FMRI RET 2017

Decreased time of incubation via Thermoplasmonic heating

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Abstract

There are over 30, 000 diseases plaguing our planet, according to the World Health Organization (WHO) and three quarters of them have no treatments which are effective. The need for accurate, fast and reliable methods of disease detection is critical towards the survival rates of infected patients. Thermoplasmonic heating could provide a means towards the development of a 'Point of Care' device capable of detecting biomarkers indicative of a specific disease, especially from non-evasive bodily fluids as in the saliva of patients. Previous studies have shown that thermoplasmonic heating was able to detect antigen/antibody interactions. We tested to see whether thermoplasmonic heating could increase the speed at which this detection occurs versus conventional incubation. We found that thermoplasmonic heating did, indeed, increase the speed of detection of antibody/antigen reactions.

Background

In 2016, the number of disease related deaths rose to 12.6 million. Among the greatest contributors were cancers and infectious diseases (5). Most afflicted patients are not aware of their diseased state until it has already progressed to a stage where it is difficult to treat. For example, oral cancer is ranked the 6th most common cancer in the world with only 60% of patients surviving a maximum of five years after initial diagnosis. Currently, the disease is first identified only through conventional examination of the oral cavity and usually only after the cancer has already metastasized. This makes the need for early detection techniques critical (2). Biomarkers for this type of cancer can be screened through the patient's saliva since any cancerous lesions in the mouth will have direct contact with saliva. Saliva can thus prove to be a useful, noninvasive method of screening for biomarkers involved in oral cancer (1). 'Point of Care' (POC) devices are used by health care professionals to obtain diagnostic results while with their patient. The goal of using these devices is to provide quick feedback with accuracy (3). A fairly new area of science and engineering involves the use of metals to regulate temperature on a nanoscale. This is called thermoplasmonics and could, theoretically, reduce the amount of time needed for complex reactions to take place, such as when incubation is required (4).

Objectives

Our goal was to investigate whether the time for an antibody/antigen reaction detection could be decreased using thermoplasmonic mixing versus the conventional method of incubation.

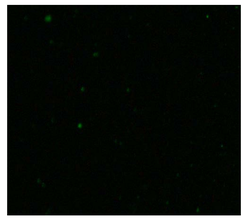
Approach

Preparatory Work

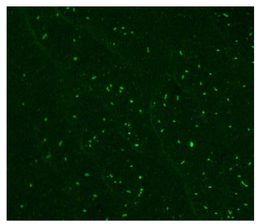
A. Gold Surface Cleaning / Slide Splitting – Piranha solution was used to clean all slides and each slide was cut in half of equal dimensions
B. Required Solutions Preparation – 3,3-Dithio-bis (sulfosuccinimidyl)propionate (DSP) was prepared in DMSO (>99%); IgG solution was prepared with Antibody Dilution Buffer (ADB)
C. Antigen Coating – Rinsing was done using DMSO and Phosphate buffered saline (PBS) and left overnight; Pure nanowater was also used to rinse the next day followed by the addition of Anti-Bovine IgG on the gold slides
D. Laser Facility Warm Up – 30 minutes was allocated towards the laser warmup
E. Optical Fiber Alignment – Alignment of microscope focusing was ensured prior to experimentation
F. Output Power Calibration – After experimentation a power meter was used to detect the intensity of the laser to ensure consistency

Method

- 14 pieces of antigen coated gold slides, treated with high concentration of fluorescent antibody solution were allowed to sit overnight. One set of 7 was marked as the experimental group and the other 7 as the control group.
- Pure water was used to flush the slides thoroughly and pictures for all samples were taken at 0 mins.
- Laser irradiation was used on the experimental group samples, shining from the bottom with a thin coat of water on the top. Meanwhile, water was added on the control slides, prepared for photography at the same spot.
- Pictures for all samples were taken after 5 mins, 10 mins, 20 mins, 25 mins and 30 mins. The pictures were named accordingly.
- Photoshop was used to analyze and quantify the amount of fluorescence produced by all samples at the time intervals previously noted. The amount and intensity of the fluorescence gave us an indication of the amount of antibody/antigen reaction taking place at that time.



Non-thermoplasmonic heating at 25 mins

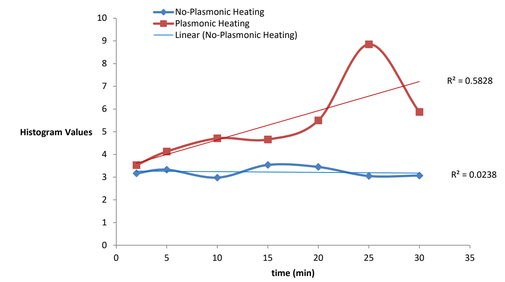


Thermoplasmonic heating at 25 mins

Conclusions

Based on the results of this experiment, thermo-plasmonic heating did increase the speed at which an antibody/antigen reaction could be detected versus conventional incubation. The graph shows that at 25 minutes, antibody/antigen binding was successfully detected, while the control group did not. This technique could prove useful in developing POC devices, targeted at screening for throat cancer.

Time (min)	Mean Value at Histogram's Green Channel	
	NO-Plasmonic Heating	Plasmonic Heating
0	2.07	
2	3.17	3.53
5	3.33	4.13
10	2.98	4.71
15	3.54	4.66
20	3.45	5.5
25	3.05	8.85
30	3.07	5.87



Referenced Resources

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For more information about the program visit: http://fmri-ret.eng.usf.edu/. The Research Experience for Teachers (RET) at the Functional Materials Research Institute at USF is funded by the National Science Foundation under award number 1301054.