Photonic sensor to monitor the harvesting of microalgae with applications in wellness and cosmetic industries.

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Abstract

Many species of microalgae have applications in the field of wellness and cosmetics. A low-cost apparatus to monitor remotely their harvesting was designed. This was achieved considering the fluorescence characteristics of the pigments present in these microorganisms. During this research dilutions of different concentrations of *Nannochloropisis gaditana*, a natural source of β-carotene, were tested.

1 Introduction

Microalgae lay on the basis of the aquatic ecosystems. However their uses extend to human health and well-being. They constitute a natural source of carotenoids which poses underlining biological features such as being antioxidant, anti-inflammatory and antitumoral, among others [1]. In the field of wellness and cosmetics they are of particular interest due to applications in creams and lotions for sun protection, in thalassotherapy and spa products [2], and even in the treatment of skin diseases like psoriasis and inflammatory pathologies [3].

The species *Nannochloropsis gaditana* can be used to extract β-carotene (which is precursor of vitamin A), in the form of powder or paste. The price of each kilogram is around $300 [3].

Due to the growing popularity of natural products, microalgae harvesting is increasing. This article presents a device that is capable of measuring the population changes of these microorganisms. It is based on detecting the fluorescence of chlorophyll types [4]. Under an ultraviolet (UV) or blue (B) excitation these pigments emit light in the band between 600 and 700 nm [5].

The following sections describe the employed samples (section 2), the use of the LIF (Laser Induced Fluorescence) to measure their fluorescence spectra (section 3), the fluorescence detection with the designed device (section 4), the results obtained with the measurements (section 5), and finally the conclusions (section 6) of this research.

2 Microalgae samples

The set of samples consist of different concentrations of *Nannochloropsis gaditana*. Starting from an initial microalgae culture, five more samples were prepared, each one with half quantity of the previous suspension. In other words, taking as reference the first culture (relative 100%) samples with 100%, 50%, 25%, 12,5%, 6,25% and 3,125% relative concentration, were obtained. The quantity of cells was later determined using cytometry (see Table 1).

The samples were provided by the Department of Applied Physics of the University of Vigo (Spain). The culture of these microalgae was done in photobioreactors, i.e. tanks using a controlled medium together with egthteen hours of light and six hours of darkness [2].

Table 1.Number of cells in each sample.

Concentration (%)	Number of cells (x 10^5)
0	Sea water (reference)
3.125	6.73
6.25	14.18
12.5	24.44
25	51.05
50	97.21
100	164.78

3 Fluorescence spectrum of *Nannochloropsis gaditana*

To obtain the fluorescence spectrum of each sample, a LIF measurement was performed [6]. A 488 nm blue laser with a ~50 mW power was used as illumination source. The detector was placed at 90º respect to the laser beam (to avoid direct incidence) as shown in Fig. 1.

The detector consists of a red–NIR (near infrared) passband filter whose purpose is to discard the wavelengths that do not correspond to a fluorescence signal. A lens was placed to couple the output of the filter to an optical fiber that will finally guide the light to a Vis-NIR spectrometer (see Fig. 1).

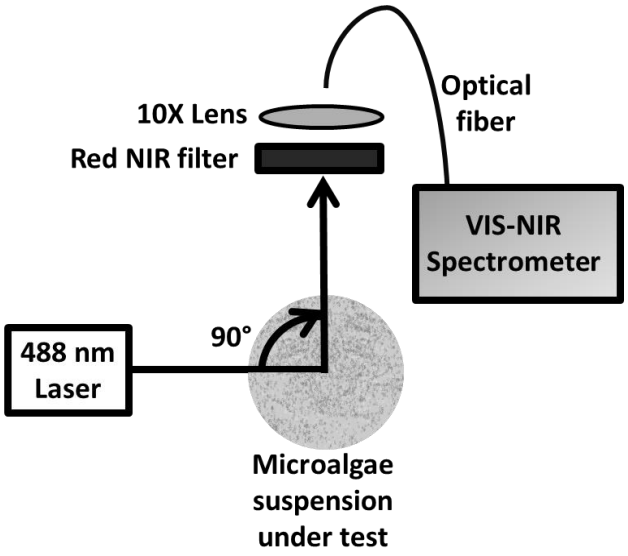

Figure 1. Schematic of the set-up for the LIF.

Figure 2 depicts the fluorescence spectrum obtained with the configuration laser + spectrometer described before. Each curve corresponds to a different concentration of *Nannochloropsis gaditana*. As it can be observed, all the signals exhibit a similar shape with a main peak around 685 nm. The intensity of the fluorescence phenomenon is proportional to the concentration.

4 Fluorescence detection with the designed device

Since the pigments present in microalgae have a different absorption band, the apparatus uses two LEDs to induce the fluorescence, the first one is blue (B, 465 nm) and the second one ultraviolet (UV, 390 nm).

The reemitted radiation is sensed by a phototransistor that has a red-NIR bandpass filter. Sources and detector are placed forming an angle of 90º between each other, to avoid direct incidence of the light (see Fig. 3).

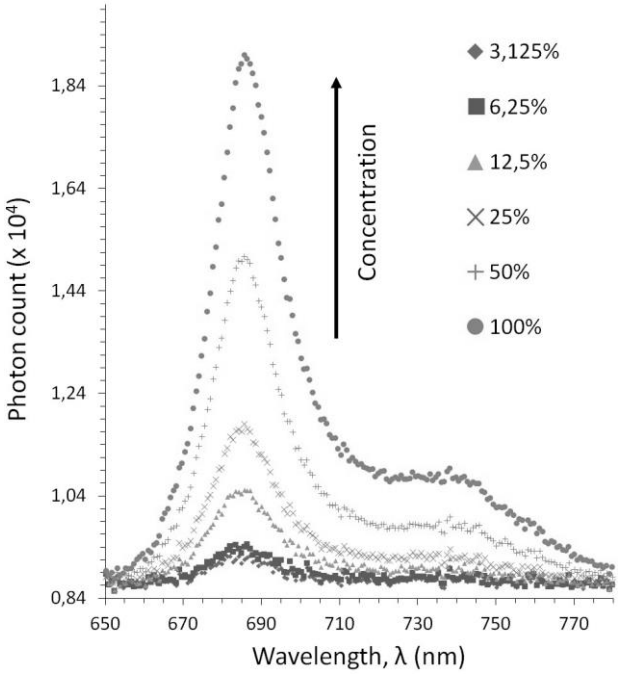

Figure 2. Fluorescence spectrum for the different samples.

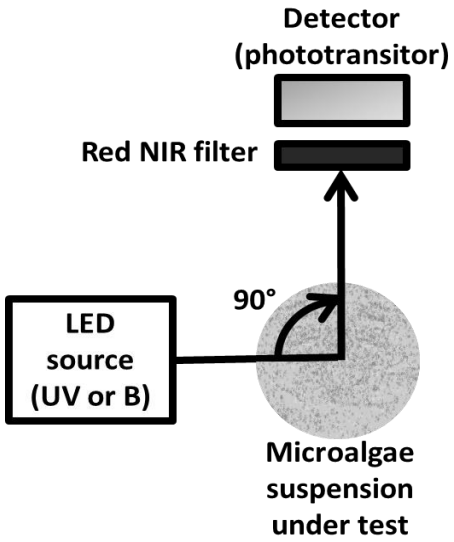

Figure 3. Schematic of the measurement in the designed device.

Apart from the sources and detector, the electronics of the device (see Fig. 4) include: an 8-bit microntroller (µC), a 16-bit analog-to-digital converter (ADC) and a ZigBee radio module to transmit the data to a computer for storage and analysis. With this module remote sensing is performed, avoiding the need of cables and easing the installation of the sensor. As a result the user has the flexibility to change the placement of the device.

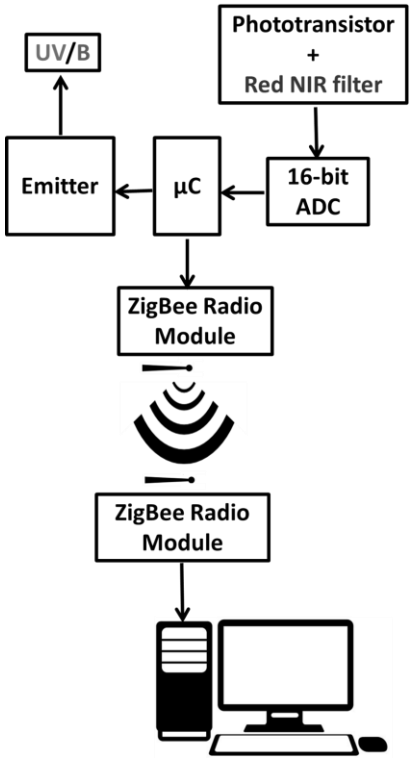

Figure 4. Functioning and different parts of the measurement system.

5 Results and discussion

Figure 5 shows the relationship between the fluorescence (ADC output) and the number of cells per milliliter illuminated with a UV and blue LEDs (squares and circles respectively). It can be oberved that the signal increases monotonically with the concentration.

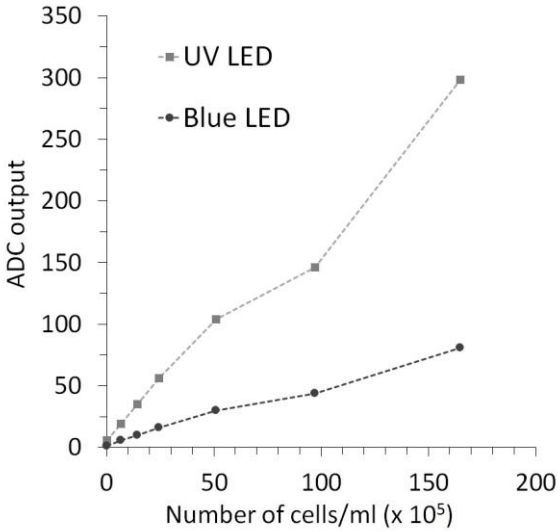

Figure 5. Detected fluorescence in function of the number of cells per milliliter.

6 Conclusion

The present work verifies the use of an unintrusive and economic photonic sensor for monitoring the population growth of microalgae that are being harvested. The fluorescence is proportional to the chlorophyll content which increases with the amount of cells. The apparatus will be able to aid the growing field of microalgae biotechnology.

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