AUTOMATING ELECTROCHEMICAL DETECTION FOR CENTRIFUGAL MICROFLUIDICS

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INTRODUCTION

Utilising point-of-care testing (POCT) for the measurement of cardiac biomarkers can play a pivotal role in expediting the initial diagnostic assessment upon arrival at critical care settings. Point-of-care (POC) devices typically incorporate analyser platforms and disposable assay cartridges which facilitate biomarker detection without the need for sophisticated instrumentation and highly specialised training. Fundamental to the operation of these devices is the automation of the sensing process which generally occurs within a microfluidic device.

Centrifugal microfluidic devices possess various attributes that complement POCT, hence, they are central to the operation of numerous commercial POC platforms [1]. The inherent characteristics of centrifugal microfluidic devices favours luminescent and optical detection approaches. However, despite the notable sensitivities afforded by these methods of detection and the compatibility with POCT, the optical components involved in the measurement process can be costly and enlarge the overall size of a POC platform. Various groups have developed centrifugal systems that are compatible with electrochemical detection by incorporating slip rings [2] or bespoke potentiostats and microcontroller devices [3].

This work describes the ongoing development of a centrifugal spinstand platform for the automated electrochemical measurement of cardiac biomarkers.

MATERIALS AND METHODS

Polylactic acid (PLA) filament (1.75mm), acrylic sheet (5mm), threaded stainless steel rods (M4) and plain stainless steel rods (6mm) were used in the fabrication of the spinstand platform. A stepper motor (Lin Engineering WO-4118S-04P) actuated the leadscrew and a brushless DC motor (NMB Technologies DIA42B20W32A) rotated the turntable. An in-house position sensor incorporating a laser diode (Laser Components 2008364) and a photodiode (Vishay TEFD4300) was mounted on the spinstand to locate the braking position of the turntable. An Arduino Uno controlled the operation of the spinstand. Screen printed electrode connectors were fabricated on an X-MAX (Qidi Tech) 3D printer and coated with carbon cement (Leit-C) and copper plated in a copper sulphate solution.

***Figure 1**. Spinstand platform including electrode connector actuation mechanism*

RESULTS & DISCUSSION

The spinstand platform, illustrated in Figure 1, has been evaluated for rotational velocities up to 4,000 RPM. It is imperative that the acceleration of the turntable does not produce excessive vibrations or unstable rotation, in particular, velocity oscillations or significant overshoot. This would compromise the ability to perform an immunoassay that relied upon the velocity magnitude to trigger events. Therefore, a PID controller was tuned and integrated which assisted in regulating the turntable velocity and dampening the response when implementing adjustments of the set velocity as shown in Figure 2.

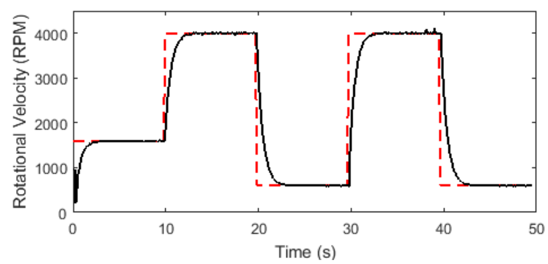

***Figure 2**. Velocity response (solid curve) of the turntable measured using an internal encoder is plotted with the applied speed profile (dashed line)*

The spinstand system has been developed to control immunoassay unit operations that occur on microfluidic discs. The system aims to support on-board electrochemical detection using a leadscrew actuation mechanism and tailored electrode connectors and has been fabricated from cost effective materials and electronic components. Moreover, the PID regulated velocity response demonstrates the stable and accurate spin velocity of the turntable which supports velocity magnitude triggered events. Hence, this system boasts several features that could support cardiac biomarker measurement in adherence with POCT standards. Further refinement of the system is required before assessing automated electrochemical measurements, however. Nonetheless, the spinstand can currently facilitate biosensing that involves removal of the immunocomplex product for subsequent measurement on an external reader system.

REFERENCES

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