Microfluidic System with a Wireless Paired Emitter Detector Diode Device as Optical Sensor for Water Quality Monitoring

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Introduction

Increased demand for improved water management is driving need for water quality monitoring systems with greatly improved price/performance characteristics. This work presents the first use of wireless paired emitter detector diode device (PEDD) as an optical sensor for colorimetric analysis of water quality in a Lab-on-a-disc device format.

In comparison to the more commonly used method of coupling a LED to a photodiode, this technique achieves excellent sensitivity and signal-to-noise ratio, with very low cost fabrication and electronics. Furthermore, its low power consumption, increasing spectral range coverage, excellent intensity and efficiency, small size, ease of fabrication and simplicity of the PEDD make it a perfect optical detector for colorimetric assays[1]. In addition, the device is ideally suited for integration with microfluidic platforms based on the centrifugal Lab-on-a-Disc concept, in which detector difficulties can arise due to the high rotation speed typically used in this approach[2].

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 LEDs acts as the light source while the other is reverse biased, acting as a detector.

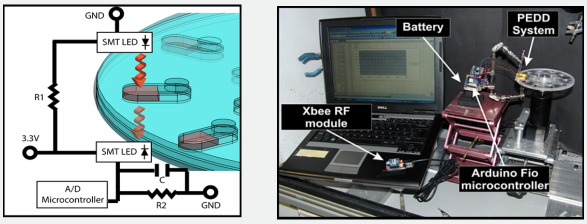

Fig. 1. Prototype configuration of the PEDD system with schematic of circuit used in the system.

Results

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

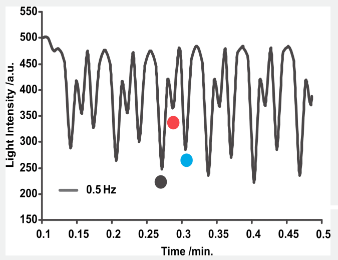

Fig. 2. Detection of three different dyes (black, red and blue) during spinning of the disc at 0.5 Hz.

The calibration of the system was performed with:

- **Bromocresol Purple (BCP) pH dye** - an analyte with chemical relevance as pH sensor dye in several processes,
- **Vitamin B12 (Cyanocobalamin)** - ensures the smooth functioning of vital life processes of the human body.

Concentration ranges of pH dyes were measured using UV-Vis spectrometry for control. The linear concentration range was from 2.5×10^{-6} to 5×10^{-5} M, higher concentrations were not accurately measured while lower concentrations were not detected (Fig. 3).

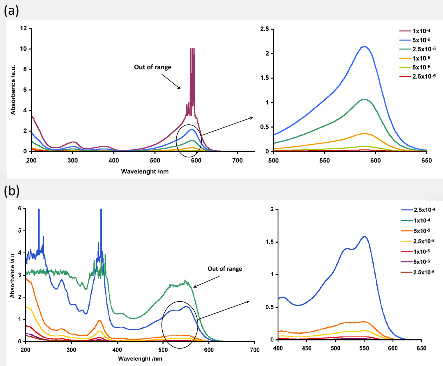

Fig. 3. UV-Vis spectra of (a) bromocresol purple, (b) vitamin B12, at different concentrations.

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

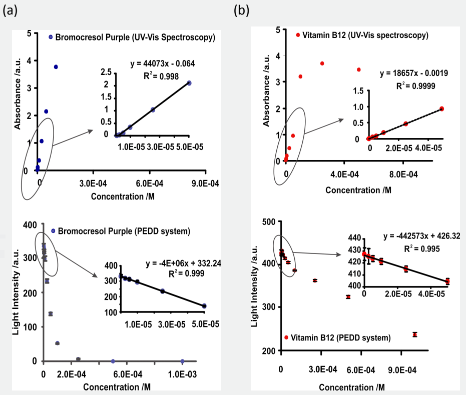

Fig. 4. Calibration curves of (a) bromocresol purple pH dye, n=6, (b) vitamin B12, n=4, using a UV-Vis spectrometer (upper side) and the PEDD system (bottom side), $L_{UV\text{-}Vis}$=1 cm, L_{PEDD}= 0.1cm.

Conclusions

Results showed close alignment between the PEDD system and standard UV-Vis spectrometry with similar limits of detection (2.5×10^{-4} M) (Figure 4a and 4b). However, the PEDD system presented a linear trend over a wider range of concentrations. In general, the experiments demonstrate the potential for the wireless PEDD to be a versatile and cheap alternative optical detector system for water quality monitoring in microfluidic applications.

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

References

[1] M. O'Toole, R. Shepherd, G. G. Wallace, D. Diamond, "Inkjet Printed LED Based pH Chemical Sensor for Gas Sensing" Anal. Chim. Acta, 652, 2009, pp.308-314.

[2] R. Gorkin, J. Park, J. Siegrist, M. Amasia, B. Lee, J. Park, J. Kim, H. Kim, M. Madou, Y. Cho, "Centrifugal Microfluidics for Biomedical Applications" Lab Chip, 10, 2010, pp.1758-1773.

Acknowledgements

Marie Curie Initial Training Network funded by the *EC FP7 People* Programme
Science Foundation Ireland under grant 07/CE/I1147