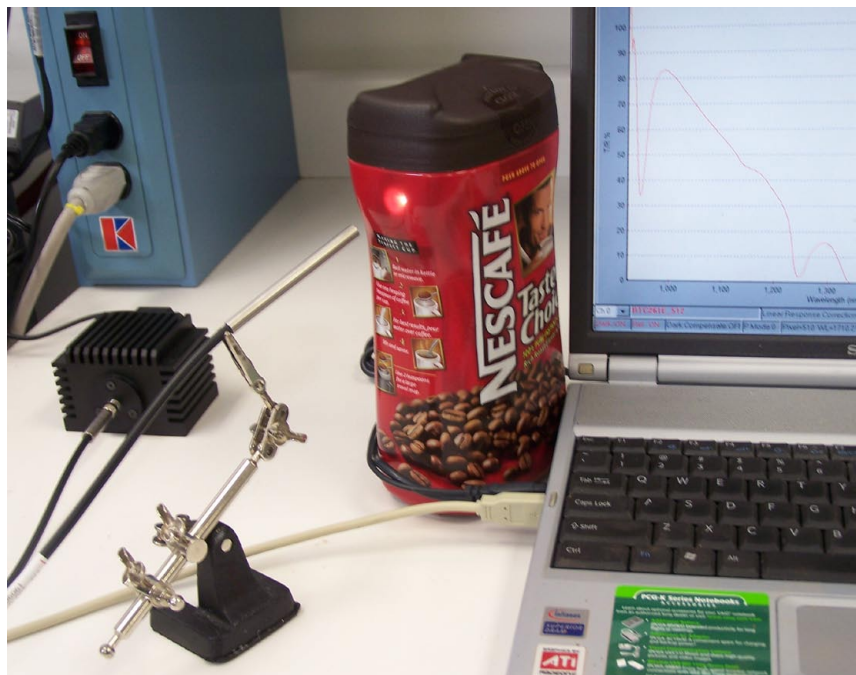


# Application Notes

## Reflectance sample measurements using BTC261E NIR InGaAs spectrometer



**B**TC261E and BTC262E are high dynamic range, low dark noise and high speed NIR InGaAs array spectrometers covering 920-1700 nm, and 1100-2200 nm, respectively. They provide flexible fiber coupling input for light and offer high measurement signal to noise performances. Their high precision temperature cooling and regulation makes them ideal for long term measurement applications such as in-process inspection, on-line monitoring and etc. The compact size of the instrument design enables portable measurement applications to be at ease even

in the field. By employing the BTC261E or BTC262E together with BW Tek's sampling accessories, various reflectance measurement application needs can be addressed with high performance at a low cost.

### Fiber Reflectance Probe Based Setup

Using a fiber reflectance probe assembly, a tungsten light source, and the BTC2xx series NIR spectrometer a fiber based reflectance measurement system can be achieved. Figure 1 is a photo of such a setup. Top left in the



**Figure 1. Fiber probe based reflectance measurement system**

photo shows a BTC2xxE NIR spectrometer. Next to it on the right is a BPS120 tungsten light source. An FRP-200-0.22-1.5-NIR fiber reflectance probe with six illumination strands and one pick is

used for connecting the light source and the spectrometer. The termination end with six strands is connected to the tungsten source, and the single strand end is connected to the spectrometer entrance. The common end of the fiber probe is terminated into a stainless steel pen-like rod with the single pick up fiber surrounded by six illumination fiber strands. Light exiting the six illumination fiber strands is at a divergence angle of roughly 25 degrees. Upon reflected back by a sample surface the light signal is then picked up by the center fiber and delivered to the

spectrometer.

During the measurement the sampling end of the probe is typically pointed at the sample at normal incidence if specular reflectance component is intended.

For applications where the specular reflectance should be excluded the probe tip is usually held at a small angle such as 10-15 degrees with respect to the sample normal.

In order to achieve a high precision measurement result the angle of the fiber probe tip and sampling distance should be kept constant. A reflectance standard with known spectral reflectivity such as PTFE can be used for use as a reference.

Below is a brief description of how to conduct a reflectance measurement using the setup. For more BW Spec software features please reference the related user manuals. With a reflectance measurement setup connected as in Figure 1 launch the BW Spec operating software. Place the PTFE reflectance standard at the same angle and sampling distance as the samples would be and adjust through BW Spec Integration time to optimize the response of the system. The integration time should be set at a value at which the relative intensity (response) from the system

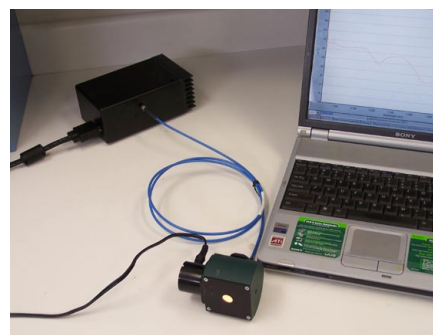
is close to the maximum scale on the graph. Dark and Reference scans are necessary for the software to calculate measurement results and display in a desired mode. From the BW Spec operating software perform a Dark scan with the probe tip pointing at a distance dark target such as the dark corners under the table. Use shutter control to block light from entering into spectrometer for Dark scan if the spectrometer is equipped with a shutter. Now place the PTFE reflectance standard at the sample position and click to take a Reference scan using BW Spec. Select T/R% or Absorbance for percent transmittance or reflectance display, or absorbance unit display. Replace the PTFE by a sample and click on Acquire One Spectrum you will thus obtain a sample spectrum in a selected display mode.

Since the light exiting the illumination fibers is at a divergent angle the sample area being illuminated becomes a function of the sampling distance. The illumination light intensity will also decrease with the increase in sampling distance. For a measurement setup aiming at a distance sample with a finite sampling area an imaging input optics assembly will become

necessary. Contact BW Tek for application specific requirements.

## Integrating sphere based setup

Many reflectance applications involve highly diffuse reflective materials or surfaces. An integrating sphere will be an ideal sampling device for diffuse transmittance and/or reflectance measurements. BW Tek's BIP1.5 integrating sphere has a built-in tungsten



**Figure 2. Diffused reflectance measurement system using an integrating sphere and a fiber**

illumination source and fiber pick up port for easy integration of a diffuse property characterization setup. Shown in Figure 2 is an integrating sphere based diffuse reflectance measurement setup. A FPC-400-0.22-1.5-NIR fiber patch cord is used to connect the NIR spectrometer on top left to the pick up port of the BIP1.5 integrating sphere as shown on the bottom left. The

# Application Notes

sphere sampling port (facing the viewer in the photo) serves for delivery of diffuse light to a sample surface as well as collecting the reflectance off the sampling area. The reflectance at the sample port is imaged and coupled into the pickup fiber which is at an 8 degree angle, to be fed into the NIR spectrometer via the fiber. Thus the sphere is providing a d/8 illumination and detection geometry. All software operating procedures are similar to what have described in previous section.



**Figure 3. Integrating sphere is placed on sample surface for measurement**

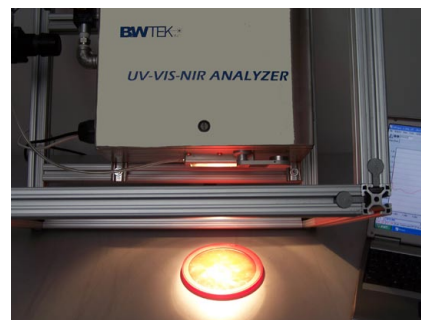


**Figure 4. Coffee sample in a container is presented to the sampling port of a sphere**

During measurements the sphere can be sit onto the surface of a sample can be presented to the sampling port. In Figure 3 the sphere is placed onto a plastic cover for measuring reflectance, while in Figure 4 a glass container is used to hold coffee samples and the container is placed with its bottom surface facing the sampling port.

## **0/θ and θ/0 illumination/detection Setup**

0/θ and θ/0 illumination/detection scheme is another method for diffuse reflectance measurement. In this scheme a light source is illuminating sample surface at 0 (or θ) degrees incidence angle, where θ is typically between 10-45 degrees. Reflected light component is picked up at θ (or 0) degrees with respect to the sample normal. Therefore this method excludes the specular reflectance off a sample. Compared with integrating sphere method this setup has the advantage of requiring simpler accessories and is more easy for installation for on-line applications. In most applications the 0/θ or θ/0 geometry is adequate for achieving satisfactory diffuse reflectance results as that obtained by using integrating spheres. Figure 5 is an on-line broadband diffuse reflectance measurement



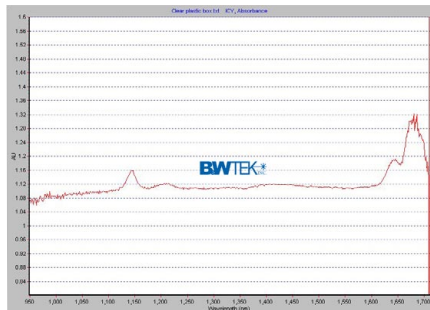
**Figure 5. A broadband on-line diffused reflectance analyzer using 0/45 illumination/detection scheme**

system that employs a 0/30 illumination and detection geometry.

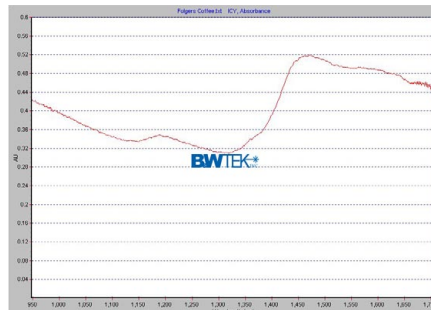
## **Sample Measurement Examples**

Using primarily integrating sphere (d/8) with BTC261E for 95 – 1,700 nm and a 0/30 setup with BTC262E for 1,120-2,150 nm several materials have been measured for their diffuse reflectance spectra. Figure 6 through Figure 20 are some of the sample reflectance spectra.

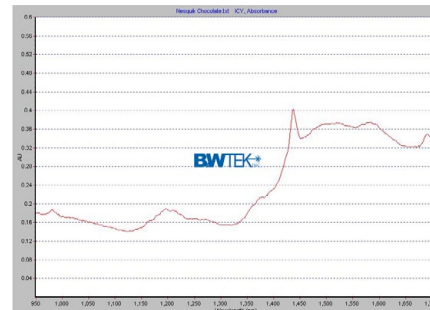




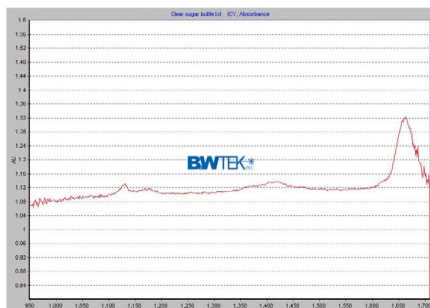
**Figure 6. Clear plastic box reflectance spectrum**



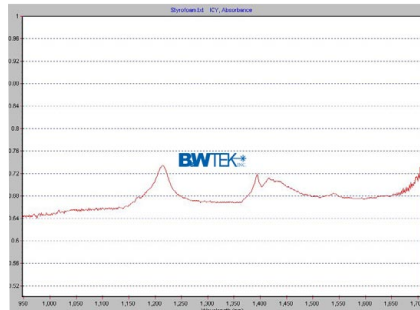
**Figure 9. Folgers coffee diffused reflectance spectrum**



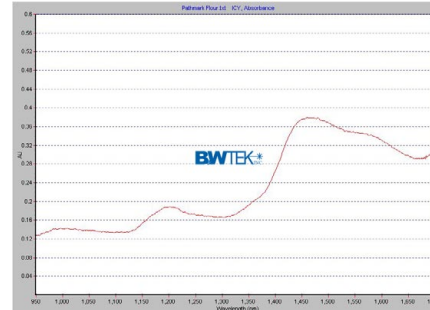
**Figure 12. Nesquik chocolate diffused reflectance spectrum**



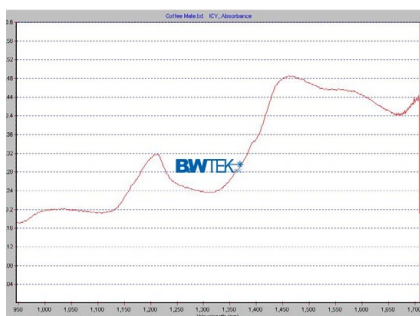
**Figure 7. Clear sugar bottle reflectance spectrum**



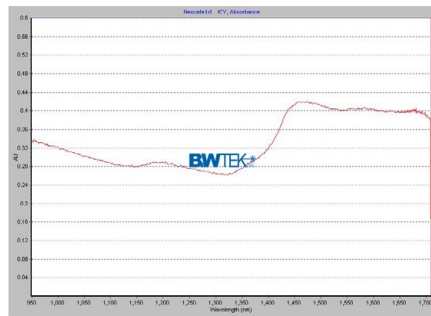
**Figure 10. A light blue Styrofoam diffused reflectance spectrum**



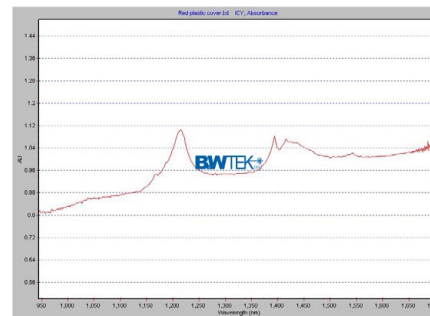
**Figure 13. Pathmark flour diffused reflectance spectrum**



**Figure 8. Coffe mate diffused reflectance spectrum**



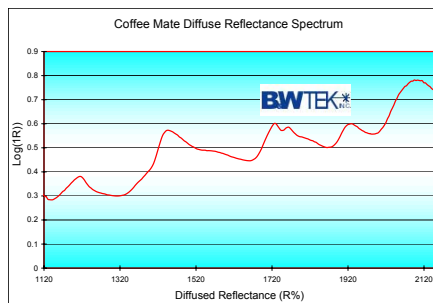
**Figure 11. Nescafe diffused reflectance spectrum**



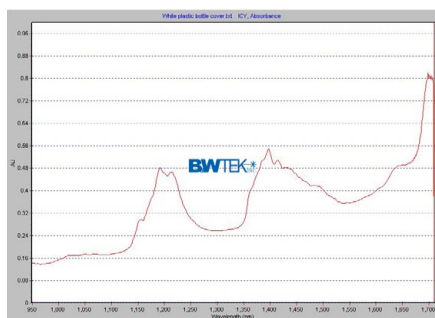
**Figure 14. A red plastic cover diffused reflectance spectrum**



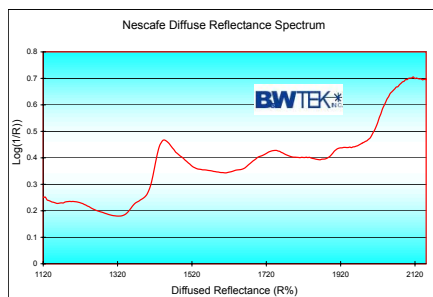
**Figure 15. A commercial sugar diffused reflectance spectrum**



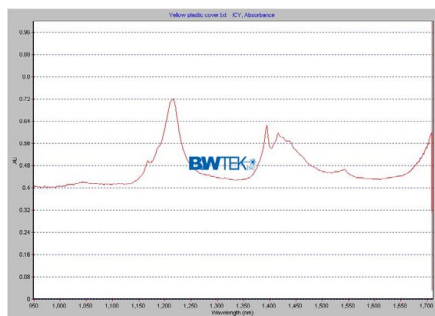
**Figure 18. Longwave NIR diffuse reflectance spectrum of a coffee mate**



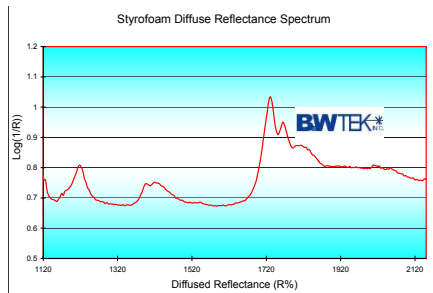
**Figure 16. A white plastic bottle lid diffused reflectance spectrum**



**Figure 19. Longwave NIR diffuse reflectance spectrum of Nescafe**



**Figure 17. A yellow plastic cover diffused reflectance spectrum**



**Figure 20. Longwave NIR diffuse reflectance spectrum of a light blue Styrofoam**