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Short communication

Simple light guide for measuring irradiance in an aqueous oxygen electrode chamber

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Abstract

The light-dependent reactions of photosynthesis are often measured with Clark-type oxygen electrodes yet the irradiance level inside aqueous oxygen electrode reaction vessels is seldom reported due to the difficulty of measuring light inside a small volume chamber. We describe a simple light guide terminating in a 90° prism that can be inserted into a reaction vessel. Incoming irradiation is directed to a commercially available quantum sensor positioned at the other end of the light guide. Both materials for and construction of the device are inexpensive.

Introduction

Many plant science laboratories routinely measure the light-dependent reactions of photosynthesis in a cell free system or an algal suspension via the use of an aqueous-phase oxygen electrode (Hunt 2003). The typical apparatus has a small volume (1–5 ml), water-jacketed, clear-sided reaction vessel that is exposed at one end to a Clark-type oxygen electrode (Clark 1956). Illumination is provided by an external source and the light must pass through the wall of the water jacket, the cooling water and the wall of the inner reaction vessel to reach the isolated thylakoids or algal suspension. Thus the loss of light through scattering and absorption can be quite high. Commercial systems include the Hansatech DW1 and DW2 (Hansatech Instruments Ltd, King's Lynn, UK) the Strathkelvin RC300 and RC350 (Strathkelvin Instruments, Glasgow, UK), the Rank OXY electrodes (Rank Brothers Ltd, Cambridge, UK) and YSI 5300 series monitors, probes and chambers (YSI Inc, Yellow Springs, Ohio).

An accurate determination of irradiance at the level of the thylakoids or algal cells is of particular interest, and usually difficult to measure. Most papers simply report the irradiance at the surface of the cuvette or sample chamber as it is difficult, or expensive, to measure the light level inside a small, 1–5-ml vessel. In this paper we describe a simple, waterproof light guide that, in conjunction with a commercially available quantum sensor, can be used to accurately measure the amount of light in the interior of an aqueous-phase oxygen electrode reaction vessel.

The device

The device consists of a right-angle prism, a glass or acrylic light guide, and an adaptor to hold a quantum sensor (Figure 1). The choice of prism and light guide are dictated by the diameter of the opening to the reaction vessel. Prisms are available from Edmund Industrial Optics (101 East Gloucester Pike, Barrington, New Jersey) as small as 0.5 × 0.71 × 0.5 mm. The prism used herein was

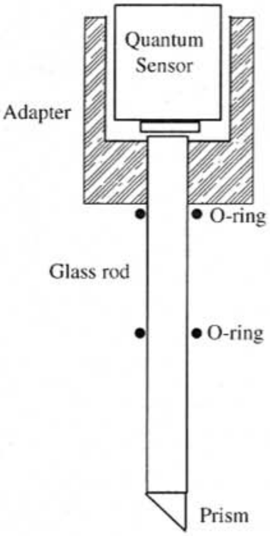

Figure 1. Schematic diagram of light guide.

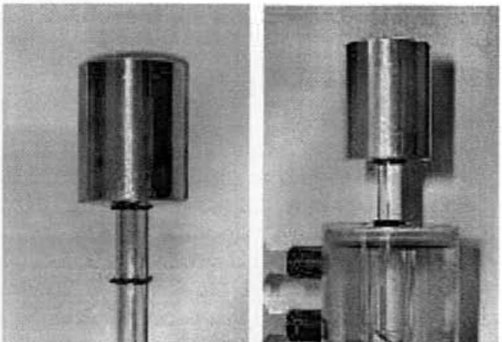

Figure 2. (left panel) Photograph of light guide. (right panel) Photograph of light guide in use on a Hansatech DW1 aqueous oxygen electrode. Quantum sensor not shown.

a Tech Spec R45-107, 6.25 × 6.25 × 8.0 mm, aluminized hypotenuse, right-angle prism (Edmund Industrial Optics) and fits through the opening in both the Hansatech DW1 an DW2 reaction vessels. The ends of a 0.9 cm diameter by 8.0 cm long glass rod were heat polished and the prism attached with lens cement (Type UV-74, Summers Optical, Fort Washington, PA). An adaptor (Figure 1b) was machined from aluminum stock to accept the light guide and a LiCor LI-190SA quantum sensor (LiCor Instruments, Lincoln, Nebraska). Aluminum stock is available from McMaster-Carr (Atlanta, Georgia) or any other metal supplier. Brass and acrylic machine easily and could be used as well, if they were available. The fit is not critical as the quantum sensor is cosine-corrected and capable of sensing all incoming irradiation, even if not perfectly aligned with the end of the light guide.

The prism end of the light guide is inserted into the liquid-filled reaction vessel and adjusted to match the height of the portion of the vessel that is being illuminated. O-rings around the light guide are used to maintain the height of the prism in the vessel. The adaptor is placed on the top of the light guide to hold the quantum sensor. A separate O-ring maintains its height so that the top of the light guide is held at the level of the quantum sensor. The reaction vessel is illuminated in the normal fashion, with light coming from the side. Light passes through the clear water jacket and reaction vessel walls, enters the face of the prism, is reflected 90°, and travels up to the quantum sensor. The loss of light through the sidewall of the transparent light guide is nil.

Cost of the device is minimal. The prism was approximately USD 32 and the other materials are very common. Any moderately equipped machine shop would be capable of machining the quantum sensor adaptor from materials on hand. The cost of the quantum sensor is, of course, additional but light meters are common instruments in most plant physiology laboratories.

References

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