CCPR-K5.2019 Key Comparison of Spectral Diffuse Reflectance

Robin Ångerman[1], Farshid Manoocheri[1], Dmitri Lanevski[1], and Erkki Ikonen[1,2]

[1] Metrology Research Institute, Aalto University, Espoo, Finland, [2]VTT MIKES, Finland
R. Ångerman's email-address: robin.angerman@aalto.fi

The key comparison CCPR-K5.2019 for spectral diffuse reflectance will be performed in the wavelength range of 360 nm to 830 nm using a 0º:d or equivalent geometrical configuration. The key comparison will be carried out in a star pattern among eleven participants using two types of samples. We will present measurement results of the evaluation tests on the quality of the samples at the conference. The samples have negligible fluorescence whose effect is less than 0.1% on the reflectance measurements. The reflectance of the samples is stable and uniform from the surface central area of 30 mm in diameter.

INTRODUCTION

At its meeting in June 2017, the Consultative Committee of Photometry and Radiometry (CCPR) decided that a key comparison of spectral diffuse reflectance would be carried out. Subsequently, CCPR assigned the Metrology Research Institute (MRI) of Aalto University and VTT MIKES metrology in Finland as the pilot laboratory. The effort will result in the key comparison reference values (KCRV) and the unilateral degree of equivalence (DOE) of each national measurement scale, both its deviation from the KCRV and the uncertainty of that deviation at the 95 % level of confidence.

The eleven participants of the CCPR-K5.2019 key comparison will include two National Metrology Institutes (NMIs) from North America, four NMIs from Asia-Pacific and five NMIs from Europe. Each participant will measure 2 pieces of matte ceramic tile samples and 2 pieces of sintered polytetrafluoroethylene (PTFE) samples, here after simply referred to as sintered PTFE samples.

After the receipt of all comparison samples from the suppliers, we have carried out a series of measurements to assess their quality, such as tests for short term stability, uniformity over a central spot of 30 mm in diameter, and the Lambertian behaviour at wavelengths of 360 nm, 580 nm, and 780 nm. Presence of possible UV-induced fluorescence has been checked using a spectrofluorometer at excitation wavelengths from 350 nm to 360 nm. For the long-term stability test, a set of four samples (two of each type) have been chosen as "Comparison reference standards" for monitoring any drifts in the spectral diffuse reflectance measurements of the gonioreflectometer at Aalto and possible changes in the comparison samples throughout the stages of the comparison.

PILOT LABORATORY MEASUREMENT SETUPS

The pilot laboratory measures the average spectral diffuse reflectance using a gonioreflectometer. The setup at Aalto [1] is shown in Figure 1. The measurement wavelength is selected using a double-monochromator configuration that has a bandwidth of 5.4 nm. The average spectral diffuse reflectance is determined by integrating the angle-resolved radiance factor over the hemisphere, for a 0º:d equivalent geometry. The setup has a combined standard uncertainty of 0.2%, determined by previous work [1]. Furthermore, the samples are measured on a regular basis against reference standards using a commercial double-beam integrating sphere-based, spectrometer, which has an 8º:d configuration [2].

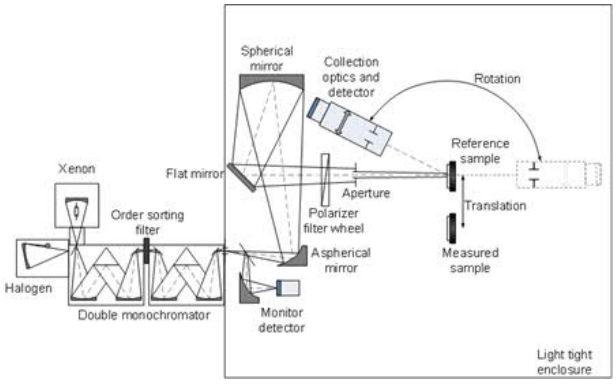

Figure 1. Schematic of the gonioreflectometer at Aalto.

In order to determine the presence of possible UV-induced fluorescence at 360 nm wavelength a spectrofluorometer was used. The setup includes a xenon arc lamp, a monochromator, and an imaging spectrophotometer. Several pieces of the comparison samples of each type were irradiated in the 350-

360 nm wavelength range. The spectral radiances of the samples were compared against a few known non-fluorescent PTFE reference samples to determine any effects due to fluorescence as apparent reflectance in the 360-830 nm wavelength range.

REFERENCE MATERIALS AND RESULTS

The sample candidates include twenty-two pieces of matte white ceramic tiles and twenty-two pieces of sintered PTFE samples. Figure 2 shows the two types of reference samples. The samples have been mounted in cap-protected frames/holders. The material dimensions for the ceramic tiles and for the sintered PTFE samples are nominally 50 mm x 50 mm x 10 mm and 50 mm diameter x 10 mm thick, respectively. Figure 3 shows the result of fluorescence measurements for three pieces of matte white ceramic tiles marked as T-i, T-ii, and T-iii and for two PTFE reference samples P-i, and P-ii. Figure 4 shows an example result of a test for the Lambertian behaviour of a reference sample of the matte white ceramic tiles at wavelengths of 360 nm, 580 nm, and 780 nm. The measurements are performed for the bidirectional radiance factor of angles ranging from 85º to -85º in 5º increments.

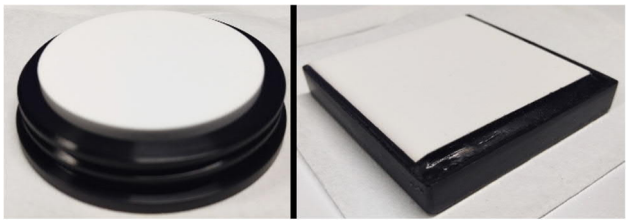

Figure 2. From left to right, a sintered PTFE puck and a matte white ceramic tile

SUMMARY

The CCPR-K5.2019 Key Comparison measurements have started with MIKES-Aalto as the pilot laboratory according to a technical protocol which follows the guidelines established by CIPM and CCPR [3-5].

The pilot laboratory measures the average spectral diffuse reflectance of two types of samples using a gonioreflectometer. The measurement results of the evaluation tests on the quality of the samples indicates that the samples have negligible fluorescence whose effect is less than 0.1% on the reflectance measurements. In the short term, the reflectance of the samples is stable and uniform from the surface central area of 30 mm in diameter. Measurement results of the sample quality will be fully presented at the conference.

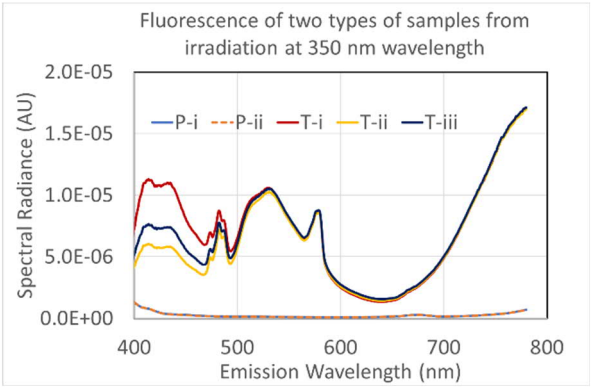

Figure 3. Fluorescence spectral radiance factor for the sintered PTFE samples, P-i, P-ii, and for ceramic tile samples, T-i, T-ii, and T-iii using an excitation wavelength at 350 nm.

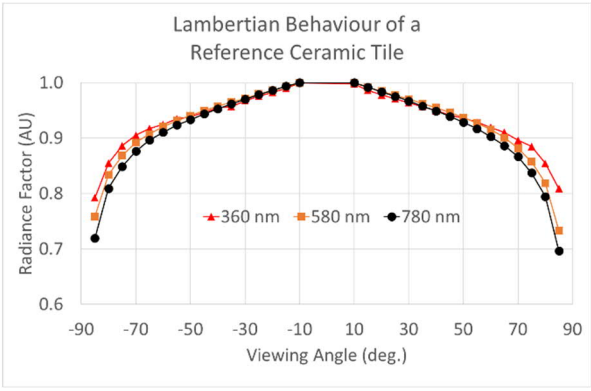

Figure 4. Normalised radiance factor for a matte white ceramic tile measured at wavelengths of 360 nm, 580 nm, and 780 nm. This tile is not circulated to other participants.

REFERENCES

1. S. Nevas, F. Manoocheri, E. Ikonen, Gonioreflectometer for measuring spectral diffuse reflectance, Applied Optics, 2004
2. Cary 7000 UV/VIS/NIR spectrophotometer with a DRA-2500 External Diffuse Reflectance Accessory, Agilent Technologies, Inc, www.agilent.com/chem.
3. T.J. Quinn, Guidelines for CIPM key comparisons BIPM, 1999 (modified 2003)
4. CCPR-G4, Guidelines for preparing CCPR Key Comparisons, CCPR Working Group on Key Comparisons, 2013
5. International Committee for Weights and Measures, Mutual Recognition of National Measurement Standards and of Calibration and Measurement Certificates Issued by National Measurement Institutes, Paris: Comité International des Poids et Mesures, 2003