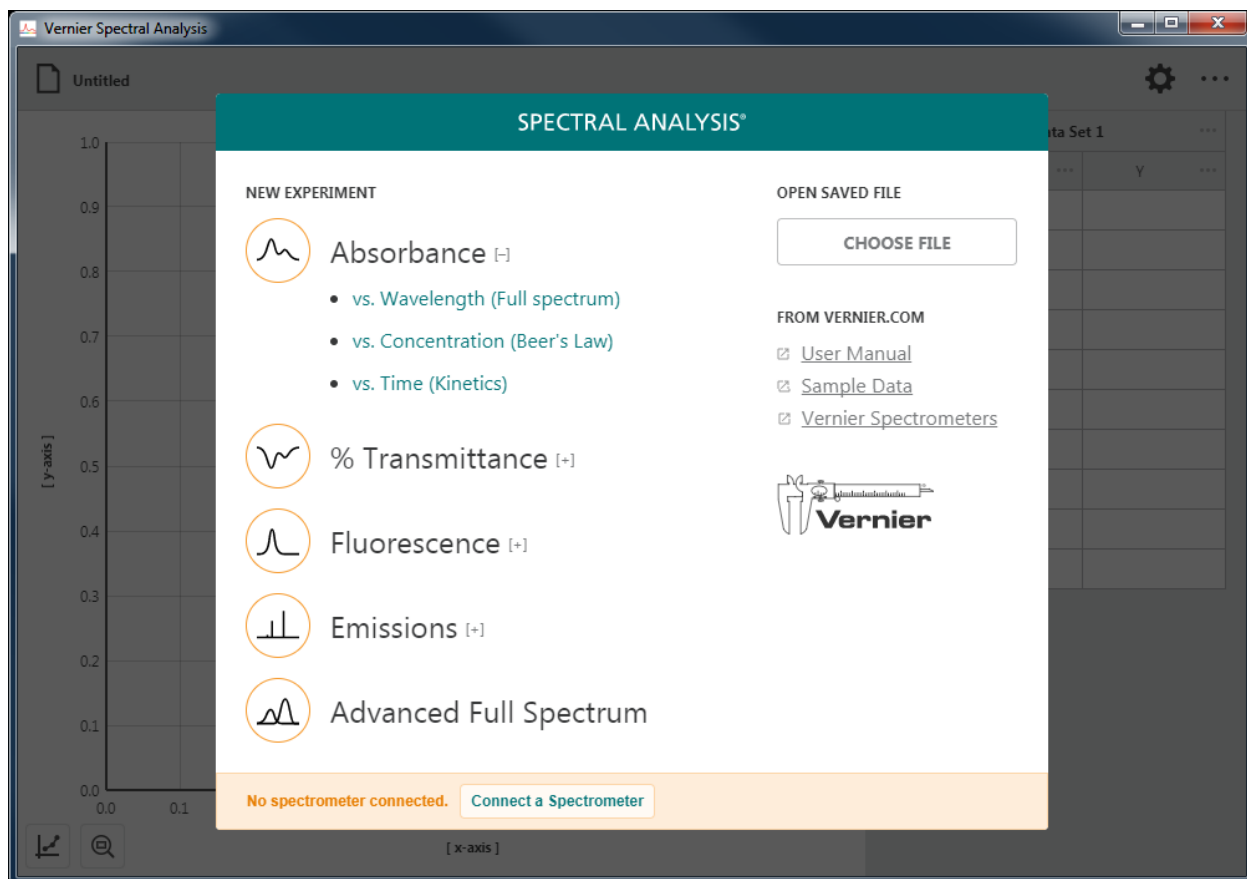


Vernier Spectral Analysis® – User Manual












Version 4.8
February 2019




ABOUT THIS GUIDE

The Spectral Analysis User Manual is an extended guide detailing the features of the Spectral Analysis app. This guide can be used with any platform-specific version of the software including the versions for Windows[®] and macOS[®] computers, Chromebook[™] notebooks, and iOS and Android[™] devices.

This document reflects features available in the 4.8.0 version of the software and is the initial release of this document.

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I. GETTING STARTED WITH SPECTRAL ANALYSIS

Downloading the Software

Windows[®] and macOS[®] Computers

Spectral Analysis software for Windows and macOS computers is a free download from the [Vernier website](#).

Chrome[™] Computing Devices

Spectral Analysis app for Chromebook[™] is a free download from the [Chrome Web Store](#).

iOS Devices

Spectral Analysis app for iPad[®], iPhone[®], and iPod touch[®] is a free download from the [App Store](#).

Android Devices

Spectral Analysis app for Android tablets and phones is a free download from [Google Play](#).

System Requirements

For up-to-date system requirements, visit www.vernier.com/spectral-analysis

Licensing Information

Spectral Analysis computer software is free and can be installed on an unlimited number of computers.

Spectral Analysis apps for Chrome, iOS, and Android are free and distributed through their respective web stores. Terms and licensing are thus determined entirely by these stores.

Privacy Statement

COPPA, SOPIPA, and FERPA Compliance

Spectral Analysis complies with federal regulations pertaining to student privacy and safety in the following ways:

- Spectral Analysis software does not collect, request, share, or store any personal information from students or teachers.
- Spectral Analysis does not display advertisements in the app.

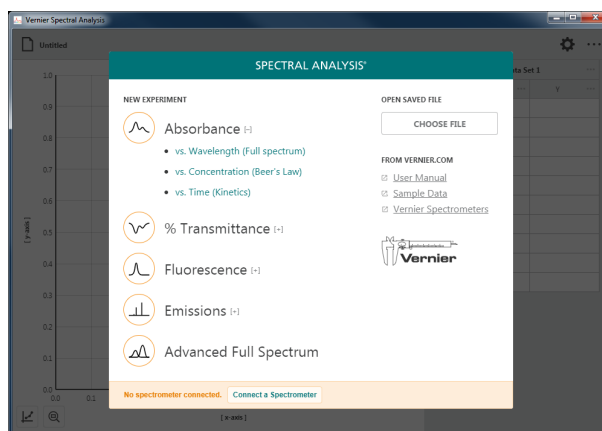
II. CONNECTING A SPECTROMETER

Follow these steps to connect a spectrometer to Spectral Analysis. The following devices are supported:

- [Go Direct[®] SpectroVis[®] Plus Spectrophotometer](#)
- SpectroVis Spectrophotometer
- [SpectroVis Plus Spectrophotometer](#)
- [Vernier Emissions Spectrometer](#)
- [Vernier Fluorescence/UV-VIS Spectrophotometer](#)
- [Vernier UV-VIS Spectrophotometer](#)


Connecting via USB

1. Launch Spectral Analysis app.

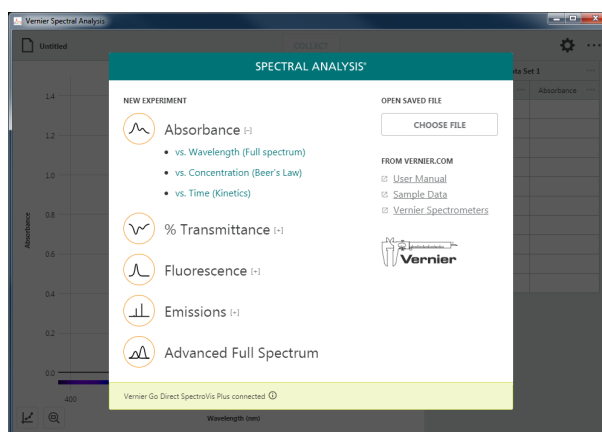


2. Connect the spectrometer to your computing device using the USB cable that came with the spectrometer.

You are ready to continue with your experiment.

TIP! Click or tap  to view information about the connected spectrometer.

TIP! Whenever possible, we recommend using spectrometers connected via USB.

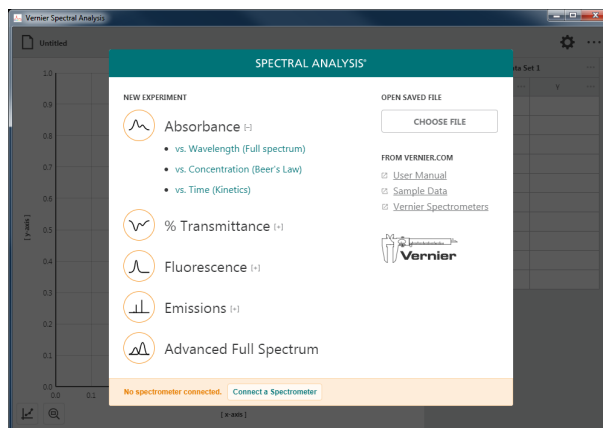


Connecting via Bluetooth® Wireless Technology

1. Launch the Spectral Analysis app.

Be sure your Go Direct® SpectroVis® Plus is charged. Press the power button to turn it on. The power LED will glow green and the Bluetooth® LED will flash blue.

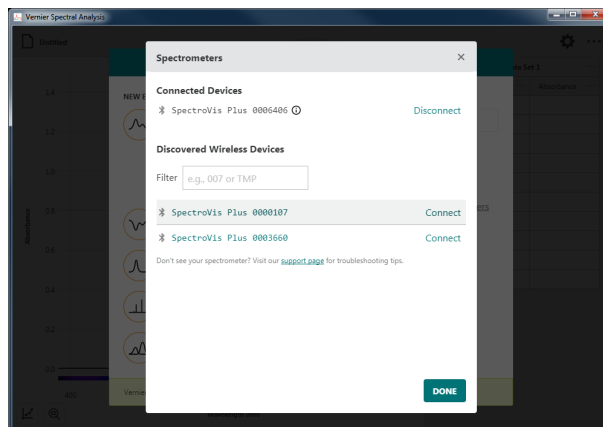
TIP! Only Go Direct SpectroVis Plus can be connected via a wireless connection. All other spectrometers must connect via USB.



2. Click or tap **Connect a Spectrometer** to view a list of available wireless spectrometers. The list can be scrolled if needed.

Click or tap your spectrometer from the list of discovered wireless devices. The app will connect to the sensor. The Bluetooth® LED on the sensor will now glow blue (no longer flashing).

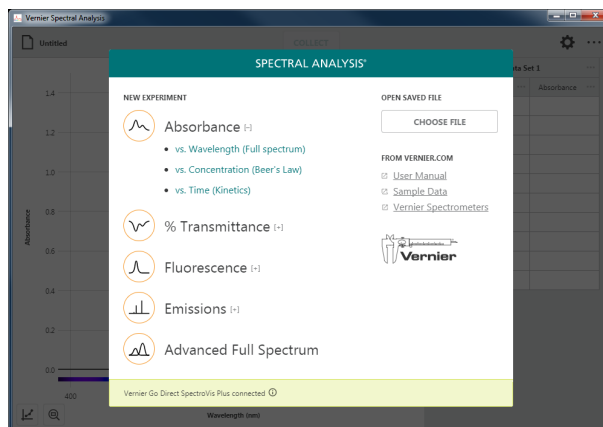
TIP! Begin typing part of your sensor's serial number into the filter to more easily find your spectrometer.



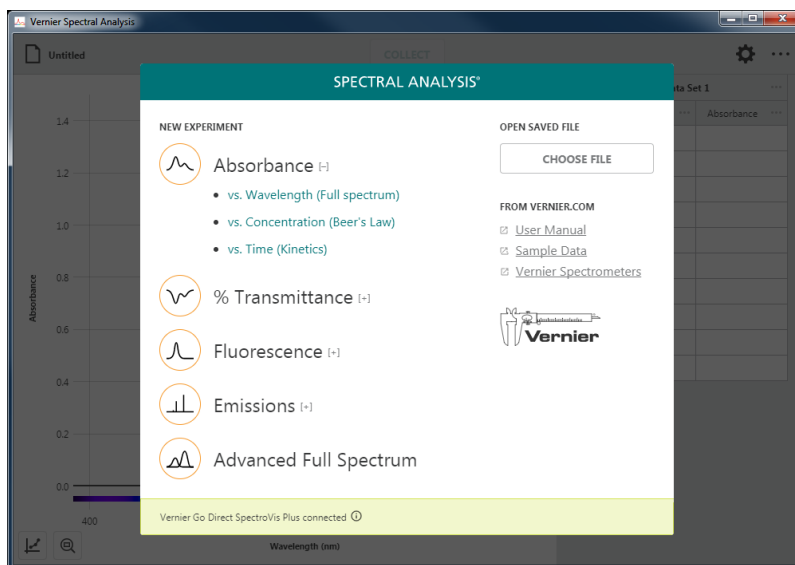
3. Click or tap **DONE**.

You are ready to continue with your experiment.


TIP! Click or tap **i** to view information about the connected spectrometer.



III. SELECTING AN EXPERIMENT



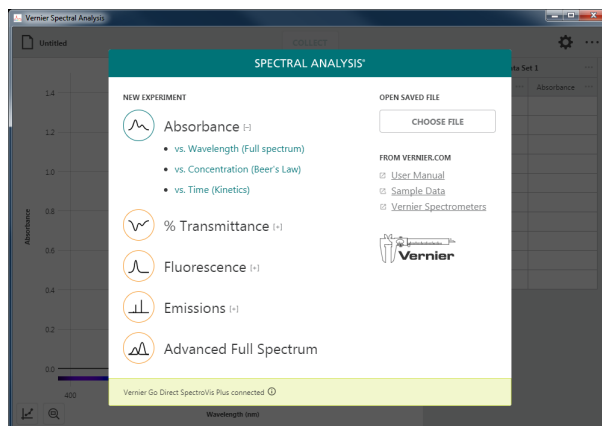
When Spectral Analysis is launched the New Experiment dialog displays. This dialog allows you to select experiment setups for the most common spectroscopy experiments. Spectrometer configuration, data-collection settings, and data displays are optimally set based on your selection. You can also use this dialog to open saved experiments, access online tutorials, and view sample data.

TIP! You can access this dialog anytime by clicking or tapping  and choosing New Experiment.

Absorbance

Select this option when you are interested in investigating or utilizing the properties of a substance related to the wavelength(s) of light a substance absorbs. The absorbance values are determined using the percentage of light from a calibrated light source that passes through the substance relative to the unobstructed light. Absorbance is calculated using the following formula:

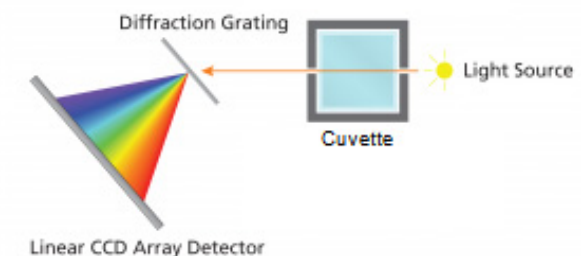
$$\text{Absorbance} = 2 - \log(\% \text{ Transmittance})$$



Spectrometer Configuration

Light Source: Internal light source

Calibration: Required



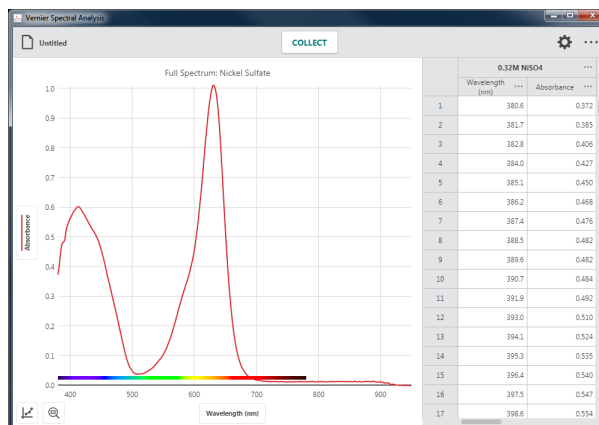
Data Collection Settings

- Absorbance vs. Wavelength

Independent Variable: Wavelength

Data Column: Absorbance

Collection Mode: Full Spectrum



- Absorbance vs. Concentration (Beer's Law)

Independent Variable: Concentration

Data Column: Absorbance

Collection Mode: Event Based

You must select a specific wavelength to be used as the basis of the absorbance data.



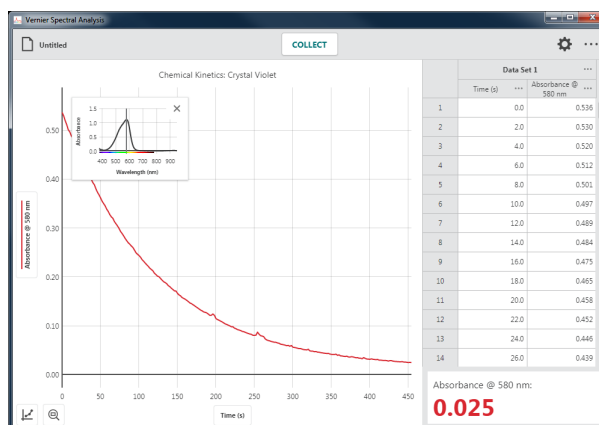
- Absorbance vs. Time (Kinetics)

Independent Variable: Time

Data Column: Absorbance

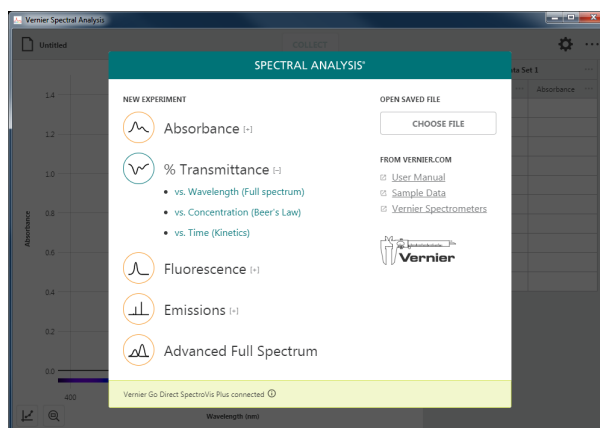
Collection Mode: Time Based

You must select a specific wavelength to be used as the basis of the absorbance data.



% Transmittance

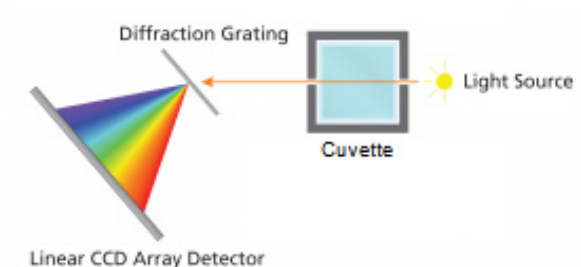
Select this option when you are interested in investigating or utilizing the properties of a substance related to the wavelength(s) of light a substance transmits. The % transmittance values are determined using the percentage of light from a calibrated light source that passes through the substance relative to the unobstructed light.



Spectrometer Configuration

Light Source: Internal light source

Calibration: Required



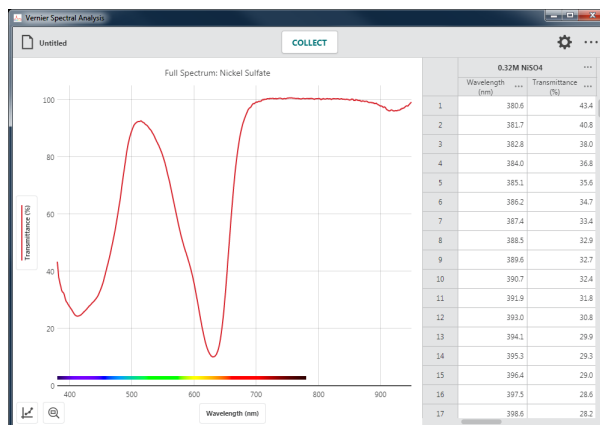
Data Collection Settings

- % Transmittance vs. Wavelength (Full Spectrum)

Independent Variable: Wavelength

Data Column: Transmittance

Collection Mode: Full Spectrum



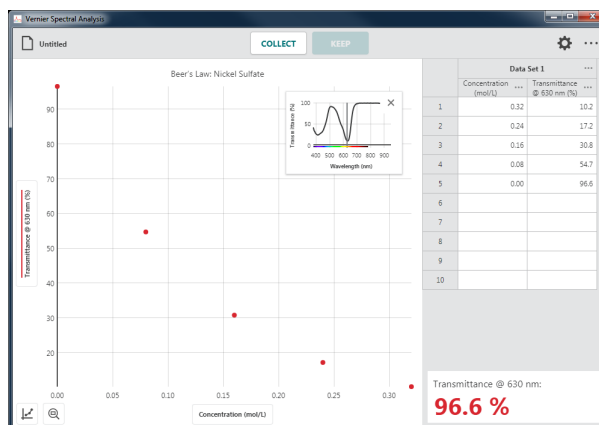
- % Transmittance vs. Concentration (Beer's Law)

Independent Variable: Concentration

Data Column: Transmittance

Collection Mode: Event Based

You must select a specific wavelength to be used as the basis of the transmittance data.



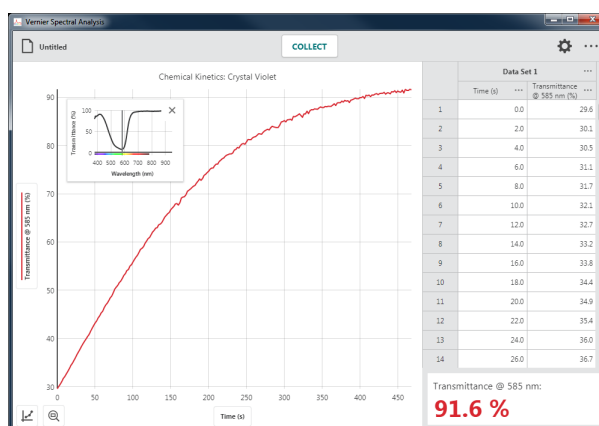
- % Transmittance vs. Time (Kinetics)

Independent Variable: Time

Data Column: Transmittance

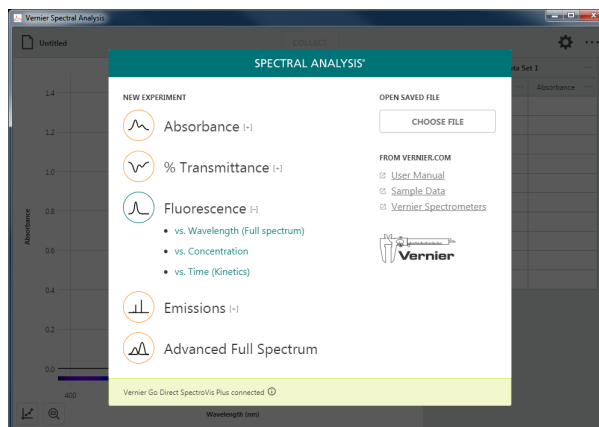
Collection Mode: Time Based

You must select a specific wavelength to be used as the basis of the transmittance data.



Fluorescence

Select this option when you are interested in investigating or utilizing the fluorescent properties of a substance relative to an excitation light source. The reported values are based on the electromagnetic radiation (light) emitted as a result of fluorescence.

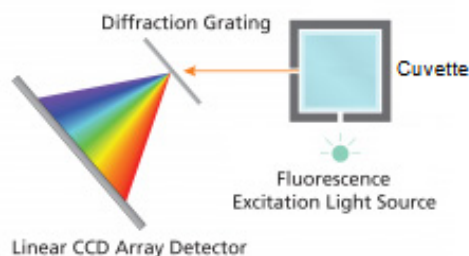


Spectrometer Configuration

Light Source: Excitation light source

- SpectroVis Plus – 405 and 500 nm LEDs built into the unit
- Fluorescence/UV-VIS – external LEDs

Calibration: Optional – baseline noise and LED scatter only



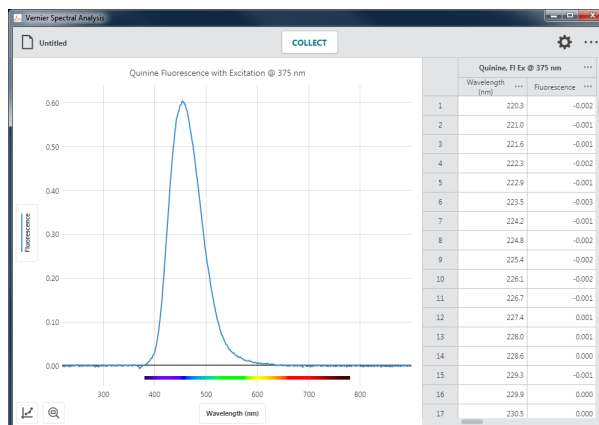
Data Collection Settings

- Fluorescence vs. Wavelength (Full Spectrum)

Independent Variable: Wavelength

Data Column: Fluorescence

Collection Mode: Full Spectrum



- Fluorescence vs. Concentration

Independent Variable: Concentration

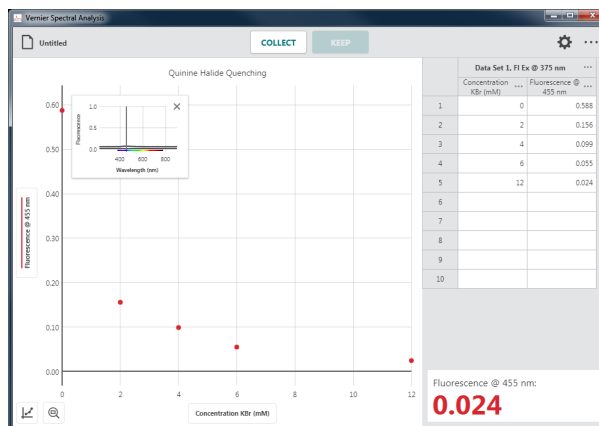
Data Column: Fluorescence

Collection Mode: Event Based

You must select a specific wavelength to be used as the basis of the fluorescence data.

TIP! You are not limited to experiments involving concentration. Select this experiment option for investigations involving fluorescence with other independent variables such as pH or excitation-LED intensity.

To change the name of the Concentration column to match your experiment, click or tap ●●● in the Concentration column heading and select Column Options.



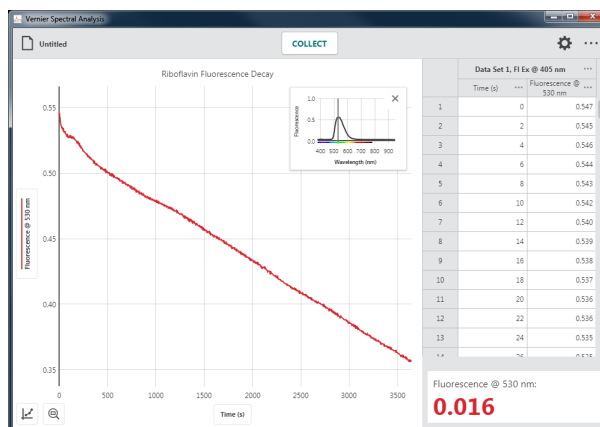
- Fluorescence vs. Time (Kinetics)

Independent Variable: Time

Data Column: Fluorescence

Collection Mode: Time Based

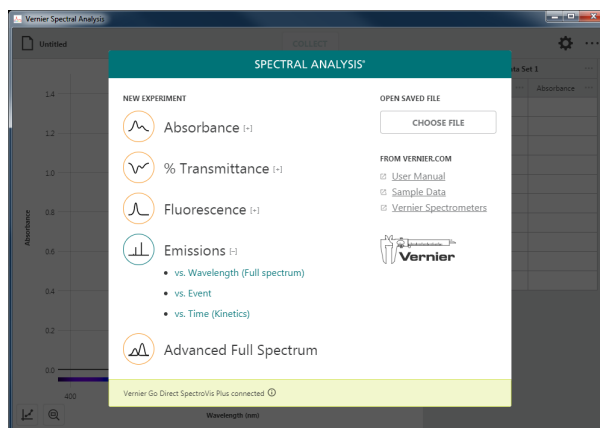
You must select a specific wavelength to be used as the basis of the fluorescence data.



Emissions

Select this option when you are interested in investigating or utilizing the component wavelengths of a light emitting source.

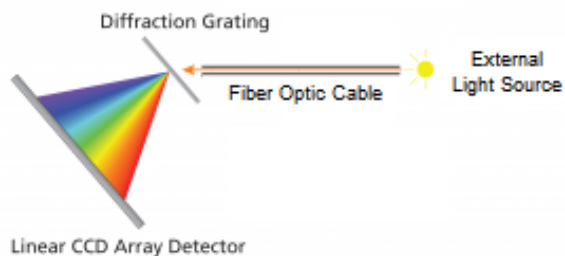
***TIP!** While you can use the Vernier Emissions Spectrometer without the optional fiber optic cable, we recommend using the cable for data collection. All other supported spectrometers require a fiber optic cable accessory (not included) in order to collect emissions data.*



Spectrometer Configuration

Light Source: External light source

Calibration: Optional – baseline noise only



Data Collection Settings

- Emissions vs. Wavelength

Independent Variable: Wavelength

Data Column: Intensity

Collection Mode: Full Spectrum



- Emissions vs. Event

Independent Variable: Event (user defined)

Data Column: Intensity

Collection Mode: Event Based

You must select a specific wavelength to be used as the basis of the intensity data.



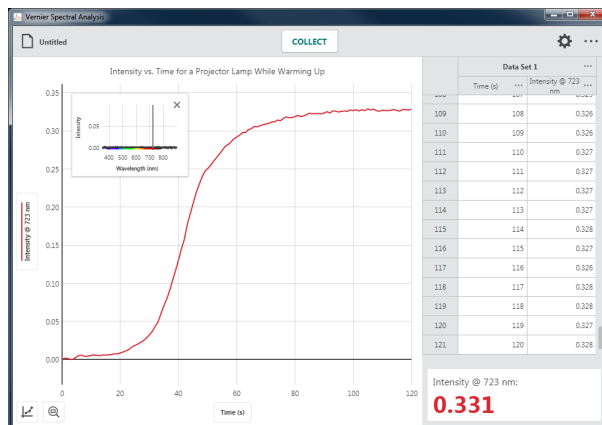
- Emissions vs. Time (Kinetics)

Independent Variable: Time

Data Column: Intensity

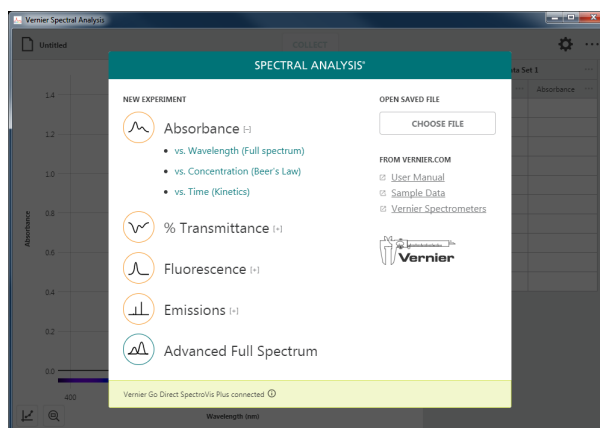
Collection Mode: Time Based

You must select a specific wavelength to be used as the basis of the intensity data.



Advanced Full Spectrum

Select this option when comparing multiple experiment types (absorbance, % transmittance, fluorescence, and emission) within the same file. Examples for using this option include investigating the relationship between absorbance and % transmittance, inquiry-based analysis of an unknown sample, and investigating the Stokes shift of a sample using absorbance and fluorescence spectra. This option can also be used to collect the raw output of your lamp.



Spectrometer Configuration

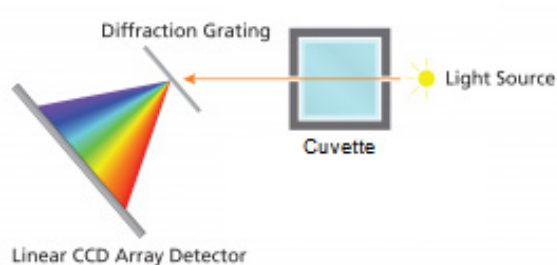
Light source and calibration options vary based on the Sensor Mode you have selected.

- Absorbance or % Transmittance

Light Source: Internal light source

Calibration: Required

Absorbance or % Transmittance



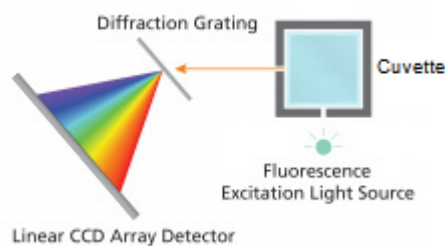
- Fluorescence

Light Source: Excitation light source

- SpectroVis Plus – 405 and 500 nm LEDs built into the unit
- Fluorescence/UV-VIS – external LEDs

Calibration: Optional – baseline noise and LED scatter only

Fluorescence



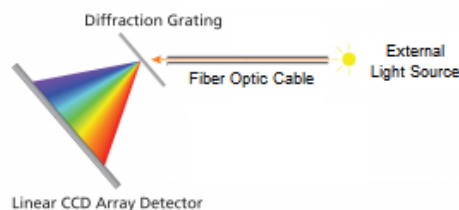
- Emissions

Light Source: External light source

Calibration: Optional – baseline noise only

***TIP!** A fiber optic cable, not included with the spectrometer, is required for most spectrometers in order to capture Emissions data.*

Emissions



Data Collection Settings

Independent Variable: Wavelength

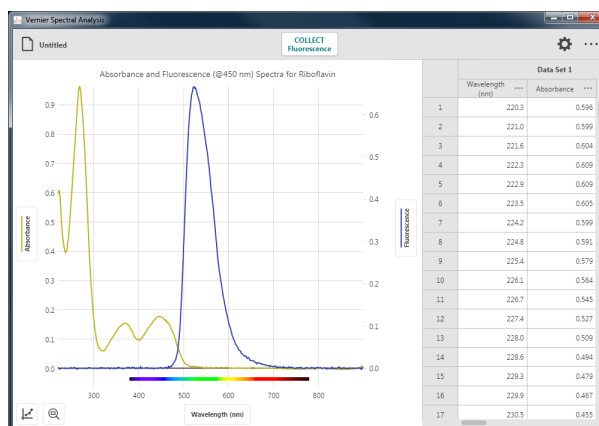
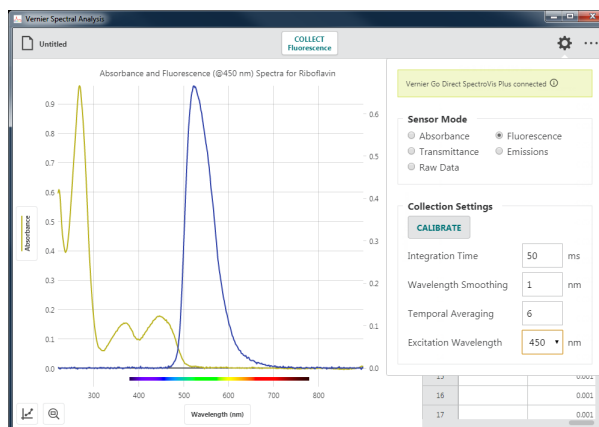
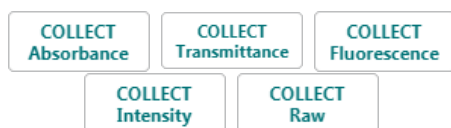
Data Column: Varies based on Sensor Mode

- Absorbance
- Transmittance
- Fluorescence
- Intensity
- Raw

Collection Mode: Full Spectrum

TIP! When data from two different sensor modes are collected, a second y-axis control is used to allow independent scaling of data.

TIP! When doing an Advanced Full Spectrum experiment, the **COLLECT** button will indicate the sensor mode selected for data collection.



The table below shows which experiment types are supported for each spectrometer.

| Spectrophometer | Absorbance | % Transmittance | Fluorescence | Emissions | Raw Data |
|---|------------|-----------------|--------------|-----------|----------|
| Go Direct [®] SpectroVis [®] Plus | • | • | • | •* | • |
| SpectroVis | • | • | | •* | • |
| SpectroVis Plus | • | • | • | •* | • |
| Vernier Emissions Spectrometer | | | | • | • |
| Vernier Fluorescence/UV-VIS Spectrophotometer | • | • | • | •* | • |
| Vernier UV-VIS Spectrophotometer | • | • | | •* | • |

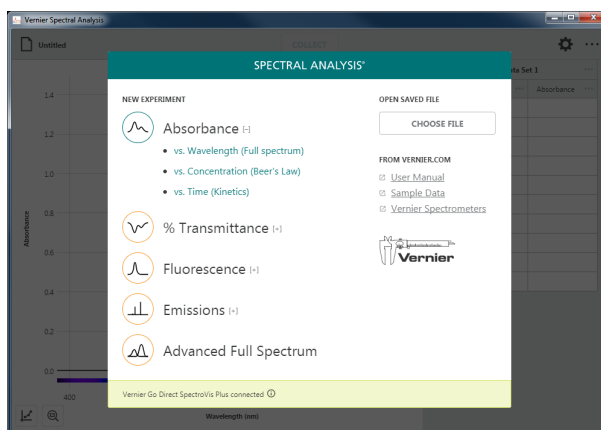
* A fiber optic cable, not included with the spectrometer, is required for measuring emissions spectra from an external light source. For the Vernier Emissions Spectrometer, an optional fiber optic cable is recommended for data collection.

IV. COLLECTING ABSORBANCE DATA

Absorbance vs. Wavelength (Full Spectrum)

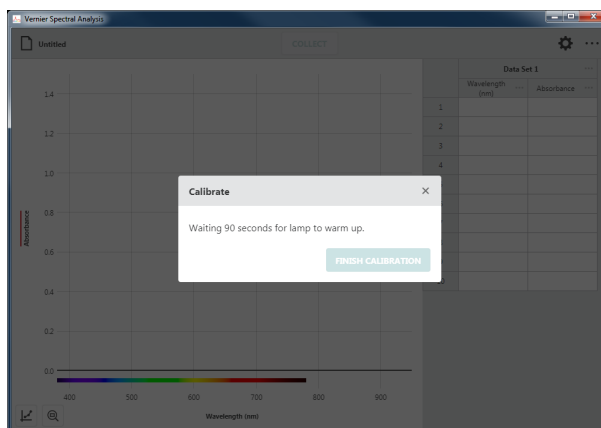
In this data-collection mode, absorbance vs. wavelength data is plotted. Data for all supported wavelengths are displayed on the graph and in the data table.

1. Select **Absorbance vs. Wavelength (Full Spectrum)** from the New Experiment dialog.



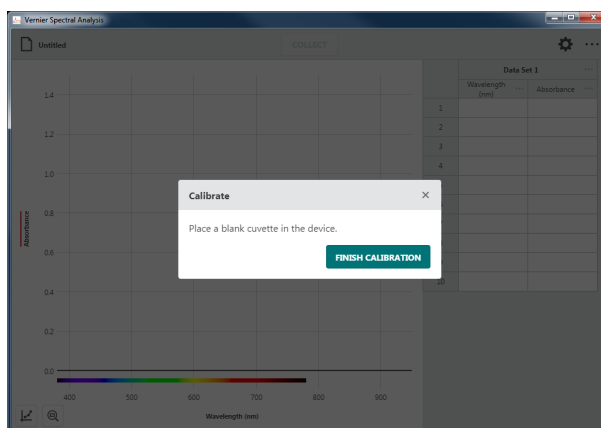
2. A calibration will automatically begin when you select this experiment type.

It can take 90 seconds or more for the lamp to illuminate fully. It is recommended that you wait for the warm up countdown to complete before proceeding with the calibration.

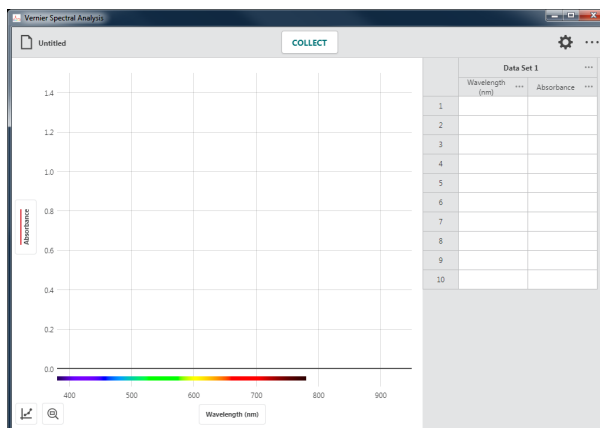


3. When the lamp warm up is complete, place a blank cuvette in the holder with the clear sides aligned with the arrow on the spectrometer. Click or tap **FINISH CALIBRATION** to complete the calibration.

TIP! To remove any effects from the solvent used to prepare your samples for testing, use a cuvette containing only the solvent (often just deionized water) for this step in the calibration.



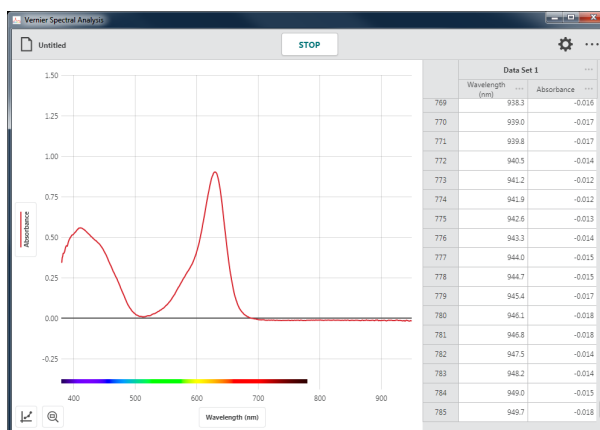
- Place your sample in the cuvette holder making sure the clear sides align with the arrow on the spectrometer.



- Click or tap **COLLECT** to start data collection.

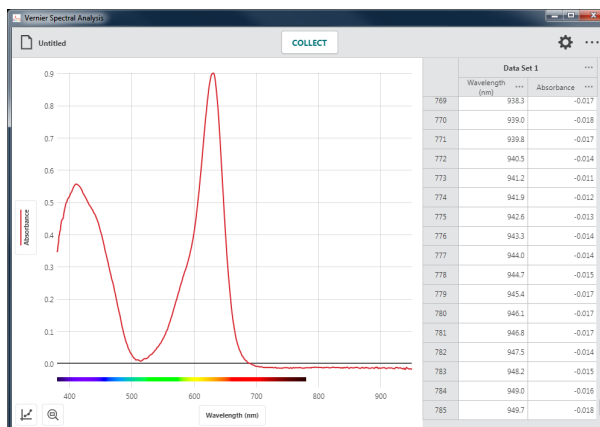
TIP! Notice that **COLLECT** changes to **STOP** while you are collecting data.

TIP! You can change samples while collecting data if desired. However, only the data displayed on the graph when you stop data collection will be retained.



- Click or tap **STOP** to end data collection and continue with data analysis.

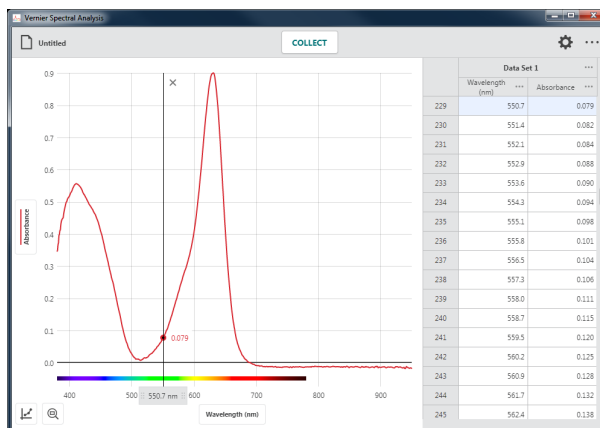
The graph automatically autoscales to fit the data.



- Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap × to dismiss the examine line.

TIP! Notice that the point you are examining on the graph is also highlighted in the data table.

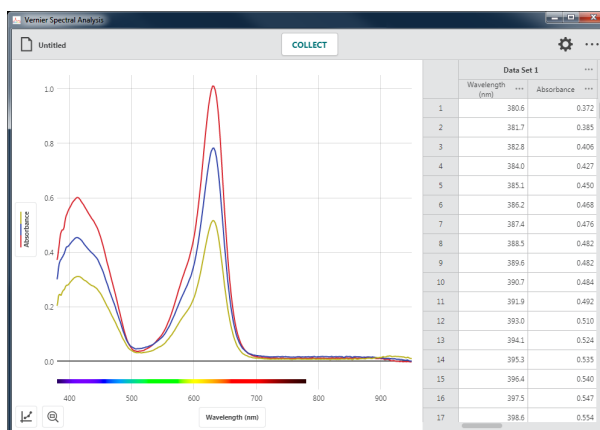


Collecting Multiple Data Sets


To collect another data set, click or tap **COLLECT** again. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set to plot.

TIP! Click or tap ••• next to the data set name for tools to rename or delete a data set.



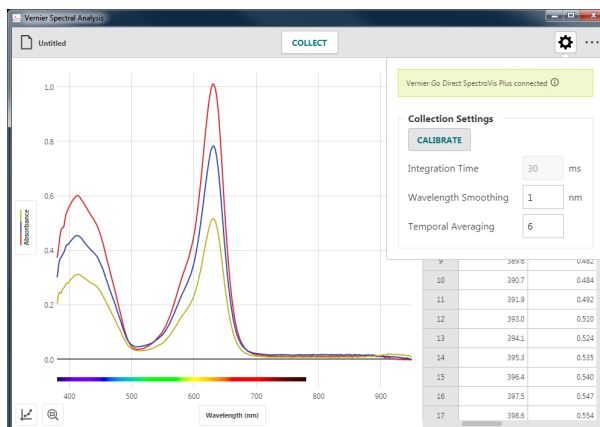
Recalibrate the Sensor

You can recalibrate your sensor if needed. Click or tap  to bring up the settings dialog.

Click or tap **CALIBRATE** to start a new calibration.

TIP! A new calibration will not apply to data that is already collected. The calibration will only apply to data collected after the calibration.

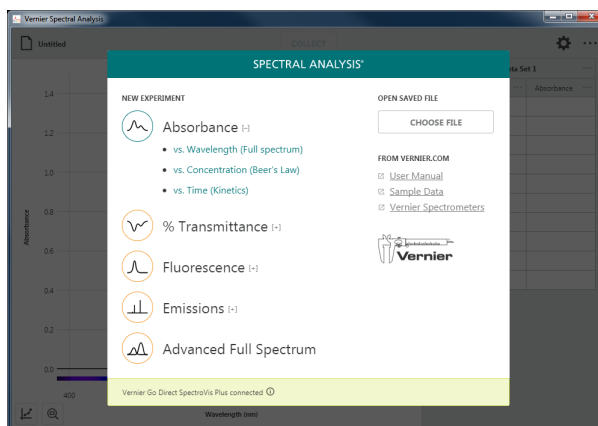
TIP! See [Appendix A](#) for a detailed description of the collection settings.



Absorbance vs. Concentration (Beer's Law)

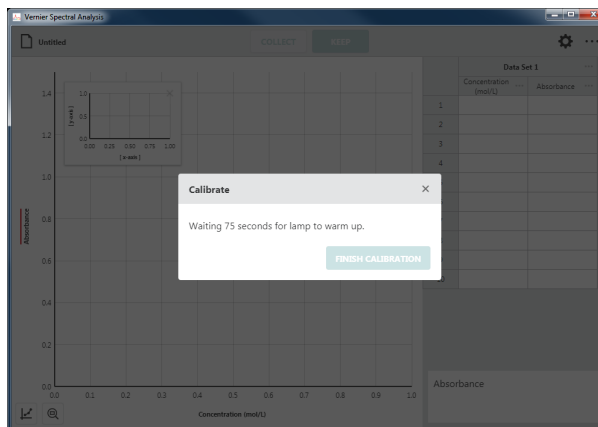
In this data-collection mode, a specific wavelength is identified as the basis of the collected data. The most common use for this data-collection mode is a Beer's law experiment. Individual data points are collected from samples with known concentrations to create a graph of absorbance data vs. concentration at the selected wavelength. Data analysis can determine the concentration of a sample containing an unknown concentration of the solute being studied.

1. Select **Absorbance vs. Concentration (Beer's Law)** from the New Experiment dialog.



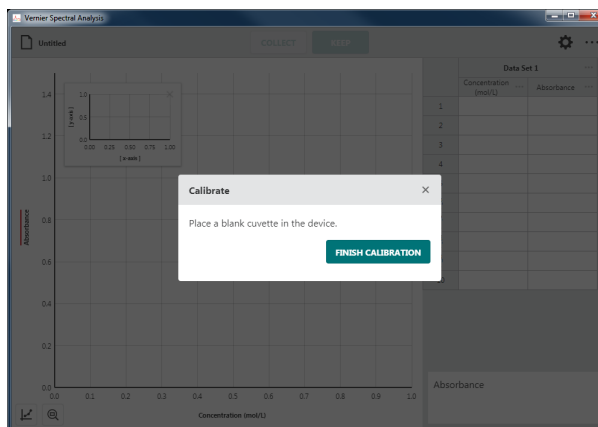
2. A calibration will automatically begin when you select this experiment type.

It can take 90 seconds or more for the lamp to illuminate fully. It is recommended that you wait for the warm up countdown to complete before proceeding with the calibration.



3. When the lamp warm up is complete, place a blank cuvette in the holder with the clear sides aligned with the arrow on the spectrometer. Click or tap **FINISH CALIBRATION** to complete the calibration.

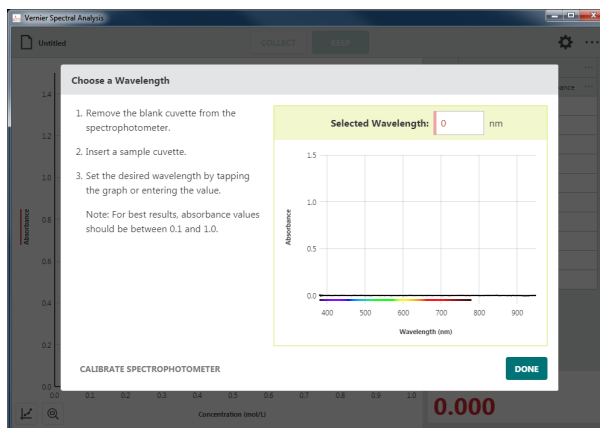
TIP! To remove any effects from the solvent used to prepare your samples for testing, use a cuvette containing only the solvent (often just deionized water) for this step in the calibration.



- Once calibration is complete, you will need to select the wavelength you will use for your experiment.

Follow the onscreen instructions for selecting a wavelength to use.

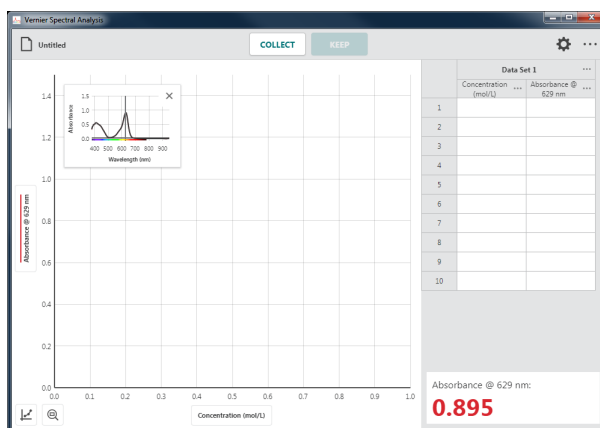
TIP! You can click or tap CALIBRATE SPECTROPHOTOMETER to calibrate the spectrometer again if needed.



- Click or tap **DONE** to use the wavelength you have selected.

TIP! You can click or tap the spectrometer meter (lower right corner of the screen) or graph inset to change the selected wavelength.

TIP! If your independent variable is not Concentration (mol/L), click or tap **•••** next to the table column heading and select Column Options to change the column name and units to match your experiment.



- Place a sample in the cuvette holder making sure the clear sides align with the arrow on the spectrometer.

Click or tap **COLLECT** to start data collection. This enables the **KEEP** button.

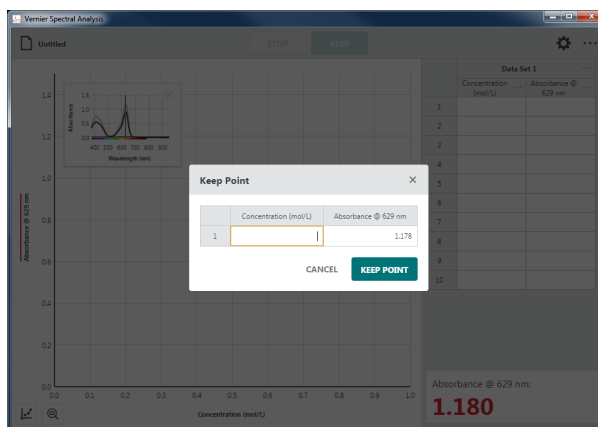
TIP! For comparison, the graph inset shows the full spectrum plot of the sample you are testing along with the spectrum used to define the wavelength.



- In this data-collection mode, you will be prompted to enter the solution concentration each time you **KEEP** a data point.

Click or tap **KEEP** when the spectrometer reading has stabilized.

TIP! The reading at the time you selected **KEEP** is shown in the dialog. Changes to the value while the Keep Point dialog is shown are ignored until the dialog is dismissed.



- Enter the corresponding concentration value for this data point, then click or tap **KEEP POINT** to record the entry in the data table.

The point is automatically plotted on the graph.

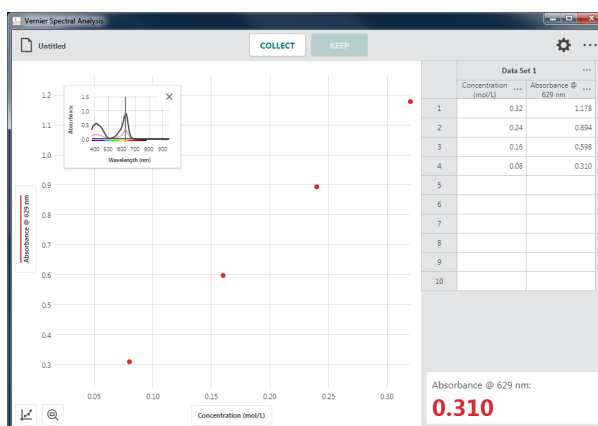
TIP! It may be necessary to move the graph inset to see the collected point. You can drag the graph to a new location or click or tap \times to dismiss it. You can click or tap \leftarrow and choose Graph Inset to redisplay the graph inset if needed.



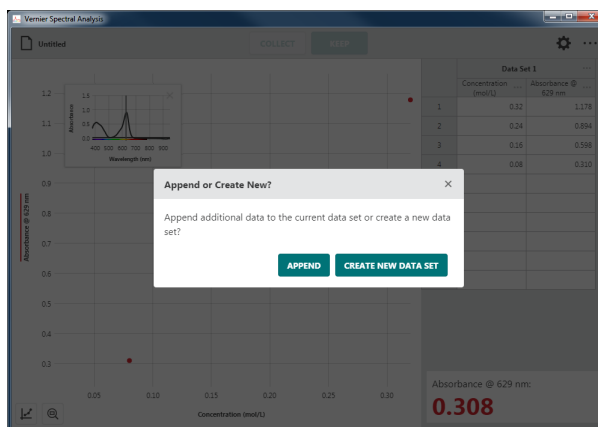
- Continue collecting data for different samples until you have collected all of your data points.

Click or tap **STOP** to end data collection and continue with data analysis.

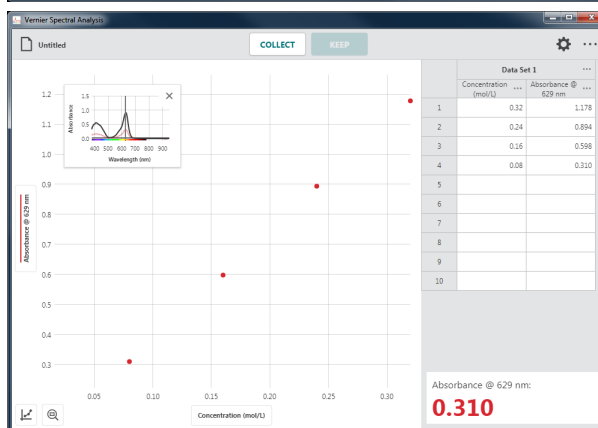
TIP! The graph rescales as you **KEEP** each point to ensure all data points are shown on the graph. After data collection is complete, the graph will autoscale to fit the data.



TIP! If you inadvertently stop data collection before all of your data points have been collected, click or tap **COLLECT** and select **APPEND** to continue collecting points in the current data set.



TIP! Double-click or double-tap a concentration value in the data table to edit the entry. Note that you can only change the concentration values. Absorbance values cannot be edited.

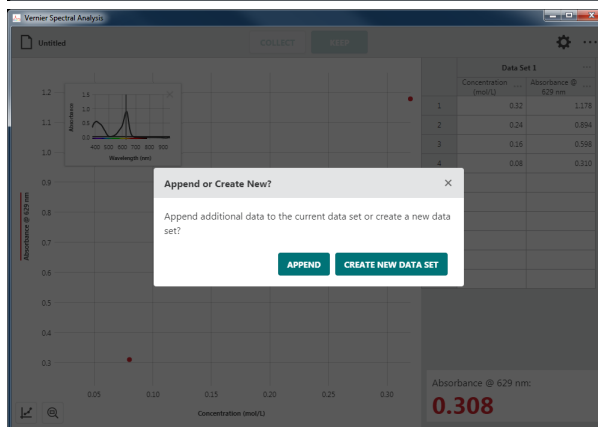


Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** and select **CREATE NEW DATA SET**. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set.

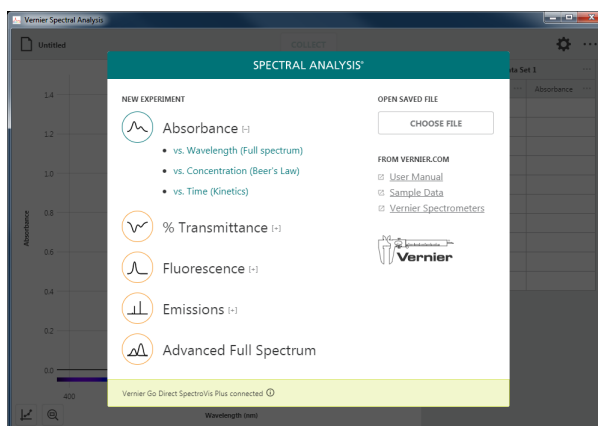
TIP! Click or tap **•••** next to the data set name for tools to rename or delete a data set.



Absorbance vs. Time (Kinetics)

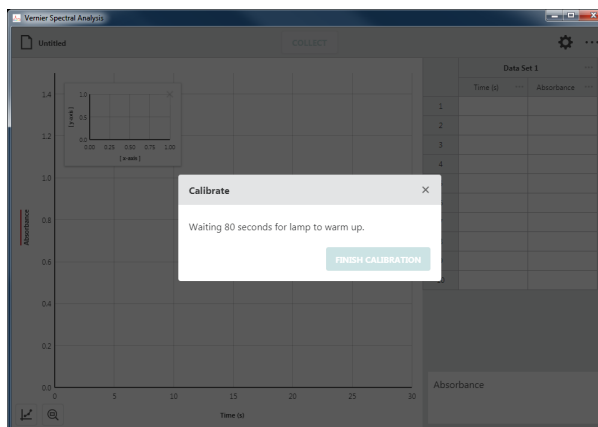
In this data-collection mode, a specific wavelength is identified as the basis of the collected data and data are collected as a function of time. The most common use for this collection mode is a Kinetics experiment where changes in the colorimetric properties of a substance change over time due to a reaction. Analysis of this data can be done to determine the rate, order, affinity, and numerous other properties of the reaction.

1. Select **Absorbance vs. Time (Kinetics)** from the New Experiment dialog.



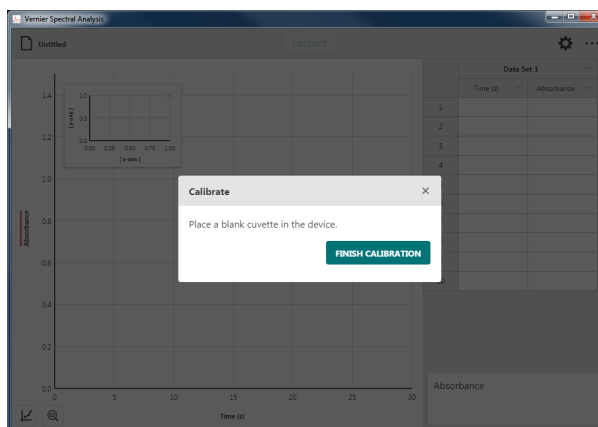
2. A calibration will automatically begin when you select this experiment type.

It can take 90 seconds or more for the lamp to illuminate fully. It is recommended that you wait for the warm up countdown to complete before proceeding with the calibration.



3. When the lamp warm up is complete, place a blank cuvette in the holder with the clear sides aligned with the arrow on the spectrometer. Click or tap **FINISH CALIBRATION** to complete the calibration.

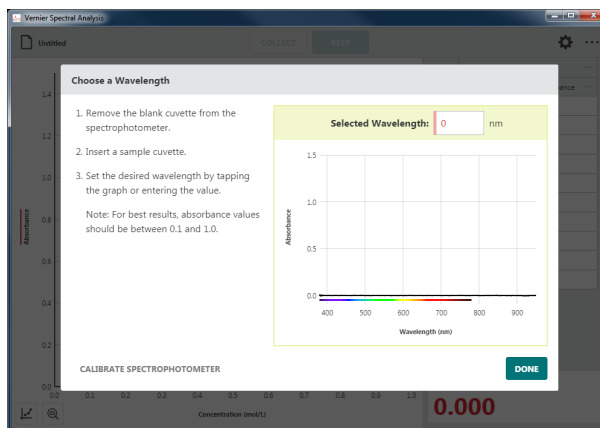
TIP! To remove any effects from the solvent used to prepare your samples for testing, use a cuvette containing only the solvent (often just deionized water) for this step in the calibration.



- Once calibration is complete, you will need to select the wavelength you will use for your experiment.

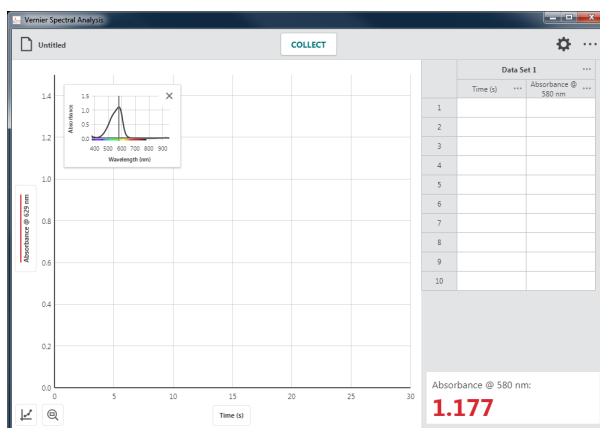
Follow the onscreen instructions for selecting a wavelength to use.


TIP! You can click or tap CALIBRATE SPECTROPHOTOMETER to calibrate the spectrometer again if needed.



- Click or tap **DONE** to use the wavelength you have selected.

TIP! You can click or tap the spectrometer meter (lower right corner of the screen) or graph inset to change the selected wavelength.



- Click or tap  to adjust the Collection Interval.

Adjust the value as needed for your experiment. The Collection Interval can be any whole number from 1 to 3600 seconds. The smallest value is automatically calculated based on your calibration and collection settings.

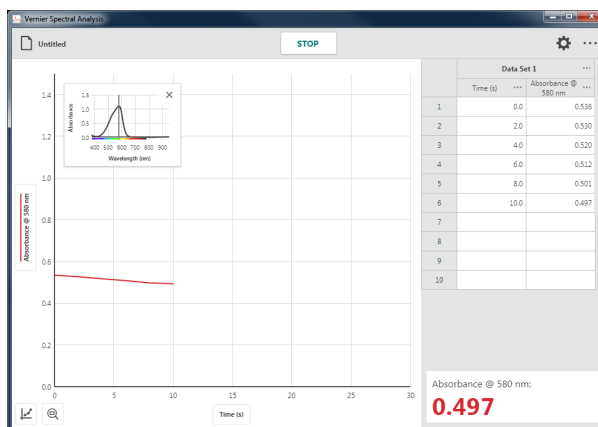
TIP! If you are using Go Direct[®] SpectroVis[®] Plus connected via Bluetooth[®] wireless technology, the minimum value is 3 seconds.

TIP! See [Appendix A](#) for a detailed description of the collection settings.



- Prepare your sample for data collection. Place the cuvette in the cuvette holder making sure the clear sides align with the arrow on the spectrometer.

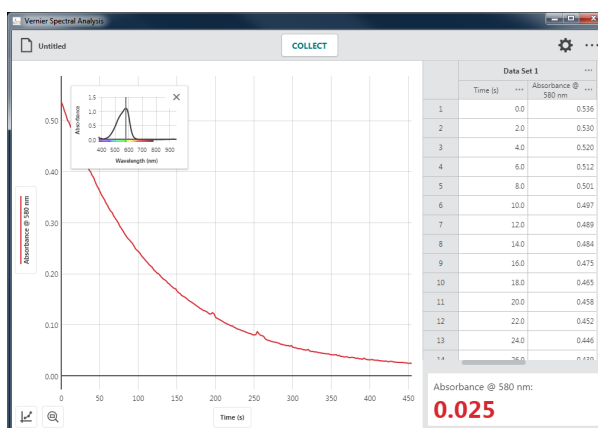
Click or tap **COLLECT** to start data collection.



- Click or tap **STOP** to end data collection and continue with data analysis.

The graph automatically autoscales to fit the data.

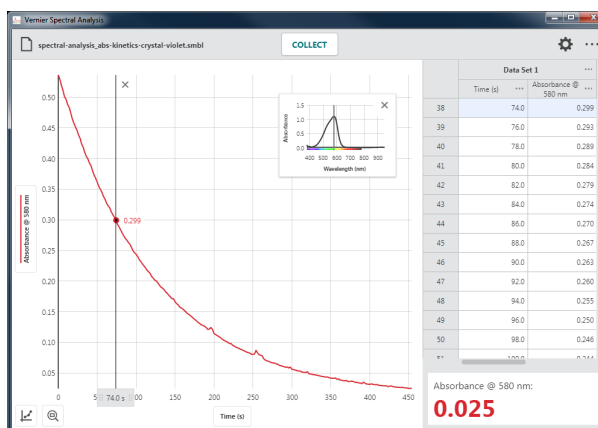
TIP! You can drag the graph inset anywhere on the graph if needed. Click or tap **x** to remove the graph inset. You can click or tap and choose Graph Inset to redisplay the graph inset if needed.



- Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap **x** to dismiss the examine line.

TIP! Notice that the point you are examining on the graph is also highlighted in the data table.



Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** again. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set to plot.

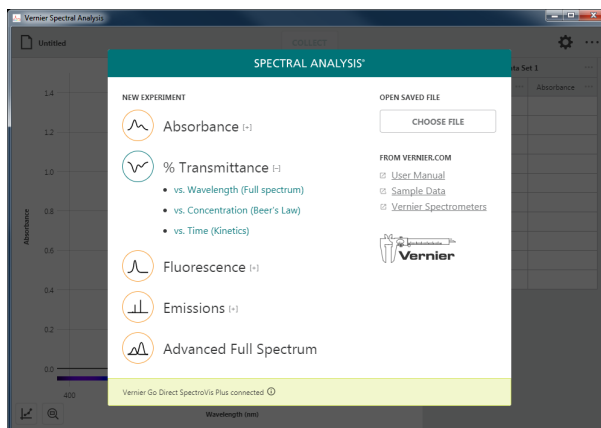
TIP! Click or tap **...** next to the data set name for tools to rename or delete a data set.

V. COLLECTING % TRANSMITTANCE DATA

% Transmittance vs. Wavelength (Full Spectrum)

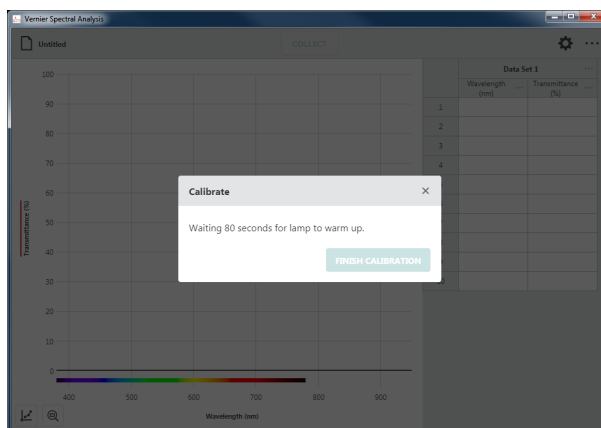
In this data-collection mode, transmittance vs. wavelength data is plotted. Data for all supported wavelengths are displayed on the graph and in the data table.

1. Select **% Transmittance vs. Wavelength (Full Spectrum)** from the New Experiment dialog.



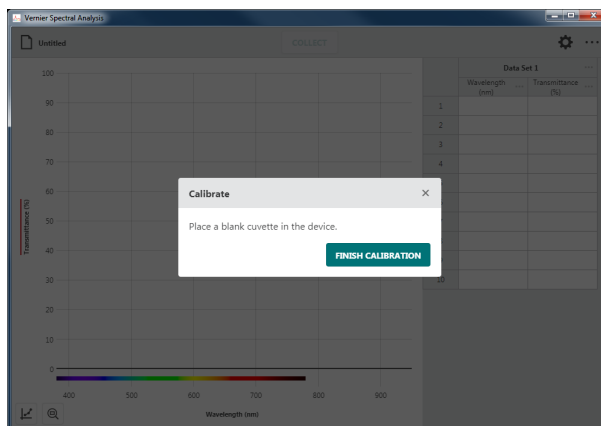
2. A calibration will automatically begin when you select this experiment type.

It can take 90 seconds or more for the lamp to illuminate fully. It is recommended that you wait for the warm up countdown to complete before proceeding with the calibration.

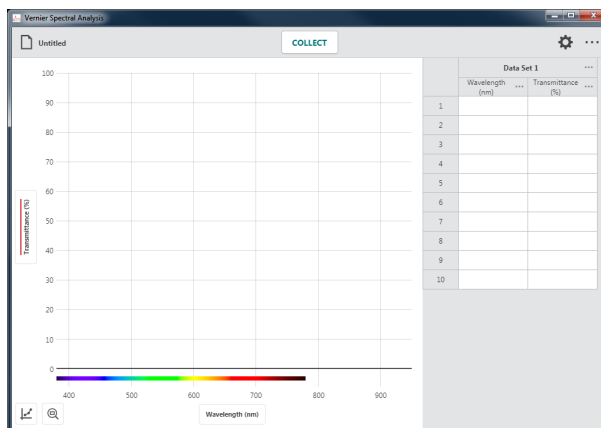


3. When the lamp warm up is complete, place a blank cuvette in the holder with the clear sides aligned with the arrow on the spectrometer. Click or tap **FINISH CALIBRATION** to complete the calibration.

TIP! To remove any effects from the solvent used to prepare your samples for testing, use a cuvette containing only the solvent (often just deionized water) for this step in the calibration.



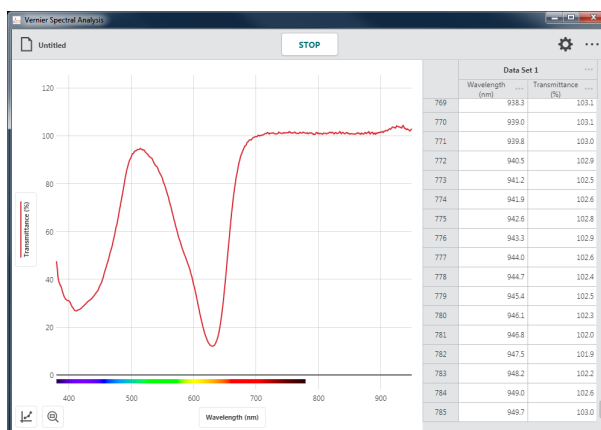
- Place your sample in the cuvette holder making sure the clear sides align with the arrow on the spectrometer.



- Click or tap **COLLECT** to start data collection.

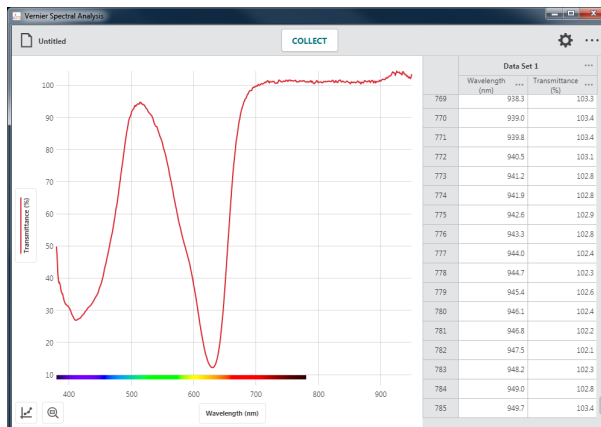
TIP! Notice that **COLLECT** changes to **STOP** while you are collecting data.

TIP! You can change samples while collecting data if desired. However, only the data displayed on the graph when you stop data collection will be retained.



- Click or tap **STOP** to end data collection and continue with data analysis.

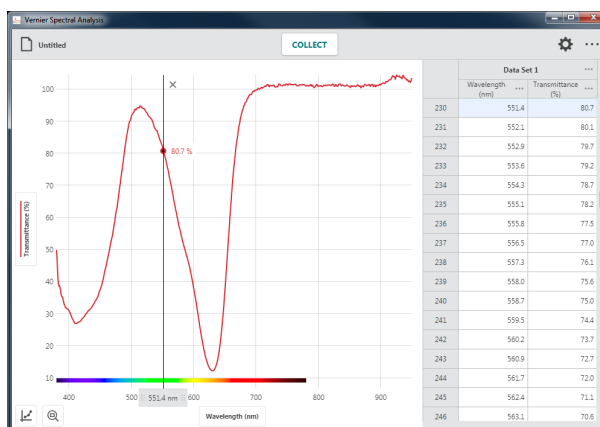
The graph automatically autoscales to fit the data.



- Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap × to dismiss the examine line.

TIP! Notice that the point you are examining on the graph is also highlighted in the data table.

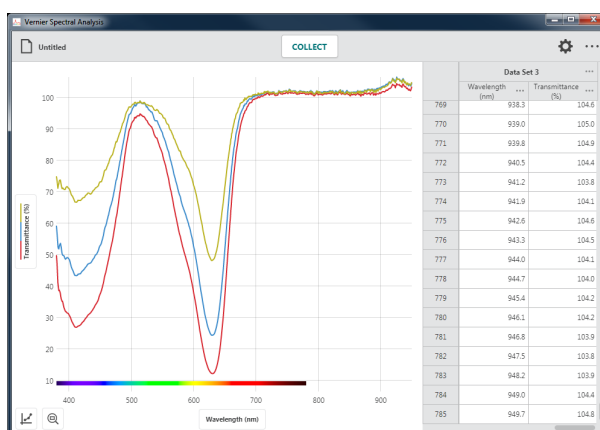


Collecting Multiple Data Sets


To collect another data set, click or tap **COLLECT** again. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set to plot.

TIP! Click or tap ●●● next to the data set name for tools to rename or delete a data set.



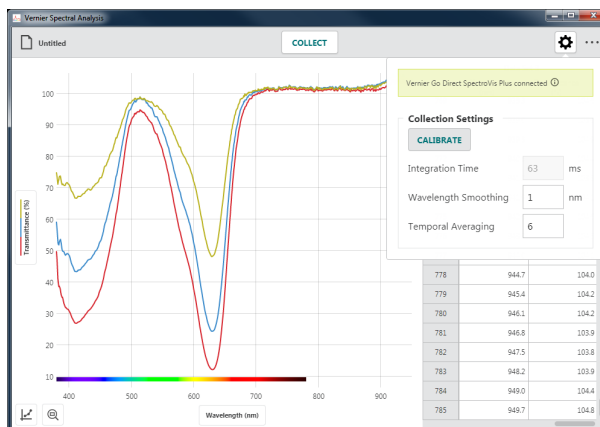
Recalibrate the sensor

You can recalibrate your sensor if needed. Click or tap  to bring up the settings dialog.

Click or tap **CALIBRATE** to start a new calibration.

TIP! A new calibration will not apply to data that are already collected. The calibration will only apply to data collected after the calibration.

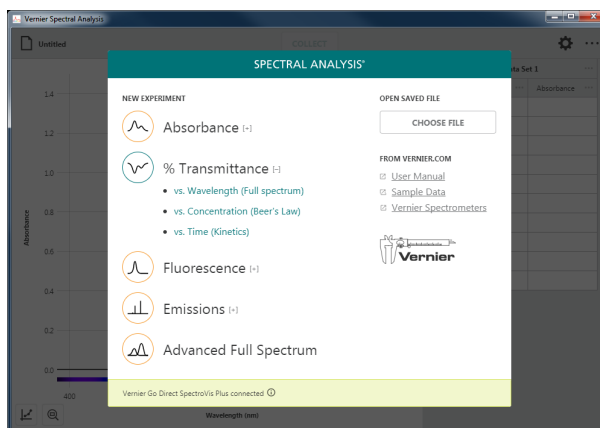
TIP! See [Appendix A](#) for a detailed description of the collection settings.



% Transmittance vs. Concentration (Beer's Law)

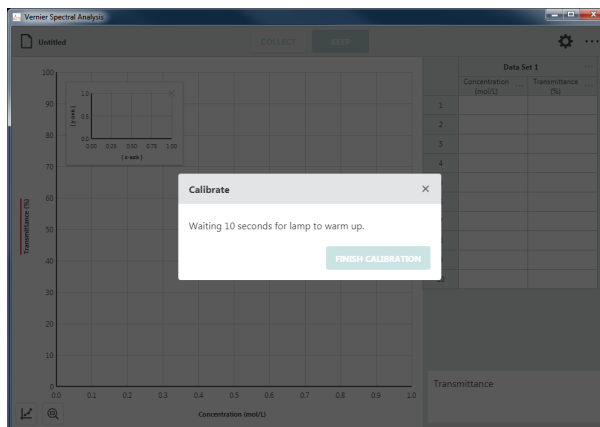
In this data-collection mode, a specific wavelength is identified as the basis of the collected data. The most common use for this data-collection mode is a Beer's law experiment. Individual data points are collected from samples with known concentrations to create a graph of transmittance data vs. concentration at the selected wavelength. Data analysis can determine the concentration of a sample containing an unknown concentration of the solute being studied.

1. Select **% Transmittance vs. Concentration (Beer's Law)** from the New Experiment dialog.



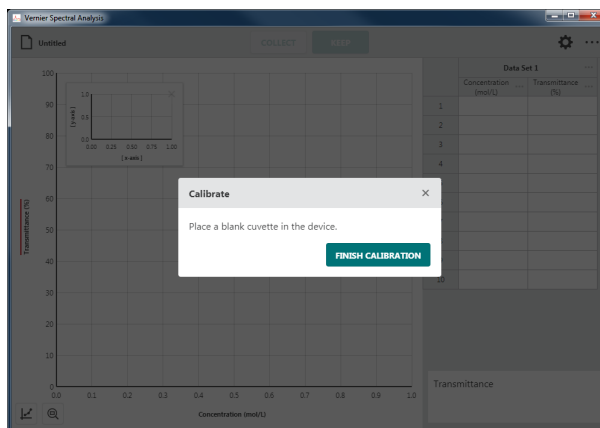
2. A calibration will automatically begin when you select this experiment type.

It can take 90 seconds or more for the lamp to illuminate fully. It is recommended that you wait for the warm up countdown to complete before proceeding with the calibration.



3. When the lamp warm up is complete, place a blank cuvette in the holder with the clear sides aligned with the arrow on the spectrometer. Click or tap **FINISH CALIBRATION** to complete the calibration.

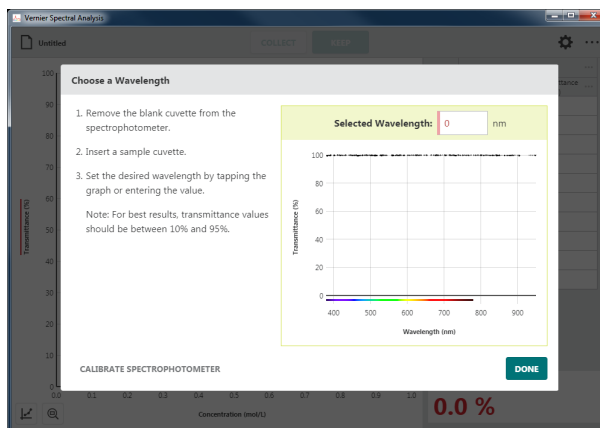
TIP! To remove any effects from the solvent used to prepare your samples for testing, use a cuvette containing only the solvent (often just deionized water) for this step in the calibration.



- Once calibration is complete, you will need to select the wavelength you will use for your experiment.

Follow the onscreen instructions for selecting a wavelength to use.

TIP! You can click or tap CALIBRATE SPECTROPHOTOMETER to calibrate the spectrometer again if needed.



- Click or tap **DONE** to use the wavelength you have selected.

TIP! You can click or tap the spectrometer meter (lower right corner of the screen) or graph inset to change the selected wavelength.

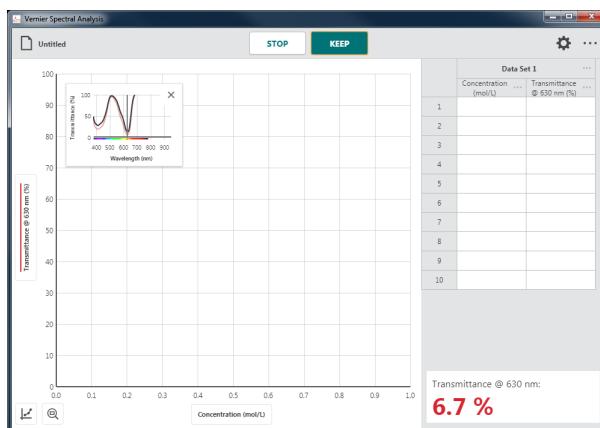
TIP! If your independent variable is not Concentration (mol/L), click or tap **•••** next to the table column heading and select Column Options to change the column name and units to match your experiment.



- Place a sample in the cuvette holder making sure the clear sides align with the arrow on the spectrometer.

Click or tap **COLLECT** to start data collection. This enables the **KEEP** button.

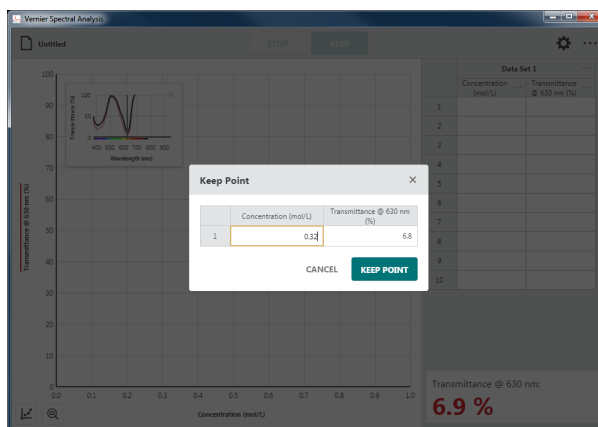
TIP! For comparison, the graph inset shows the full spectrum plot of the sample you are testing along with the spectrum used to define the wavelength.



- In this data-collection mode, you will be prompted to enter the solution concentration each time you **KEEP** a data point.

Click or tap **KEEP** when the spectrometer reading has stabilized.

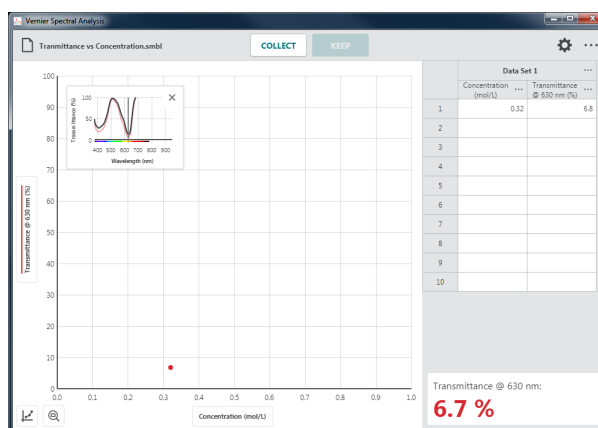
TIP! The reading at the time you selected **KEEP** is shown in the dialog. Changes to the value while the Keep Point dialog is shown are ignored until the dialog is dismissed.



- Enter the corresponding concentration value for this data point, then click or tap **KEEP POINT** to record the entry in the data table.

The point is automatically plotted on the graph.

TIP! It may be necessary to move the graph inset to see the collected point. You can drag the graph to a new location, or click or tap \times to dismiss it. You can click or tap \times and choose Graph Inset to redisplay the graph inset if needed.



- Continue collecting data for different samples until you have collected all of your data points.

Click or tap **STOP** to end data collection and continue with data analysis.

TIP! The graph rescales as you **KEEP** each point to ensure all data points are shown on the graph. After data collection is complete, the graph autoscales to fit the data.



TIP! If you inadvertently stop data collection before all of your data points have been collected, click or tap **COLLECT** and select **APPEND** to continue collecting points in the current data set.

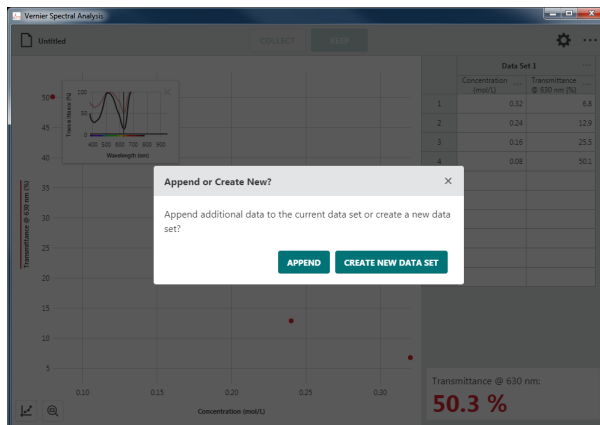
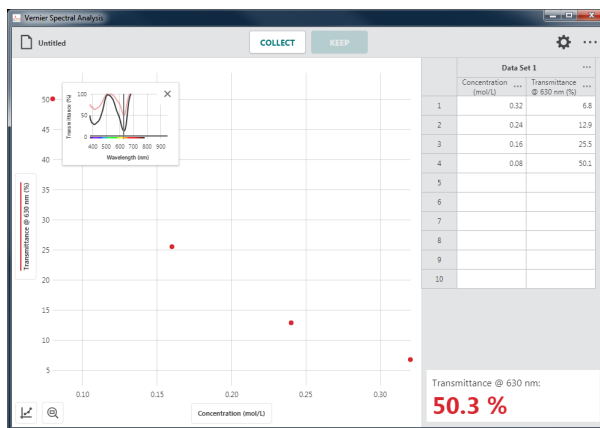
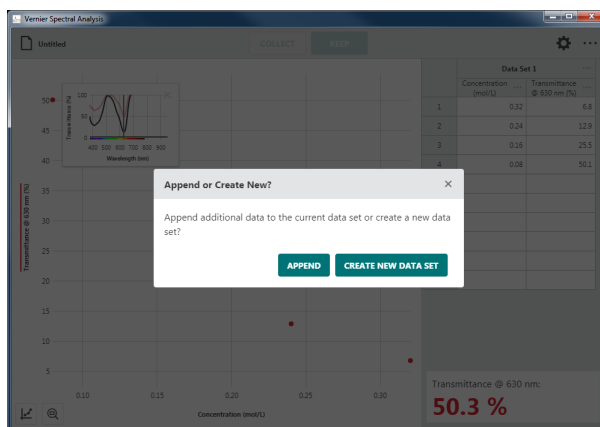
TIP! Double-click or double-tap a concentration value in the data table to edit the entry. Note that you can only change the concentration values. Transmittance values cannot be edited.

Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** and select **CREATE NEW DATA SET**. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set.

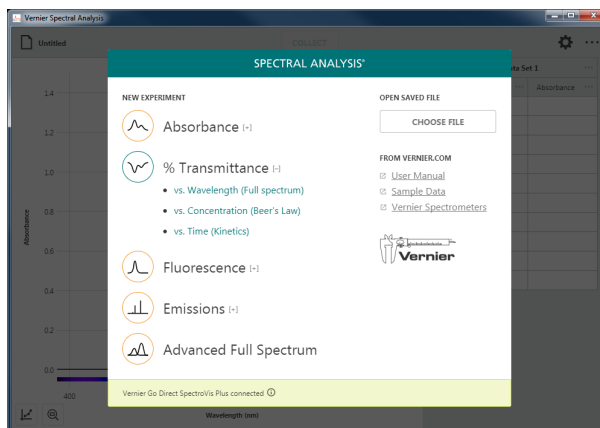
TIP! Click or tap **•••** next to the data set name for tools to rename or delete a data set.



% Transmittance vs. Time (Kinetics)

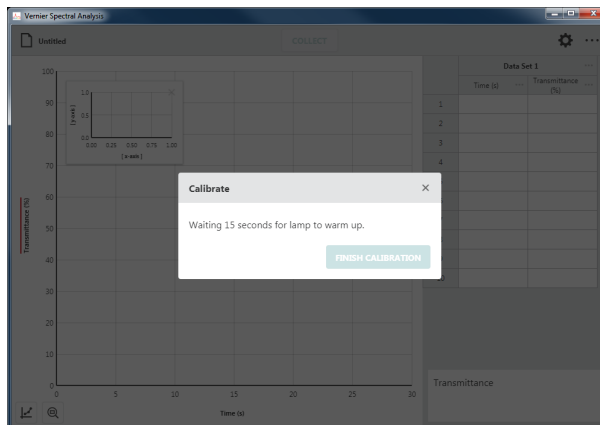
In this data-collection mode, a specific wavelength is identified as the basis of the collected data and data are collected as a function of time. The most common use for this collection mode is a Kinetics experiment where changes in the colorimetric properties of a substance change over time due to a reaction. Data analysis can determine the rate, order, affinity, and numerous other properties of the reaction.

1. Select **% Transmittance vs. Time (Kinetics)** from the New Experiment dialog.



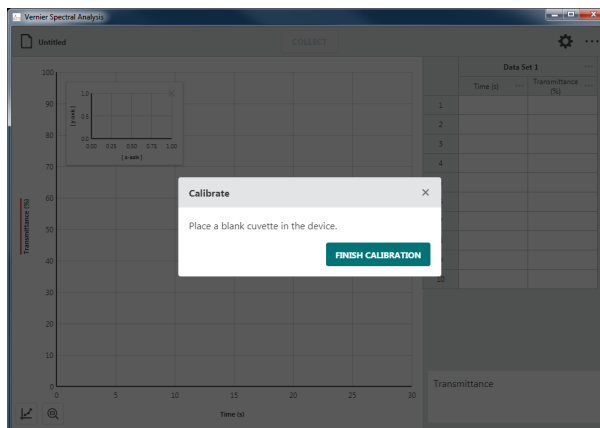
2. A calibration will automatically begin when you select this experiment type.

It can take 90 seconds or more for the lamp to illuminate fully. It is recommended that you wait for the warm up countdown to complete before proceeding with the calibration.



3. When the lamp warm up is complete, place a blank cuvette in the holder with the clear sides aligned with the arrow on the spectrometer. Click or tap **FINISH CALIBRATION** to complete the calibration.

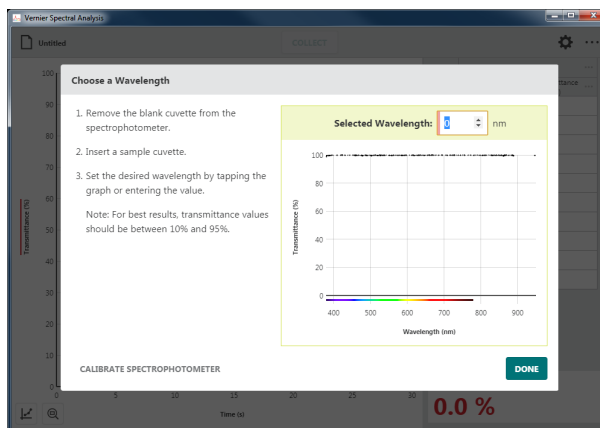
TIP! To remove any effects from the solvent used to prepare your samples for testing, use a cuvette containing only the solvent (often just deionized water) for this step in the calibration.



- Once calibration is complete, you will need to select the wavelength you will use for your experiment.

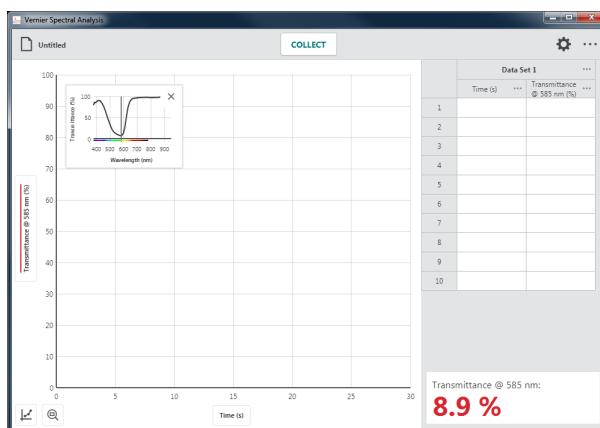
Follow the onscreen instructions for selecting a wavelength to use.


TIP! You can click or tap CALIBRATE SPECTROPHOTOMETER to calibrate the spectrometer again if needed.



- Click or tap **DONE** to use the wavelength you have selected.

TIP! You can click or tap the spectrometer meter (lower right corner of the screen) or graph inset to change the selected wavelength.



- Click or tap  to adjust the Collection Interval.

Adjust the value as needed for your experiment. The Collection Interval can be any whole number from 1 to 3600 seconds. The smallest value is automatically calculated based on your calibration and collection settings.

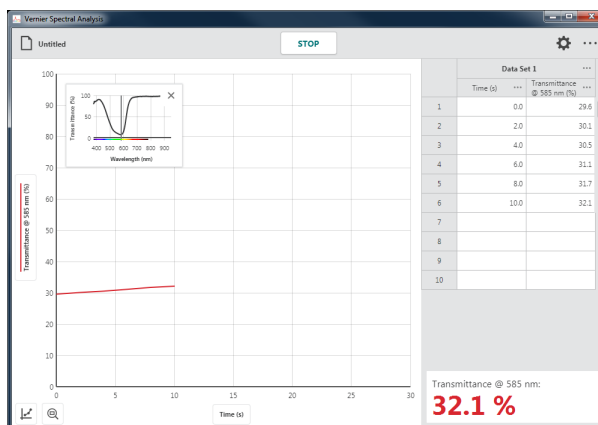
TIP! If you are using Go Direct® SpectroVis® Plus connected via Bluetooth® wireless technology, the minimum value is 3 seconds.

TIP! See [Appendix A](#) for a detailed description of the collection settings.



- Prepare your sample for data collection. Place the cuvette in the cuvette holder making sure the clear sides align with the arrow on the spectrometer.

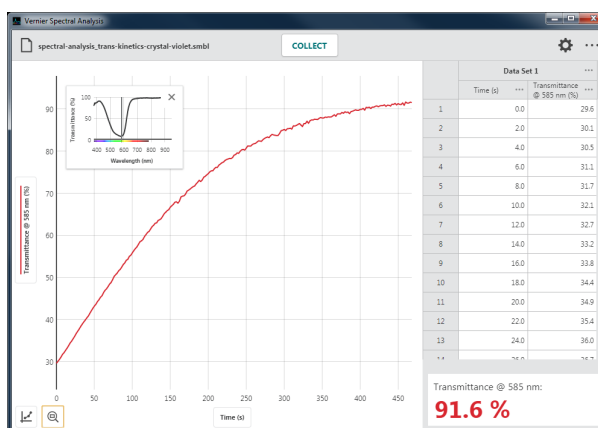
Click or tap **COLLECT** to start data collection.



- Click or tap **STOP** to end data collection and continue with data analysis.

The graph automatically autoscales to fit the data.

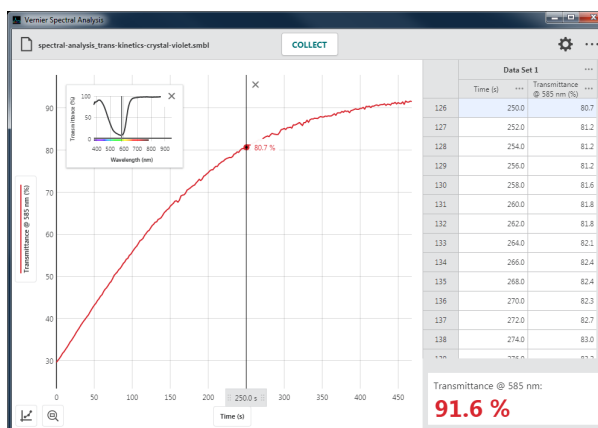
TIP! You can drag the graph inset anywhere on the graph if needed. Click or tap **×** to remove the graph inset. You can click or tap and choose Graph Inset to redisplay the graph inset if needed.



- Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap **×** to dismiss the examine line.

TIP! Notice that the point you are examining on the graph is also highlighted in the data table.



Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** again. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set to plot.

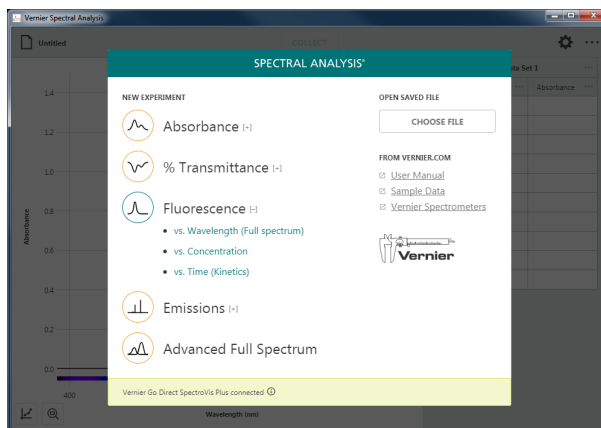
TIP! Click or tap **⋮** next to the data set name for tools to rename or delete a data set.

VI. COLLECTING FLUORESCENCE DATA

Fluorescence vs. Wavelength (Full Spectrum)


In this data-collection mode, fluorescence vs. wavelength data is plotted. Data for all supported wavelengths are displayed on the graph and in the data table.

1. Select **Fluorescence vs. Wavelength (Full Spectrum)** from the New Experiment dialog.



2. The Settings dialog will automatically display.

Calibration is not required; however, you may want to calibrate before collecting data to set a baseline reading and to remove excitation-LED light scatter from your data.

TIP! You will need a cuvette filled with the solvent you used to prepare your fluorescence sample. Click or tap  and follow the on-screen instructions.



3. Adjust the Excitation Wavelength to select the wavelength you want to use. The wavelength options shown depend on the spectrometer you are using.

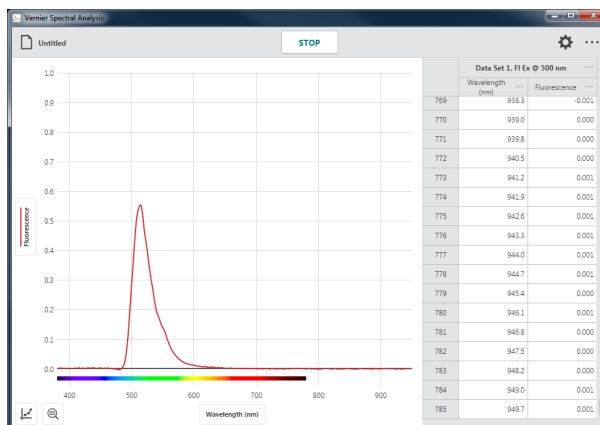
TIP! When using the Vernier Fluorescence UV-VIS Spectrophotometer, the default excitation wavelength is 375 nm. The app cannot automatically detect the wavelength of the LED you are using. Be sure to update this value to match your LED.




- Click or tap  to start data collection.

TIP! If you have cuvettes with four clear sides, use them here. If not, be sure the clear sides of your cuvette align with the arrow on the spectrometer.

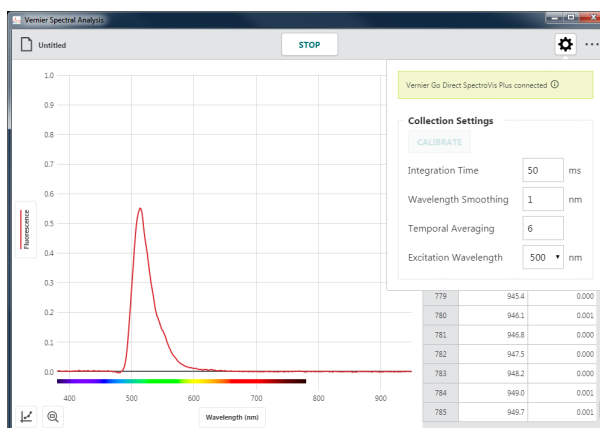
TIP! Notice that  changes to  while you are collecting data.



- Click or tap  to bring up the Settings dialog again.

See [Appendix A](#) for a detailed description of the collection settings.

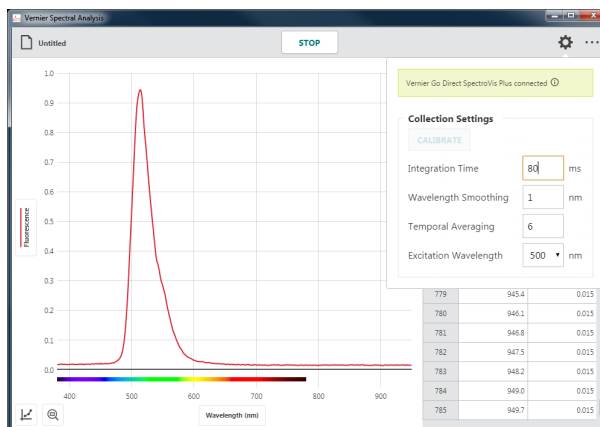
TIP! Click or tap off the Settings dialog to dismiss it. When using a computer or Chromebook™, you can also hit the ESC key to dismiss the dialog.



- Change the Collection Settings as needed for your experiment.

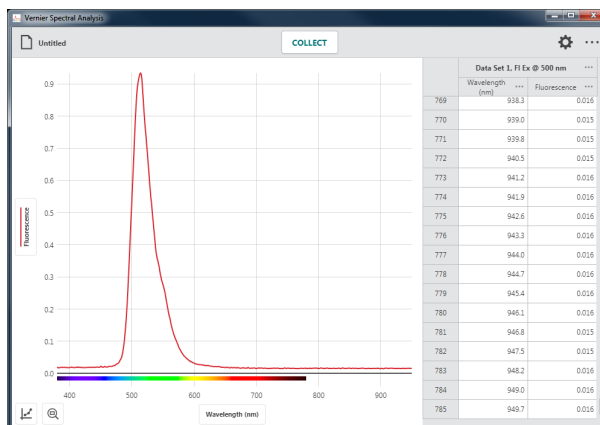
TIP! Making changes to the settings while you are collecting data will help you understand how these changes affect the collected data.

TIP! Altering Collection Settings may cause your baseline or LED scatter to change. You may want to stop data collection and recalibrate before continuing with data collection.



- Click or tap  to end data collection and continue with data analysis.

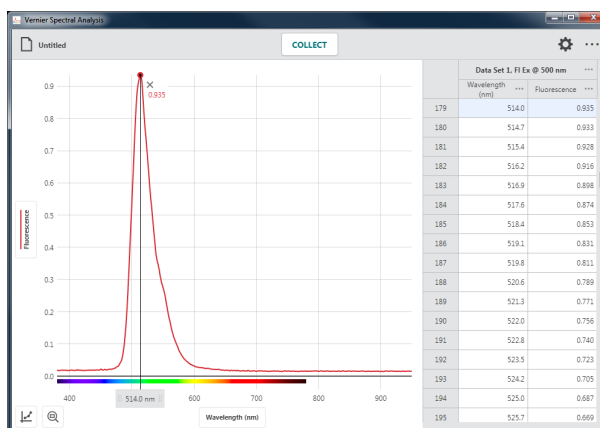
The graph automatically autoscales to fit the data.




- Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap × to dismiss the examine line.

TIP! Notice that the point you are examining on the graph is also highlighted in the data table.



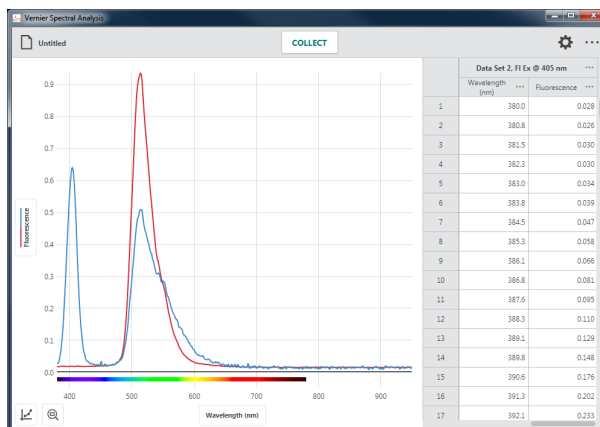
Collecting Multiple Data Sets

To collect another data set, click or tap  again. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set to plot.

TIP! Your data set name will automatically include the excitation wavelength indicated in settings.

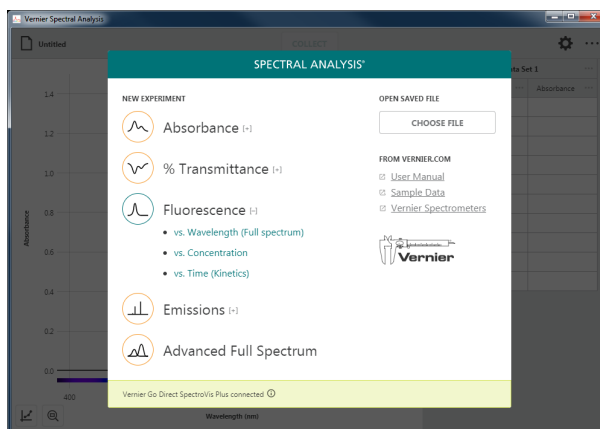
TIP! Click or tap **•••** next to the data set name for tools to rename or delete a data set.



Fluorescence vs. Concentration

In this data-collection mode, a specific wavelength is identified as the basis of the collected data. Individual data points are collected from samples with known concentrations to create a graph of the fluorescence vs. concentration data at the selected wavelength. Data analysis can determine the concentration of a sample containing an unknown concentration of the solute being studied. You are not limited to experiments involving concentration. This data-collection option can be used for other investigations with independent variables that affect fluorescence such as pH, halide concentration, or excitation-LED intensity.

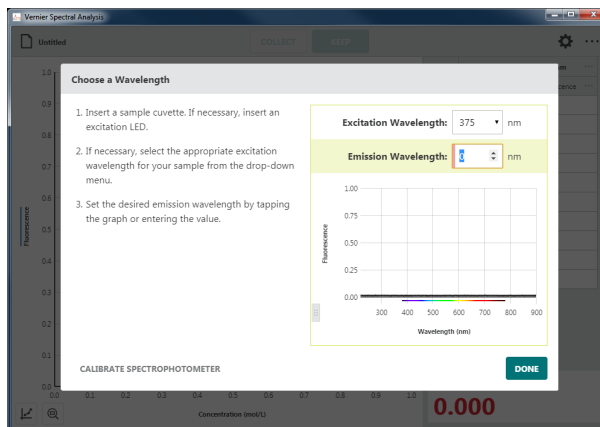
1. Select **Fluorescence vs. Concentration** from the New Experiment dialog.



2. The Choose a Wavelength dialog will automatically display.

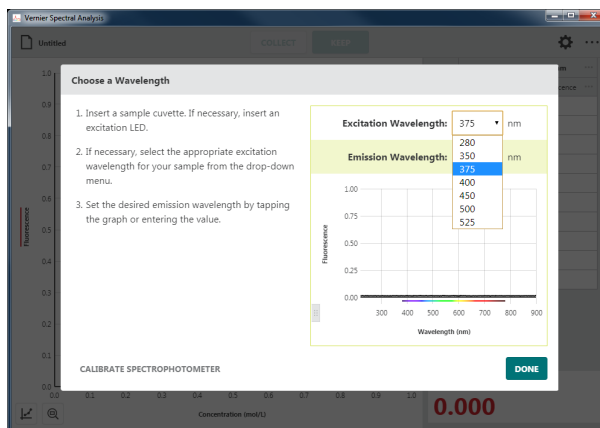
Calibration is not required; however, you may want to calibrate before collecting data to set a baseline reading and to remove excitation-LED light scatter from your data.

TIP! You will need a cuvette filled with the solvent you used to prepare your fluorescence sample. Click or tap CALIBRATE SPECTROPHOTOMETER and follow the on-screen instructions.



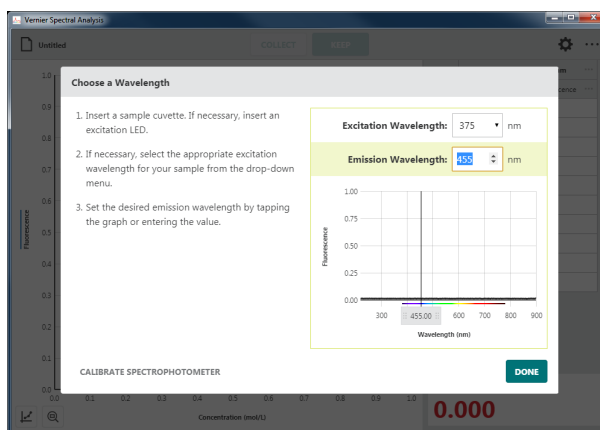
3. Select the Excitation Wavelength you are using for your experiment. The wavelength options shown depend on the spectrometer you are using.

TIP! When using the Vernier Fluorescence UV-VIS Spectrophotometer, the default excitation wavelength is 375 nm. The app cannot automatically detect the wavelength of the LED you are using. Be sure to update this value to match your LED.



4. Follow the onscreen instructions for selecting the fluorescence emission wavelength to use for your experiment.

TIP! You may want to start with a Fluorescence vs. Wavelength experiment to find the spectrometer settings that work best for your experiment. The default spectrometer settings may not show a significant spectrum in this dialog.




5. Click or tap **DONE** to use the wavelength you have selected.

TIP! You can click or tap the spectrometer meter (lower right corner of the screen) or graph inset to change the selected wavelength.

TIP! If your independent variable is not Concentration (mol/L), click or tap **•••** next to the table column heading and select Column Options to change the column name and units to match your experiment.



- If needed, click or tap  and change the spectrometer settings to optimize the fluorescence data for your sample.

See [Appendix A](#) for a detailed description of the collection settings.

TIP! This assumes you know the settings that work best. Typically they are pre-determined using a Fluorescence vs. Wavelength experiment.

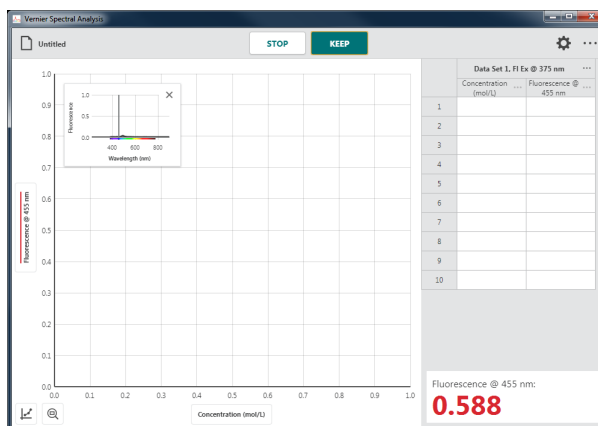
TIP! Click or tap off the Settings dialog to dismiss it. When using a computer or Chromebook™, you can also hit the ESC key to dismiss the dialog.




- Place your sample in the cuvette holder. Click or tap  to start data collection. This enables the  button.


TIP! If you have cuvettes with four clear sides, use them here. If not, be sure the clear sides of your cuvette align with the arrow on the spectrometer.

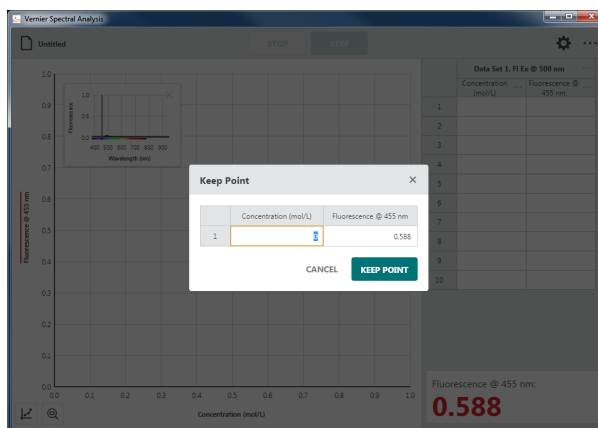
TIP! For comparison, the graph inset shows the full spectrum plot of the sample you are testing along with the spectrum used to define the wavelength.



- In this data-collection mode, you will be prompted to enter the solution concentration each time you  a data point.


Click or tap  when the spectrometer reading has stabilized.

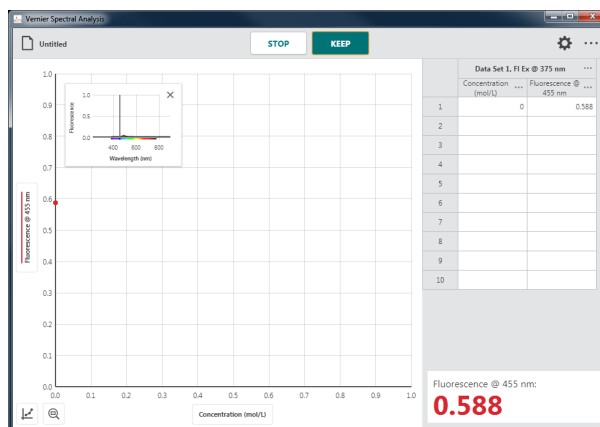
TIP! The reading at the time you selected  is shown in the dialog. Changes to the value while the Keep Point dialog is shown are ignored until the dialog is dismissed.



- Enter the corresponding concentration value for this data point, then click or tap **KEEP POINT** to record the entry in the data table.

The point is automatically plotted on the graph.

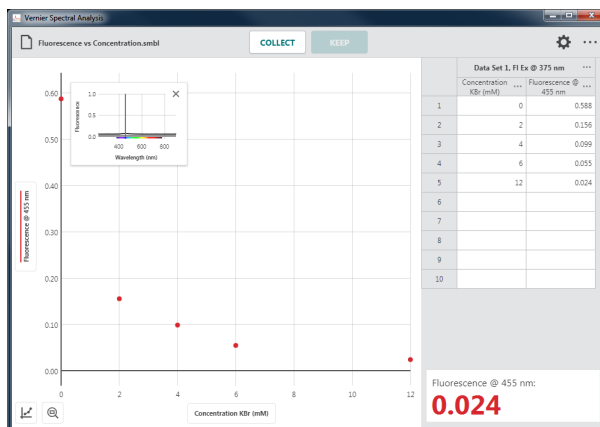
TIP! It may be necessary to move the graph inset to see the collected point. You can drag the graph to a new location or click or tap \times to dismiss it. You can click or tap  and choose Graph Inset to redisplay the graph inset if needed.



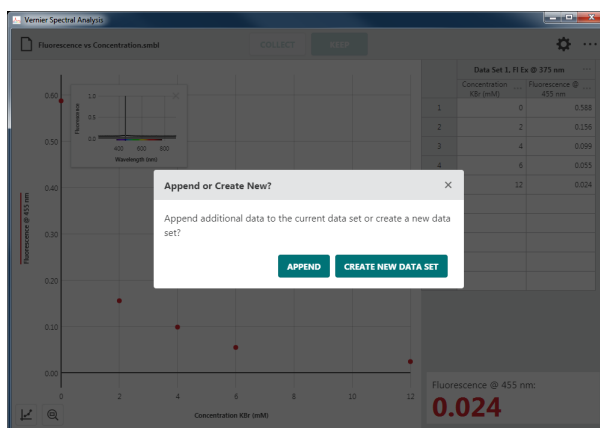
- Continue collecting data for different samples until you have collected all of your data points.

Click or tap **STOP** to end data collection and continue with data analysis.

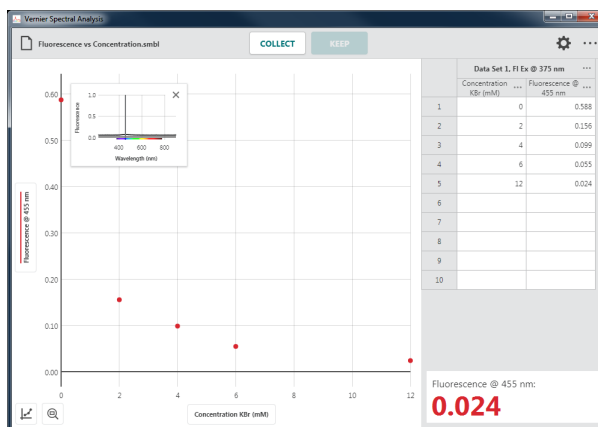
TIP! The graph rescales as you **KEEP** each point to ensure all data points are shown on the graph. After data collection is complete, the graph will autoscale to fit the data.



TIP! If you inadvertently stop data collection before all of your data points have been collected, click or tap **COLLECT** and select **APPEND** to continue collecting points in the current data set.



TIP! Double-click or double-tap a concentration value in the data table to edit the entry. Note that you can only change the concentration values. Fluorescence values cannot be edited.

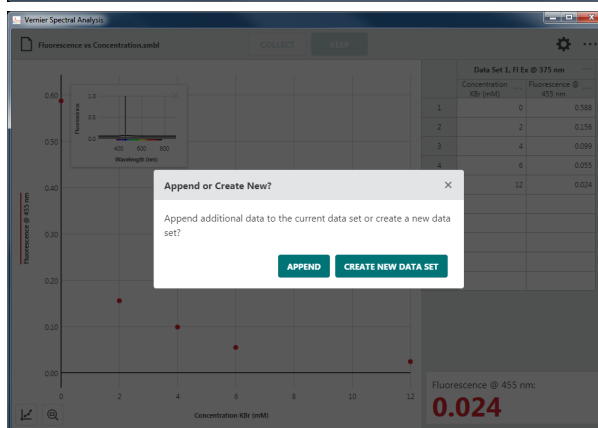


Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** and select **CREATE NEW DATA SET**. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set.

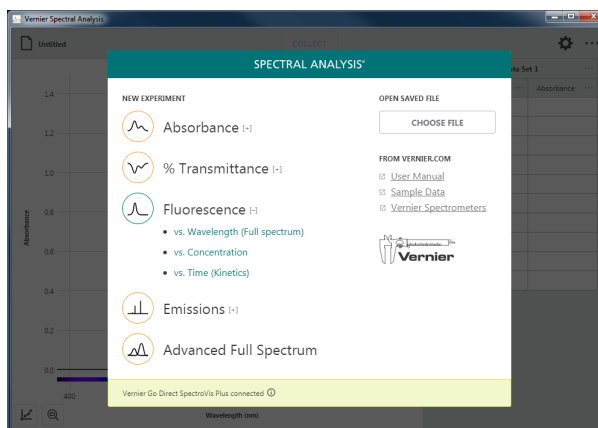
TIP! Click or tap **...** next to the data set name for tools to rename or delete a data set.



Fluorescence vs. Time (Kinetics)

In this data-collection mode, a specific wavelength is identified as the basis of the collected data. The most common use for this collection mode is a Kinetics experiment. Changes in the fluorescence properties of a substance change over time due to a reaction. Data analysis can determine the rate, order, affinity, and numerous other properties of the reaction.

1. Select **Fluorescence vs. Time (Kinetics)** from the New Experiment dialog.



- The Choose a Wavelength dialog will automatically be shown.

Calibration is not required; however, you may want to calibrate before collecting data to set a baseline reading and to remove excitation-LED light scatter from your data.

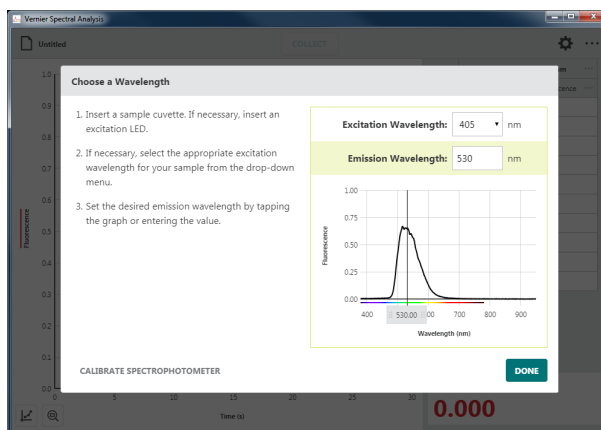
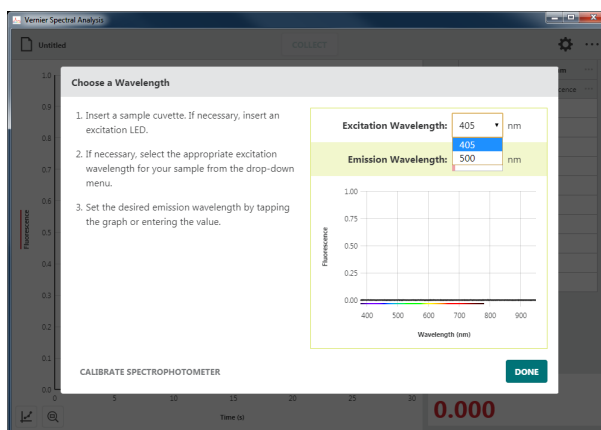
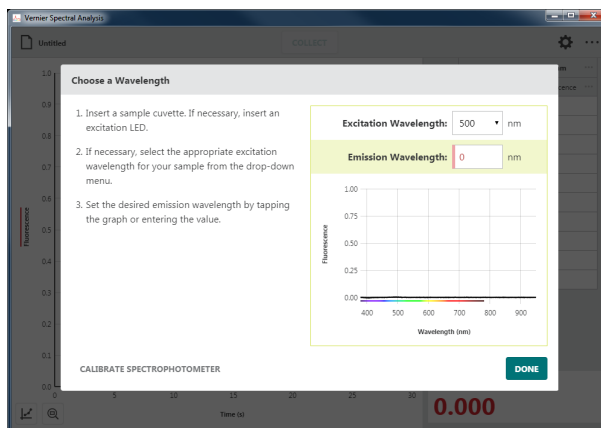
TIP! You will need a cuvette filled with the solvent you used to prepare your fluorescence sample. Click or tap CALIBRATE SPECTROPHOTOMETER and follow the on-screen instructions.

- Select the Excitation Wavelength you are using for your experiment. The wavelength options shown depend on the spectrometer you are using.

TIP! When using the Vernier Fluorescence UV-VIS Spectrophotometer, the default excitation wavelength is 375 nm. The app cannot automatically detect the wavelength of the LED you are using. Be sure to update this value to match your LED.

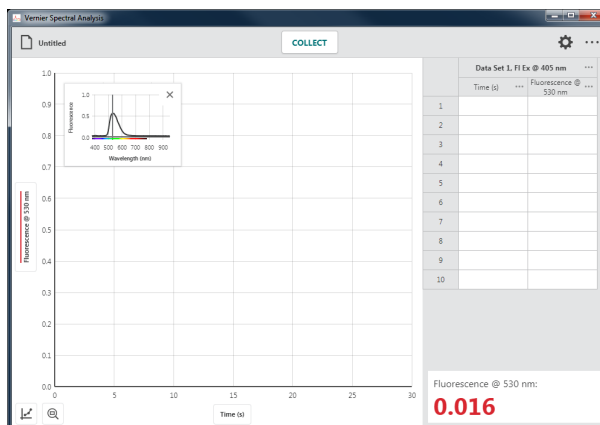
- Follow the onscreen instructions for selecting the fluorescence Emission Wavelength to use for your experiment.

TIP! You may want to start with a Fluorescence vs. Wavelength experiment to find the spectrometer settings that work best for your experiment. The default spectrometer settings may not show a significant spectrum in this dialog.



- Click or tap **DONE** to use the wavelength you have selected.

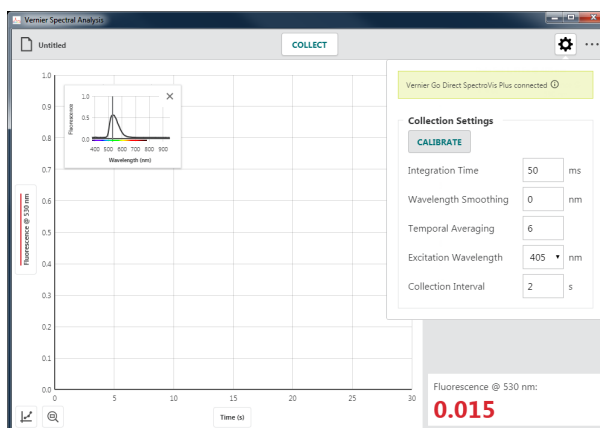
TIP! You can click or tap the spectrometer meter (lower right corner of the screen) or graph inset to change the selected wavelength.



- Click or tap . If needed, change the spectrometer settings to optimize the fluorescence data for your sample.

See [Appendix A](#) for a detailed description of the collection settings.

TIP! This assumes you know the settings that work best. Typically they are pre-determined using a Fluorescence vs. Wavelength experiment.



- Adjust the Collection Interval value as needed for your experiment. The Collection Interval can be any whole number from 1 to 3600 seconds. The smallest value is automatically calculated based on your calibration and collection settings.

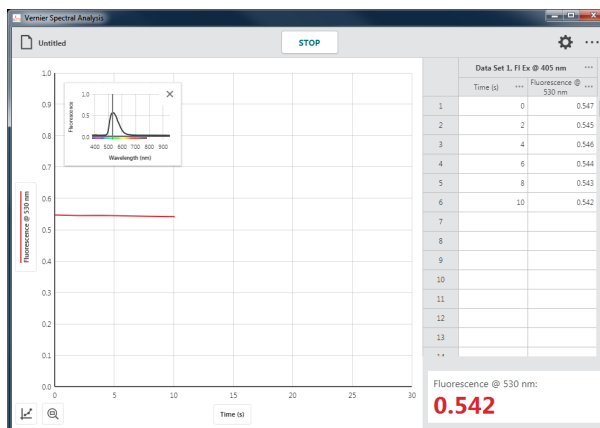
TIP! If you are using Go Direct[®] SpectroVis[®] Plus connected via Bluetooth[®] wireless technology, the minimum value is 3 seconds.



TIP! Click or tap off the Settings dialog or hit the ESC key to dismiss the dialog.

- Place your sample in the cuvette holder. Click or tap **COLLECT** to start data collection.

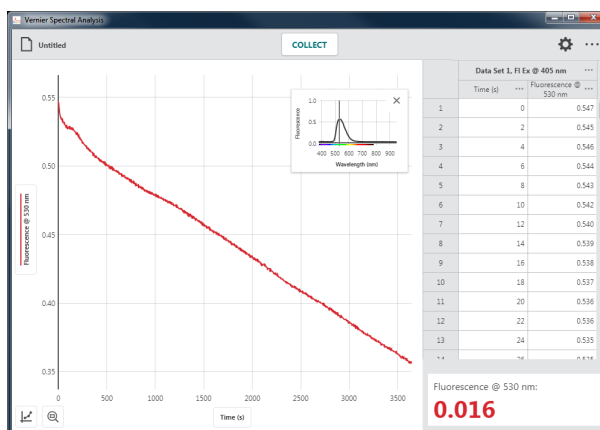
TIP! If you have cuvettes with four clear sides, use them here. If not, be sure the clear sides of your cuvette align with the arrow on the spectrometer.



- Click or tap **STOP** to end data collection and continue with data analysis.

The graph automatically autoscales to fit the data.

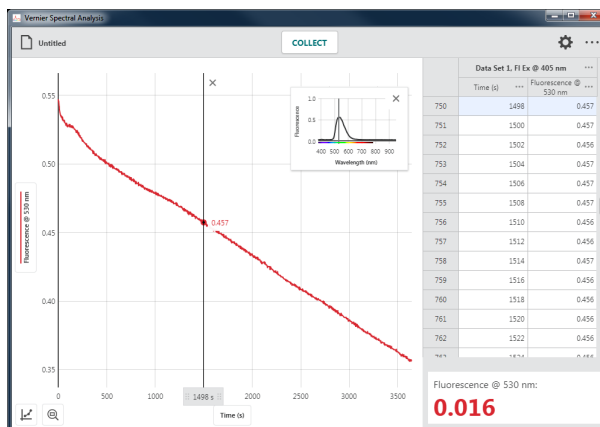
TIP! You can drag the graph inset anywhere on the graph if needed. Click or tap **×** to remove the graph inset. You can click or tap and choose Graph Inset to redisplay the graph inset if needed.



- Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap **×** to dismiss the examine line.

TIP! Notice that the point you are examining on the graph is also highlighted in the data table.



Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** again. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set to plot.

TIP! Click or tap **⋮** next to the data set name for tools to rename or delete a data set.

VII. COLLECTING EMISSIONS DATA

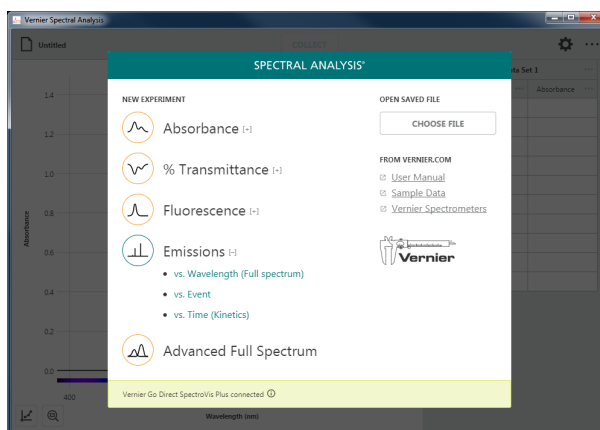
Emissions vs. Wavelength (Full Spectrum)


In this data-collection mode, intensity vs. wavelength data is plotted. Data for all supported wavelengths are displayed on the graph and in the data table.

1. Select **Emissions vs. Wavelength (Full Spectrum)** from the New Experiment dialog.

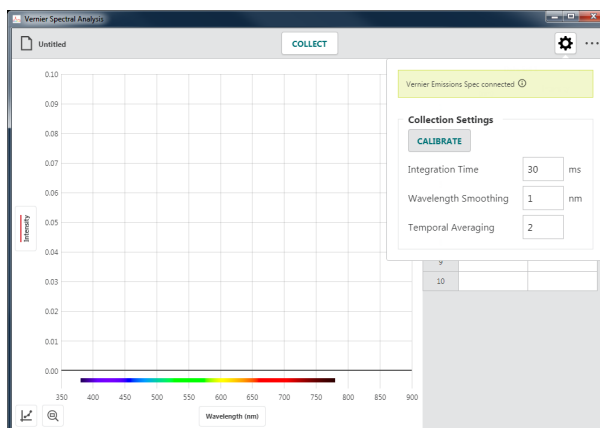
Insert or connect a fiber optic cable to your spectrometer. The accessory fiber optic cables do not come with the spectrometers.

TIP! When using the Vernier Emissions Spectrometer, it is recommended that you use a fiber optic cable even though you can collect data without it.



2. Calibration is not required; however, you may want to take a baseline (dark) measurement before collecting data. Click or tap  to bring up the Settings dialog.

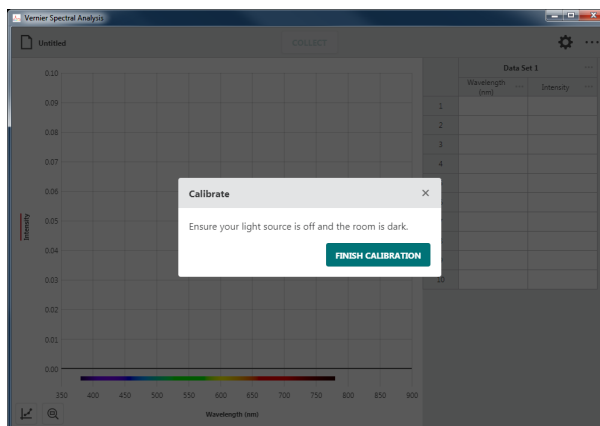
TIP! See [Appendix A](#) for a detailed description of the collection settings.



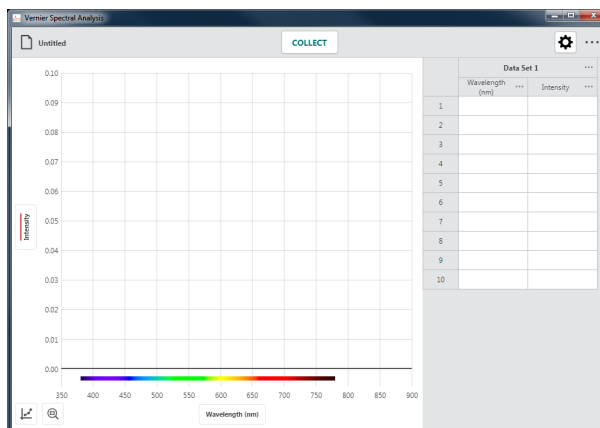
3. Click or tap  and follow the on-screen instructions to calibrate the spectrometer.

TIP! When calibrating the spectrometer, be sure the fiber optic cable is aligned as it would be during data collection and that the emissions light source is off.

TIP! Click or tap off the Settings dialog or hit the ESC key to dismiss the dialog if calibration is not desired.

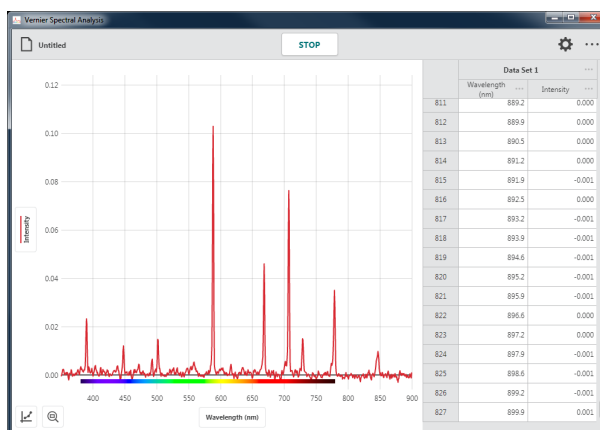


- Turn your light source on. Be sure to give it time to fully illuminate before starting data collection.



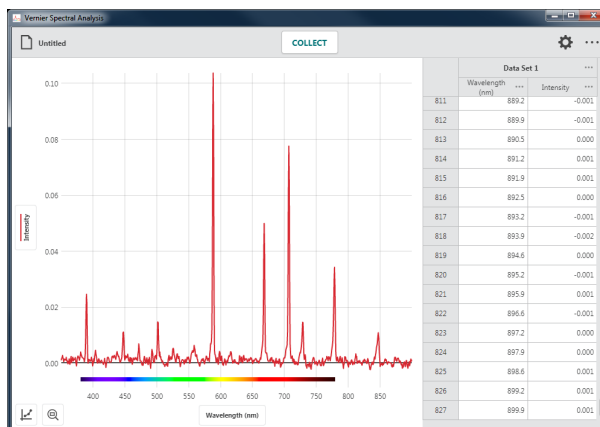
- Click or tap **COLLECT** to start data collection.

*TIP! Notice that **COLLECT** changes to **STOP** while you are collecting data.*



- Click or tap **STOP** to end data collection and continue with data analysis.

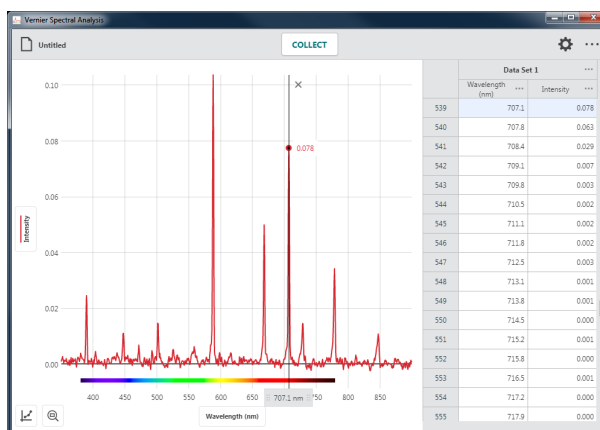
The graph automatically autoscales to fit the data.



- Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap × to dismiss the examine line.

TIP! Notice that the point you are examining on the graph is also highlighted in the data table.



Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** again. Your original data set is retained and the new data set is displayed on the graph.

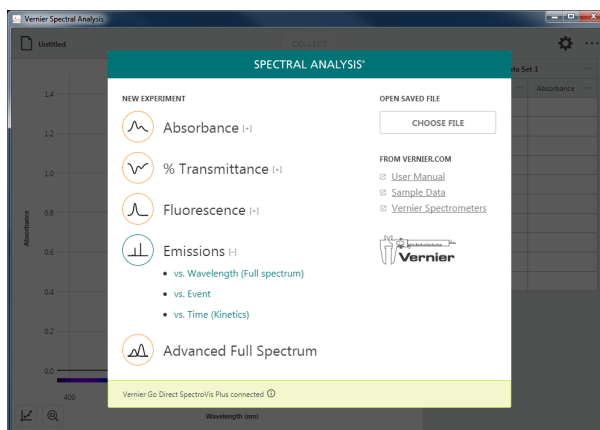
TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set to plot.

TIP! Click or tap ●●● next to the data set name for tools to rename or delete a data set.

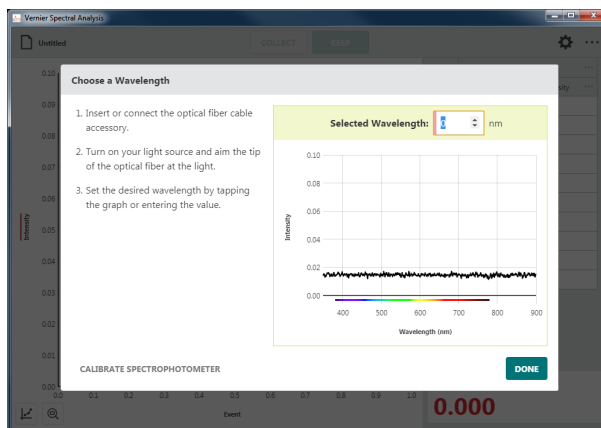
Emissions vs. Event

In this data-collection mode, a specific wavelength is identified as the basis of the collected data. The independent variable “Event” will depend on the experiment you are performing. Individual data points are collected from samples to create a graph of the intensity vs. “event” data at the selected wavelength.

- Select **Emissions vs. Event** experiment.

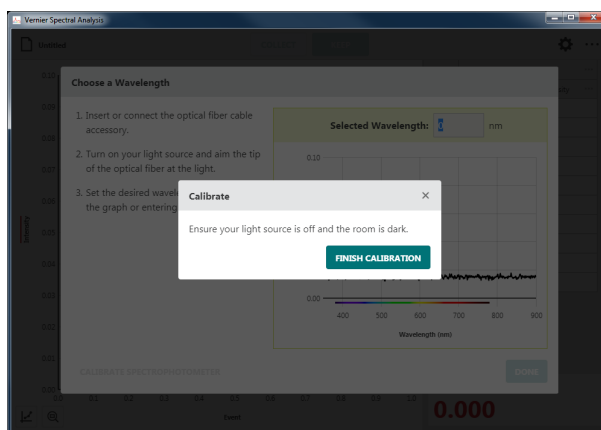


2. Calibration is not required; however, you may want to take a baseline (dark) measurement before collecting data.

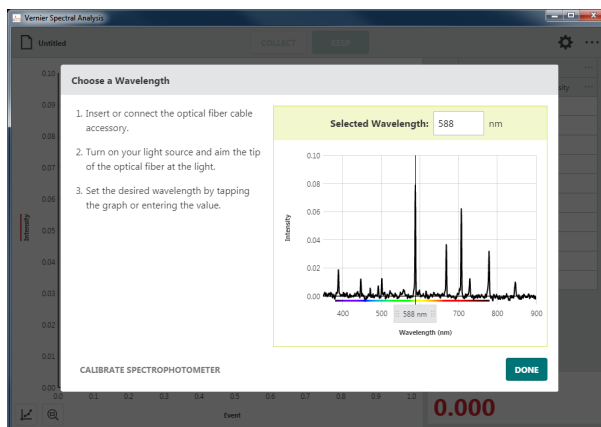


3. If needed, click or tap CALIBRATE SPECTROPHOTOMETER and follow the on-screen instructions to calibrate the spectrometer.

TIP! When calibrating the spectrometer, be sure the fiber optic cable is aligned as it would be during data collection and that the emissions light source is off.



4. Turn your light source on. Be sure to give it time to illuminate fully. Follow the onscreen instructions for selecting the wavelength to use for your experiment.



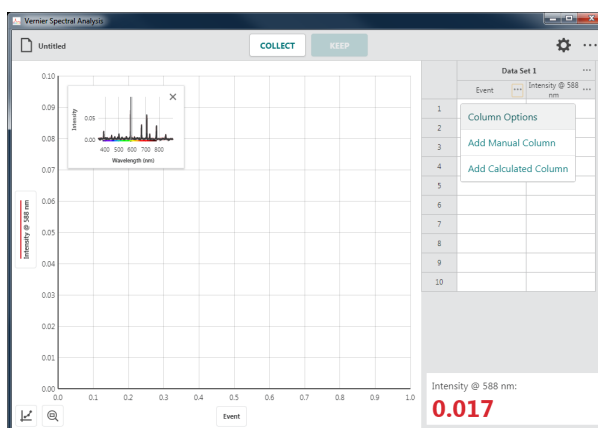
Vernier Spectral Analysis[®] – User Manual

5. Click or tap **DONE** to use the wavelength you have selected.

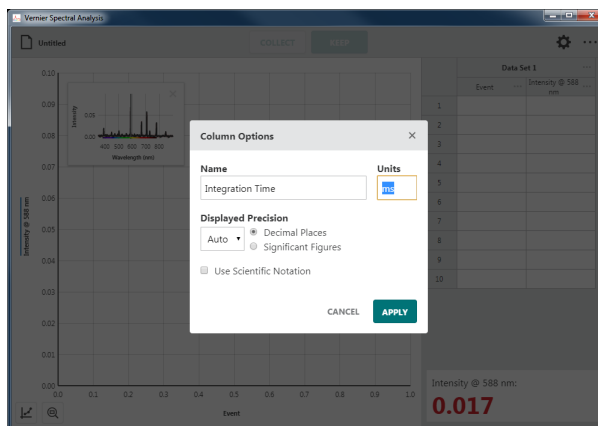
TIP! You can click or tap the spectrometer meter (lower right corner of the screen) or graph inset to change the selected wavelength.



6. Click or tap **⋮** next to the table column heading Event to change the column name.



7. Select Column Options and change the column name and units to match your experiment.



- Click or tap **DONE** to use the new column name.

TIP! Notice that the label on the bottom-axis (x-axis) is updated automatically.



- Click or tap **COLLECT** to start data collection. This enables the **KEEP** button.

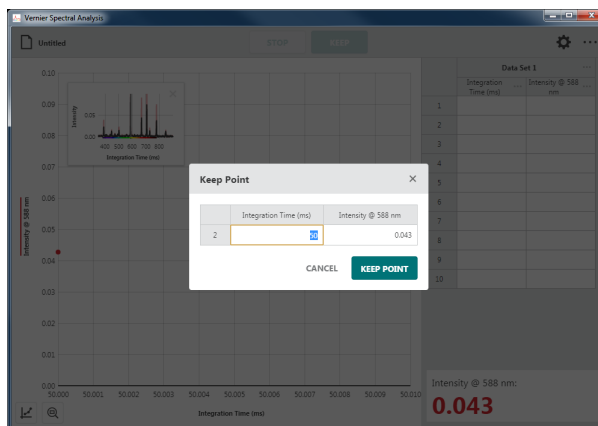
TIP! For comparison, the graph inset shows the full spectrum plot of the sample you are testing along with the spectrum used to define the wavelength.



- In this data-collection mode, you will be prompted to enter the independent-variable value each time you **KEEP** a data point.


Click or tap **KEEP** when the spectrometer reading has stabilized.

TIP! The reading at the time you selected **KEEP** is shown in the dialog. Changes to the value while the Keep Point dialog is shown are ignored until the dialog is dismissed.



- Enter the corresponding independent-variable value for this data point, then click or tap **KEEP POINT** to record the entry in the data table.

The point is automatically plotted on the graph.

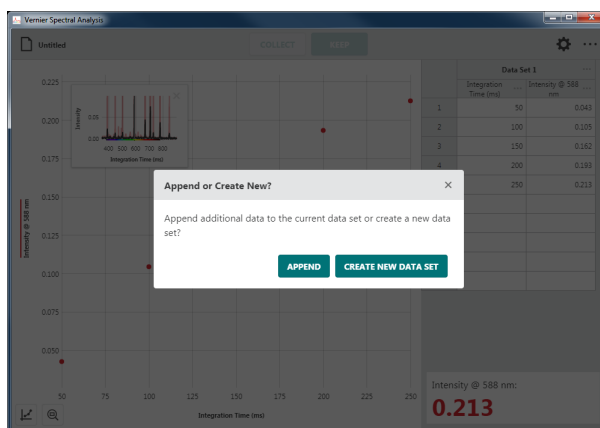
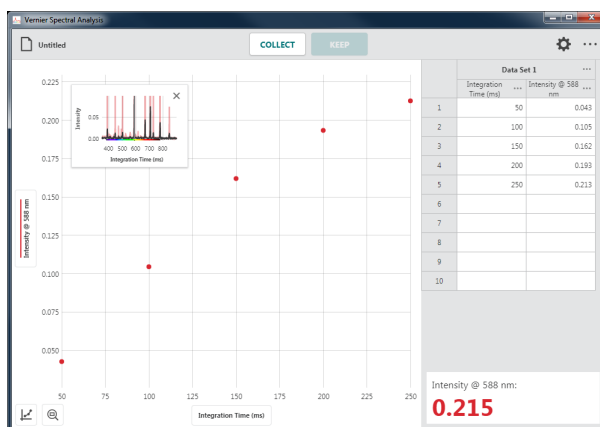
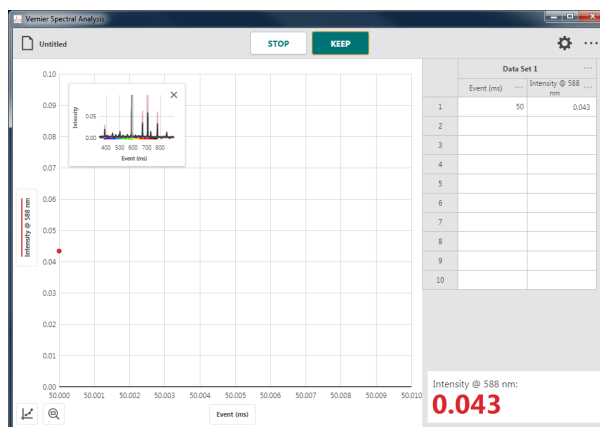
TIP! It may be necessary to move the graph inset to see the collected point. You can drag the graph to a new location or click or tap \times to dismiss it. You can click or tap  and choose Graph Inset to redisplay the graph inset if needed.

- Continue collecting data for different samples until you have collected all of your data points.

Click or tap **STOP** to end data collection and continue with data analysis.

TIP! The graph rescales as you **KEEP** each point to ensure all data points are shown on the graph. After data collection is complete, the graph will autoscale to fit the data.

TIP! If you inadvertently stop data collection before all of your data points have been collected, click or tap **COLLECT** and select **APPEND** to continue collecting points in the current data set.



TIP! Double-click or double-tap an independent-variable column value in the data table to edit the entry. Note that you can only change the independent-variable column values. Intensity values cannot be edited.

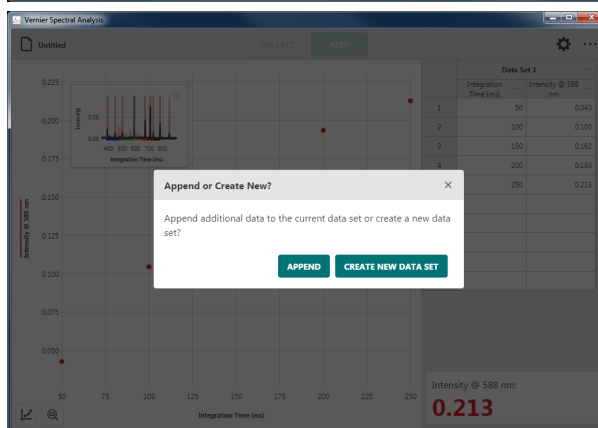


Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** and select **CREATE NEW DATA SET**. Your original data set is retained and the new data set is displayed on the graph.

TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set.

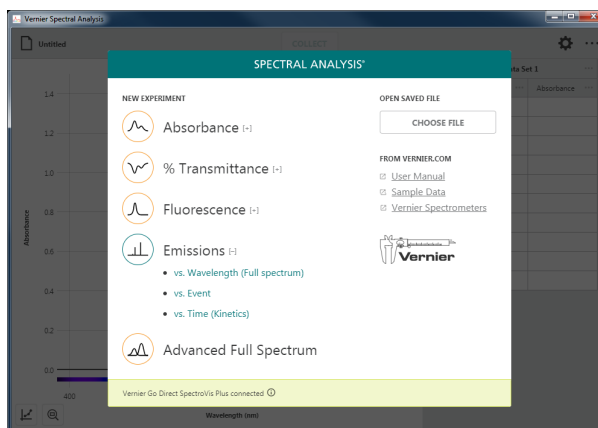
TIP! Click or tap **⋮** next to the data set name for tools to rename or delete a data set.



Emissions vs. Time (Kinetics)

In this data-collection mode, a specific wavelength is identified as the basis of the collected data. One use for this collection mode is to investigate changes in the emission properties of an external light source over time. This example experiment is looking at the changes in light intensity (at 723 nm) as a projector bulb warms up.

1. Select **Emissions vs. Time (Kinetics)** experiment.

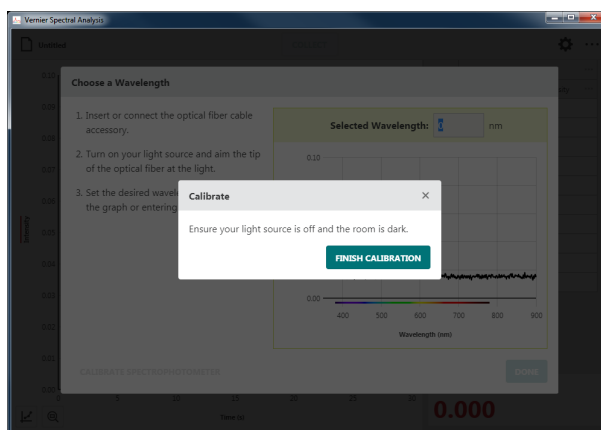


2. Calibration is not required; however, you may want to take a baseline (dark) measurement before collecting data.

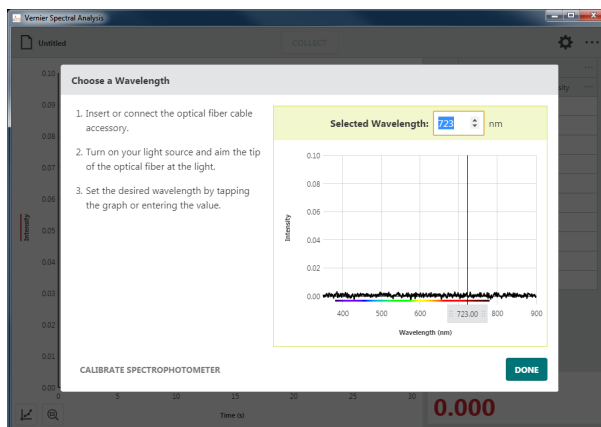


3. If needed, click or tap CALIBRATE SPECTROPHOTOMETER and follow the on-screen instructions to calibrate the spectrometer.

TIP! When calibrating the spectrometer, be sure the fiber optic cable is aligned as it would be during data collection and that the emissions light source is off.

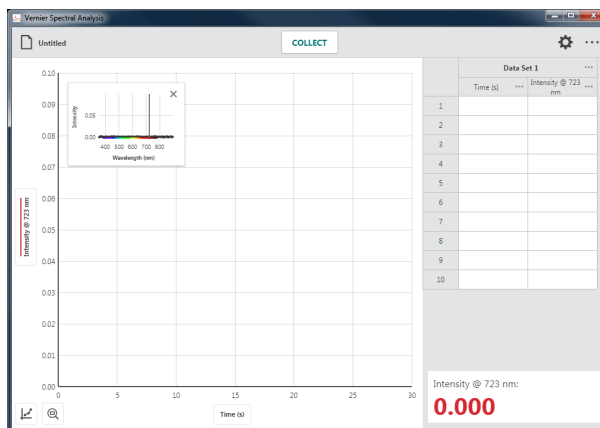


4. Turn your light source on. Be sure to give it time to illuminate fully. Follow the onscreen instructions for selecting the wavelength to use for your experiment.



- Click or tap **DONE** to use the wavelength you have selected.

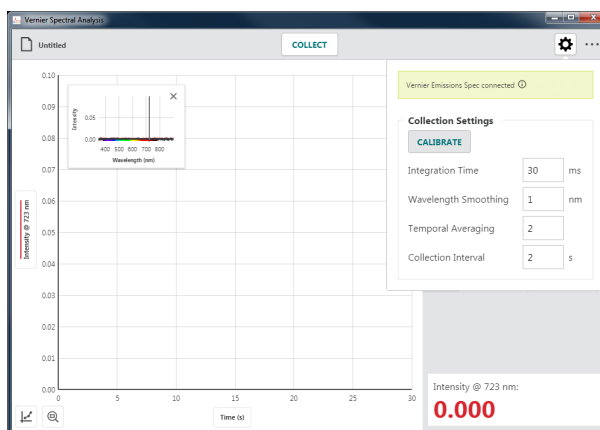
TIP! You can click or tap the spectrometer meter (lower right corner of the screen) or graph inset to change the selected wavelength.



- Click or tap **Settings**. If needed, change the spectrometer settings to optimize the intensity data for your light source.

TIP! This assumes you know the settings that work best. Typically they are pre-determined using an Emissions vs. Wavelength experiment.

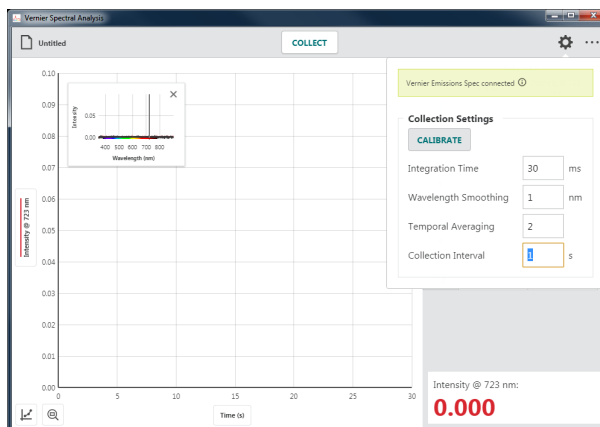
TIP! See [Appendix A](#) for a detailed description of the collection settings.



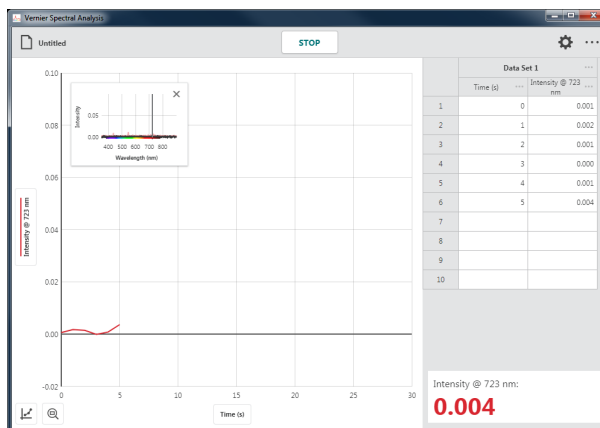
- Adjust the Collection Interval value as needed for your experiment. The Collection Interval can be any whole number from 1 to 3600 seconds.

TIP! If you are using a Go Direct[®] SpectroVis[®] Plus connected via Bluetooth[®] wireless technology, the minimum value is 3 seconds.

TIP! Click or tap off the Settings dialog or hit the ESC key to dismiss the dialog.




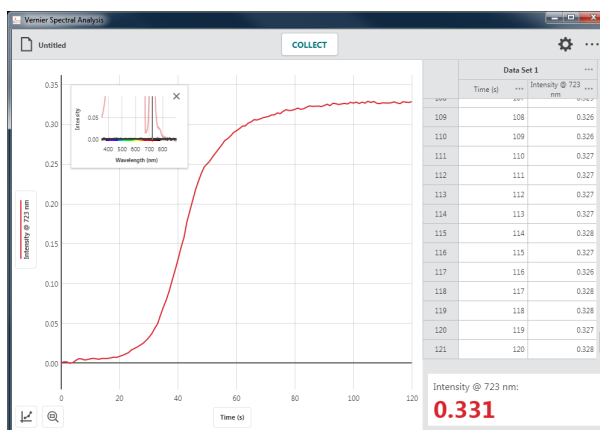
8. Click or tap **COLLECT** to start data collection.



9. Click or tap **STOP** to end data collection and continue with data analysis.

The graph automatically autoscales to fit the data.

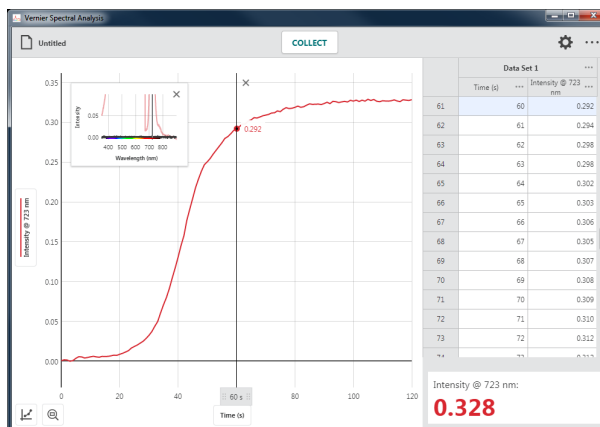
TIP! You can drag the graph inset anywhere on the graph if needed. Click or tap **×** to remove the graph inset. You can click or tap  and choose Graph Inset to redisplay the graph inset if needed.



10. Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap **×** to dismiss the examine line.

TIP! Notice that the point you are examining on the graph is also highlighted in the data table.



Collecting Multiple Data Sets

To collect another data set, click or tap **COLLECT** again. Your original data set is retained and the new data set is displayed on the graph.

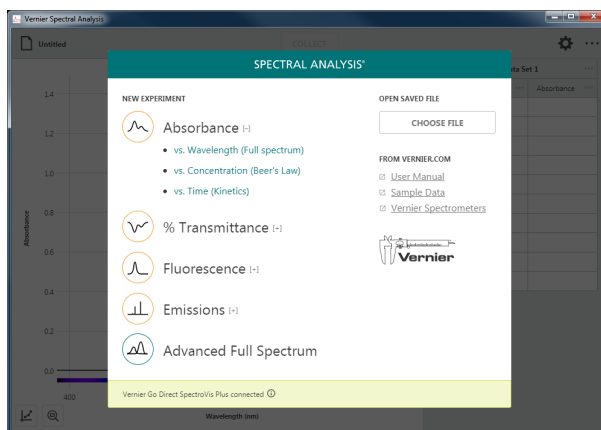
TIP! To change what is plotted on the graph, click or tap the left-axis (y-axis) label and select the desired data set to plot.

TIP! Click or tap **⋮** next to the data set name for tools to rename or delete a data set.

VIII. COLLECTING ADVANCED FULL SPECTRUM DATA

In this data-collection mode, you can collect Absorbance, % Transmittance, Fluorescence, and Emissions data all in the same file. You can also collect Raw data, which can be used to collect the raw signal from your lamp. For this example we compare the absorbance and fluorescence spectrum of Riboflavin (vitamin B2).

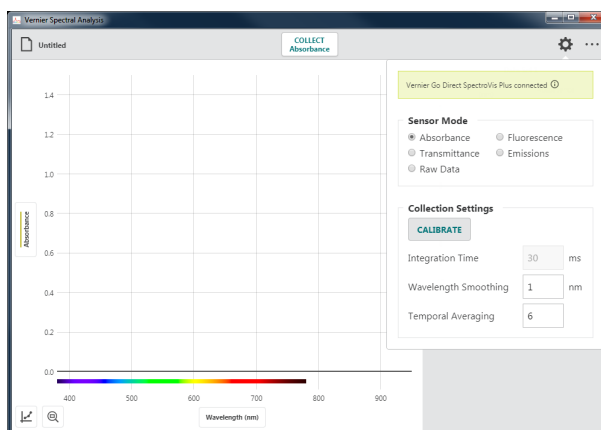
1. Select Advanced Full Spectrum.





2. The Settings dialog will automatically display. The default Sensor Mode is Absorbance.

TIP! The Collection Settings options available depend on the selected Sensor Mode. Corresponding values entered in one mode will persist as you switch between modes.



TIP! See [Appendix A](#) for a detailed description of the collection settings.

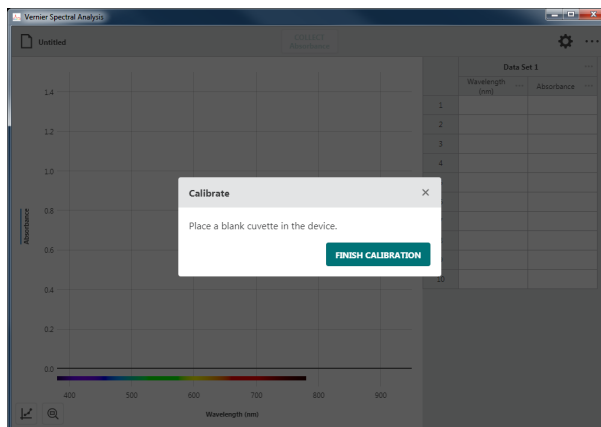


3. For Absorbance and Transmittance modes, calibration is required. Click or tap  and follow the on-screen instructions.

Click or tap  to complete the calibration.

TIP! If you have not calibrated your spectrometer when required, you will be forced to calibrate when you click or tap

 OR .

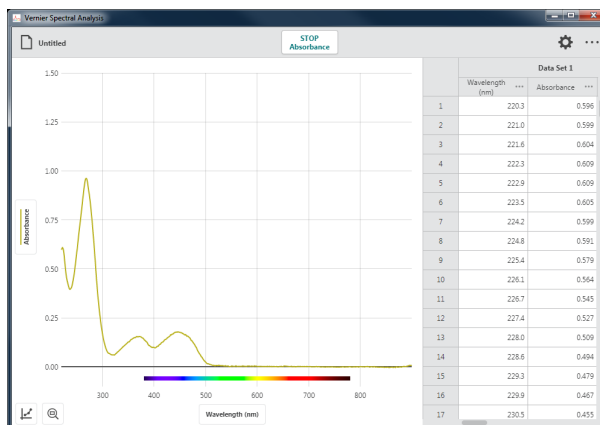


Vernier Spectral Analysis[®] – User Manual

- Place your sample in the cuvette holder with the clear sides aligned with the arrow on the spectrometer.

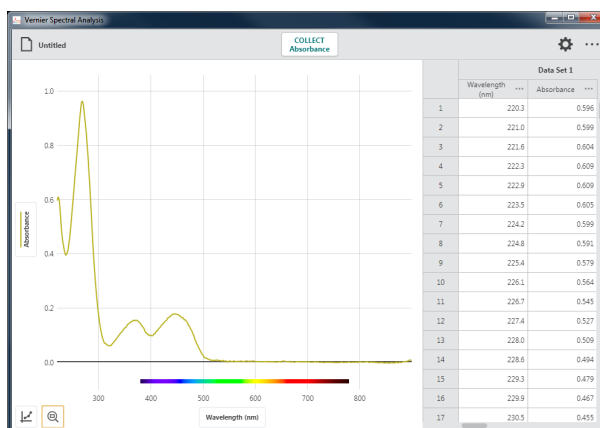
Click or tap **COLLECT Absorbance** to start data collection.

TIP! Notice that **COLLECT Absorbance** changes to **STOP Absorbance** while you are collecting data.

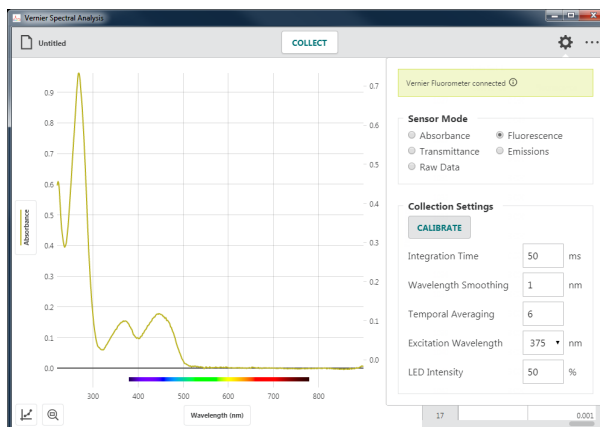


- Click or tap **STOP Absorbance** to end data collection and continue with data analysis.

The graph automatically autoscales to fit the data.



- Click or tap **Settings** and select the Fluorescence Sensor Mode.



- Adjust the Excitation Wavelength to select the wavelength you want to use. The wavelength options shown depend on the spectrometer you are using.

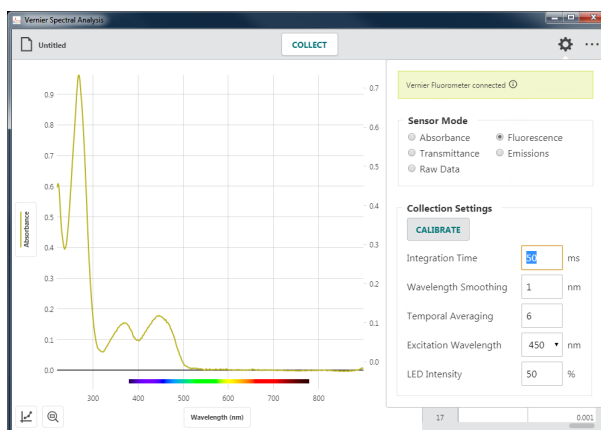
TIP! When using the Vernier Fluorescence UV-VIS Spectrophotometer, the default excitation wavelength is 375 nm. The app cannot automatically detect the wavelength of the LED you are using. Be sure to update this value to match your LED.



- Change the Collection Settings as needed for your experiment.

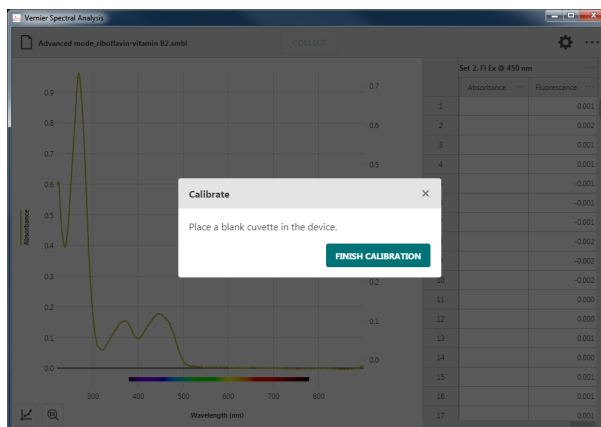
See [Appendix A](#) for a detailed description of the collection settings.

TIP! It may be necessary to make changes to the settings while you are collecting data to see how these changes affect the collected data.



- Calibration is not required in Fluorescence mode; however, you may want to calibrate before collecting Fluorescence data to set a baseline reading and to remove excitation-LED light scatter from your data.

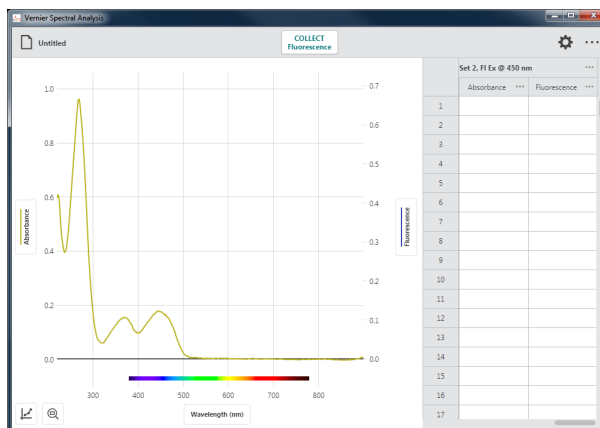
TIP! You will need a cuvette filled with the solvent you used to prepare your fluorescence sample. Click or tap **CALIBRATE** and follow the on-screen instructions.



- Click or tap off the Settings dialog or hit the ESC key to dismiss the dialog.

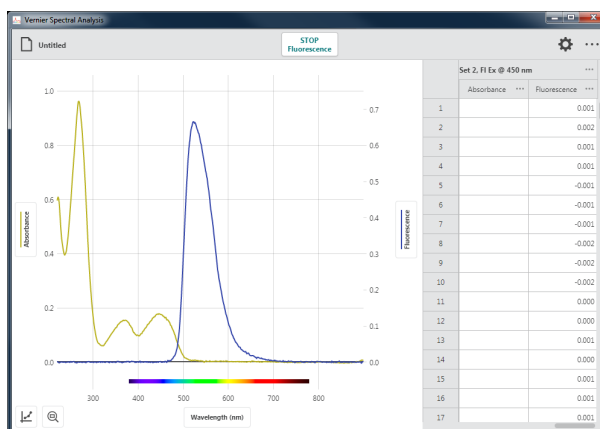
TIP! When data from two different sensor modes are collected, a second (right) y-axis control is used to allow independent scaling of different data types.

TIP! The first collected data type is plotted on the left y-axis. The second data type is plotted on the right y-axis. Subsequent data types are added to the left y-axis.



- With your sample still in the cuvette holder, click or tap **COLLECT Fluorescence** to start data collection.

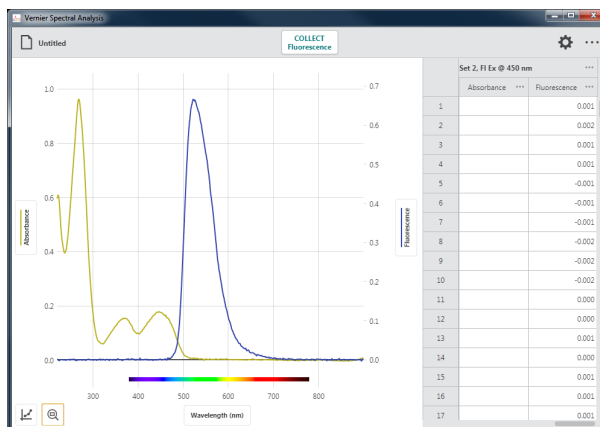
TIP! Notice that **COLLECT Fluorescence** changes to **STOP Fluorescence** while you are collecting data.



- Click or tap **STOP Fluorescence** to end data collection and continue with data analysis.

The graph automatically autoscales to fit the data.

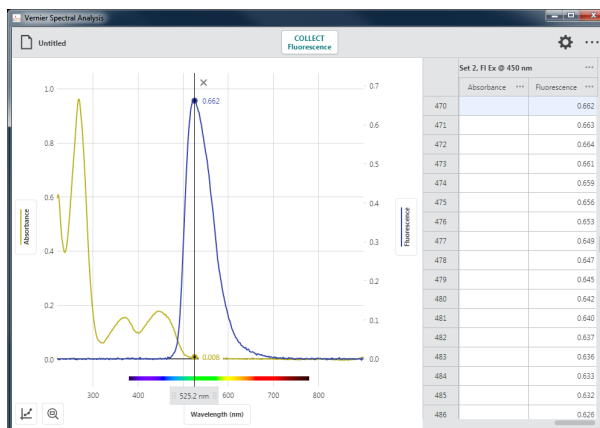
TIP! Data Sets in Spectral Analysis are symmetric. That is why there is an empty Absorbance column in the Fluorescence data set. There will also be an empty Fluorescence column added to the original Absorbance data set.



- Click or tap the graph to examine a data point. Click or tap another point or drag the examine line to view other data points.

Click or tap \times to dismiss the examine line.

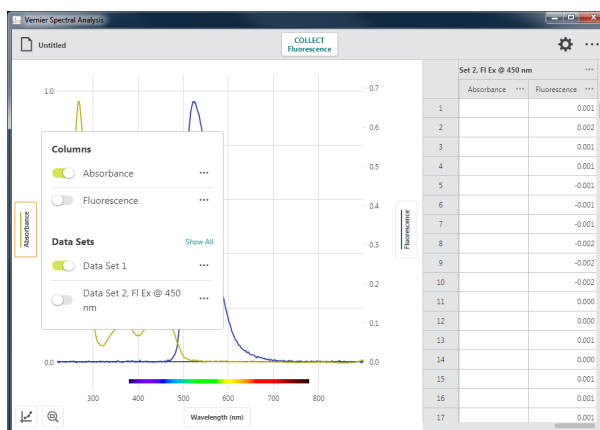
TIP! Notice that you are examining points from both graphs at the same time.



Collecting Additional data

You can continue to collect additional Full Spectrum data using these or other Sensor Modes as needed for your experiment.

TIP! Collecting additional data types (Transmittance, Emissions, or Raw) will have their data plotted on the left-axis. To change what is plotted on the graph, click or tap the left-axis or right-axis label and select the desired columns and data sets to plot.



TIP! When using Go Direct® SpectroVis® Plus, SpectroVis Plus, or SpectroVis, collecting Absorbance or Transmittance data after collecting data from one of the other data types (Fluorescence, Emissions) will require calibration of the sensor to maintain data accuracy, even if you had previously calibrated the spectrometer. This is because the spectrophotometer's internal light source must be turned off when using these other sensor modes.

The Vernier UV-VIS and Fluorescence/UV-VIS Spectrophotometers utilize shutters to block the different light sources, so recalibration is not required.


TIP! Spectral Analysis and Graphical Analysis™ 4 can be open at the same time. This is often helpful in Advanced Full Spectrum mode when collecting large sets of data. You can collect your full spectra of absorbance and fluorescence in Spectral Analysis and analyze it at the same time in Graphical Analysis 4 in manual entry mode.

IX. ANALYZING DATA

Applying a Curve Fit

Apply a curve fit to find the equation of the best-fit curve based on your data. Curve fit models include Proportional, Linear, Quadratic, Power, Inverse, Inverse Squared, Natural Exponent, Natural Log, Sine, Cosine, and Cosine Squared. A curve fit is useful when interpolation and extrapolation are needed to estimate data values using your collected data.

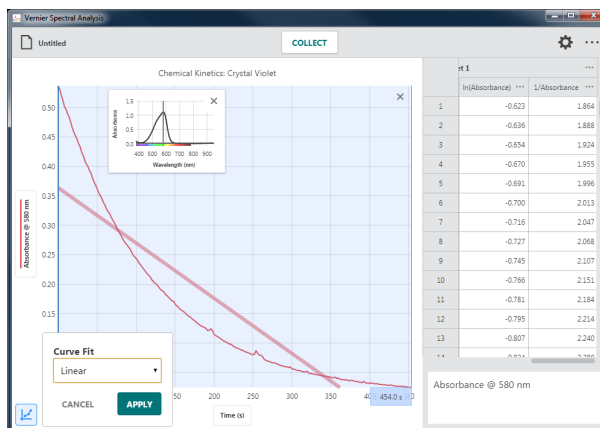
Follow the steps below to apply a curve fit to your data.

1. Click or tap  to access the graph tools.

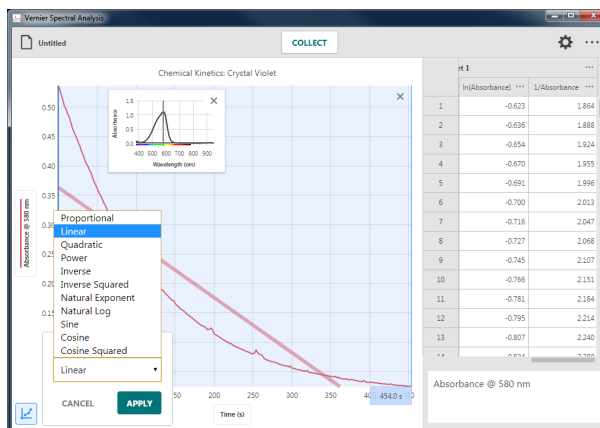


2. Choose Apply Curve Fit. The default model is linear.

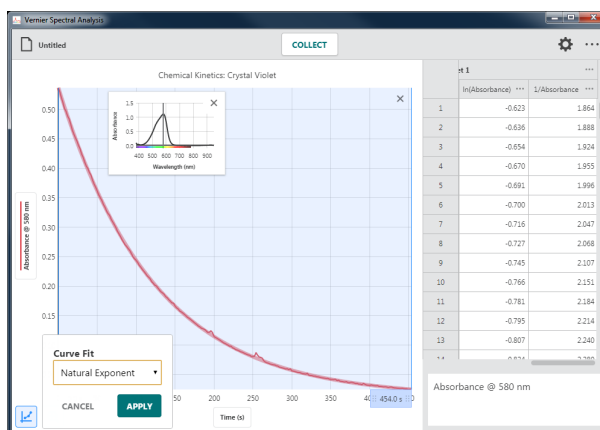
TIP! Curve fits are based on all of the data when Apply Curve Fit is selected without first selecting a region. To fit a curve based on a portion of your data, select a region before accessing the curve fit tool.



- Click or tap the curve fit drop-down to view the available curve fit models.



- Select a curve fit model to preview the fit with your data.

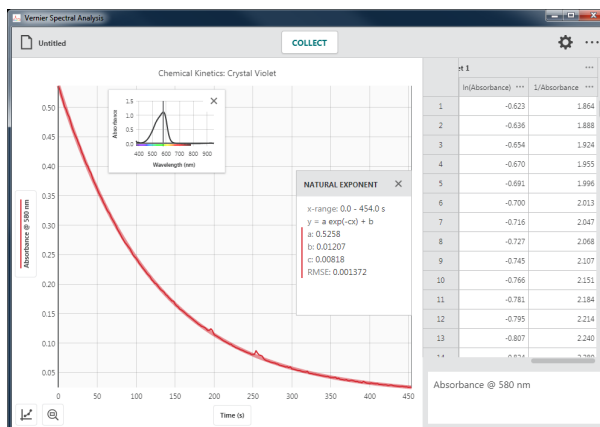



- Click or tap **APPLY** to display the curve fit equation and coefficients. Curve fits for all plotted columns are calculated.

The curve fit details dialog includes the RMSE (root mean square error), a measure of how well the fit matches the data.

TIP! You can reposition the curve fit details dialog by dragging it up and down the right boundary of the associated region.

TIP! You can manually adjust the curve fit region by dragging the edges. The curve fit equation will automatically update.




- To view graph values based on a curve fit model, you will need to use the Interpolate feature. Click or tap  to access the graph tools and select Interpolate.

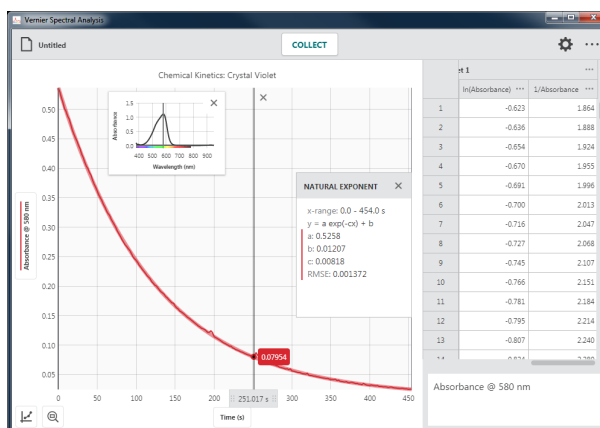
TIP! When Interpolate is used without a curve fit model, the examine line will follow the straight-line path between two data points and will not move beyond your data points (extrapolate).



- Click or tap on the graph to examine the curve fit. The data values reported are calculated using the curve model evaluated at the point selected.


TIP! To extrapolate beyond your data points, you will need to rescale the graph.

TIP! Click or tap  in the curve fit details dialog to remove the curve fit from the graph.



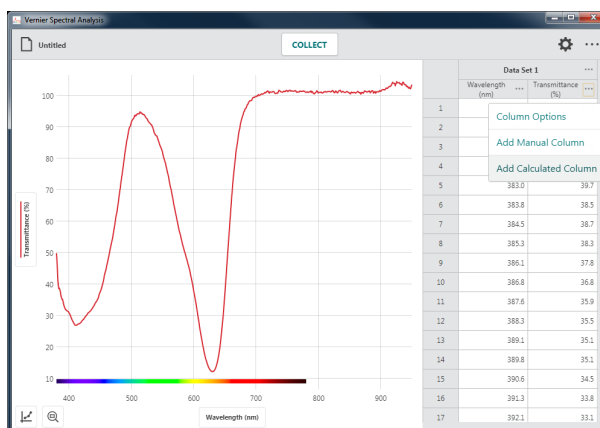
Adding Calculated Columns

Calculated columns are data columns with values calculated from other data columns based on a mathematical formula. A calculated column is useful when you need to transpose data that can be analyzed graphically with a linear or other function.

- Click or tap  next to a column name to access the column tools.

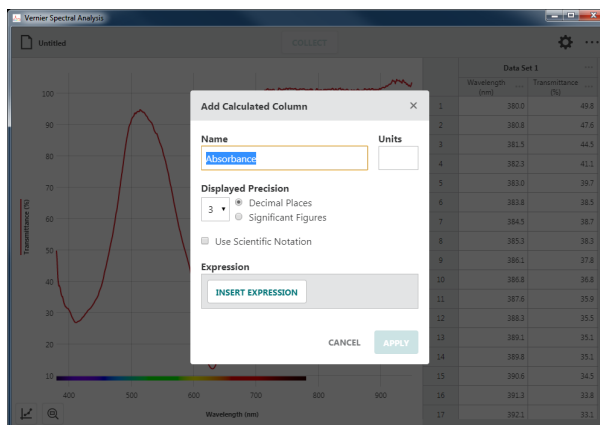
TIP! The available options depend on the type of column you have. Options include Column Options, Add Manual Column, Add Calculated Column, and Delete Column.

TIP! Since data sets are symmetric, columns added or modified in one data set are likewise added or modified in all data sets.



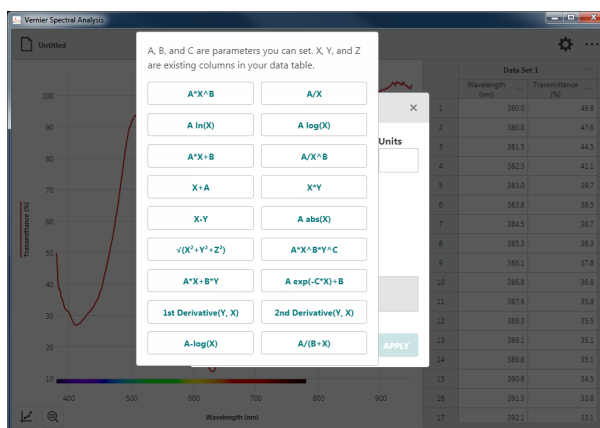
- Choose Add New Calculated Column to create a new calculated column.

You can modify the column name, add units, and adjust the display precision of the new column as desired.



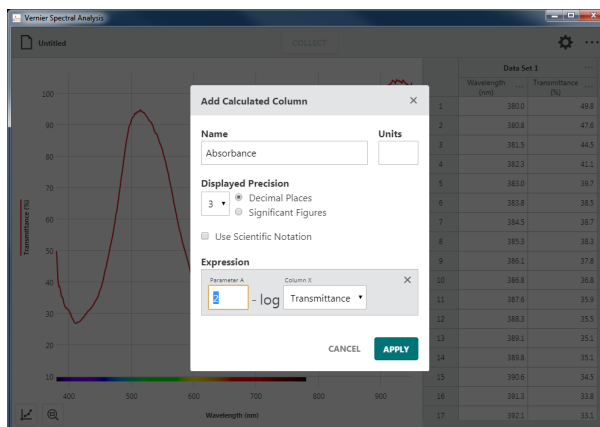
- Click or tap **INSERT EXPRESSION** to view your expression options.

TIP! A, B, and C represent constants. X, Y, and Z represent data columns from your data table.



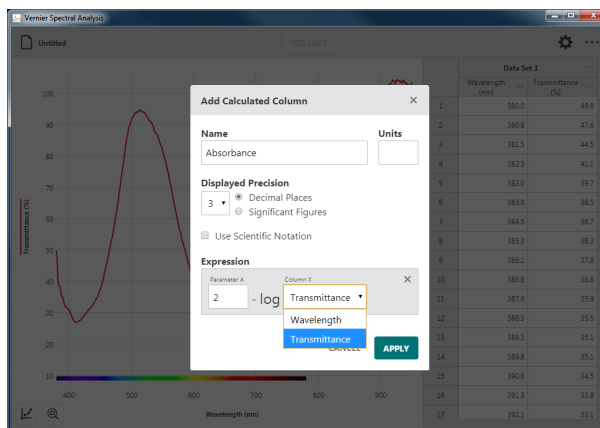
- Select the desired expression to use for your calculated column.

Modify the constants as needed.



- Click or tap on the column drop-down and modify the column selection as needed.

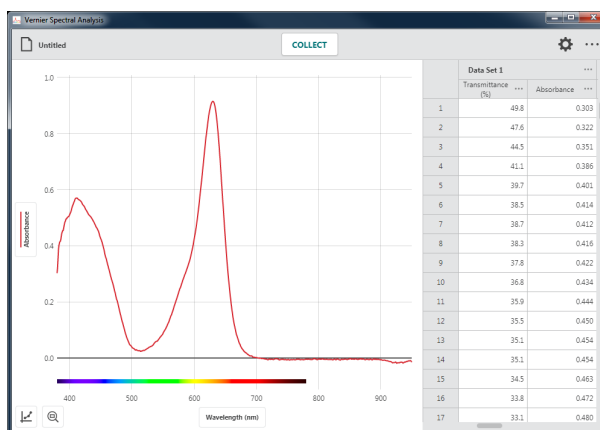
TIP! The column from which you accessed the column tools is used in the calculated column expression by default.



- Click or tap **APPLY** to create the calculated column.

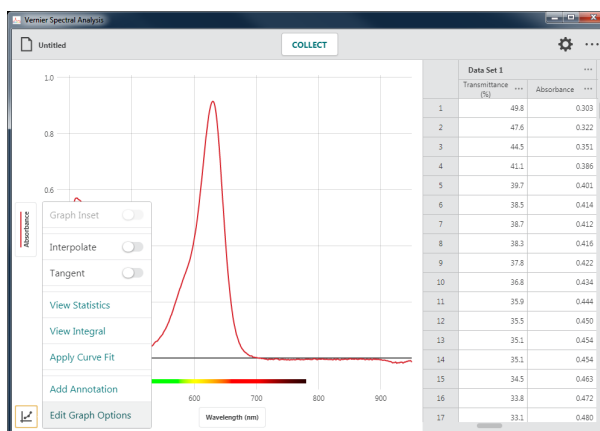
TIP! The new calculated column will appear in the table to the right of the column used to access the column tools.

TIP! The new calculated column is plotted on the graph replacing the column upon which the calculated column is based. If the original column is not plotted when the calculated column is created, the calculated column will not be plotted automatically.

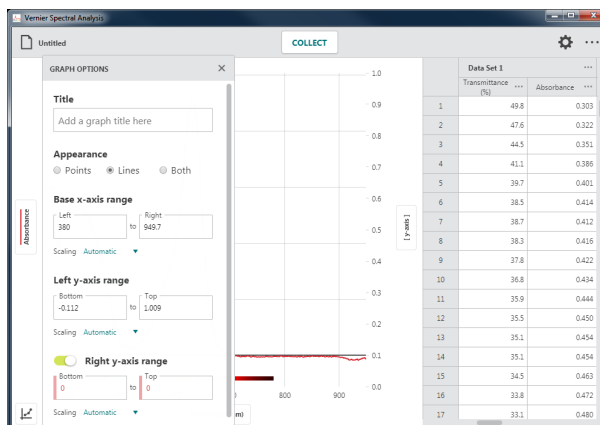


- To plot the original data along with the calculated column data, you can use a second, right y-axis. This feature independently scales the two data columns to fit the graph.

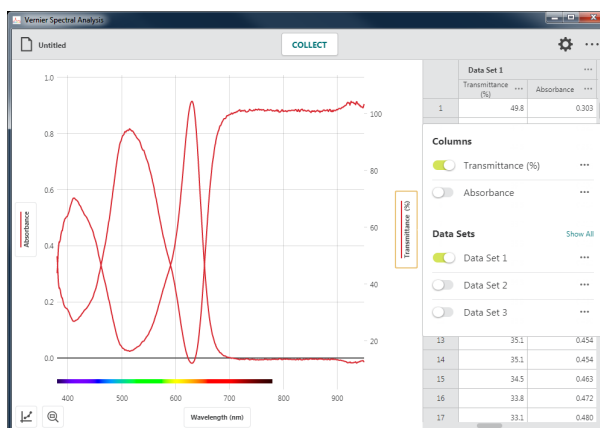
Click or tap and select Graph Options.



- Click or tap Right y-axis range to add a second y-axis control to your graph.



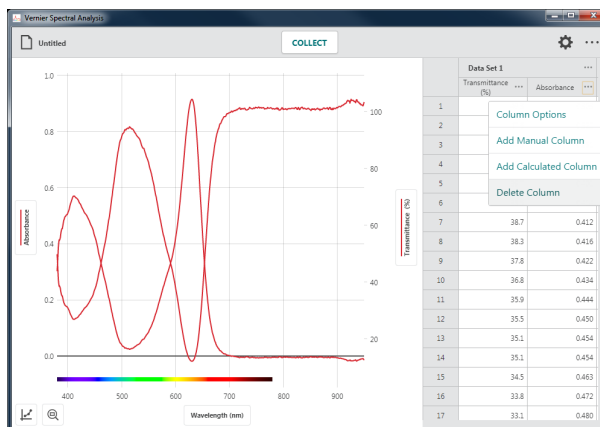
- Click or tap [y-axis] and select the column(s) and data set(s) you want plotted on the right y-axis.



Deleting a Calculated Column

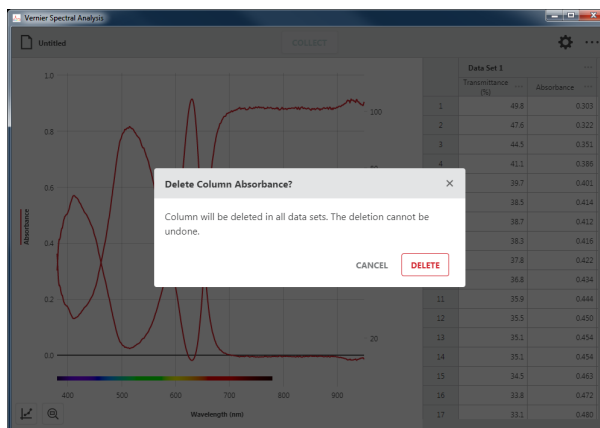
- To delete a calculated column, click or tap **⋮** next to a column name you want to delete. Choose Delete Column to remove the calculated column.

TIP! Spectrometer data, wavelength, and time columns cannot be deleted.

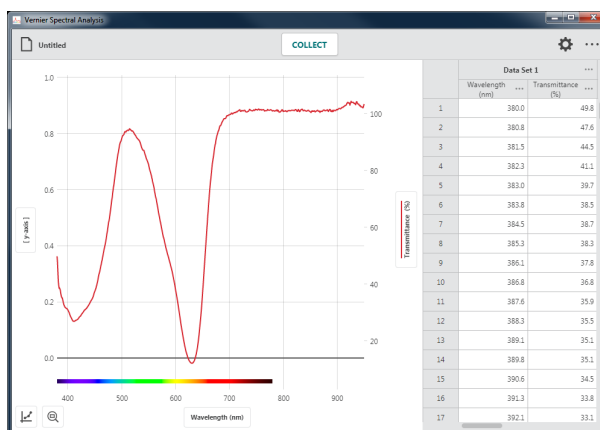


2. Deleting a column cannot be undone. Click or tap **DELETE** to confirm the deletion.

TIP! Since data sets are symmetric, deleting a column from one data set will remove the corresponding column from all data sets.



If the calculated column was plotted when deleted, it is removed from the graph.



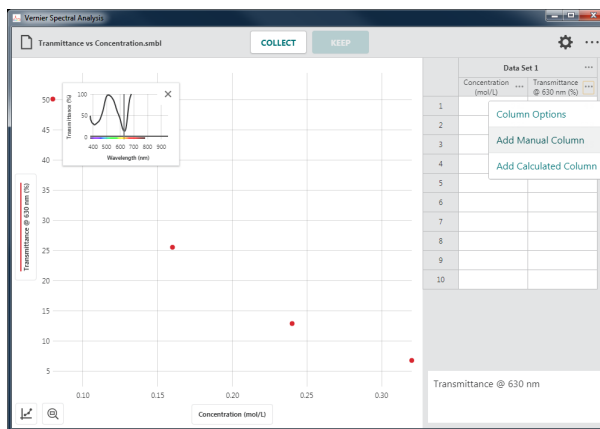
Adding Manual Columns

Manual columns are data columns that require manual data entry. Use manual columns when you want to enter hand-calculated data.

1. Click or tap **...** next to a column name to access the column tools.

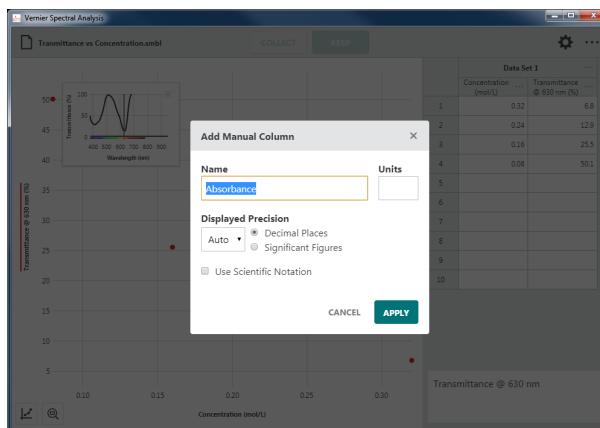
TIP! The available options depend on the type of column you have. Options include *Column Options*, *Add Manual Column*, *Add Calculated Column*, and *Delete Column*.

TIP! Since data sets are symmetric, columns added or modified in one data set are likewise added or modified in all data sets.



2. Choose Add Manual Column to create a new manual-entry column.

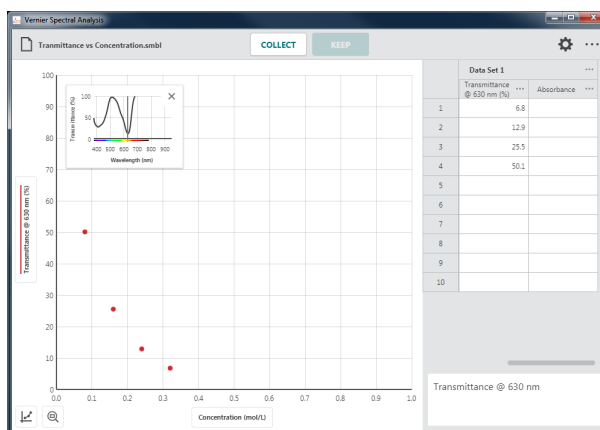
You can modify the column name, add units, and adjust the display precision of the new column as desired.



3. Click or tap **APPLY** to create the manual column.

TIP! The new calculated column will appear in the table to the right of the column used to access the column tools.

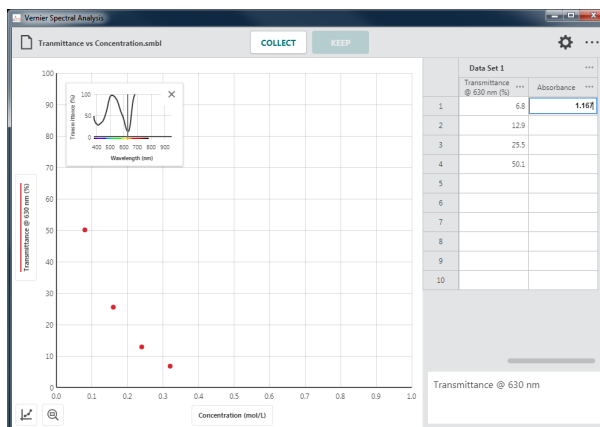
TIP! The new manual column is not plotted on the graph automatically.



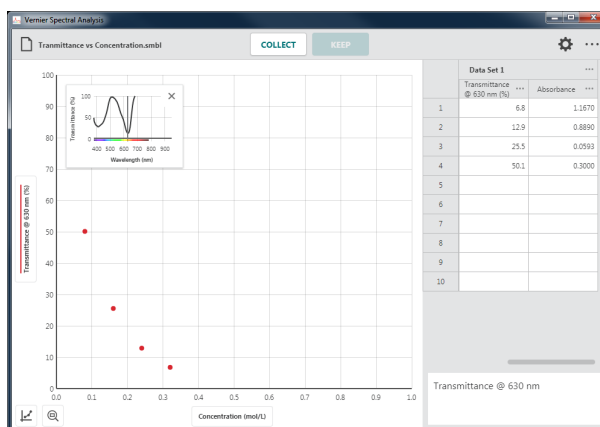
4. Double-click or double-tap in a manual column cell to enter a value.

TIP! You can use Cut, Copy, and Paste tools to add values into manual columns.

TIP! The event-based “Concentration or Event” column is also a manual column that can be edited.

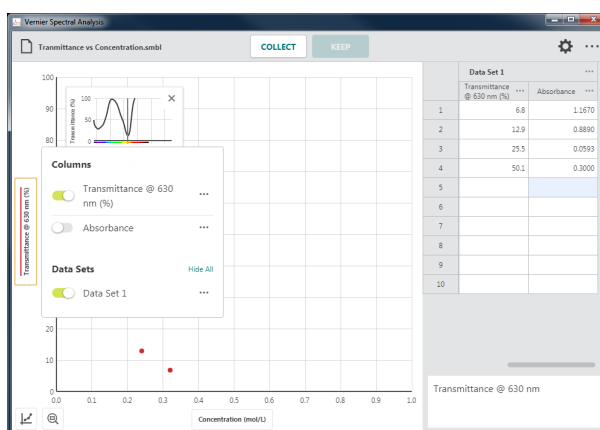


5. Enter data values into the table.



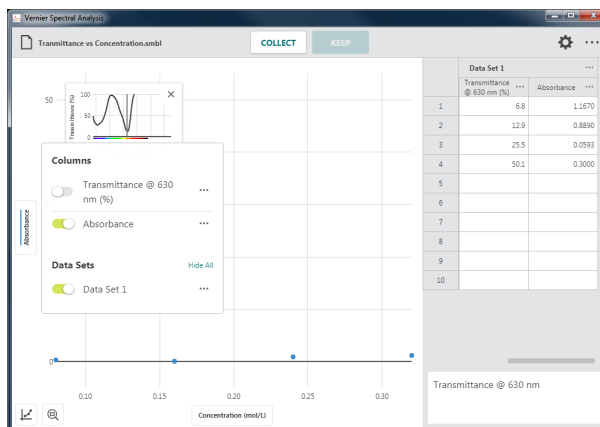
6. Click or tap the left-axis (y-axis) label to change what is plotted on the graph.


TIP! You can also plot the data using a second, right y-axis. See *Adding a Calculated Column (steps 7–9) for instructions.*

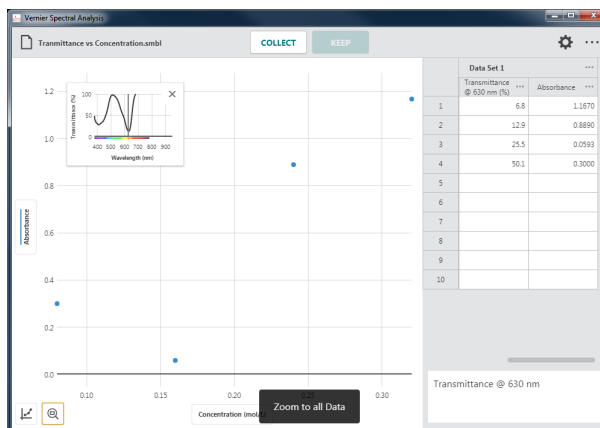


7. Modify the selection to plot the manual column data on the graph.

TIP! Click or tap a column name to add or remove the column from the graph.



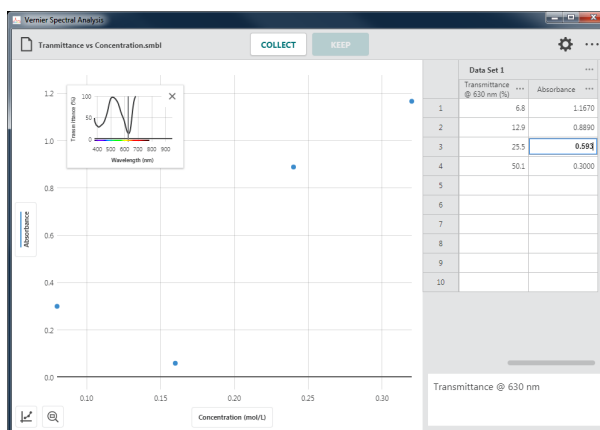
- Click or tap  to autoscale the graph to fit your data.



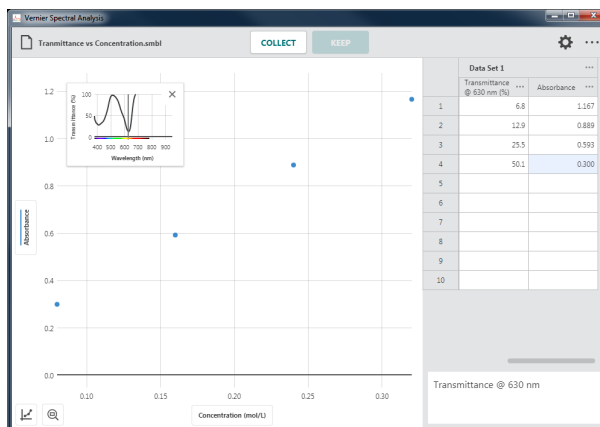
Modifying a Manual Column Entry

- Errors in data entry can be corrected.

Double-click or double-tap in a manual column cell to modify the entry.



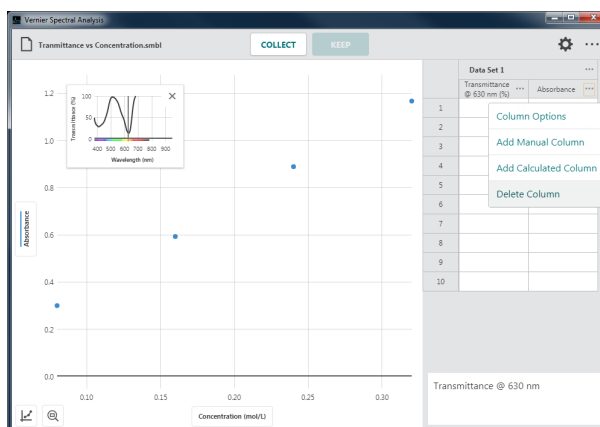
- The graph will automatically update as data values are corrected.



Deleting a Manual Column

1. To delete a manual column, click or tap **•••** next to a column name you want to delete. Choose Delete Column to remove the Manual Column.

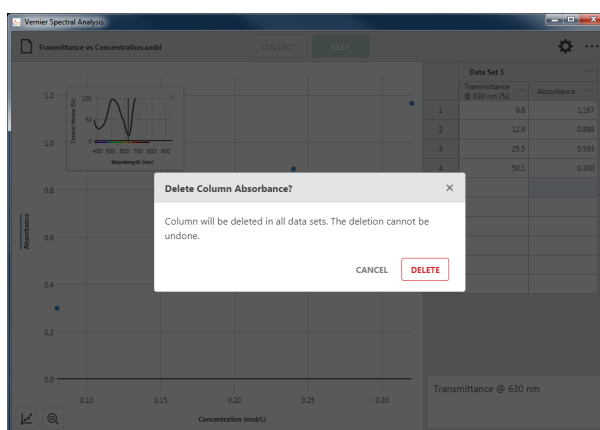
TIP! Spectrometer data, wavelength, and time columns cannot be deleted.



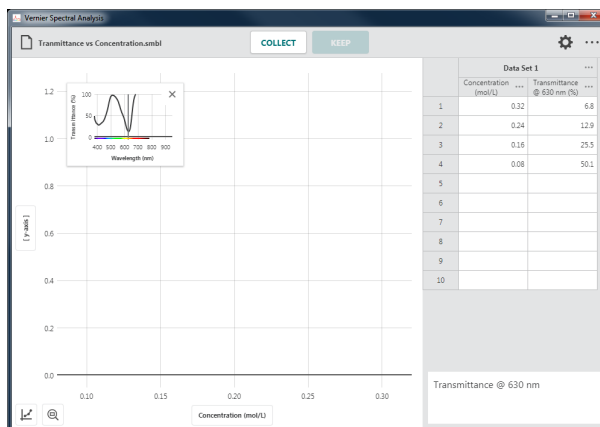
2. Deleting a column cannot be undone.

Click or tap **DELETE** to confirm the deletion.

TIP! Since data sets are symmetric, deleting a column from one data set will remove the corresponding column from all data sets.



If the calculated column was plotted when deleted, it is removed from the graph.



Using Cut, Copy, and Paste Tools

Select Cells

- Click or tap a single cell.
- To select a range of cells, click-and-drag or touch-and-drag.
- To select a single row, click or tap a row number.
- To select a range of rows, click-and-drag or touch-and-drag along the row numbers.
- To select a single column, click or tap a column header.
- To select a range of columns, click-and-drag or touch-and-drag across the column headers.
- To select a single data set, click or tap a data set header.
- To select a range of data sets, click-and-drag or touch-and-drag across the data set headers.

Copy to the Clipboard

- **Windows[®]**: Right-click and select Copy (or Ctrl-C)
- **macOS[®]**: Command-C (⌘-C)
- **Chromebook[™]**: Alt-click and select Copy (or Ctrl-C)
- **iOS and Android[™]** (and other touch-screen devices): Long-touch within the selection and select Copy

Cut (and Copy) to the Clipboard

- **Windows**: Right-click and select Cut (or Ctrl-X)
- **macOS**: Command-X (⌘-X)
- **Chromebook**: Alt-click and select Cut (or Ctrl-X)
- **iOS and Android** (and other touch-screen devices): Long-touch within the selection and select Cut

Paste from the Clipboard


- **Windows**: Right-click and select Paste (or Ctrl-V)
- **macOS**: Command-V (⌘-V)
- **Chromebook**: Alt-click and select Paste (or Ctrl-V)
- **iOS and Android** (and other touch screen devices): Long-touch within the selection and select Paste

TIP! When using Paste to copy data from multiple columns, you must first add the appropriate number of manual columns to your data table.

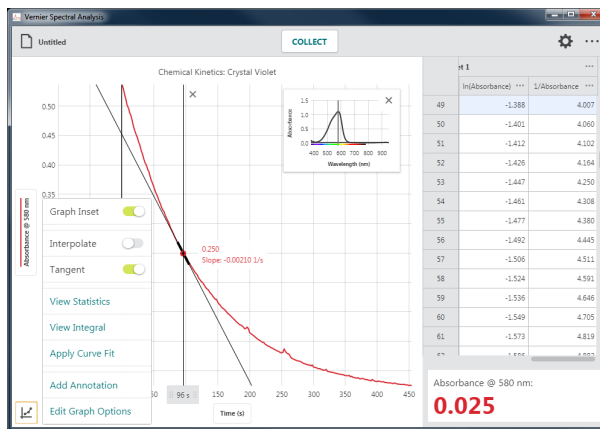
Using Other Analysis Tools

Below are some additional data analysis tools available in Spectral Analysis.


Tangent

Click or tap  and choose Tangent to calculate the rate of change of the data (slope) at the examined point. The tangent value is determined based on the points immediately around the examined point.

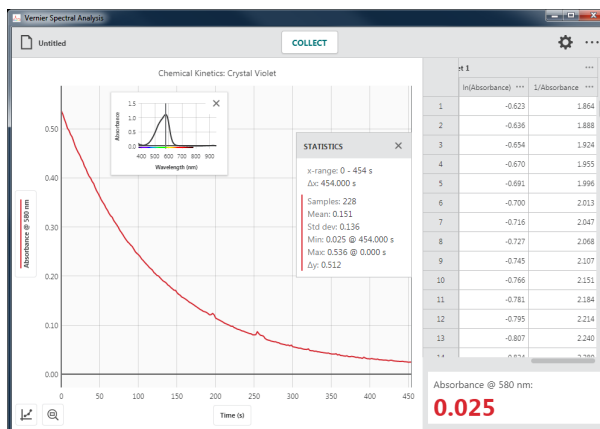
TIP! You cannot use Interpolate and Tangent at the same time. Choosing one will de-select the other.




View Statistics

Click or tap  and choose View Statistics to calculate statistical attributes based on your data. Displayed values include number of points, mean, standard deviation, minimum, maximum, and range. Statistics for all plotted columns are calculated.

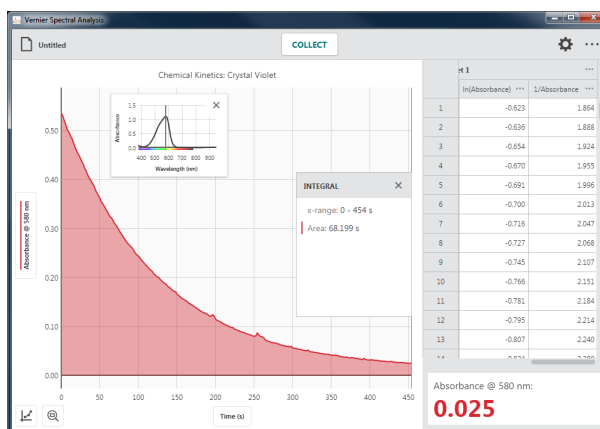
TIP! The statistics are based on all of the data when View Statistics is selected without first selecting a region.



View Integral


Click or tap  and choose View Integral to calculate the numerical integral (area) associated with your data. The associated area is shaded and the value is displayed. Regions above the bottom-axis (x-axis) are positive, while regions below are negative. Areas for all plotted columns are calculated.

TIP! Integrals are based on all of the data when View Integral is selected without first selecting a region.

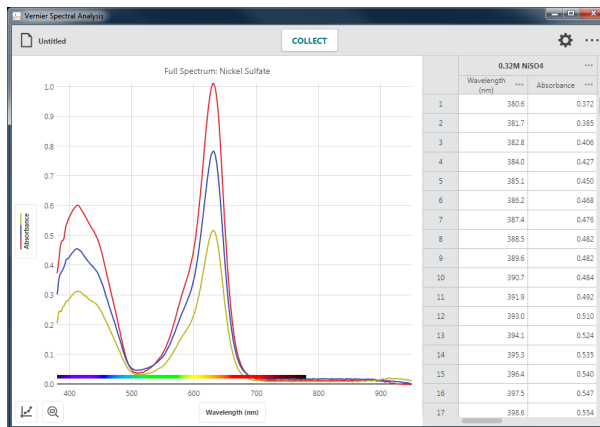


Scaling the Graph

There are multiple tools within Spectral Analysis to help you adjust the graph to best display your data.

Zoom – 


The Zoom button allows you to quickly rescale the graph.



To scale the graph to a specific section of your data, click-and-drag or touch-and-drag across the graph to select the desired region.


TIP! You can click-and-drag or touch-and-drag the boundaries of a selected region to adjust the region as needed.



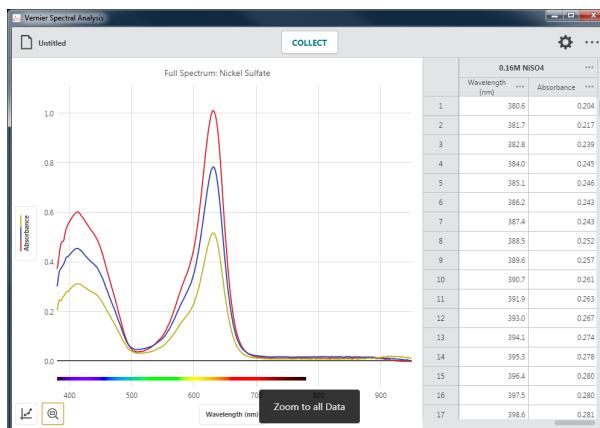
When a region is selected, click or tap  to rescale the graph to fit the selection.

The left and right boundaries will match the selected region. The top and bottom boundaries will automatically adjust to show all data within the region.



When there are no selected data, click or tap  to rescale the graph to fit all data points.

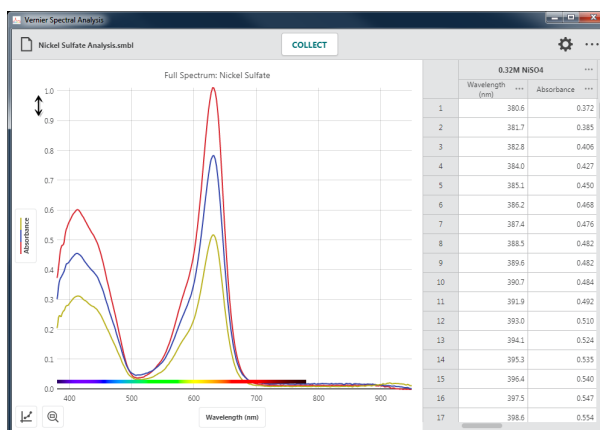
The left and right boundaries will match the left and right extremes of your data. The top and bottom boundaries will automatically adjust to show all data.




Panning the Graph

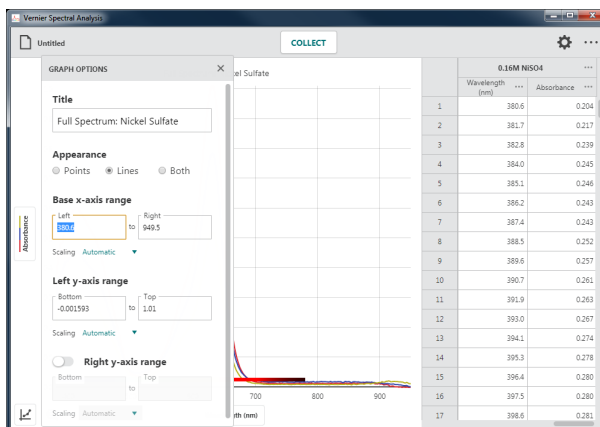
Click-and-drag or touch-and-drag near one of the axes to pan, or move the graph without changing the scaling. Starting near the bottom-axis (x-axis) will pan the graph horizontally. Starting near the left-axis or right-axis (y-axis) will pan the graph vertically.

TIP! In addition to panning, touch-screen devices can use a two-finger pinch gesture to rescale the graph.



Manual Graph Scaling

Click or tap  and select Graph Options to manually configure the graph range. Adjust the base (x-axis) and left (y-axis) range values as needed.



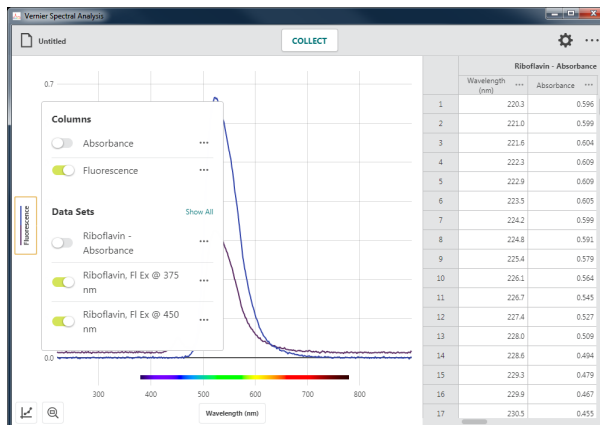
X. MODIFYING THE APPLICATION DISPLAY

Changing What is Graphed

Left-Axis Label (y-axis)

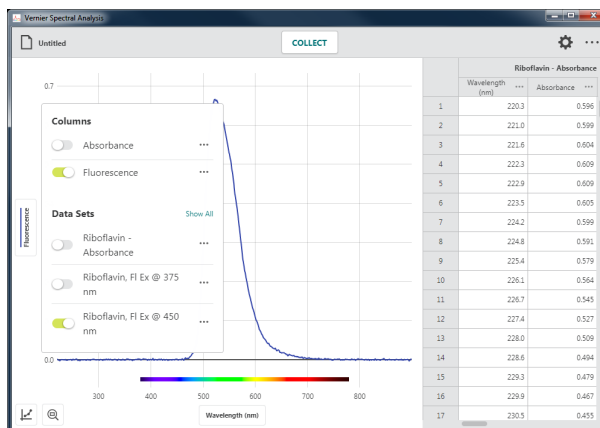
Click or tap the left-axis label to change the data that is plotted on the graph. Click or tap a column name to add or remove the column data from the graph.

Tip! Column data for all selected data sets are displayed on the graph.



Click or tap a data set name to show or hide the selected column data for a specific data set.

Tip! Use the Show All and Hide All options to quickly show or hide data from every data set.

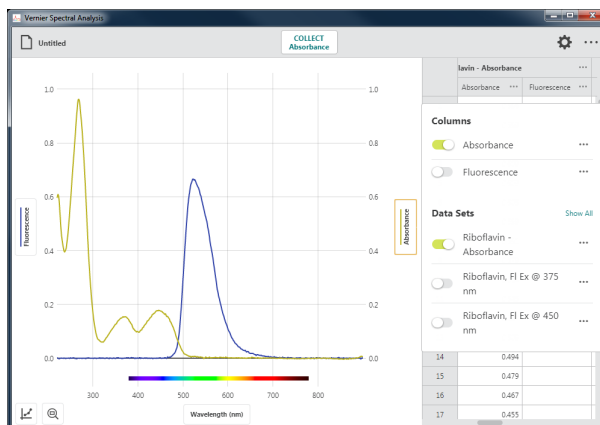


Right-Axis Label (double y-axis)

Click or tap the right-axis label to change the data that is plotted on the graph.

- Click or tap a column name to add or remove the column data from the graph.
- Click or tap a data set name to show or hide the selected column data for a specific data set.

Tip! The right-axis label provides all of the same functionality as the left-axis label.



Bottom-Axis Label

Click or tap the bottom-axis (x-axis) label to select the desired independent variable for your graph. Only one column can be used as the independent variable for any graph.

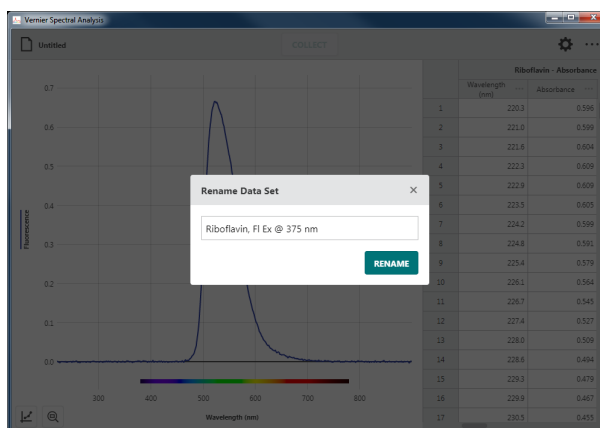
TIP! You cannot plot a column vs. itself. If the column you select for the independent variable is already plotted, that column will be removed from the vertical axis.



Renaming Data Sets and Columns

Data Set Names

Click or tap ... next to a data set name and choose Rename Data Set to change the default data set name.

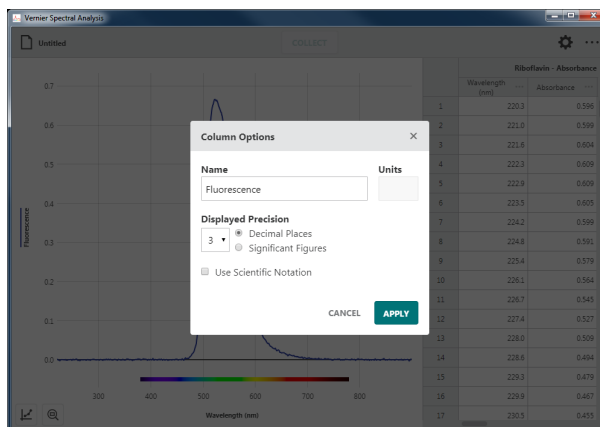


Column Options (Name and Display Precision)

Click or tap ... next to a column name and choose Column Options to change the column name and displayed precision.


TIP! For manual and calculated columns, you can also change the units from this dialog.

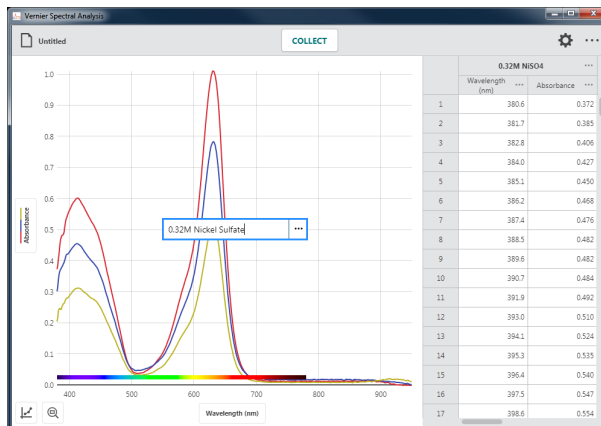
TIP! For calculated columns, you can also modify the calculation.



Adding Annotations

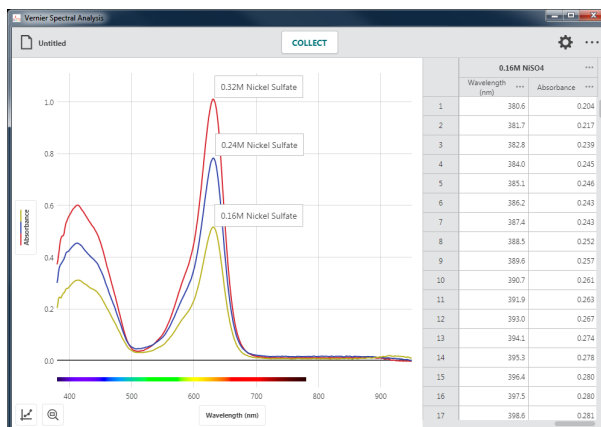
Adding a Graph Annotation

Click or tap  and choose Add Annotation to add text labels to your graph.



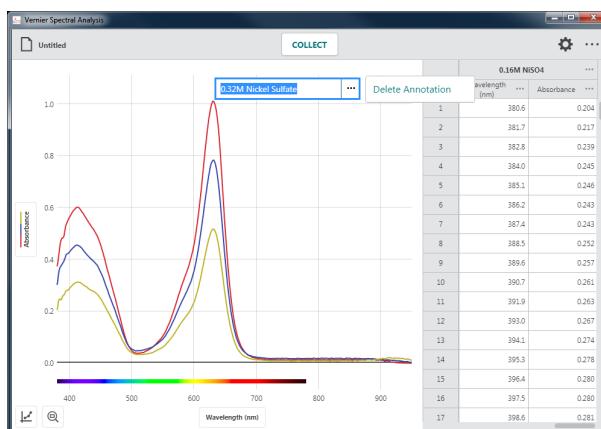
Click-and-drag or touch-and-drag an annotation to reposition it on the graph.

TIP! You can add multiple annotations to a graph.




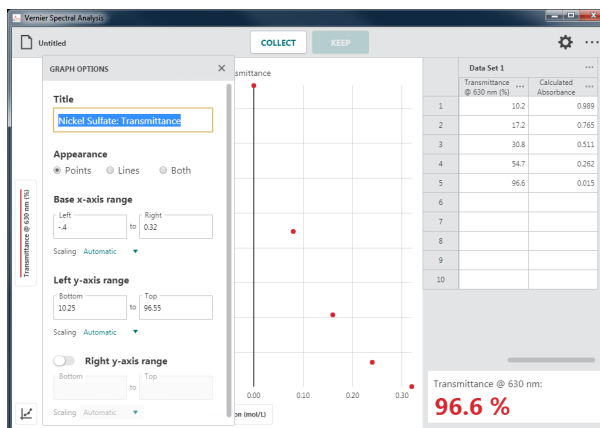
Double-click or double-tap an existing annotation to edit the text.

Click or tap  to delete the annotation.




Title

Click or tap  and choose Graph Options to add a title to your graph. The title will appear centered above the graph.



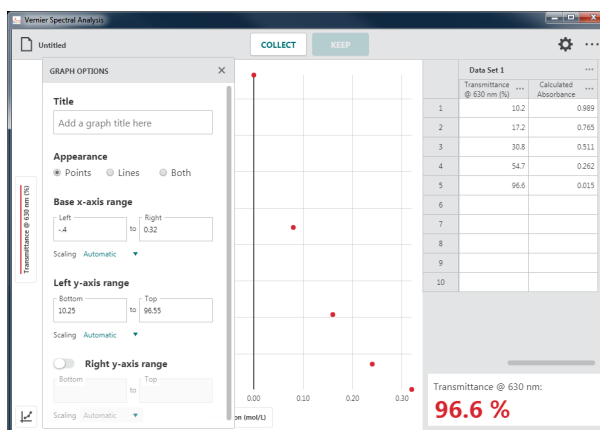
Adjusting the Appearance

Graph Appearance

Click or tap  and choose Graph Options to manually configure the graph appearance.

- Points

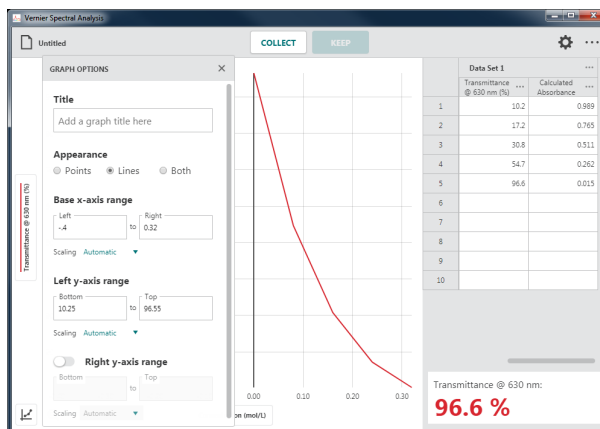
Choose Points to show data as unconnected dots. This is the default option for event-based spectrometer experiments.



- Lines

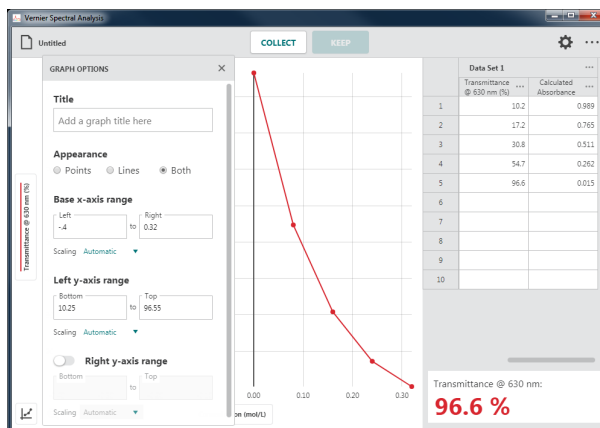
Choose Lines to show linear segments drawn between the data points.

This is the default option for full spectrum and time-based spectrometer experiments.




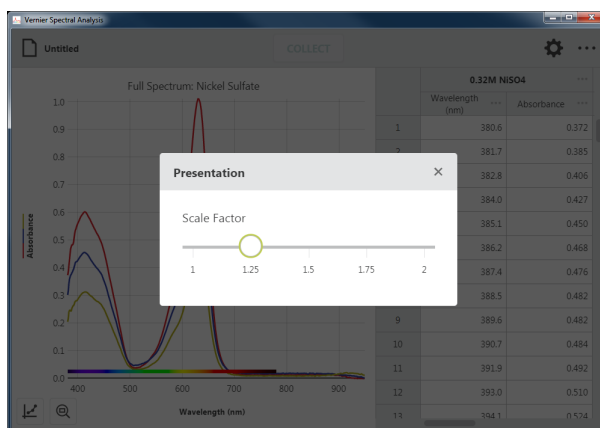
- Both

Choose Both to show data as dots connected by linear segments.




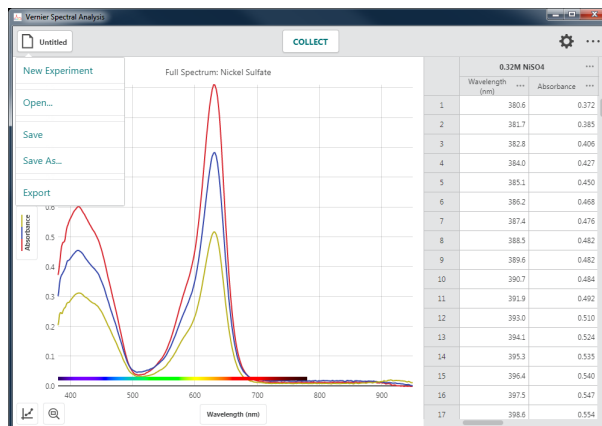
Overall Presentation

Click or tap  from the top toolbar and choose Presentation to modify the font-size scale factor used in Spectral Analysis. This is particularly useful when presenting the app with a projector or viewing the app on a device with a high-resolution screen.



XI. MANAGING FILES


Click or tap  to access the File menu. From the File menu, you can open, save, and export Spectral Analysis files, along with other tasks.



Saving a File

Spectral Analysis files contain data-collection settings, graphs, data tables, and analyses. These files have .smbl extensions and can be opened and modified on any device running Spectral Analysis. The data from these files can also be opened using our Logger Pro 3 software.

Save

Click or tap  to access the File menu. Choose Save to save the current file. If your file has not been saved, a Save File dialog will be displayed. Enter the desired file name and storage location to save the file. You can save the file directly to your device, to an accessible cloud storage location such as Google Drive™ or Dropbox, or to a connected storage device such as a USB drive or SD card. **Note:** Not all options are available on every platform.


If your file has already been saved, choosing Save will overwrite the previously saved file with the current file (in the same file location) without user confirmation.

TIP! The file menu icon will show the name of the file once the file is saved (e.g., ).

Save As...


Choose Save As... from the File menu to display the Save file dialog. You can rename the file and save it to a new storage location. Save As will not automatically overwrite a previously saved file.

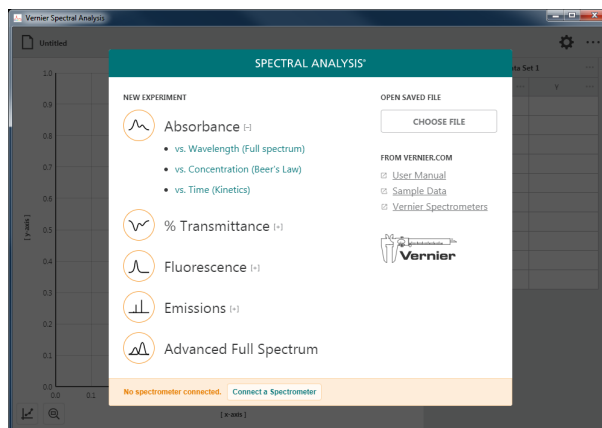
Opening a File

Click or tap  to access the File menu. Choose Open... to display your device's Open File dialog. You can access files stored on your device, from an accessible cloud storage location such as Google Drive or Dropbox, or from a connected storage device such as a USB drive or SD card. **Note:** Not all options are available on every platform.

You can choose to open previously saved Spectral Analysis (.smbl) files or comma separated

value (.csv) files.


You can also open a file from the New Experiment dialog. Click or tap  to display your device's Open File dialog.



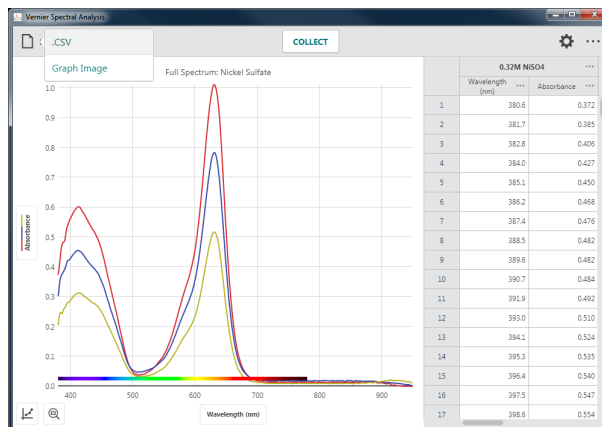
Exporting a File


There are two options for exporting a file: .CSV and Graph Image.

Export .CSV

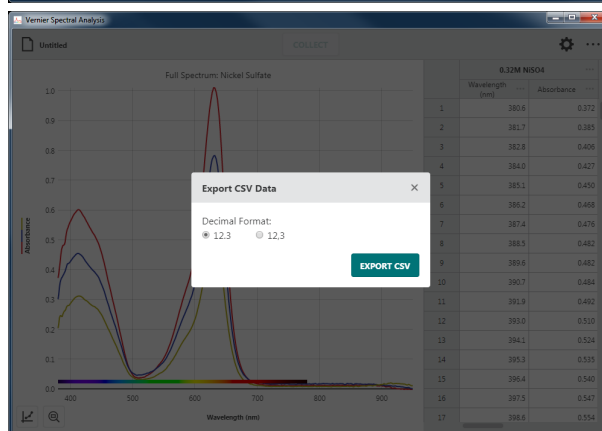
Click or tap  to access the File menu.

Choose Export ► .CSV to export your experimental data as a .CSV file.




Select the appropriate decimal separator for your data, then click or tap  to save the file.

TIP! Use this feature to save the data in .csv format for further analysis with a spreadsheet application or to print your data.



Export Graph Image

Click or tap  Untitled to access the File menu. Choose Export ► Graph Image to export your experimental data as an image file (.png) of the Spectral Analysis graph.

TIP! Use this feature to create images of your data for inclusion in a lab report or for submission to an instructor via file sharing, emailing, or printing.



Printing a File

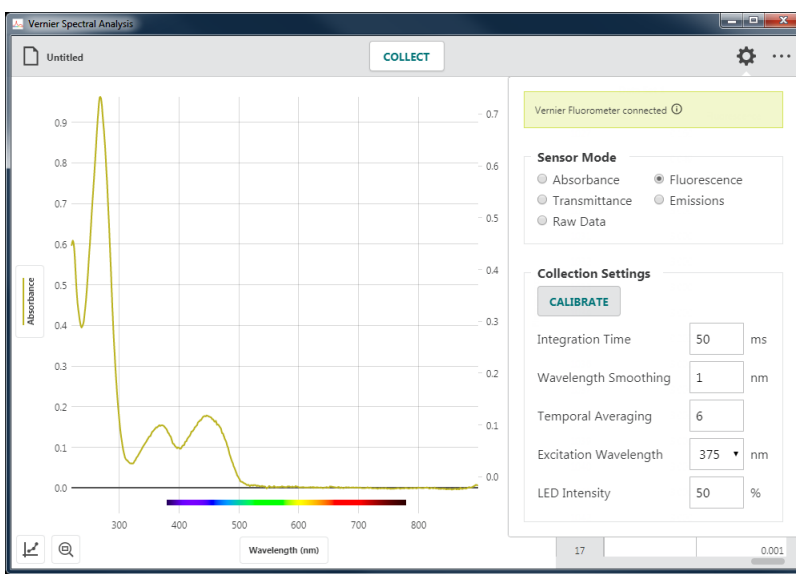
You cannot print directly from Spectral Analysis. To print a Spectral Analysis file, use File ► Export to create the desired file (.csv or .png). Print the resulting file using the print options available on your device.

TIP! For more information regarding printing from Spectral Analysis, see www.vernier.com/ti/3789


APPENDICES

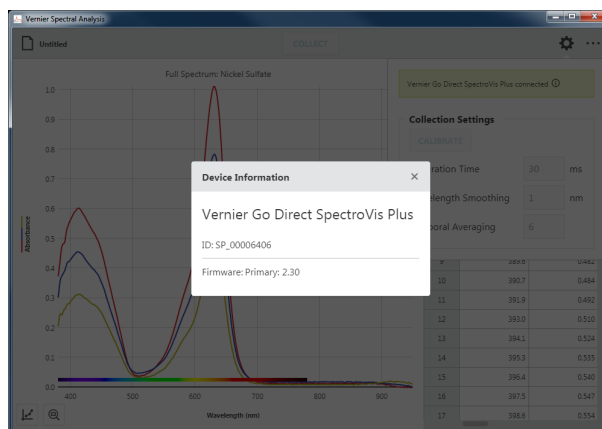
APPENDIX A – Spectrometer Settings

The following information describes the spectrometer setting options available in Spectral Analysis. The available tools depend on the experiment type and the connected spectrometer.



Device Information

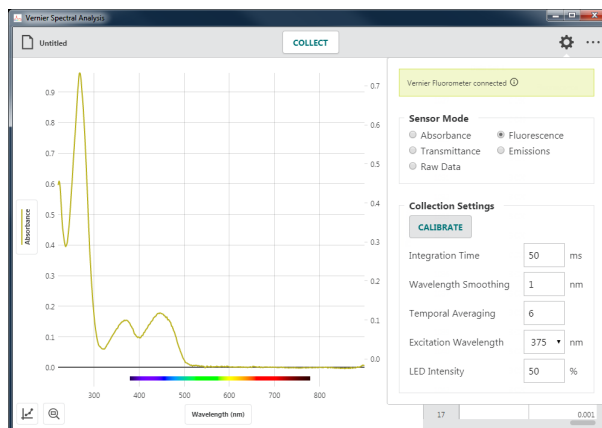
Click or tap  to view information about the connected spectrometer.



Sensor Mode

This option is only shown for an Advanced Full Spectrum experiment.

Select the type of full spectrum data you want to collect. Choices include Absorbance, Transmittance, Fluorescence, Emissions, or Raw Data. Available choices depend on the spectrometer you are using.



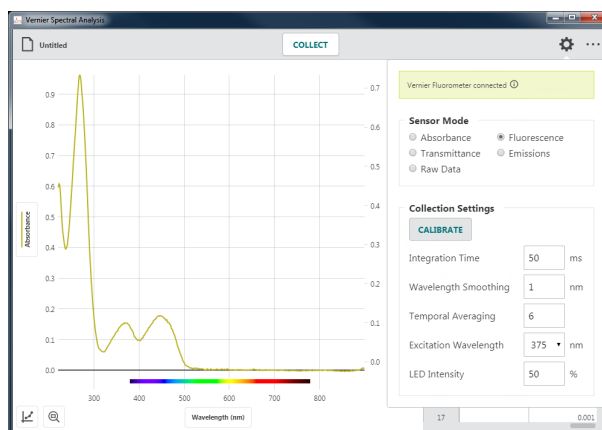
Collection Settings

The available options depend on the experiment type and the connected spectrometer.

- **Calibrate**

Click or tap **CALIBRATE** to start a new calibration from Settings.

TIP! **CALIBRATE** is not available while you are actively collecting data.



TIP! For fluorescence and emission data collection, it is best to determine the Collection Settings parameters before performing the calibration. This can be an iterative process to get your best data.

- **Integration Time**

Values are whole numbers between 0 and 500 ms.

The integration time is the time that the individual diodes in the sensor array are exposed to light before the reading is recorded and reset to zero. The diodes respond linearly to light until they approach saturation.

TIP! This is the most commonly manipulated parameter.

TIP! For Absorbance and % Transmittance experiments, the integration time is determined during calibration and is not editable.

- **Wavelength Smoothing**

Values are whole numbers between 1 and 10.

Wavelength smoothing is used to reduce the affects of noise on your spectrometer measurements. The smoothing calculation uses a boxcar average of a specific number of points on either side of the measured wavelength. A value of 5 will average each data point with the five data points on either side of that point, averaging 11 values for each reading.

***TIP!** The higher the wavelength smoothing value, the higher the signal to noise ratio for your data. However, there is a corresponding loss in spectral resolution. This can result in a peak maxima being shifted and inaccurate.*

- **Temporal Averaging**

Values are whole numbers between 1 and 10.

Use this value to determine the number of internal measurements that are used to determine the reported spectrometer reading. The more readings that are averaged, the better the signal to noise ratio. This directly impacts the time between reported measurements.

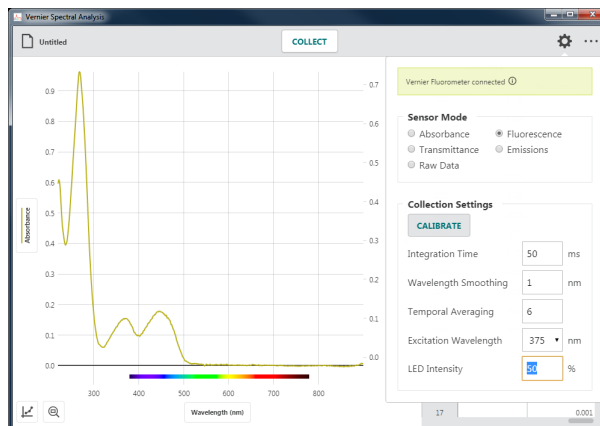
***TIP!** A value of 10 will average ten internal readings before reporting a value. If your Integration Time is set to 500 ms, the spectrometer readings will be updated once every 5 seconds.*

***TIP!** You cannot modify this value when using Go Direct[®] SpectroVis[®] Plus connected to your device via Bluetooth[®] wireless technology.*

- **LED Intensity**

Values are whole numbers between 0 and 100%.

This value is only available when collecting fluorescence data using the Vernier Fluorescence/UV-VIS Spectrophotometer. Use this to control the excitation-LED intensity. Use this feature to explore the affects of excitation intensity on fluorescence.



- **Collection Interval**

The Collection Interval can be any whole number from 1 to 3600 seconds. The smallest value is determined based on the collection settings. The software will calculate this value for you. If a smaller value is desired, consider lowering the Integration Time, Wavelength Smoothing, or Temporal Averaging, if possible.

If you are using Go Direct[®] SpectroVis[®] Plus connected via Bluetooth[®] wireless technology, the minimum value is 3 seconds.



- **Excitation Wavelength**


Click or tap the drop-down to select that desired excitation wavelength. The wavelength options shown depend on the spectrometer you are using.


When using SpectroVis Plus or Go Direct SpectroVis Plus, the selection is used to turn on the excitation LED. The default wavelength is 500 nm.

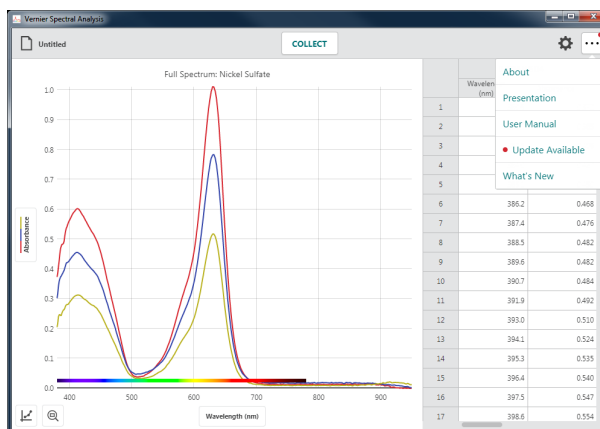
When using the Vernier Fluorescence UV-VIS spectrometer, the default excitation wavelength is 375 nm. The app cannot automatically detect the wavelength of the LED you are using.



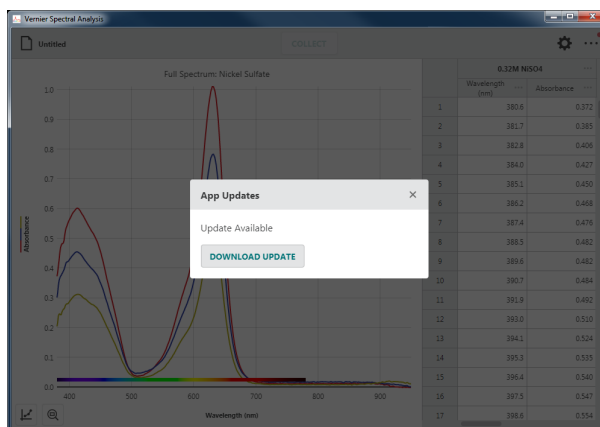
APPENDIX B – Updating Spectral Analysis on a Computer

Spectral Analysis computer software automatically checks for updates when your computer has an internet connection. When a newer version of software is available, the Other Options button on the top toolbar is displayed with a red dot, .

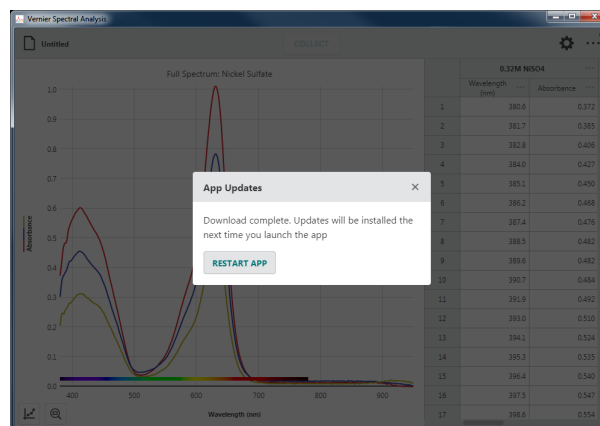
1. Click or tap  to access the Other Options menu and select  Update Available.




2. Click or tap  to download the update.

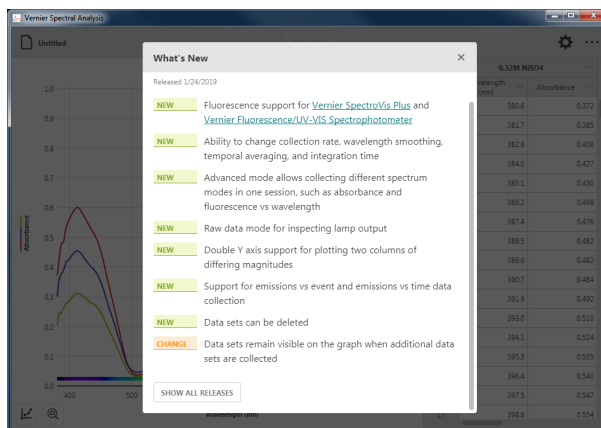


3. The app must restart for the update to install. Click or tap  to complete the update.



4. Click or tap  on the top toolbar to access the Other Options menu. Choose What's New to view a summary of the new features and fixes available in the new version of Spectral Analysis.

TIP! Click or tap  to see changes made in previous versions.



APPENDIX C – Getting Additional Help

Curriculum Resources

Vernier offers a complete set of lab books for elementary through college. For more information, see www.vernier.com/books

The following Vernier lab manuals have experiments that utilize Spectral Analysis:

- *Biology with Vernier*
- *Investigating Biology Through Inquiry*
- *Chemistry with Vernier*
- *Advanced Chemistry with Vernier*
- *Investigating Chemistry Through Inquiry*
- *Vernier Chemistry Investigations for Use with AP Chemistry*

Technical Assistance from Vernier Software & Technology

For access to user manuals, forums, and our technical information library, please visit our website at www.vernier.com/support

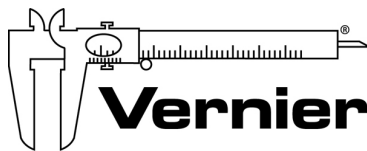
You can also contact us directly.

United States or Canada

888.837.6437
support@vernier.com
www.vernier.com

Vernier International

941.349.1000
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www.vernier-intl.com



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Toll Free (888) 837-6437 • (503) 277-2299 • FAX (503) 277-2440
support@vernier.com • www.vernier.com

Version 4.8.0

Revised February 2019

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