A Wireless Paired Emitter Detector Diode Device as an Optical Sensor for Lab-on-a-Disc Applications

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Introduction

Over the last decade increased awareness of long term consequences of water contamination has taken the spotlight of the chemical sensing community, as water quality monitoring plays a crucial role in understanding and managing potential risks. This spurred the need of development of inexpensive optical sensors capable of wireless communication[1,2].

This report describes the first use of a wireless paired emitter detector diode device (PEDD) as an optical sensor for colorimetric analysis for Lab-on-a-Disc applications. The method achieves excellent sensitivity and signal-to-noise ratio (SNR) in comparison to the more commonly employed method of coupling a light emitting diode (LED) to a photodiode. The low cost, small size, low power consumption, increasing spectral range coverage (247–1550 nm), intensity and efficiency, ease of fabrication and simplicity of the PEDD make it an ideal optical detector for colorimetric assays[3]. In terms of microfluidics, the non-contact PEDD detection scheme aligns perfectly with centrifugal Lab-on-a-disc systems, which typically have difficulties in monitoring during rotation[4].

Prototype

The instrument consists of two Surface Mount (SMT) LEDs, placed above and below the sensing area of a disc, with supporting electronics (Fig. 1). One LED acts as the light source while the other is reverse biased, acting as a detector.

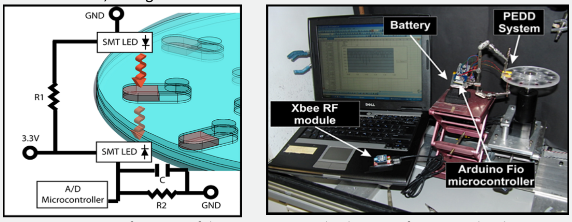

Fig. 1. Prototype configuration of the PEDD system with schematic of circuit used in the system.

Calibration of the system

Preliminary characterization of the device showed the light intensity from three different colour dyes placed in sequential disc reservoirs (Fig. 2).

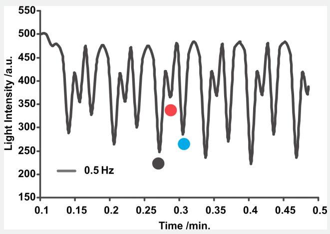

Fig. 2. Detection of three different dyes (black, red and blue) during spinning of the disc at 0.5 Hz.

The calibration of the system was performed with:

- **Bromocresol Purple (BCP) pH dye.**
- **Vitamin B12 (Cyanocobalamin).**

Concentration ranges of both analytes were measured using UV-Vis spectrometry for control. the linear relationship between absorbance and dye concentration was found to be in the concentration range from 2.5x10^{-6} to 5x10^{-5} M, higher concentrations were not accurately measured while lower concentrations were not detected (Fig. 3).

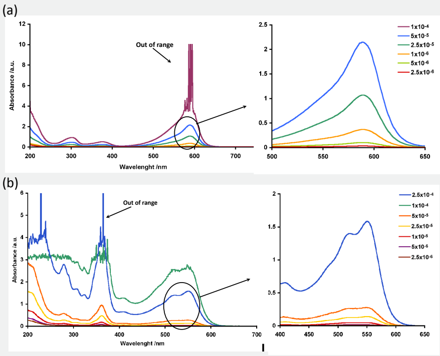

Fig. 3. UV-Vis spectra of (a) Bromocresol Purple, (b) Vitamin B12, at different concentrations.

Results

A serie of dilutions for both analytes were examined with the PEDD system in the disc reservoirs.

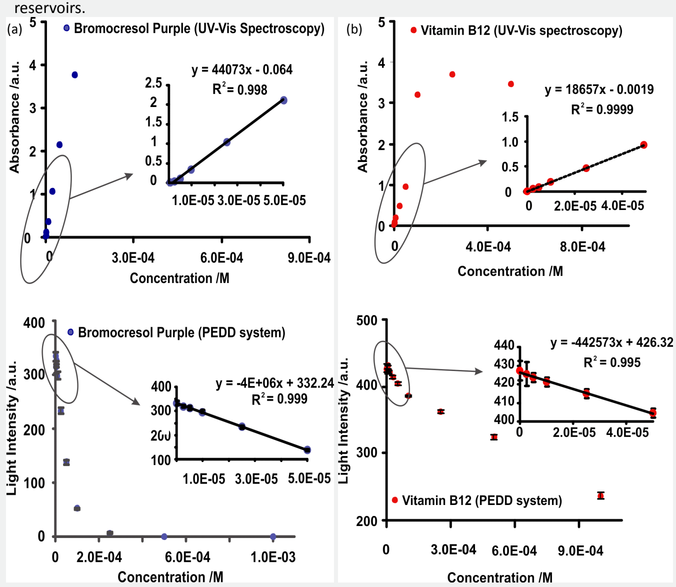

Fig. 4. Calibration curves of (a) Bromocresol Purple pH dye, n=6, (b) vitamin B12, n=4, using a UV-Vis spectrometer (upper side) and the PEDD system (bottom side), $L_{UV\text{-}Vis}$=1 cm, L_{PEDD}= 0.1cm.

Conclusions

A portable system for long-term colorimetric analysis in solution has been developed. This device incorporates low power detection coupled with wireless communication and power supply into Lab-on-a-disc system. Integration of a wireless communication device allows data acquisition according to individual needs. Similar limits of detection between PEDD system and standard UV-Vis spectrometer, 2.5x10^{-4} M, imply that the system is highly sensitive thus allowing for detection even low concentrations levels. In general, this shows potential for the PEDD system to be a cheap and versatile alternative optical detector for lab-on-a-disc applications.

Further work on the system would include better packaging in order to improve the detection limit by reducing external light noise and more extensive experimentation with various analytes in point-of-care settings.

References

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