine the infrared reflectivity of building glass following the GBT 2680-94 procedure.

Experimental

The Agilent Cary 630 was fitted with the 10 Degree Specular Reflectance accessory (Figure 1) .

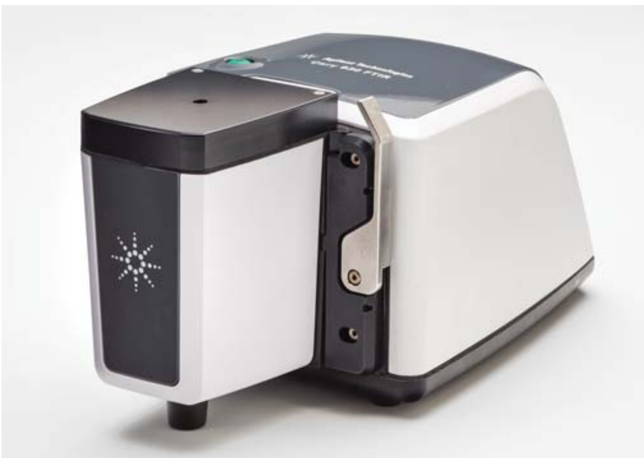

Figure 1. The 10 degree Specular Reflectance Accessory

This accessory slides on to the front of the Cary 630 engine, and locks into place with no alignment required. Software recognition allows the user to load methods specific to the analysis, providing a simple, easy-to-use interface. The sample was placed on the top of the accessory as shown in Figure 2.

Figure 2. The 10 degree Specular Reflectance Accessory connected to the Cary 630.

The background was a gold coated slide to provide a 100% reflectance background. Samples were labeled as follows:

Sample label	Description
Reference	Uncoated sheet glass
Sample 1	Coated glass
Sample 2	Coated glass
Sample 3	Coated glass

All 4 samples were measured at an incident angle of 10°, 64 scans at 4 cm^{-1} resolution. The samples were measured in % reflectivity from which the Hemispherical solar irradiance was calculated.

Results and Discussion

The graph in Figure 3 shows the raw data of % reflectance vs wavenumber.
The data was then entered into the following equation to yield the hemispherical solar irradiance .

$$\rho_h \approx \sum_{4.5}^{25} G_\lambda \cdot \rho_\lambda$$

Where:

ρ_λ is sample % reflectivity

G_λ is irradiance index under 293K (refer to Table 1)

The % reflectivity from Figure 3 was multiplied by the irradiance factor (G_λ) at each wavelength. The results were plotted as the corrected reflectivity versus wavelength (in microns) as shown in Figure 4.

The data set for each sample was then summed and reported back as a value of how effective the coating is at reflecting IR light. The higher the value, the more reflective the coating in the IR.

The reference, Sheet glass, is uncoated and allows most of the IR light through the glass and into the building.

Therefore, thin film coatings on the glass, Samples 1 – 3, are used to change how much light enters the building. Samples 1 and 3 are more reflective than the reference sheet glass, thereby reducing the amount of IR light, i.e. heat, that enters the building. Sample 2 seems to have more of an anti-reflection coating on it as it is less reflective than the uncoated sheet glass reference.

	Reference	Sample 1	Sample 2	Sample 3
Solar Irradiance	10.3	19.3	9.5	95.2

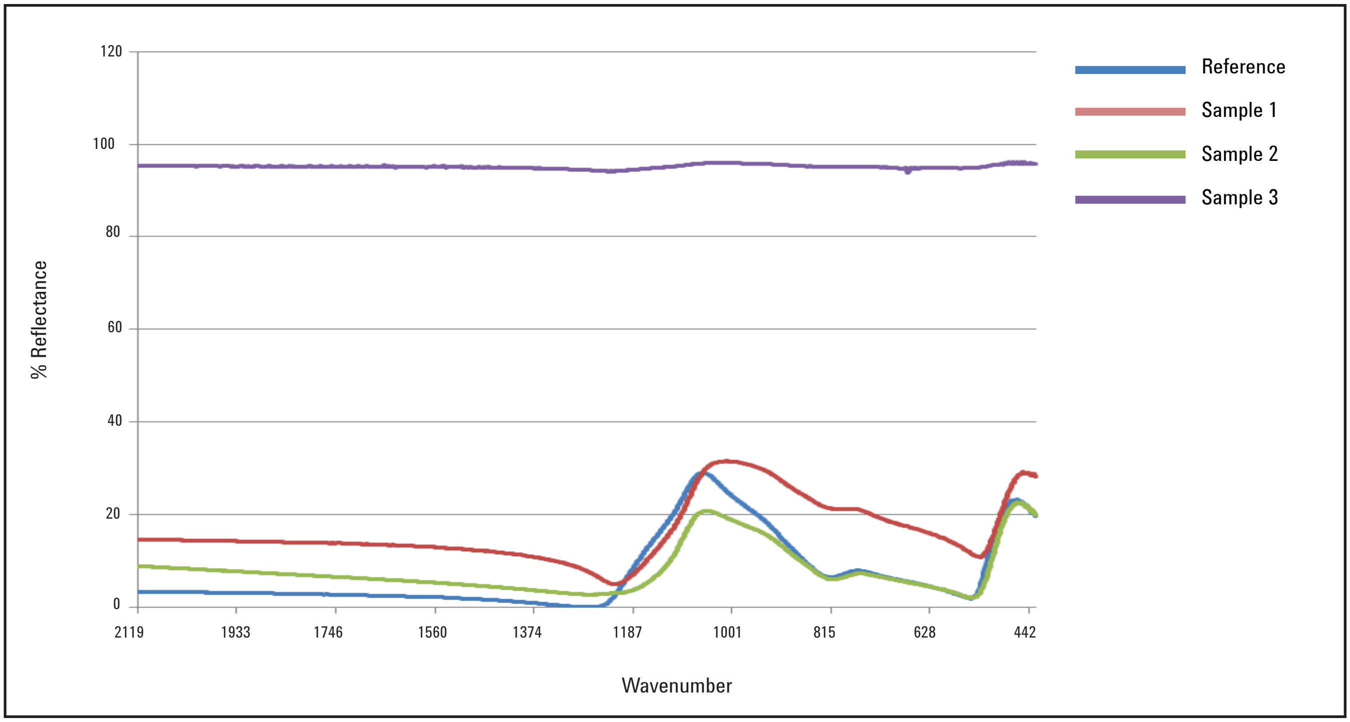

Figure 3. Percent reflectance plotted against wavenumber

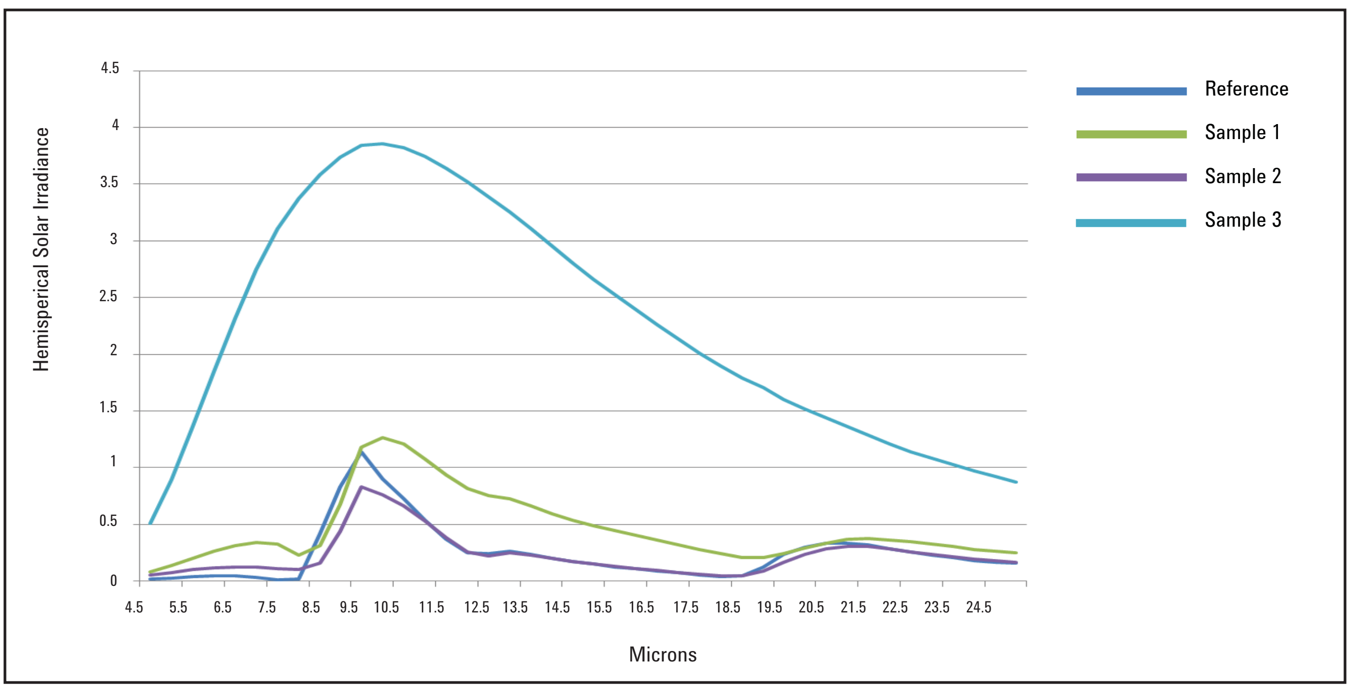

Figure 4. Corrected reflectivity plotted against wavenumber

Table 1. Factors (G_λ) to calculate the irradiance index as a function of wavelength (microns)

micron	G_λ	micron	G_λ
4.5	0.0053	15	0.0281
5	0.0094	15.5	0.0266
5.5	0.0143	16	0.0252
6	0.0194	16.5	0.0238
6.5	0.0244	17	0.0225
7	0.029	17.5	0.0212
7.5	0.0328	18	0.02
8	0.0358	18.5	0.0189
8.5	0.0379	19	0.0179
9	0.0393	19.5	0.0168
9.5	0.0401	20	0.0159
10	0.0402	20.5	0.015
10.5	0.0399	21	0.0142
11	0.0392	21.5	0.0134
11.5	0.0382	22	0.0126
12	0.037	22.5	0.0119
12.5	0.0356	23	0.0113
13	0.0342	23.5	0.0107
13.5	0.0327	24	0.0101
14	0.0311	24.5	0.0096
14.5	0.0296	25	0.0091

Conclusion

The amount of infrared light reflected is altered to varying degrees by the coating on the glass. Two of the coatings improved the reflectivity, reducing the warming effects of infrared light, while one of the samples lowered the reflectivity, allowing more infrared light to enter the building. The Cary 630 FTIR with the 10 degree Specular Reflectance Accessory can easily measure large or small glass samples and report back the data in a variety of formats through automated methods set up within the MicroLab software.

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