Application Note

Thermally Stabilizing Your Spectrometer with the USB-TC

Background

Changes in a spectrometer's ambient environment can have a significant impact on optical performance. Temperature-related changes in the optical bench and optical bench components are a potential source of wavelength and baseline drift, peak distortion and changes in detector sensitivity. These changes can impact the accuracy of measurements made in environments where the ambient temperature fluctuates, such as on a manufacturing floor or other industrial setting, in an open air environment or even in a standard laboratory where heating and air conditioning systems can create temperature variations. Fortunately, there are several passive, procedural and active methods available to minimize the impact of ambient temperature changes on your measurements.

Passive temperature control can be achieved through spectrometer design as illustrated by the outstanding thermal stability of the Torus Concave Grating Spectrometer for Vis-NIR measurements. With wavelength drift of only 0.0056 nm/ ºC, the Torus ensures that optical performance does not change significantly as the ambient temperature changes.
Also, procedural steps during the experiment can be used to mitigate the impact of temperature on spectrometer performance. Steps such as taking frequent reference and dark measurements, continuously monitoring the reference during the experiment and using electric dark correction help to address temperature fluctuations that occur during the experiment.

Active temperature control is achieved through the use of devices that thermally stabilize the spectrometer. Thermoelectric coolers like the ones found in Ocean Optics' QE65 Pro Back-Thinned CCD Spectrometer and NIRQuest spectrometers with InGaAs detectors for use in the NIR region work to regulate the detector temperature to decrease baseline noise and drift. Environmentally controlled chambers like the SteadiQ, which are designed to control the environment around your spectrometer, also can be used to ensure the spectrometer's environment remains at a consistent temperature. Thermal regulation of the optical bench itself is achieved with a new spectrometer accessory option called the USB-TC. The USB-TC heats the spectrometer to a specified set point above the fluctuating ambient temperature and maintains this temperature within 0.1 ºC of the set point for the duration of your measurements.

Ocean Optics USB-TC

The USB-TC attaches directly to USB2000+ or USB4000 spectrometers to maintain a preselected temperature, ensuring that the

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spectrometer's optical alignment remains consistent throughout the experiment regardless of ambient temperature variations. The USB-TC provides excellent thermal regulation when repeatable results are most critical. The major benefits of thermally regulating the spectrometer with the USB-TC are improvements in baseline stability and in peak location, shape and intensity.

The improvement in baseline stability relative to a non-temperature stabilized spectrometer is shown in Figure 1. The data was acquired for a single wavelength in the dark region of the spectrometer representing the spectrometer baseline. The intensity at this wavelength was recorded every minute for 6.5 hours in an environment with typical ambient temperature fluctuations. As shown in Figure 1, the baseline of the spectrometer that was maintained at 40 ºC by the USB-TC stabilizes more quickly and remains more stable than the baseline of the non-temperature regulated spectrometer.

Regulating the temperature of the spectrometer with the USB-TC also has an incredible impact on peak location, shape and intensity over a wide temperature range as shown in Figure 2. Spectral data was acquired with a temperature regulated spectrometer exposed to ambient temperatures ranging from 0 to 45 ºC. As shown in the plot zoomed in on the spectral region from 570-585 nm, the peak location, shape and intensity remained incredibly consistent over this wide temperature range.

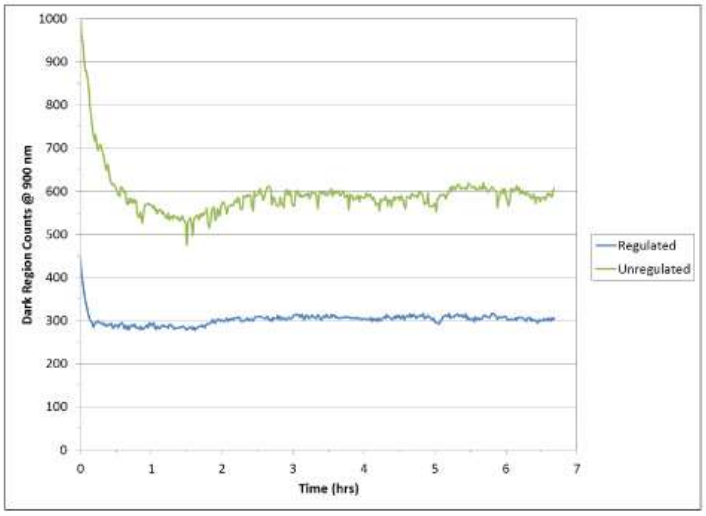

Figure 1: Temperature Regulated Versus Unregulated CCD Spectrometers: Dark Region Monitored at 900 nm for 6.5 hours

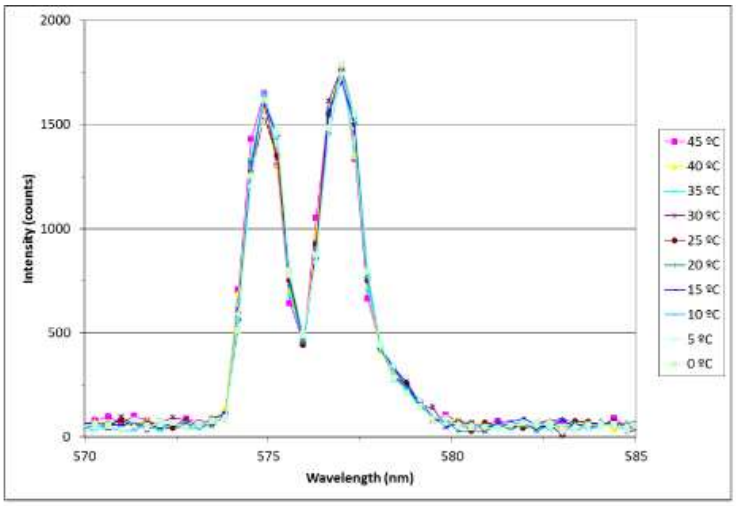

Figure 2: Spectral Data Acquired with a Temperature Regulated Spectrometer over Temperature Range from 0 to 45 ºC

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Conclusions

Optical drift caused by ambient temperature fluctuations must be addressed to ensure accurate spectroscopy measurements. Changes in baseline and peak location, symmetry and intensity can result when temperature variations are not taken into consideration. The USB-TC is a new active temperature controller that provides great thermal stability over a wide ambient temperature range. The USB-TC heats the spectrometer to a user specified temperature and maintains it at that temperature throughout the experiment eliminating measurement variability caused by ambient temperature variations. As shown in Figures 1 and 2, the USB-TC minimizes baseline drift and helps to maintain peak location, shape and intensity over a wide temperature range.

The USB-TC is available with preselected set-point temperatures covering the 25 – 55 ºC range. The system will maintain the set point temperature in ambient temperatures ranging from 5 – 40 ºC below the set point temperature. The USB-TC stabilizes to within 0.1 ºC of the final temperature within 30 minutes of power-up with constant ambient temperature.

Variation in experimental conditions is the enemy of measurement accuracy with ambient temperature changes representing a significant challenge. As described above, there are several approaches available to minimize the impact of temperature change in your measurement environment. The advantage to the modular spectroscopy approach is that there are multiple products and procedures available to mitigate the impact of temperature change. These products allow you to select the most suitable method for your environment and measurement conditions.