Enhancing Rapid Detection and Quantification of Covid 19 Antibodies using Quartz Crystal Microbalance

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Introduction

With the growing need for efficient diagnostic tools in the medical field during the COVID-19 pandemic, we attempted to address the concerns by researching methods for enhanced antibody detection and quantification.

Our goals for this were to:

- Multiply the process so many machines may be run at once
- Attempt to streamline the overall process so it is easy to use

The Quartz Crystal Microbalance (QCM) is an open-source device designed to be extremely sensitive to small amounts of antibodies present in a blood serum sample. In order to analyze the data accurately, we measured baselines for each level of antibody concentration so we could compare the data accurately. Unfortunately, due to unforeseen circumstances we were unable to analyze the data we collected.

Procedure

- Sensors were positioned within the Quartz Crystal Microbalance (QCM), and calibration was performed manually using ultrapure water (UPW), confirming the chamber was fully submerged and void of air. Following this, a peristaltic pump system was connected to the chamber to ensure a consistent flow rate.
- Copper was administered to the sensors (Figure 1) via the peristaltic pump. Subsequently, a post-copper wash was carried out by introducing Phosphate Buffered Saline (PBS) solution via the pump system.
- Data collection for both sensors was initiated using the open-source software openQCM.
- The binding process for the S1 Protein Receptor Binding Domain - His Tag (RBD-HT) to the sensor was initiated by introducing RBD-HT solution to the loading pipette in intervals. The detection criterion involved observing a frequency drop of 15 Hz or more, signifying the adherence of antibodies to the sensor.
- Once the RBD-HT solution was nearly depleted from the loading pipette, PBS was added in two consecutive intervals in preparation for the 1:1000 antibody serum.
- Once the PBS was nearly depleted form the loading pipette, the dilute antibody solution (1:1000 serum) was added via autopipette in five increments of 100 µL.
- We created a post high dilution sample baseline by adding PBS. After that, we repeated the previous step with 1:100 serum solution.
- Upon finalizing data collection, the QCM sensor was subjected to a cleansing process involving the sequential additions of PBS, Glycine, Stripping Buffer, Glycine, and PBS. This process was performed twice.
- The QCM sensor was then sterilized with a bleach solution, cleansed with UPW, and replated with copper. Following the copper application, UPW was reintroduced and completely withdrawn from to ensure no liquid remains in the QCM sensor chamber.
- The pump system was dismantled and thoroughly rinsed with a bleach solution, followed by a final rinse with UPW. The QCM machine was then disassembled and the sensor was placed into a bell jar vacuum chamber, which was then returned to the freezer.

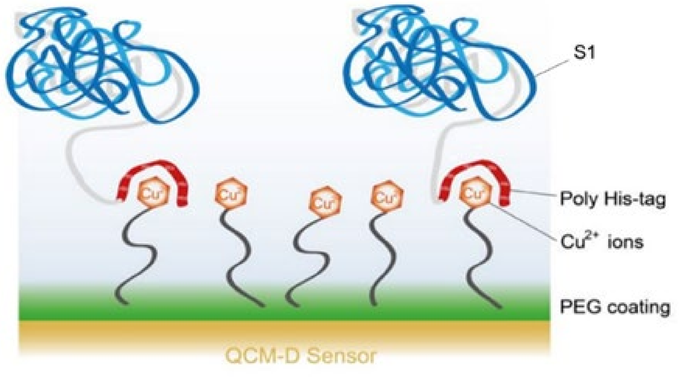

Figure 1. Copper ions were used to bind QCM-D plated with gold electrodes. The sensor was mounted above and below the quartz crystal to detect changes in the frequency (Hz). The copper ions would be used to bind to the His-tag; immobilizing the S1-RBD to the sensor surface.

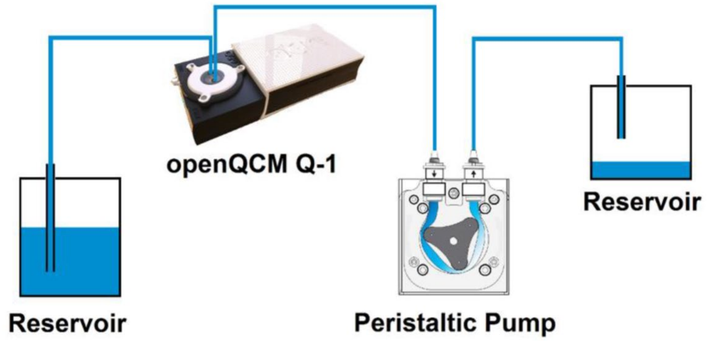

Figure 2. OpenQCM model as referenced in the procedure above. Peristaltic pump is set up to run multiple openQCMs for easy field testing and portability. Right reservoir was replaced with open siring tip for controlled application of liquids

Expected Results

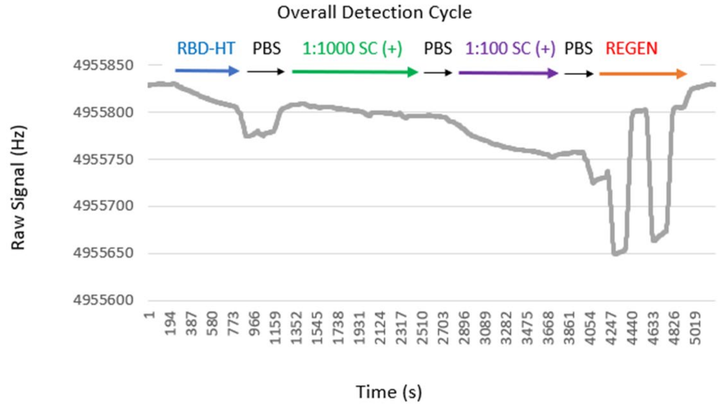

Figure 3 : The expected results should show a slight reduction in the raw signal (Hz) at the first RBD-HT wash. After a rinse of PBS to wash the leftover RBD-HT another drop in signal should be observed when we add a 1:1000 dilution of serum (+) to the system. Another wash of PBS clears the system and a 1:100 dilution of serum (+) is added to the system, inducing a much larger drop in signal. A final PBS is done and we regen the system back to its original state. The overall data was measured after the 1:100 dilution was added and waited for the signal to stabilize.