Thesis title:

Capacitive Biosensor Interface Circuit Design for Fast and Low-Cost Detection of Microsystin-LR

Abstract:

Microcystin-LR (MCLR) is a naturally occurring toxin produced by cyanobacteria. It is the most investigated cyanobacterial peptide toxin due to its frequent presence in cyanobacterial blooms in rivers and lakes all over the world [1]. MCLR is generally associated with hepatoxicity. The toxic effect of MCLR is due to their inhibition of protein phosphatases. Every year, hundreds of livestock are killed or sickened by ingesting cyanotoxins-contaminated water [2, 3]. For Drinking water, a guideline value for MCLR was introduced by World Health Organization at 1ug/L.

The analysis of MCLR is mostly carried on by reversed-phase high-performance liquid chromatography combined with ultra-violet detection [4]. Affinity-based capacitive biosensor is also investigated for doing real-time, non-enzyme-prepared analysis. This thesis is about an investigation on MCLR detection based on capacitive biosensor by focusing on fast and low-cost detection method.

In my work, a measurement system was verified. In this system, polymer capacitors are used for modeling the capacitive sensor with capacitor arrays connected mimicking capacitance change of the sensor when MCLR is present. Then a differential structure converts capacitive change into voltage before it gets amplified and filtered around frequency 8KHz. Next an experiment was designed and implemented with capacitive sensors assembled into the system and the result was recorded and analyzed. The last part is about updating the measurement system: (1) Increasing it’s signal to noise ratio by keeping the amplification and filtering traces as differential; (2) Improving the differential structure to a fully balanced one such that it’s more robust to common mode variations of capacitive sensors with time and temperature.

[1] S. Loyprasert, et al “Label-free capacitive immunosensor for microcystin-LR using self-assembled thiourea monolayer incorporated with Ag nanoparticles on gold electrode”, Biosensors and Bioelectronics, vol. 24, pp. 78-86, June 2008.

[2] V. R. Beasley, W. O. Cook, and A. M. Dahlem, “Algae intoxication in livestock and waterfowl”, Veterinary Clinics of North America: Food Animal Practice, vol. 5, pp. 345-361, 1989.

[3] A. D. Thomas, M. L. Saker, and J. H. Norton, “Cyanobacterium cylindro-spermopsis raciborskii as a probably cause of death in cattle in northern Queensland”, Australian Veterinary Journal, vol. 76, pp. 592-594, 1998.

[4] J. Rapala, et al, “Detection of microcystins with protein phosphatase inhibition assay, high-performance liquid chromatography-UV detection and enzyme-linked immunosorbent assay: Comparison of methods”, Analytica Chimica Acta, vol. 466, Issue 2, pp. 213-231, 2002