Autolab Application Note PV06

Using the Autolab Spectrophotometer for Calibration of the White LED Lights

Keywords

Metrohm Autolab Optical Bench, solar cells, DSC, LED light, calibration, Autolab spectrophotometer.

Introduction

This application note presents the procedure to determine the responsivity value for calibrating the white lights of the Metrohm Autolab Optical Bench.

Three types of white lights are available, listed in Table 1, in addition to the colored LED lights discussed in Application Note PV05.

Table 1 - List of the different white LED lights available for the Metrohm Autolab Optical Bench.

Color	Article Code	Temperature (K)
Cool White	LDCCW	6500
Warm White	LDCWW	4100
Neutral White	LDCNW	3000

The names of the white lights does not refer to their actual temperature, but to how the light is perceived by our eyes. Higher temperatures are considered cool, while lower temperatures are considered warm. The cool white light has a “blueish” color, while the warm white light has a more “orange” color. Neutral white light has a color with little blue or orange in it.

As in the case of colored LED lights, the performance of the white LED lights with respect to their intensity also changes over time. Therefore, periodic calibration is advisable.

In this example the cool white LED light is used. The same procedure can be applied to the other types of white LED lights.

A calibrated photodiode, which is part of the Metrohm Autolab Optical Bench, is useful for the calibration of the LED lights. The photodiodes in the Metrohm Autolab Optical Bench are delivered with the responsivity data (η, in A/W) vs. wavelength (λ, in nm). The suitable responsivity value is selected corresponding to the color of the LED light to be calibrated. For example, the responsivity associated with a 627 nm wavelength (red LED light) could be 0.32 A/W.

However, it is not possible to use a single value of the responsivity for the white light, since the white color is the combination of lights of different wavelengths.

The strategy is to use the normalized intensity values as multiplication factors for the responsivity values, for a specific range of wavelengths. In this way, the responsivity is weighted by factors which depend on the amount of the intensity at each wavelength. The light intensity of the white LED is collected between 400 nm to 700 nm, and then normalized. The values of the normalized light intensity are used as weighting factors on the calculation of the averaged responsivity, later used for the calibration.

Experimental setup

A Metrohm Autolab PGSTAT204 with a Metrohm Autolab Optical Bench is used, together with one of the three white LED lights listed in Table 1. The setup is shown in Figure 1.

Figure 1 – On the left, the rail equipped with an LED light and the photodiode. In the center, the Metrohm Autolab PGSTAT204. On the right, the LED driver.

In order to collect the light intensity along the visible light spectrum, i.e., from 400 nm to 700 nm, an Autolab spectrophotometer is used, see Figure 2. A 200 μm diameter optical fiber is connected to the spectrometer and placed at a distance of 20 cm from the light source.

Figure 2 - The Autolab spectrophotometer.

The experiment is performed in a dark environment, in order to avoid light pollution that may interfere with the measurements.

The procedure

A plot of the light intensity vs. wavelength is collected with the spectrometer, and normalized to the highest value, see Figure 3.

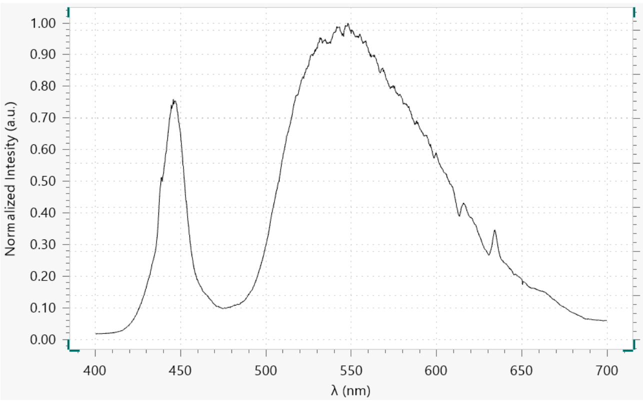

Figure 3 - Normalized intensity vs. wavelength of a cool white LED light

The responsivity vs. wavelength plot provided by the manufacturer of the photodiode is shown in Figure 4.

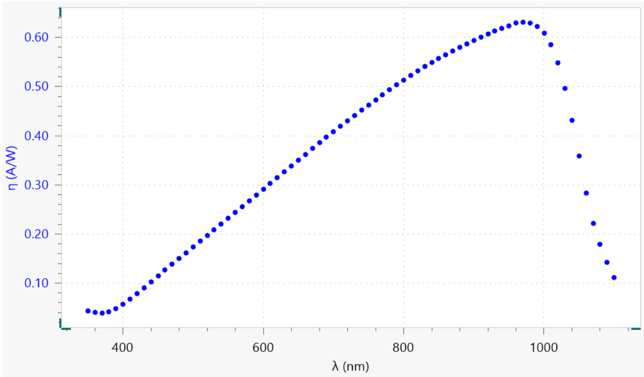

Figure 4 - Responsivity vs. wavelength plot, specific to the photodiode used for the measurement.

Since the range of suitable wavelengths of the white LED lights is limited to the visible light, i.e., from 400 nm to 700 nm, the same range of wavelengths is chosen from the plot of Figure 4, 350 nm – 1100 nm, and shown in Figure 5.

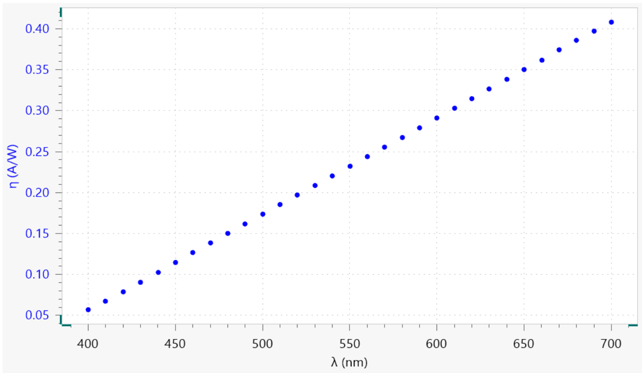

Figure 5 – Responsivity vs. wavelength plot, from 400 nm to 700 nm.

In order to weight the responsivity values (Figure 5) with the normalized intensity (Figure 3), a match in wavelengths is needed. In fact, to have a consistent calculation, the weights must be taken at the same wavelengths as the responsivity. For example, the responsivity at 400 nm must be multiplied with the normalized light intensity at 400 nm. The “interpolate” command in NOVA is used to find the normalized light intensity values for the wavelengths presented in Figure 5. Finally, the weighted responsivity, averaged over the whole visible range of wavelengths $\overline{\eta}_w$, is calculated with Equation 1.

$$\overline{\eta}_w = \frac{\sum_{i=1}^{n} w_i \cdot \lambda_i}{n} \qquad 1$$

Where w are the weights and λ are the wavelengths. The calculated value is $\overline{\eta}_w$ = 0.143 A/W. With this value it is possible to perform the usual calibration procedure as outlines in Application Note PV05.

Conclusions

In this document, a procedure is explained to obtain the photodiode responsitivity value which can be used to calibrate the white LED lights.

The intensity of the white light is collected with a spectrometer and normalized. The responsitivity vs. wavelength values of the photodiode are taken and weighted by the normalized intensity. Finally, the average of the weighted responsitivity is calculated.

Date

09 January 2017