Improving Sensitivity of the Lab on a Chip Device by Using Spectroelectrochemistry

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Pathogen detection is limited in applications due to lack of portability and disposability of sensitive and selective equipment. While accurate equipment exists in the laboratory, it is expensive, bulky, and requires trained personnel. In recent years researchers have been improving on the lab on a chip device to reduce false negatives and false positives, thereby increase sensitivity and selectivity. Specifically, Dr. Basuray's lab has created a shear enhanced lab on a chip, which utilizes a nanoporous membrane made of randomly arranged carbon nanotubes (CNT) to reduce the parasitic double layer and improve sensitivity and selectivity. To improve selectivity further, this report investigates the feasibility of utilizing spectroelectrochemistry, which combines optical and electrical detection.

Spectroelectrochemistry further increases sensitivity by combining two powerful detection methods. Molecules that are electrically detectable will display a change in current from the applied voltage, and molecules that are optically detectable will display a change in light intensity. If a molecule binds to the nanotubes, it will be detected by at least one of the detection methods.

Interdigitated electrodes packed with nanotubes have shown to be highly sensitive and selective, cost effective, and precise in Basuray's chip. Packing carbon nanotubes (CNT) between the electrodes creates a nanoporous substance, which increases mixing and reduces the effect of the parasitic double layer.

In order to apply spectroelectrochemistry, ReS2 was substituted for CNT and the change in current caused by an induced AC voltage was measured for different concentrations using an

electrochemical impedance spectroscopy (EIS) machine. ReS2 is reactive to light and has highly manipulative properties as it is a two dimensional anisotropic material.
It was found that ReS2 behaves similar to a dielectric, indicating that testing with optical detection is of interest.

An ReS2 and multi-walled CNT chip were prepared separately. Using serial dilution, 1M, 10^-1M, 10^-2M, 10^-3M, 10^-4M, 10^-5M, and 10^-6M KCl solutions were prepared. Starting with the lowest concentration, the KCl was pumped through the chip at a rate of 1 microliter per minute. The KCl was allowed to be pumped for 1 hour. Each concentration was tested with 5 voltages (100 mV, 200 mV, 300 mV, 400 mV, 500 mV).

It was found that ReS2 behaves very similar to a dielectric. An interesting and unexpected result was that 10^-6M KCl did not follow the pattern that the remaining concentrations followed. This is thought to be attributed to an error in preparing the KCl solution. The experiment will be repeated and the error will be tested.

Based on the results, it is thought that further analysis of ReS2 as a suitable replacement for CNT is beneficial. Its proven optical properties and newly found electrical properties indicate that it will serve well as a nanoporous substance to pack the chip with.

It is suggested that in the future this experiment should be repeated and conducted in a dark environment, and then light environment. The chip should be prepared in a dark room and then tested in an absence of light. Measurements of the different voltages, configurations and concentrations should be obtained. Then it should be retested after being exposed to bright light. In addition it is suggested that single stranded DNA should be hybridized and connected to ReS_2.

References

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