Tech Note

ISE-730 Oxygen Electrode and DO2-100 Current-to-Voltage Adapter

Overview

In 1954, Dr. Leland Clark invented the first membrane-covered electrode designed to measure the concentration of oxygen in blood, solution, and gases. This electrode was innovative because it was the first electrode to have both the anode and the cathode under the same non-conductive polyethylene membrane. The limited permeability of the membrane reduced the amount of oxygen depleted from the sample which permitted accurate quantitative measurements of the oxygen concentration to be made. Dr. Clark's electrode was the prototype for many of the biosensors used today, including the sensors used in blood gas analyzers and probes, like the iWorx ISE-730, used in teaching and research laboratories.

How They Work

The ISE-730 oxygen electrode has a Teflon™ membrane that permits a limited amount of oxygen to diffuse from the solution being measured to the electrolyte solution that covers the platinum cathode and silver anode of the electrode. The ISE-730 is supplied with a polarizing voltage of -0.80V from the DO2-100 current to voltage adapter. The polarizing voltage creates a flow of electrons, or current, between the platinum and silver elements of the electrode. The amount of current that flows between the anode and the cathode is proportional to the concentration of oxygen in the electrolyte that bathes these two electrodes, which is proportional to the concentration of oxygen in solution.

In addition to providing a polarizing voltage for the oxygen probe, the DO2-100 converts the current output of the oxygen probe to a voltage output that can be recorded. The DO2-100 also amplifies this output voltage to a level that is easily recorded by a data acquisition unit. The output of the DO2-100 is 10mV for every nanoampere of current that is flowing. If a two-point calibration is performed using room temperature deionized water, saturated with oxygen, and then deoxygenated water at the same temperature, the voltage output of the DO2-100 adapter can be related to the oxygen concentration in the chamber. The DO2-100 adapter also has an offset control which allows the recording to be positioned on the screen without affecting the calibration of the electrode.

Equipment Setup

1. Plug one end of a male DIN8-maleDIN8 cable into the DIN8 input of an iWorx data acquisition unit or amplifier. Plug the other end of the cable into the DIN connector on the DO2-100 current to voltage adapter (Figure 1 on page 2).
2. Attach the cable of the oxygen electrode to the BNC connector on the DO2-100 current to voltage adapter.
3. Place the electrode in the reaction chamber.

Calibration of the ISE-730 Oxygen Electrode

1. Fill the polarograph chamber with fresh deionized water before proceeding with the calibration procedure.
2. Place the electrode in the chamber and turn up the speed of the stirrer to the maximum rate that allows the stir bar to rotate evenly. If the solution in the chamber is stirred, changes in oxygen concentration reach the electrode instantaneously. If a stirrer is not used, changes in the rate of oxygen production are limited by the rate of diffusion.
3. Begin recording the output of the oxygen electrode. Note on the recording that the measurement is from water saturated with oxygen at room temperature. Note the room temperature.

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4. When the trace settles down to steady baseline, record for an additional 10 seconds before going to the next step.
5. Use a micropipette to add 10µl (microliters) of 1.5M Sodium Dithionite (oxygen depletion) solution to the water in the reaction chamber for every milliliter of water in the chamber. In a few seconds, this small amount of solution will deplete all the oxygen from the deionized water stirring in the chamber. Record the drop in the oxygen concentration in the chamber until the trace is a flat line at a lower amplitude (Figure 2 on page 3). Note that this is the recording for water depleted of oxygen at room temperature.

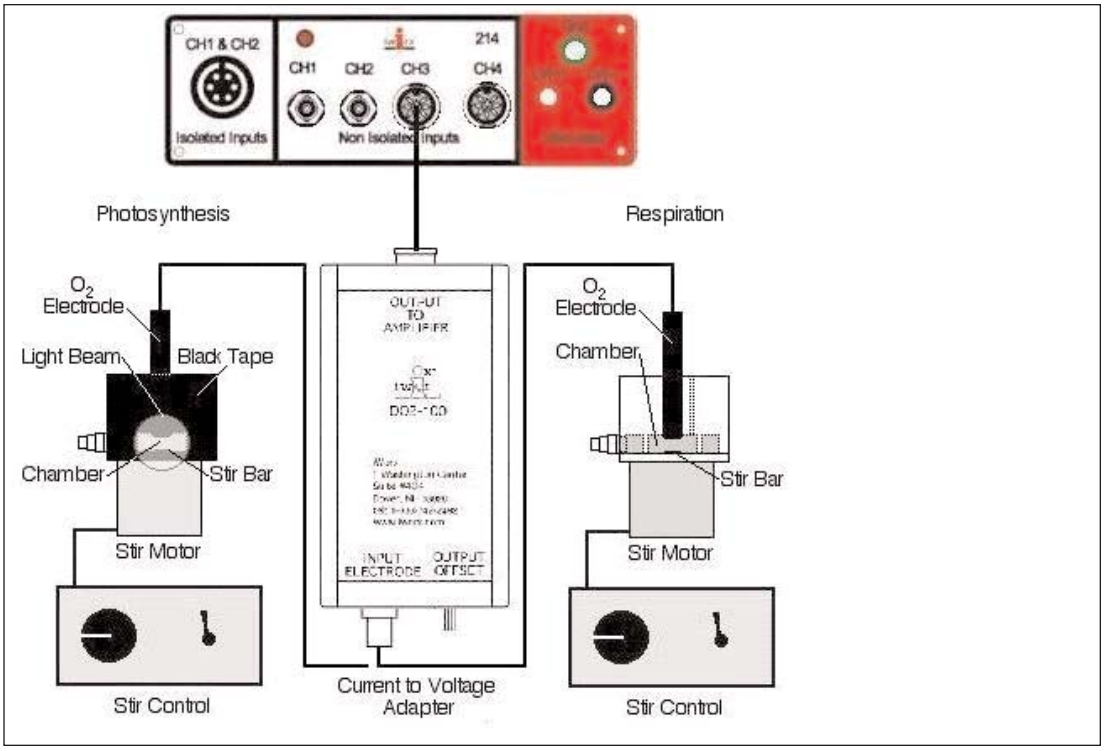

Figure 1: Equipment used to record cellular respiration and photosynthesis: DO2-100 current to voltage adapter; ISE-730 oxygen electrode; RPC-100 respiration/photosynthesis chamber; data acquisition system.

6. Stop the recording.
7. Turn off the stirrer for the chamber. Remove the water and the oxygen depletion solution from the chamber with a plastic-tipped Pasteur pipet. Rinse the chamber 3 or 4 times with deionized water from a squirt bottle. Fill the chamber with deionized water and turn on the stirrer.
8. Determine the temperature (oC) and the barometric pressure in the lab. The oxygen concentrations in deionized water, over a short range of temperatures at 760mmHg, have been calculated and listed in Table 1. The absorption coefficients of oxygen and the vapor pressures of water at these temperatures are also listed.
9. The concentration of oxygen dissolved in deionized water, or its solubility (S), can be determined more accurately by using the following equation:

S = (a/22.414) ((P-p)/P) (r%/100)

where a is the absorption coefficient of O2 at temperature, p is the vapor pressure of water at temperature, P is the barometric pressure, and r% is the percent oxygen in the air. At 26oC and 760mmHg, assuming the concentration of oxygen in air is 21%, S = 252µMO2:

(0.02783/22.414L/mole) ((760-25.09mmHg)/760mmHg) (21/100)
= 252µMO2

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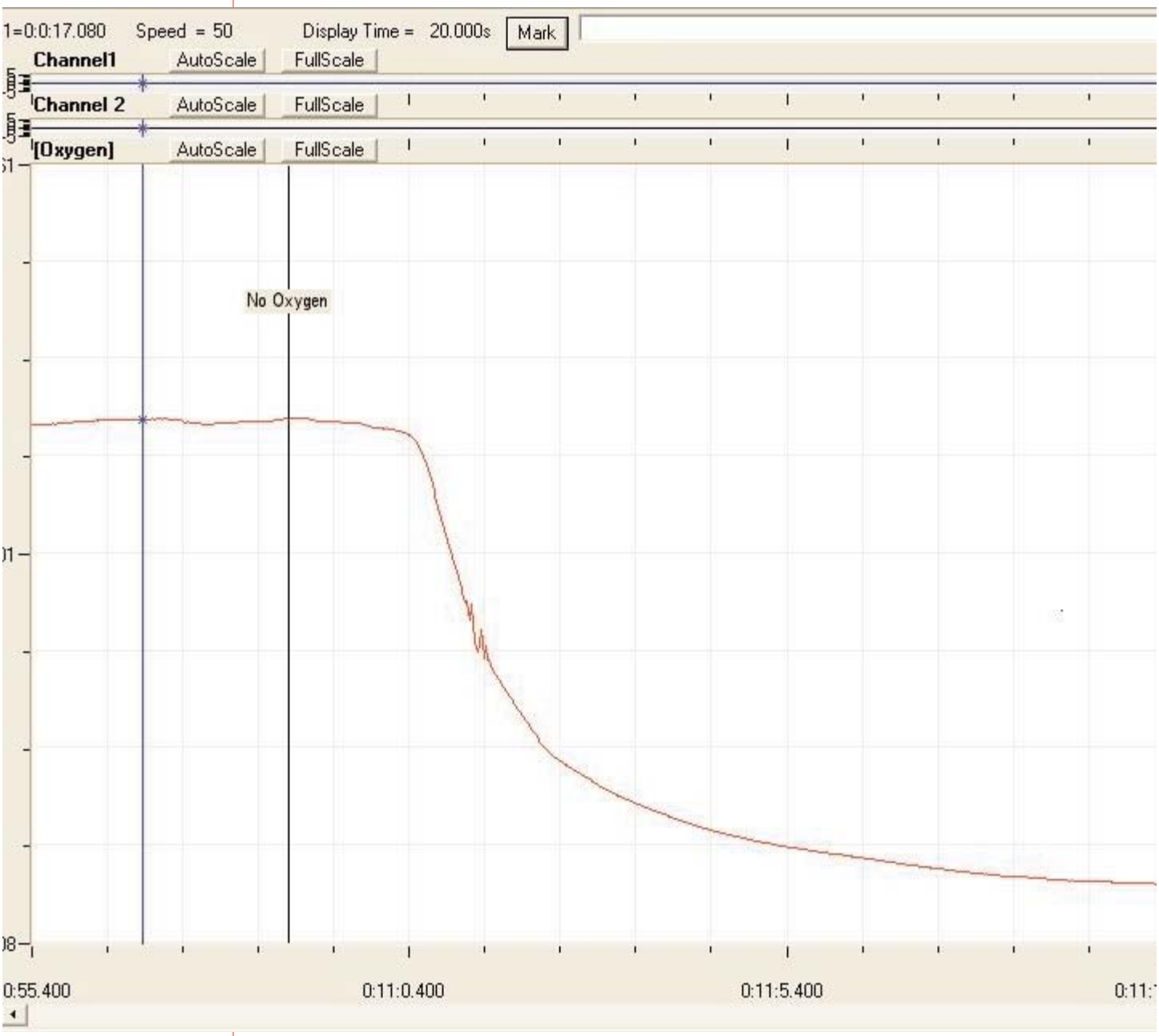

Figure 2: Output of oxygen electrode before and after the depletion of oxygen from the water in the chamber.

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Table 1: Oxygen Concentration [O2] in Air-Saturated Deionized Water at 760mm Hg

Temperature ^{o}C	O_2 Absorbance Coefficient (a)	H_2O Vapor Pressure (p) (mmHg)	O_2 [uM)
20	0.03102	17.54	284
21	0.03044	18.65	278
22	0.02988	19.83	273
23	0.02934	21.07	267
24	0.02881	22.38	262
25	0.02831	23.76	257
26	0.02783	25.09	252
27	0.02736	26.74	247
28	0.02691	28.35	243
29	0.02649	30.04	238
30	0.02608	31.82	234

Experiments

Experiments using the ISE-730 Oxygen Electrode and the DO2-100 Current to Voltage Adapter can be downloaded by clicking on the following links:

Print-disabled Carbon Dioxide Fixation in Intact Cells Experiment (PDF file).

User Area (password protected)
High resolution press optimized or low resolution screen optimized Carbon Dioxide Fixation in Intact Cells Experiment (PDF file)

Care of the ISE-730 Microelectrode

Instructions on the assembly, preparation, handling, cleaning and storage of the ISE-730 oxygen electrode are contained in the tech note from the January/February 2005 edition of the iWorx Newsletter at: http://www.iworx.com/newsletter/JanFeb05/Oxygenelectrode.pdf

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