Temperature Corrected Oxygen Sensor

Calibration for Temperature Dependence

Calibration is expected to be slightly different for each electrode, and to slowly change over time as the electrode oxidizes. A reasonable rule of thumb might be to redo the calibration procedure every 6 months and also change electrolyte solution.

As described by the Nernst equation, electrochemical potential and thus sensor voltage increases with temperature at a given oxygen concentration. We use sensor readings for two points of oxygen concentration over a range of temperatures to compensate for this temperature dependence. The first point is water saturated with oxygen, constantly stirred while in contact with air, and the second point is zero dissolved oxygen using saturated sodium metabisulfite (an oxygen scavenging reagent) to eliminate all oxygen, while limiting contact with air. We assume that sensor voltage maps oxygen concentration linearly between these two values at a given temperature.

Note that the saturation concentration of oxygen in water varies with temperature, decreasing by about 47% as water is heated from 0 to 30 C, as shown in figure 1. Thus, the saturation calibration value is not constant across temperatures. This needs to be taken into account when making the calibration.Note that oxygen saturation concentration will increase with atmospheric pressure, and that sensor voltage will vary with salinity independent of oxygen concentration, but we do not correct for these factors.

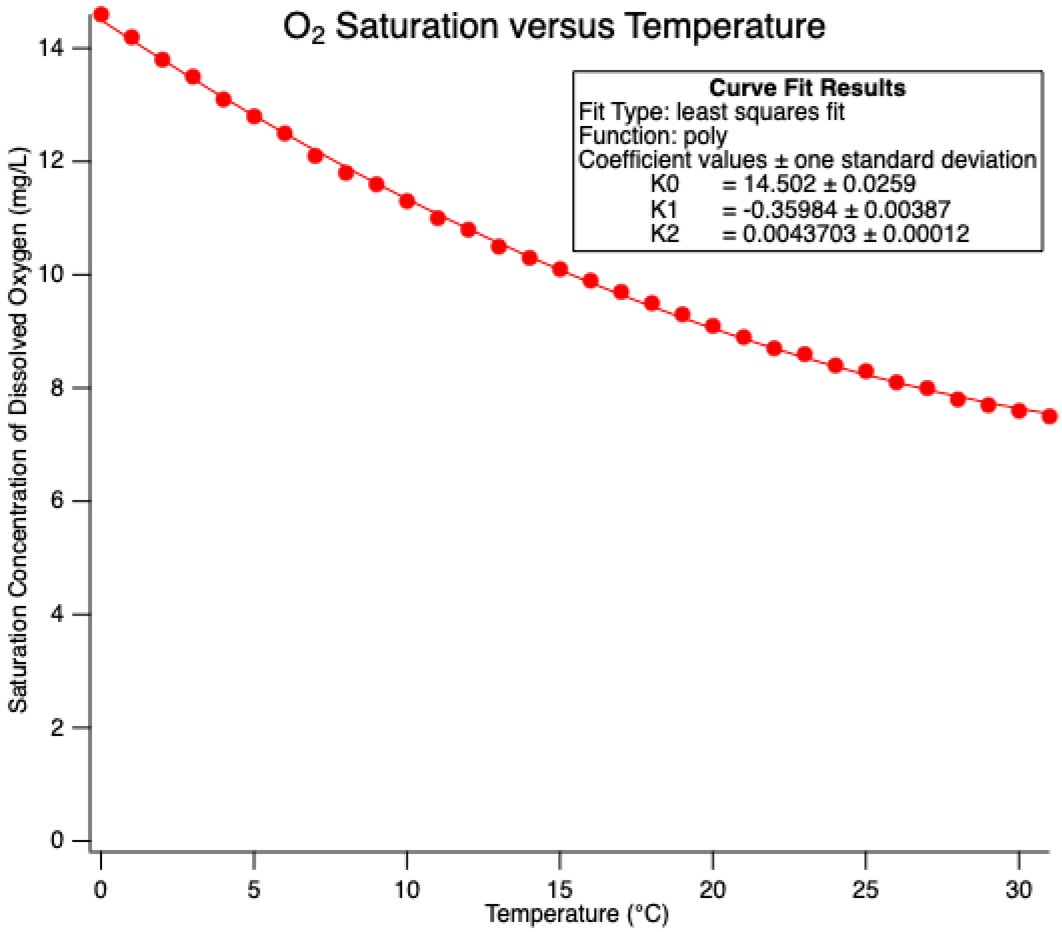

Figure 1. Oxygen saturation concentration as a function of temperature.

The calibration data were obtained by attaching a thermistor to the oxygen sensor and submerging the pair of sensors in a small flask filled with water which was then placed in a hot water bath which was gradually cooled by periodic addition of ice cubes. Constant gentle swirling of the small flask was applied. It was noted that more vigorous swirling resulted in higher voltages, and that cessation of stirring rapidly resulted in decreasing voltage from the sensor as oxygen was depleted near the sensor by the coupled oxidation-reduction reaction that drives the sensor voltage (see Figure 2).

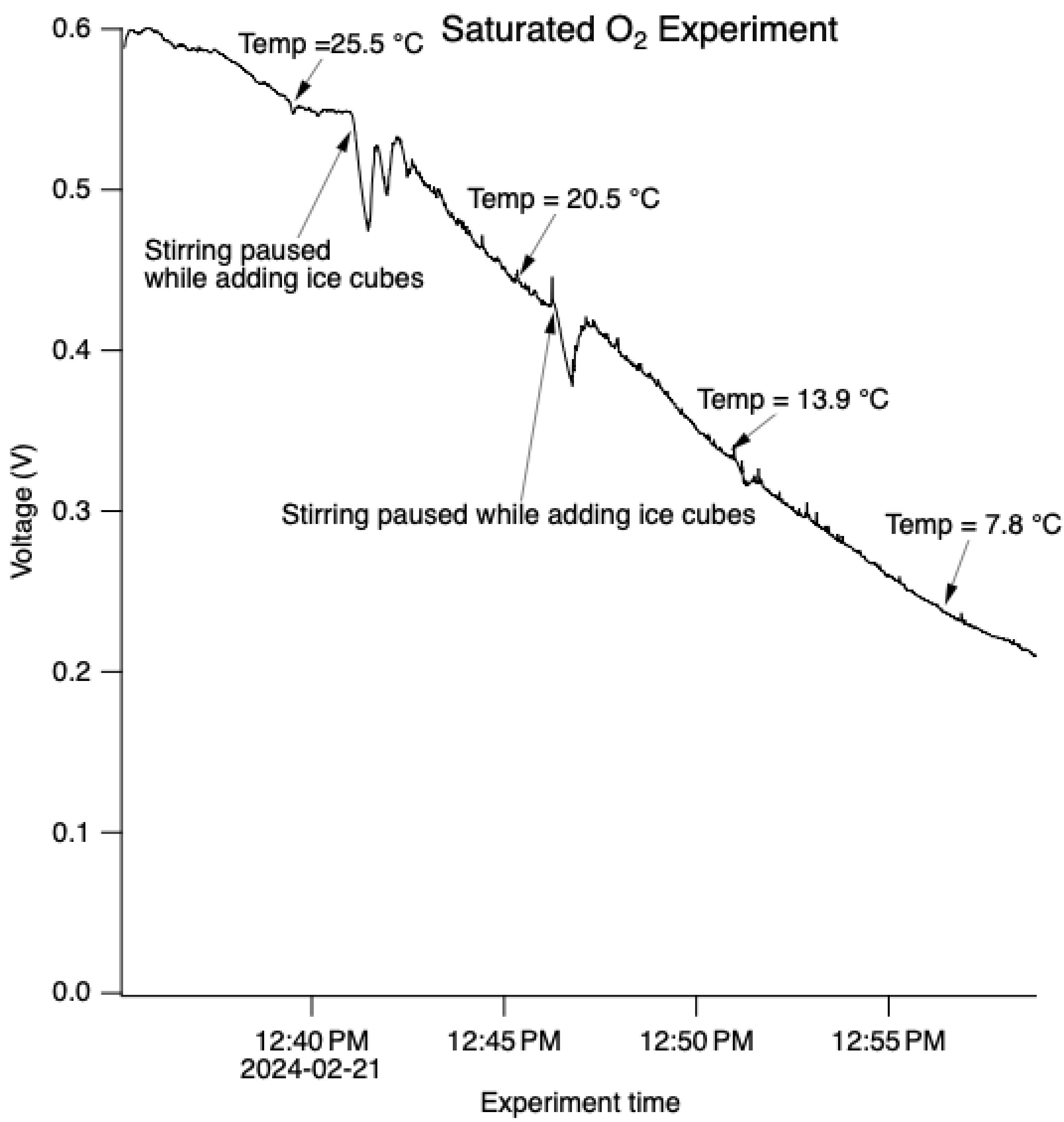

Figure 2. Results for monitoring sensor voltage with cooling while maintaining saturated oxygen concentration in the sample.

For the saturated oxygen data, the swirling also worked to increase mixing of oxygen between air and water. Remember, more oxygen from the air is needed as the water cools and saturation concentration increases. For the zero oxygen experiment, it is best to wrap the flask with film if possible to limit exchange with air, and to monitor undissolved sodium metabisulfite so more of the chemical can be added if necessary. See Figure 3 where sulfite was exhausted and sensor voltage rapidly rose until more of the sulfite was added, upon which it rapidly fell again.

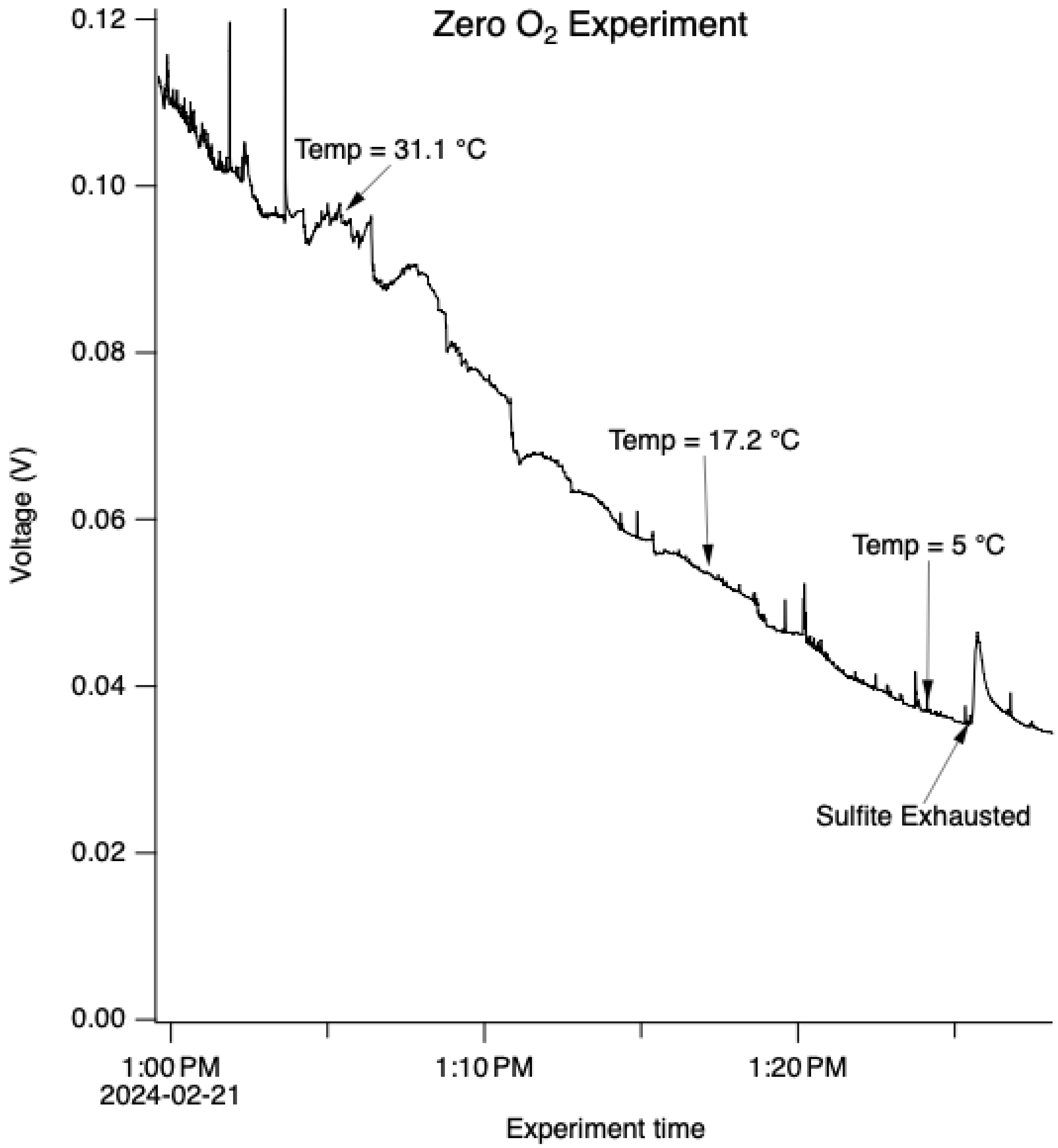

Figure 3. Results for monitoring sensor voltage with cooling while maintaining zero oxygen concentration in the sample using saturated sodium metabisulfite.

The Sensor voltage was logged continuously with an Analog Discovery 2 while temperature was monitored with the temperature setting of a Klein multimeter. Voltage was noted in approximately half degree steps.

Voltage versus temperature was plotted for both sets of data (Fig. 4). A linear fit over the temperature range of interest (5 to 30 °C) was deemed accurate enough to calculate the zero oxygen voltage and the saturated oxygen voltage as a function of temperature. A quadratic fit to data from a published lookup table was used to calculate oxygen saturation concentration at each temperature.

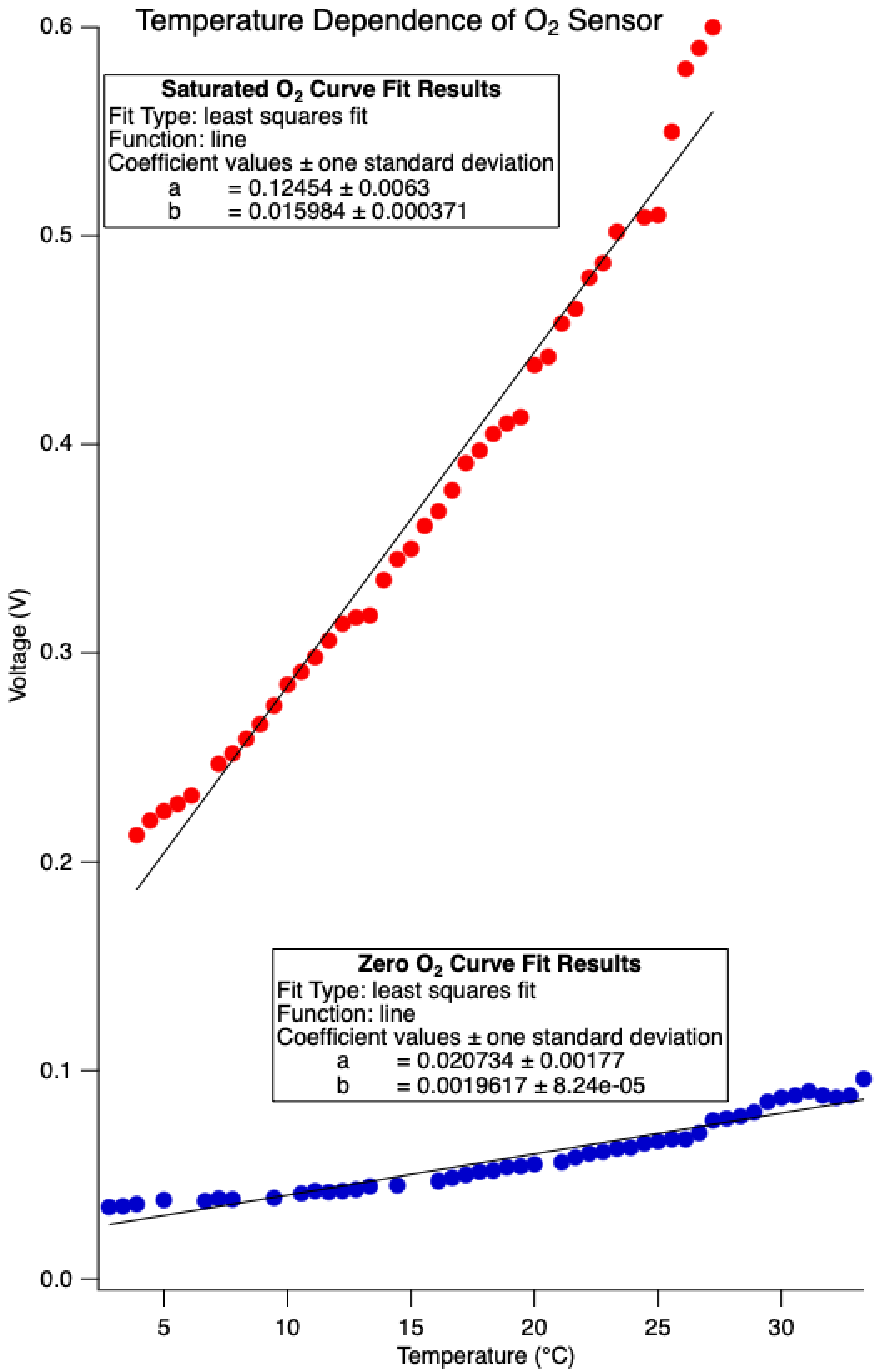
Temperature Dependence of O2 Sensor
Saturated O2 Curve Fit Results
Fit Type: least squares fit
Function: line
Coefficient values ± one standard deviation
a = 0.12454 ± 0.0063
b = 0.015984 ± 0.000371
Zero O2 Curve Fit Results
Fit Type: least squares fit
Function: line
Coefficient values ± one standard deviation
a = 0.020734 ± 0.00177
b = 0.0019617 ± 8.24e-05
Voltage (V)
Temperature (°C)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
5
10
15
20
25
30

Figure 4. Sensor voltage versus temperature for the two conditions of saturated oxygen and zero oxygen levels. Values for a linear fit are shown.

The method to calculate oxygen concentration from sensor voltage and temperature is as follows:

get measuredTemperature, in °C
get measuredVolts from sensor, in V
calculate Volts for zero oxygen at measuredTemperature using linear fit params (fig 4)
calculate Volts for saturated oxygen at measuredTemperature using linear fit params (fig 4)
calculate saturation concentration at measuredTemperature (mg/l) using quadratic fit params (fig 1).

Calculate temperature corrected oxygen concentration as:

$$oxygen\ concentration = \frac{saturation\ conc\ at\ measuredTemp \times (measuredVolts - ZeroVolts)}{(SaturatedVolts - ZeroVolts)}$$