Equivalent electrical model circuit for COVID-19 electrochemical detection

Cesar A. Hernandez
Johann F. Osma
CMUA. Department of Electrical and Electronic Engineering, Universidad de los Andes, Carrera 1E # 19A-40, Bogota 111711, Colombia
jf.osma43@uniandes.edu.co

Abstract
Human respiratory infections caused by different pathogenic threats are a severe risk for the population worldwide [1]. Recently, an unprecedent outbreak of the newly designated Coronavirus disease 2019 (COVID-19) [2] has caused, to date, over 169000 deaths around the globe [3]. The societal and economic impact are still to be realized. While research around the globe has shown a remarkable amount of fast track results, it has also been questioned the readiness level of health systems in different countries. As an immediate counter measure to avoid catastrophic scenarios, the accurate and timely diagnosis of potential cases is required [4]. Currently, diverse methods are available to perform fast (<2 h) detection, however, instrumentation and reagents costs are considered a major drawback for routine application.

Electrochemical technologies have proven to accomplish the requirements for fast and economically amendable screening tools, different groups have demonstrated applicability of electrochemical biosensors for human influenza (H1N1) [5], rabies [6], human papilloma virus [7], among others. One of the main advantages of electrochemical technologies is that it allows to obtain readily accountable results, which translates in market products that require little training, which make them perfect candidates in emergency situations. On the other hand, the design and development of devices based in electrochemical technologies requires a careful understanding of each element that would partake in the final measurement. As part of this endeavor, a proper modelling and characterization of the target is required. In this work we, present the equivalent electrical model circuit for different measurement strategies focused in the COVID-19 viral particle (virion), ranging from the single particle electrical characteristics, to suspension dispersed virus (colloid) and immobilization. The basic model is based in the dielectric properties of the virion structure, represented by the single shell and the dual shell spherical model [8]. The results provide a simple capacitive representation which can be used for the more complex scenarios, in which the diffusive effect of the suspension medium and the immobilization molecules should be accounted for in order to avoid misreading and, correspondingly, misdiagnosis.

REFERENCES

[1] D. M. Morens and A. S. Fauci, "Emerging Infectious Diseases: Threats to Human Health and Global Stability," *PLoS Pathog.*, vol. 9, no. 7, pp. 7–10, 2013.
[2] S. Kang *et al.*, "Recent Progress in understanding 2019 Novel Coronavirus associated with Human Respiratory Disease: Detection, Mechanism and Treatment," *Int. J. Antimicrob. Agents*, no. xxxx, p. 105950, 2020.
[3] WHO, "Coronavirus disease 2019 (COVID-19) - Situation Report-93," 2020.
[4] P. Pokhrel, C. Hu, and H. Mao, "Detecting the COVID-19," *Preprints*, no. October, pp. 1–29, 2020.
[5] D. Nidzworski *et al.*, "A rapid-response ultrasensitive biosensor for influenza virus detection using antibody modified boron-doped diamond," *Sci. Rep.*, vol. 7, no. 1, pp. 1–10, 2017.
[6] A. Adnane, "Electrochemical Biosensors for Virus Detection," *Biosens. Heal. Environ. Biosecurity*, 2011.
[7] L. F. Urrego, D. I. Lopez, K. A. Ramirez, C. Ramirez, and J. F. Osma, "Biomicrosystem design and fabrication for the human papilloma virus 16 detection," *Sensors Actuators, B Chem.*, vol. 207, no. Part A, pp. 97–104, 2015.
[8] N. Nasir and M. Al Ahmad, "Cells Electrical Characterization: Dielectric Properties, Mixture, and Modeling Theories," *J. Eng. (United Kingdom)*, vol. 2020, 2020.