Photosynthesis by CO_2 change

Apparatus

CO_2 sensor

Container for leaves (bottle supplied with sensor is ideal)

Good handful of fresh leaves.

Light source - broad spectrum or grow lamp.

Beaker or clear bottle to act as heat shield.

Coloured filters (e.g. theatrical gels)

Optional

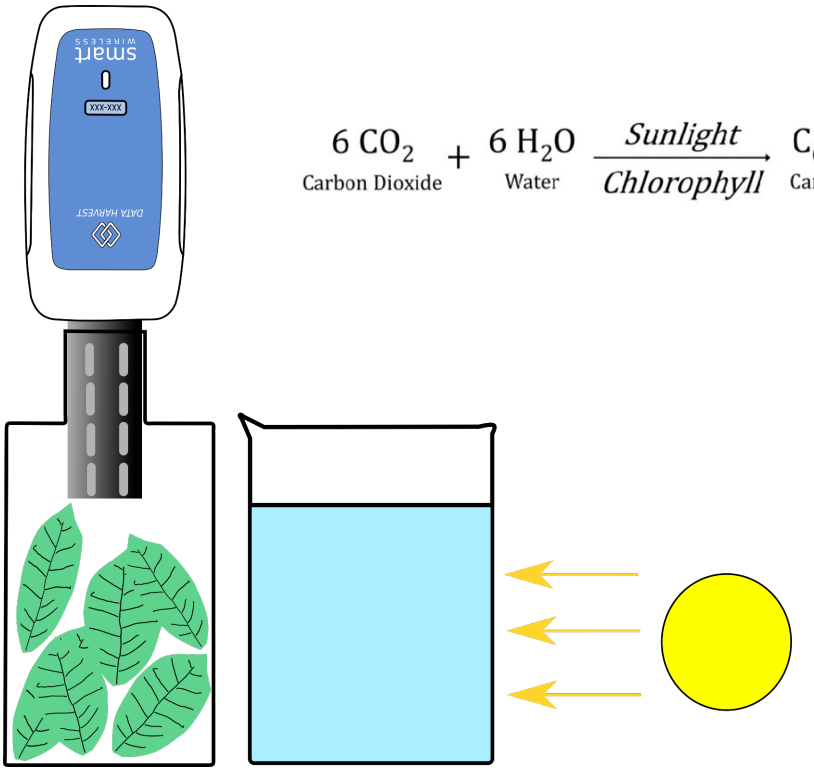
Light sensor

Data recording setup.

5 minute recording

Intersample time 5 seconds.

Select Start to begin, stop after duration.



$$6\,CO_2 \underset{\text{Carbon Dioxide}}{} + 6\,H_2O \underset{\text{Water}}{} \xrightarrow[Chlorophyll]{Sunlight} C_6H_{12}O_6 \underset{\text{Carbohydrate}}{} + 6\,O_2 \underset{\text{Oxygen}}{}$$

The practical uses the rate of CO_2 production as a measure of photosynthesis.

The CO_2 sensor can measure small changes in concentration of the gas.

The setup is generic, once you have it working you can modify the apparatus to show the effect of

1. Light intensity - move the light closer or further away from the plant.
2. Light colour - insert coloured filters between the light and plant.
3. Effect of changing the CO_2 concentration on photosynthesis.
4. Efficiency of different plants (shade adapted vs full sun species).

Practical notes

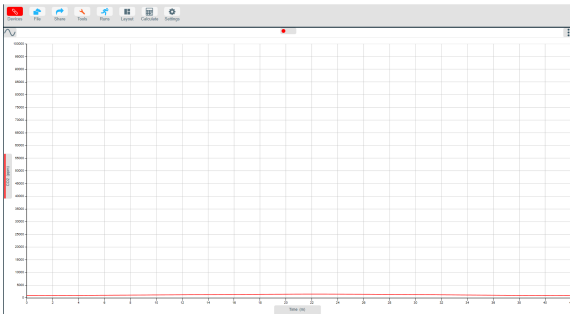
We are dealing with living biological materials, they will show variability and what might work yesterday may not work today. The method is a generic method that should work for most practical setups, but be prepared to change detail to make it work.

It is possible to over pack the chamber with leaves, as a rule “less is more”.

1. Setup up the apparatus as shown in the diagram. You need a heat shield if you are using a light source that becomes hot (for example and incandescent filament lamp). To start have the plant chamber, heat shield and light source close together.
2. Link the CO_2 sensor to the software. Use settings to change the intersample period to at least 5 seconds. Leave all other settings as default.
3. Cover the plant (or turn lights off to place the plant in deep shade) and select start to begin collecting data. After a few points have been collected select the Y axis to be scaled to min to max.
4. You should get enough data in 5 minutes to see the change in CO_2 with time. In the dark CO_2 should be increasing.
5. Switch the light source on and continue recording for the same length of time you did for dark condition

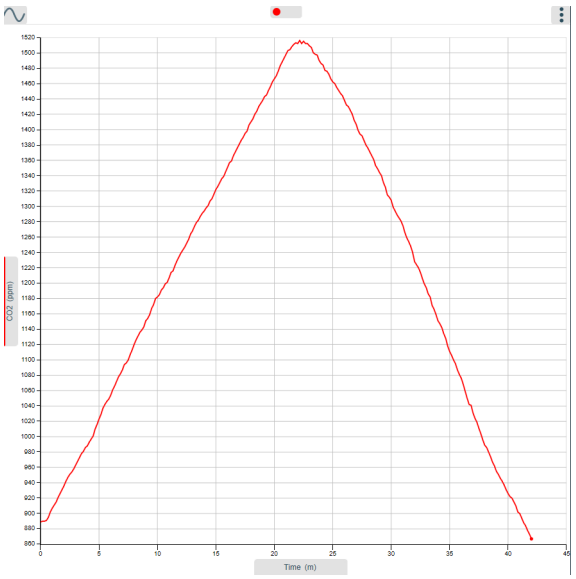
Example of data as collected.

This example data was a 45 minute recording with 20 minutes in the dark and 20 minutes illuminated by a broad spectrum growing lamp.



The data will need re-scaling to Min to Max (autoscale)

The data clearly shows a constant increase in CO_2 in the environment chamber during a period of darkness.



Analysis of the data.

You need to find the rate of change of CO_2 in the dark and in the light - before changing anything in the practical (for example light intensity or light colour)

Rate of CO_2 change for dark phase

Run	Experiment set up	Start CO_2 level	Peak CO_2 level	Change in CO_2	Change in time (s)	Change in CO_2/ Change in time

The Experiment setup is how you have setup up the apparatus, for example control = just like the apparatus diagram, Red filter = red filter between plant and light source, Distance 12cm = how far from light source to plant chamber etc.

Rate of CO_2 change for light phase

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Extension.

The apparatus once setup gives the potential for seeing what happens as you alter the light environment around the plant.

1. Change the light by placing a coloured filter between the light source and plant.
2. Compare different plants e.g. shade adapted and bright sun adapted.
3. Use a light sensor to measure light intensity and make sure the change in light was linear.

Changes to data collection worth considering.

1. Not all plants are “quick photosynthesisers, the example data used Maple / sycamore leaves or Laurel (both in abundant supply locally). Alternative methods suggest Spinach or Basil as good fast responders.
2. Use a shorter collection period in a - a 5 minute data collection will show the trend.
3. Exhale into the apparatus and use a trigger to start data collection when the CO_2 has fallen to a common value - ideal for Overlay and comparative data.

Note using the CO_2 and Oxygen together is possible, the Oxygen has a sensitivity of 0.01% (100 ppm) and the CO_2 has a sensitivity of 1 ppm (0.0001%), typical CO_2 changes in the test practicals was 600 -800 ppm. Use separate axis for oxygen and carbon dioxide and set both to Min to Max, initially the data will look poor, but with the light off you will soon see a rise in carbon dioxide a matching fall in oxygen.

Turning the light on will see a rise in oxygen and a fall in carbon dioxide.

For best results use a single layer of leaves over the side of the container that receives the light, if you over pack the vessel the leaves not receiving light will move to respiration and the changes in oxygen will be lost in the background noise.

This is a good test of how you understand photosynthesis and the apparatus set up.