NFC-enabled on-site precision diagnostics powered by a smartphone

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On-site rapid diagnosis at low cost is key for the monitoring and prevention of diseases, particularly in remote areas. There is, however, a lack of affordable, versatile digital diagnostic platforms available in the market that can be easily adapted to unforeseen situations such as the rapid spread of pathogens and global pandemics.

Lateral Flow Assay (LFA) is one of the most widely used Point-of-Need (PoN) tools for diagnostic testing since it is portable and simple to use [1,2]. Most LFA devices, however, rely on colorimetric detection, which only provides qualitative or at best semi-quantitative results. Many efforts have focused on addressing the lack of quantification on this type of devices by combining LFAs and electrical detection, but the integration of metallic electrodes on nitrocellulose membranes remains a bottleneck.

One of the main challenges for on-site diagnosis is the need of a portable reader amenable for the analysis in the fields. The development of wireless technologies, such as Bluetooth, Wi-Fi and Near-Field Communication (NFC), has enabled the real-time communication of data to accessible platforms, where they can be analyzed and stored [3]. The biggest differentiator of NFC, however, is that it is powered passively without batteries through wireless inductive coupling. NFC allows exchange of electrical power large enough (10 mW) to operate low-power and low-cost electronics, including microcontrollers and sensors. Mobile-operated wireless technology, which combines rapid communication and wireless power supply on the same unit, is an emerging area with promising applications in PoN diagnostics.

In this work, we present two new key technologies to realize the next-generation of rapid digital diagnostics for on-site testing: (i) a disposable nitrocellulose-based platform with integrated hydrophilic 3D metal electrodes (eNC) to facilitate quantitative electrochemical detection on LFAs; (ii) a programmable wireless and batteryless potentiostat powered by NFC technology to perform electrochemical analysis using a smartphone [4]. The versatile NFC-potentiostat enables the use of typical electroanalytical techniques employed in (bio)sensing (cyclic voltammetry, chronoamperometry, square wave voltammetry) by customizing the setup conditions according to the detection process. We have also designed an Android application for use in the field and a 3D-printed phone case to house the NFC-potentiostat and connect the disposable eNCs. The operation of the integrated system (NFC-eNC) was demonstrated by measuring the products of a modified commercial ELISA kit to detect Maize Mosaic Virus, a devastating crop pathogen. The results of the electrochemical measurements were compared to traditional spectroscopic ELISA measurements to validate our on-site testing device.
The NFC-eNC platform reported in this work is highly versatile and can be modified to detect multiple analytes by tailoring the bioreceptors (i.e., antibodies, aptamers) or enzyme conjugates, for applications in other fields, such as healthcare and food safety. We aim to create the next generation of digitized tests for rapid detection of diseases at the PoN.

References

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