# Ethanol Sensor

## (Order Code ETH-BTA)

The Ethanol Sensor measures the concentration of ethanol in the air above an aqueous sample. This sensor can be used in a wide range of tests and experiments in biological, agricultural, food, and environmental sciences. It can be used to determine the rate of ethanol production during fermentation and to measure the discrete amount of ethanol in a given sample. This sensor has a wide variety of applications.

- Measure the rate of ethanol production by yeast.
- Determine if specific organisms can utilize ethanol fermentation as a metabolic pathway.
- Determine which sugars yeast can ferment.
- Investigate variables that increase or decrease the rate of ethanol production.
- Determine the concentration of ethanol in a solution.

## What is Included with the Ethanol Sensor

- Ethanol Sensor
- 1 replacement Ethanol cap assembly
- Tape for Ethanol Sensor
- #6 stopper for Ethanol Sensor
- 250 mL Nalgene bottle with lid

## Collecting Data with the Ethanol Sensor

This sensor can be used with the following interfaces to collect data.
- Vernier LabQuest® 2 or original LabQuest as a standalone device or with a computer
- Vernier LabQuest Mini with a computer
- Vernier LabPro® with a computer or TI graphing calculator
- Vernier SensorDAQ®
- CBL 2™
- TI-Nspire™ Lab Cradle

## Data-Collection Software

This sensor can be used with an interface and the following data-collection software.
- **Logger *Pro* 3**  This computer program is used with LabQuest 2, LabQuest, LabQuest Mini or LabPro.Version 3.8.6 or newer is required.
- **Logger Lite**  This computer program is used with LabQuest 2, LabQuest, LabQuest Mini or LabPro. Version 1.7 or newer is required.
- **LabQuest App**  This program is used when LabQuest 2 or orginal LabQuest is used as a standalone device. Version 1.7 or newer for original LabQuest and version 2.1 or newer for LabQuest 2 is required.

- **DataQuest™ Software for TI-Nspire™**  This calculator application for the TI-Nspire™ can be used with the TI-Nspire™ Lab Cradle. Requires DataQuest™ version 3.6 or newer.
- **EasyData App**  This calculator application for the TI-83 Plus and TI-84 Plus can be used with CBL 2 and LabPro. Version 2.4 or newer is required. This can be downloaded from the Vernier website, www.vernier.com/easy/easydata.html, and then transferred to the calculator. See the Vernier web site, www.vernier.com/calc/software/index.html for more information on the App and Program Transfer Guidebook.
- **LabVIEW™**  National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. It is used with SensorDAQ and can be used with a number of other Vernier interfaces. See www.vernier.com/labview for more information.

**NOTE:** Vernier products are designed for educational use. Our products are not designed nor recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

## Preparing the Ethanol Sensor for Use

1. Remove the tip of the cap from the sensor. Discard the tissue paper covering the cap (first use only).
2. Cut a 1.5 centimeter piece of plumber's tape (included).
3. Cover the cap entirely with the tape and inspect the tape for wrinkles or gaps.
4. Place the tip over the tape and verify that it is secure before proceeding.

**Note:** Remove the tape from the cap at the end of the experiment. For best results, use a new piece of tape on each day the sensor is used.
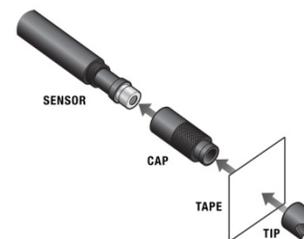


*Figure 1  Assembly of sensor, cap, tape, and tip*

## Optional Calibration Procedure

It may not be necessary to perform a calibration when using the Ethanol Sensor in the classroom. If your experiment or application is evaluating the rate of ethanol production, such as determining fermentation rates with yeast, or the relative change in ethanol concentration, then the stored calibration works well.

For quantitative analysis of ethanol samples, it is best to use a two-point calibration to improve accuracy. The two points you choose for your calibration will depend on the expected amount of ethanol in your sample. For best results at low concentrations (0.1–1%), calibrate using 1% and 0.1% ethanol. For best results at

high concentrations (1.0–3.0%), calibrate using 3.0% and 1% ethanol. If you are measuring an intermediate range you can also calibrate using 0.2% and 2.0% ethanol.

The instructions for calibration are dependent on the data collection interface you are using.

### Calibrating the Ethanol Sensor with a Computer
1. Create two standards of ethanol depending on your expected concentrations of ethanol, and then place each sample into a separate large test tube. Ensure the test tube is large enough to accommodate the Ethanol Sensor.
2. Set up the Ethanol Sensor using the instructions on Preparing the Ethanol Sensor for Use.
3. Starting with the higher standard, position the Ethanol Sensor 1 cm above the fluid level in the test tube. Allow the sensor to equilibrate for five minutes.
4. Choose Calibrate from the Experiment menu and then click Calibrate Now in the Sensor Settings dialogue box.
5. Set up the Ethanol Sensor using the instructions in the Preparing the Ethanol Sensor for Use section and allow it to warm up in air for 5 minutes.
6. Starting with the higher standard, position the Ethanol Sensor 1 cm above the fluid level in the test tube.
7. Enter the known value for Reading 1.
8. When the voltage reading for Reading 1 stabilizes (~1 minute), click Keep.
9. Remove the Ethanol Sensor from the test tube and allow the reading to stabilize for at least 60 seconds.
10. Select the lower concentration standard. Position the Ethanol Sensor 1 cm above the fluid level in the test tube.
11. Enter the known value for Reading 2.
12. After the voltage reading stabilizes, click Keep.
13. In order to save the calibration to the sensor (recommended), click the Calibration Storage tab, then click Set Sensor Calibration. Click OK.
14. To collect data, continue with the steps in the Collecting Data section below.

### Calibrating the Ethanol Sensor with LabQuest App
1. Create two standards depending on your expected concentrations of ethanol, and then place each sample into a separate large-mouth test tube. Ensure the test tube is large enough to accommodate the Ethanol Sensor.
2. Set up the Ethanol Sensor using the instructions on Preparing the Ethanol Sensor for Use.
3. Starting with the higher standard, position the Ethanol Sensor 1 cm above the fluid level in the test tube. Allow the sensor to equilibrate for five minutes.
4. Choose Calibrate from the Sensors menu and tap Calibrate Now.
5. Set up the ethanol sensor using the instructions on Preparing the Ethanol Sensor for Use and allow it to warm up in the air for 5 minutes.
6. Starting with the higher standard, position the Ethanol Sensor 1 cm above the fluid level in the test tube.
7. Enter the known standard value for Reading 1.
8. When the voltage reading for Reading 1 stabilizes (~1 minute), tap Keep.

9. Remove the Ethanol Sensor from the test tube and allow the reading to stabilize for at least 60 seconds.
10. Select the lower concentration standard. Position the Ethanol Sensor 1 cm above the fluid level in the test tube.
11. Enter the known standard value for Reading 2.
12. After the voltage reading stabilizes, tap Keep.
13. In order to save the calibration to the sensor (recommended), tap the Storage tab and tap Save Calibration to Sensor. Tap OK.
14. To collect data, continue with the steps in the Collecting Data section, below.

### Making Ethanol Standards for Calibration
To make solutions for the ethanol calibration, you will need to dilute fresh, stock ethanol to the appropriate concentration. Denatured ethanol or non-denatured, grain ethanol may be used. Ethanol that is 70% is more stable than 95%. For the most accurate results, use a volumetric flask to make the standards. Use the following equation to guide you:

$$C_1V_1 = C_2V_2$$

- $C_1$ is the concentration of the stock solution (typically 70% or 95%).
- $V_1$ is the amount of stock solution to be added (you will solve for this).
- $C_2$ is the desired concentration in %.
- $V_2$ the total final volume.
- $V_2 - V_1$ = amount of distilled water to add to the stock solution.

It may be necessary to do a serial dilution in order to get the precision you need for your standards. The following table shows an example of a serial dilution to make 0.1% ethanol starting with 70% ethanol.

| Original concentration of ethanol | Amount of ethanol to add (mL) | Final volume (ethanol and water) (mL) | Final concentration |
|---|---|---|---|
| 70% | 14.3 | 100.0 | 10% |
| 10% | 10.0 | 100.0 | 1% |
| 1% | 10.0 | 100.0 | 0.1% |

## Collecting Data
1. Connect the Ethanol Sensor to the data-collection interface.
2. Start the data-collection software.
3. The software will identify the sensor and load a default data-collection setup.
4. It is necessary to warm up the Ethanol Sensor for 5 minutes before taking readings. To warm up the probe, simply leave it connected to the interface with the data-collection software running.
5. The 250 mL fermentation chamber and #6 split stopper included with the sensor provide a convenient setup as shown in figure 2. Place the chamber on a stir plate to keep the sample moving. Wrap the stopper around the sensor, rather than sliding it on or
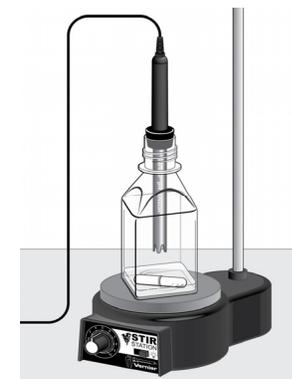


*Figure 2*

off. Sliding the stopper on or off may result in the tip coming off and potentially being lost. When students are placing the probe in the fermentation chamber, they should gently twist the stopper into the chamber opening. **Note: The sensor is a gas sensor. It should never be submerged in liquid.**

6. Start data collection.

## Specifications

| | |
|---|---|
| Range | 0% to 3% |
| Accuracy (factory calibration) | ±1.5% at 3% |
| Accuracy (custom calibration) | |
|    1–3% | ±0.5% at 3% |
|    0.1–1% | ±0.3% at 1% |
| Resolution | |
| 13-bit (SensorDAQ) | 0.01% from 2–3% |
| | 0.005% from 1–2% |
| | 0.0005% from 0–1% |
| 12-bit (LabPro, LabQuest, LabQuest 2, | 0.02% from 2–3% |
|   TI-Nspire Lab Cradle, LabQuest Mini) | 0.01% from 1–2% |
| | 0.001% from 0–1% |
| 10-bit (CBL 2) | 0.04% from 2–3% |
| | 0.02% from 1–2% |
| | 0.002% from 0–1% |
| Response time | 95% of full scale in 60 seconds |
| Stored calibration values | |
| coefficient | −2.995 |
|            power | 0.9054 |

> This sensor is equipped with circuitry that supports auto-ID. When used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, SensorDAQ, TI-Nspire™ Lab Cradle,or CBL 2™, the data-collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor.

## How the Ethanol Sensor Works

The Vernier Ethanol Sensor uses a metal oxide semiconductor to detect ethanol concentrations in the air. The ethanol vapor reacts with the metal oxide and is consumed in a combustion reaction which reduces the internal resistance of the sensor element. An amplifier is used to convert the change in sensor resistance to a response voltage, which is converted into an appropriate ethanol concentration by the data-collection software. A power function is used for calibration due to the large response range. **Note:** The sensing element is very sensitive to ethanol vapor and also responds to a wide range of other volatile organic compounds. It also responds to water vapor and carbon dioxide gas to a lesser degree. Built-in temperature, pressure, and humidity compensation are not provided. For best results, calibrate and use at room temperature.

## Suggested Experiments

### Determine which Sugars Yeast can Metabolize
In this lab, students determine if a particular strand of yeast can ferment a variety of different sugars including both monosaccharides and disaccharides. Yeast and sugar are combined in the fermentation chamber and ethanol concentration data is collected over a period of ten minutes. From this data, students can better understand how yeast utilize sugar for food.

### Observe Ethanol and $CO_2$ Production during Fermentation
Using the Biochamber 2000 and a $CO_2$ Gas Sensor, students can collect data on both products of fermentation at the same time. Carbon dioxide and ethanol concentrations will both increase if fermentation is occurring. Conversely, if aerobic respiration is occurring students will see an increase in carbon dioxide, but not in ethanol. This experiment can be done with a variety of organisms known to undergo fermentation or cellular respiration.

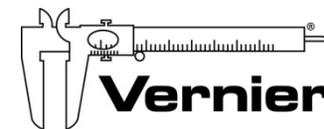### Measure the Concentration of Ethanol in a Sample
A popular chemistry lab is the synthesis and distillation of ethanol. The Ethanol Sensor can be used to accurately determine if ethanol was produced. The amount of ethanol can be accurately determined up to 3%. This application is also useful to see how long it takes particular strains of yeast to produce given quantities of ethanol.

## Accessories and Replacement Parts

| Name | Order code |
|---|---|
| Ethanol Cap Assemblies (package of 3) | ETH-CAPS |
| #6 stopper for Ethanol Sensor | ETH-STOP |
| Tape for Ethanol Sensor | ETH-TAPE |
| 250 mL Nalgene Bottle w/Lid | CO2-BTL |
| BioChamber 2000 | BC-2000 |

## Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use.