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Real Sample Covid-19 Detection From Total RNA Screening By Using Biosensor

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ABSTRACT

The rapid and accurate detection of COVID-19 is critical in managing and controlling the spread of the virus. This study aims to develop a Carbon Quantum Dots (CQD) based biosensor for the detection of COVID-19 from total RNA extraction in real samples. The main objectives of this research are to test the performance of the CQD-Interdigitated Electrode (IDE) biosensor in terms of sensitivity, specificity, and reproducibility, to evaluate signal interactions and amplification between the Coronavirus and biomarkers using the Electrical Measurements Test (Keithley 2450), as well as to validate the biosensor's efficiency by comparing it with the established Reverse Transcription Polymerase Chain Reaction (RT-PCR) method. The CQD-IDE biosensor was meticulously tested for its ability to detect the presence of Coronavirus RNA in various samples. Sensitivity and specificity metrics were rigorously assessed, showing promising results that indicate high detection accuracy. Signal interactions were analyzed through Keithley 2450, demonstrating significant amplification correlated with the presence of target viral RNA. Clinical validation was performed on real clinical samples, demonstrating a detection accuracy of 98% compared to standard RT-PCR methods. Comparative validation against RT-PCR highlighted the CQD-IDE biosensor's potential for rapid, reliable, and cost-effective COVID-19 diagnostics. These findings suggest that the CQD-IDE biosensor could be a valuable tool in the ongoing efforts to enhance COVID-19 detection capabilities, offering a robust alternative to current diagnostic methods.

Keywords: *Covid-19, Carbon Quantum Dots, Aluminium-Interdigitated Electrode,* Reverse Transcription Polymerase Chain Reaction

1. INTRODUCTION

On 11 March of 2020, the World Health Organization (WHO) announced the novel coronavirus outbreak, which is well known as Coronavirus Disease 2019 (Covid-19), as the pandemic that was caused by the Severe-Acute-Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The novel coronavirus was initially spotted in Wuhan, Hubei province, China in November 2019. The failed attempt to suppress it there resulted in the spreading of the virus globally in early 2020. The Covid-19 virus can be rapidly transmitted via respiratory droplet (when the patients sneeze, cough or talk) and indirect-contact with contaminated surfaces or objects and airborne regions [1]. The unprecedented challenges caused by COVID-19 pandemic towards global public health necessitate the development of rapid, accurate, and scalable diagnostic tools. Therefore, it is important to have rapid and accurate detection methods to contain the SARS-CoV-2 spreads.

The COVID-19 pandemic has highlighted significant weaknesses in the current diagnostic infrastructure, particularly regarding speed, accessibility, and scalability. Traditional diagnostic methods like Reverse Transcription Polymerase Chain Reaction (RT-PCR), though highly accurate, are often hindered by necessity due to costly laboratory equipment, trained personnel, and lengthy processing times. These challenges are especially pronounced in resource-limited settings, where rapid and widespread testing is essential for effective disease management and control.

The aim of this study is to develop a Carbon Quantum Dots (CQD) based biosensor for detection of real sample Covid-19 from total RNA extraction. The main objective in this study is to evaluate signal interaction and amplification between the Coronavirus transmitted disease with biomarkers using the Electrical Measurements Test (Keithley 2450) as well as to test the performance of CQD biosensor in Coronavirus target detection based on its sensitivity, specificity, and reproducibility. In the end of this study, the validation of CQD based biosensor was performed by using real clinical samples to validate and compare its efficiency with RT-PCR.

This study consists of developing, characterizing and optimizing the biosensor's sensing elements, including nanomaterial applications (carbon quantum dots), interdigitated electrodes (IDE) as a transducer, and DNA probe bioreceptor. The sensing elements were developed by modifying the surface of IDE with CQDs, silanization of APTES, immobilization step for DNA probes for hybridization event between DNA probes and target analytes (RNA). The physical characterization and electrical characterization of the surface interaction for