UMKC Visit Report

By: Teboho Moeketse

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Background

The volume of electrochemical bioelectronic sensing devices has exponentially increased in the market and healthcare sectors over the past years. This has triggered early diagnosis and monitoring of ever-escalating diseases based on their respective biomarkers in human physiology. Point-of-care testing of these biomarkers in human biofluids is mostly invasive and requires in-person healthcare centre visits where clinicians may offer services. However, the growth of modern devices involving non-invasive measures is expected to continue, driven by changes in healthcare delivery aiming at delivering less costly care closer to the patient's home, allowing healthcare workers to make clinical decisions at the site of testing. This is in line with the United Nations Sustainable Development Goals (SDGs), aiming to achieve universal health coverage and provide access to safe and affordable medication and health services for all. Hence, the current research project focuses on the portable biosensor device design and construction, as one of the rapidly emerging research fields in micro-manufacturing, which will be achieved by employing electrochemical skills and elementary electronics engineering knowledge. This poses the potential to provide continuous, real-time physiological information via non-invasive measurements of these biochemical markers. The UMKC, under the electrical and computing engineering department, was a stepping stone into the prototyping of the device.

Objectives

The UMKC visit was aimed at designing and constructing a fully functional electrochemical handheld electronic readout device for the sensing of relevant disease biological markers under the supervision of Professor M. Rahman (UMKC host).

To achieve the stated aim, the collaboration between the two laboratories, nano-micro-Manufacturing (NMMF-UWC) and the School of Computing and Electrical Engineering (UMKC), was fruitful. NMMF provided facilities for electrochemical sensors and printed electrodes as sensor platforms, which were used for evaluation and testing of the device, while the electronic resources were developed at UMKC. Therefore, the necessary objectives included:

a. To fabricate the sensor platforms using screen-printing and electrochemical methods with simple materials such as graphene nanosheets, which was done before leaving UWC.

b. To fabricate a prototype electrochemical readout using a breadboard and electronics components.

c. Customise the developed prototype into a portable and possibly wearable biomedical device.

e. Evaluation of the device's performance using ascorbic acid as a target biomolecule quantified.

f. Optimisation of the device's response by variation of electronic components.

g. Customising a prototype on the prototyping printed circuit board.

Achievements

Device construction

During the visit, a prototype was constructed on a breadboard as a resemblance of a diagnostic tool for the biomarkers of interest. This electronic base was evaluated by quantifying the ascorbic acid because of its good electrochemical response properties. The development of the device included optimising the sensitivity of the device by altering some of the components, such as resistors and capacitors. Since the aim was to have a portable biomedical tool, further development was conducted in which a printed circuit board was used to miniaturise the prototype instead of using a breadboard with a rat nest of wires, as illustrated in Figure 1.

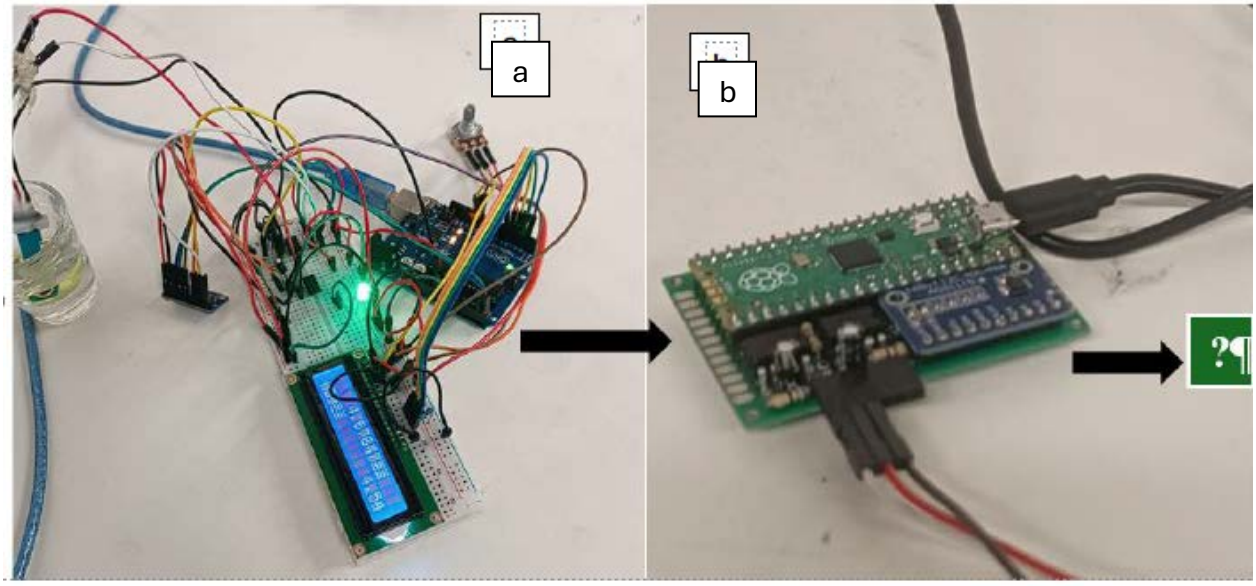

Figure 1: Device construction on a breadboard (a), and portable transformed device on a prototype circuit board.

Manuscript

The manuscript, which integrates electrochemistry and electronics, is under development and will be published soon. The delay in completion was due to some experiments, which had to be done in the UWC to validate the performance of the device, as the initial work was done in the electrical laboratory, where electrochemical resources were limited.

Challenges

As much as the laboratory visited had all the essential resources one could need, the only challenge was the availability of the electrochemical tools, which could be used in conjunction with electronics. For this reason, there had to be improvisation when the application was performed for the invented prototype. The organic chemistry laboratory, which was organised for use when needed, was helpful, but to a certain extent.

Changes and improvements

It would be great to use the available facilities in the engineering department (electrical) to direct research into real-life applications by transferring the knowledge acquired in the laboratory during prototyping into industrial innovation. This can be achieved by using the

high-quality standard printing facilities, ranging from screen printing to sophisticated 3D printing instruments. The laboratory can also be diversified by directing part of the research to solving health-related problems. In this way, more tools will be available to accommodate interdisciplinary research.

The benefits of the UMKC / UWC Exchange Programme

This programme has played a major role not only in our department, which is driving research into innovative technologies, but also in my personal growth as a researcher. For now, our Nano-micro manufacturing facility (NMMF) is equipped with a human resource trained in UMKC to pursue its goals. Prof Rahman has done a wonderful job guiding an Electrochemist in understanding the building of electronic circuits and programming them to function accordingly. Now the knowledge will be transferred to other researchers in our department through training workshops in consultation and collaboration with UMKC. This visit was also beneficial, as the knowledge acquired can now easily be transferred into the printing technology available in our laboratories. Three months were, however, not enough to acquire everything the knowledge. Therefore, paying a visit again in the near future with new objectives will be beneficial since they will be based on prior knowledge.

Besides the academic point of view, it was a wonderful experience to be in Kansas City. The accommodation was great, and the means of transport was also of a world-class standard. Moreover, getting to know different people with diverse cultures was also a lesson. The list of experiences is endless.