High-performance imaging system for measurement of biophoton emission

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Abstract: All biological tissue emits radiation in the visible spectrum too weak to be seen with the naked eye. We present an imaging system and method enabling quantization and monitoring of biophoton emission utilizing a low-light-level imaging array coupled with time series image analysis. This system is adaptable for diagnostic purposes.

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Photons are continuously absorbed and emitted by all living cells. One possible means of releasing energy when an electron changes energy states during a biochemical reaction is via biophoton emission[1]. This emission is coherent like laser light and present over the entire the visible spectrum[2]. It is measurable using ultra-sensitive low-noise detectors in completely dark enclosures, and does not require the use of markers, external illumination or applied stimulation[3]. This weak radiation can be imaged using a high-performance, low-noise, cooled CCD array similar to those developed for long-exposure astronomical images. Utilizing this system, high-resolution images can be obtained and analyzed to monitor the amount and location of the emission as a function of time.

This system is comprised of a nearly photon-limited imaging CCD array, imaging optics, staging, light-tight dark box and time series analysis of images. It provides quantitative data enabling the monitoring of location and amount of biophoton emission across biological tissue enabling the determination of function states of living systems. Figure 1(A) shows a chlorophyll fluorescence image with a one-minute exposure, while Fig. 1(B) shows a biophoton emission image taken after the chlorophyll fluorescence decays with a ten-minute exposure. These images represent ambient radiation emitted by the sample in complete darkness. Note that different leaf types have different amounts of emission and that details such as veins can be clearly seen. The amount of emission can be quantified and plotted as a function of time [Fig. 1(C)] to study processes such as response to injury. These techniques can be applied to study functional states and processes of living systems in biological, plant and medical sciences.

Fig. 1. (A) 1-minute exposure showing chlorophyll fluorescence in total darkness. (B) 10-minute exposure showing biophoton emission in total darkness. (C) Average biophoton emission for 2 areas within an injured leaf showing comparison of activity as a function of time (with background image subtracted).

References