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 openQCM machine is designed to be extremely sensitive for 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 obtain and analyze the data we collected, but shown below is the openQCM graphed data..

Procedure

- Warm up bell jar with sensors by removing it from the freezer. Set up laptop with the QCM machines plugged in and open up the openQCM program. You will need two separate windows of the program running, one for each sensor.
- Place sensors in the QCM and lock the window in place. Next, calibrate the sensors by first pulling through 5 ml of water until no bubbles are seen on the sensor. Set up pump system and connect to power source.
- Apply copper (5 mM CuSO4) to sensors in 1 ml aliquots and set pumps to 30 ml/hr. Complete a post copper wash by adding ~1 ml 1X PBS solution.
- Start data collection for both sensors on the openQCM programs. Wait for signal to stabilize.
- Start RBT-HT binding to the sensor by adding 100 microliters of RBD-HT solution using an autopipette. Add a second and third right after each other. Look for a 15 Hz or more drop in the frequency.
- When the RBT-HT solution falls between 2 black lines on loading pipette, add 1 ml of 1X PBS and increase flow rate to 30 ml/hr. Add another milliliter of 1X PBS.
- When the 1X PBS falls between the black lines, add 100 microliters more of dilute solution (1:1000 for serum) using an autopipette. Immediately add another 100 microliters more and repeat three more times.
- Create a post high dilution sample baseline by adding 100 microliters of 1X PBS. Repeat previous step with 1:100 microliter solution.
- Create the 1:100 sample baseline by adding 100 microliters of 1X PBS and another immediately after.
- Wash the surface of the QCM by First adding 1 ml of 1x PBS, wait until the top falls between the two black lines then add the next solutions one right after another: 100 microliters of the 100 mM Glycine pH 1.5, 1mL of Stripping Buffer, 100 microliters of 100 mM Glycine pH 1.5, 1 mL of 1X PBS, 100 microliters of Glycine, 1 mL of Stripping Buffer, 100 ul 100 mM Glycine pH 1.5, 1 mL 1X PBS, then proceed to cleaning.
- Stop the openQCM software and close out of the window. Unplug the USB cable from the QCM device and clean the QCM as follows:
  - Pull through 50 mL of 10% bleach solution, add 1 mL DI water, pull through 1 mL of 5 mM CuSO4, repeat the DI water as needed, then finally pull all liquid through so none remains
- Disassemble the pump system and rinse with bleach solution and finally DI water. Disassemble QCM machine and replace the sensor into the bell jar vacuum and place back in freezer.

Expected Results

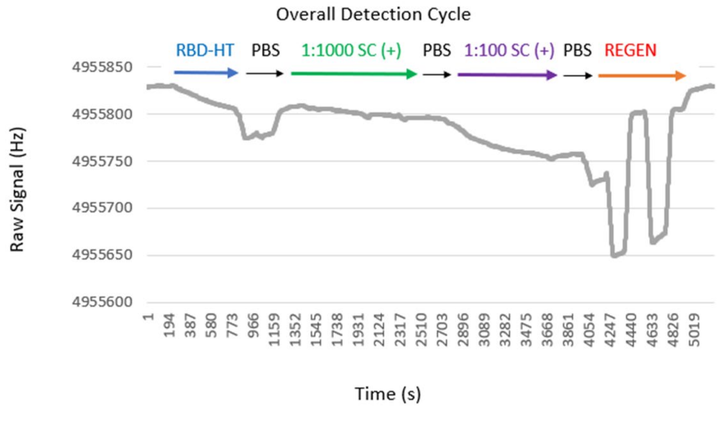

Figure 3 : The expected results should show a slight reduction in the raw signal (Hz) at the first RBD-HT wash. After a rinse of PBS to wash the leftover RBD-HT another drop in signal should be observed when we add a 1:1000 dilution of serum (+) to the system. Another wash of PBS clears the system and 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.

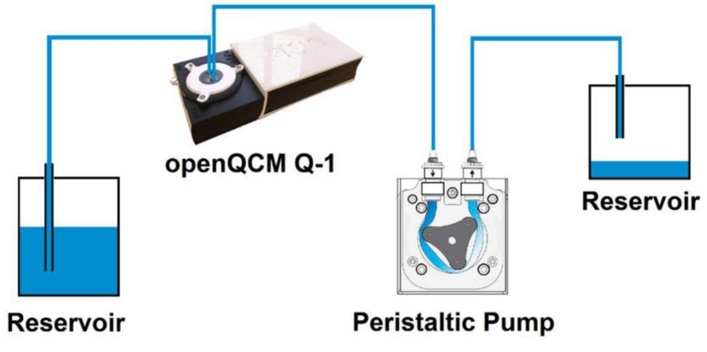

Figure 1. openQCM model as referenced in the procedure above. Peristaltic pump is set up to run multiple openQCMs for easy field testing and portability. Right reservoir was replaced with open siring tip for controlled application of liquids

Figure 2. 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 protein to the sensor surface.