Electrochemical sensors for pandemics management: a review of current diagnostic devices and new rapid-deploy systems

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Abstract
Electrochemical biosensors have been impacting the research community since the 60s with the first generation of glucose oxidase biosensor. These devices have been allowing for quantitative and rapid detection of almost any type of analyte in a short time and with point-of-care (PoC) readout. Despite, the consumer market came to know almost only the glucometer, these systems have a huge applicability and the potential to overcome the limitations of their widespread optical cousins, the Lateral Flow Assays (LFAs) overall in terms of sensitivity.
Situations like the one we are living with SARS-CoV-2 virus, from local outbreaks to pandemics would radically change their impact on our societies if these tools would come to be rapidly available. The easy connection of the readout systems to the web would allow real-time monitoring of the spread, planning of effective actions to limit it, modelling and obtaining accurate prevision to minimize the economical and societal impacts.
In this work, we present and shortly discuss the recently proposed electrochemical systems for the detection of the SARS-CoV-2 and other viruses and of the immunization against them [1,2], for this we will space from voltammetry- and impedance-based sensors to graphene field effect transistors (GraFETs) [3,4]. Moreover, we introduce and discuss ideas we are currently exploring in our lab to produce scalable printed biosensors for rapid-deploy for the PoC. Electrical biosensors (with potential for SARS-CoV-2 detection) are based on the use of various printing technologies (inkjet- and screen-printing, stamping etc.) and the use of nanomaterials to improve their electro-catalytic or receptors binding capabilities. They (may) take advantage of recently developed antibodies and aptamers (specific to the virus surface proteins) immobilized on the electrodes' surface using various strategies.
We propose three approaches: the first one is a simple impedance-based label-free and mediator-free system and a low-cost smartphone based readout (Figure 1a, b, c), which has already been tested with a model protein and showed LOD in the nM range.
The second approach is based on the same concept but using a nicotinamide adenine dinucleotide (NADH) redox mediator and either the aforementioned impedance readout system or the widespread glucometer for the readout (Figure 1d, c, d). Finally, the third approach uses a labelled sandwich one with enzymatic amplification (glucose as substrate, glucose dehydrogenase enzyme, and NADH as product) being both low-cost and easy-to-use readout technologies (Figure 1e, c, f).

REFERENCES
[1] H. Huang et al. *ACS Nano* (2020) acsnano.0c02618.
[2] B. Udugama et al. *ACS Nano* (2020) acsnano.0c02624.
[3] G. Seo et al. *ACS Nano* (2020) acsnano.0c02823.
[4] X. Zhang et al. (2020) http://arxiv.org/abs/2003.12529, 1–20.

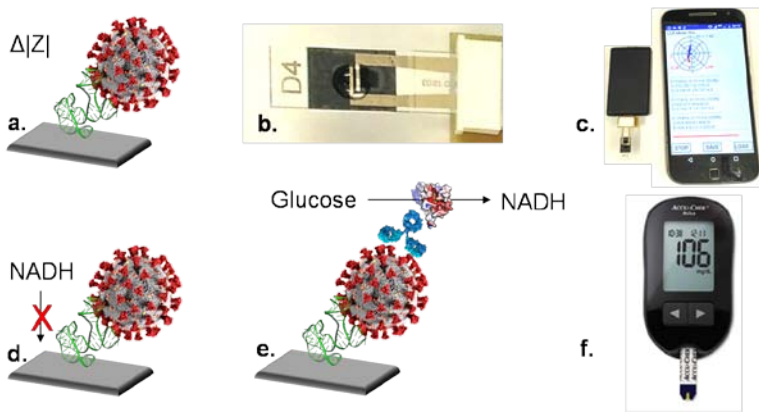
FIGURES


Figure 1: Schematic of the proposed SARS-CoV-2 virus detection strategies. Label-free detection of the impedance variation due to virus-aptamer binding (a) on the printed electrodes surface (b) readout by impedance commercially available app. (c). Reduction of NADH mediator access sites onto the electrode surface due to virus-aptamer binding (d) and readout by impedance (c) or commercially available glucometer (f). Labelled sandwich detection using glucose dehydrogenase as enzymatic label for signal amplification (e) and readout by glucometer (f).