Effects of Protein Adsorption and Thrombus Formation on pH Sensor

Introduction

Protein adsorption is defined as "adsorption (that is, adhesion or sticking) of protein(s) on a variety of surfaces."[1] The adhesion of proteins to a surface is a useful tool in several different aspects. In the example of medical devices, it can be used to coat surfaces to make them less susceptible to an immune response. In this case, the use of protein adsorption was to test its effect on the accuracy of a pH sensor.

Thrombus formation is defined as "a clot of blood formed within a blood vessel and remaining attached to its place of origin."[2] In the case of this lab, there was no thrombus formation because there was not enough time for it to occur.

Materials and Methods

For this experiment a pH/ORP/ISE Temperature sensor was used to measure the pH values. First, we measured the pH values of the phosphate buffered saline, or PBS. This was done while stirring the solution using a magnetic stir plate. The values collected using the pH sensor were then plotted on a computer using the SPARKvue software. We started with a pH value of 8.5 and worked our way down to a pH of 5.5, allowing the sensor to continue recording the mV values for 10 seconds after the mV leveled off at each pH.

Next the pH sensor was soaked in 10mL of sheep blood with 5mg of calcium chloride added for 10 minutes. Once the 10 minutes were up, the pH sensor was dipped in water to remove the loosely adhered proteins.

Lastly, we repeated measuring the pH values of the PBS with the sheep blood and calcium chloride on the pH sensor.

Results

Using MATLAB, the time vs. mV response before the sensor was soaked in the sheep blood and calcium chloride and after it was soaked was plotted. The resulting graphs are shown below.

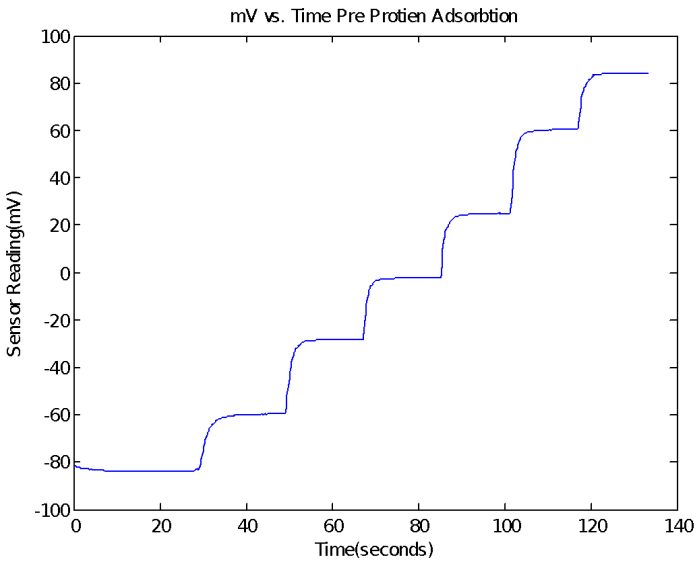

Figure (1). This figure shows the mV versus time measured pre protein adsorption.

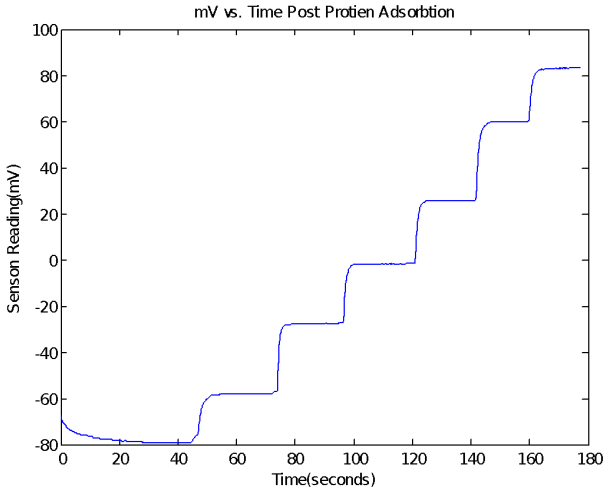

Figure (2) This figure shows the mV versus time measured post protein adsorption.

The plot of pH vs. mV sensor response before and after the sensor was soaked in the sheep blood and calcium chloride solution was also created using MATLAB and are shown below.

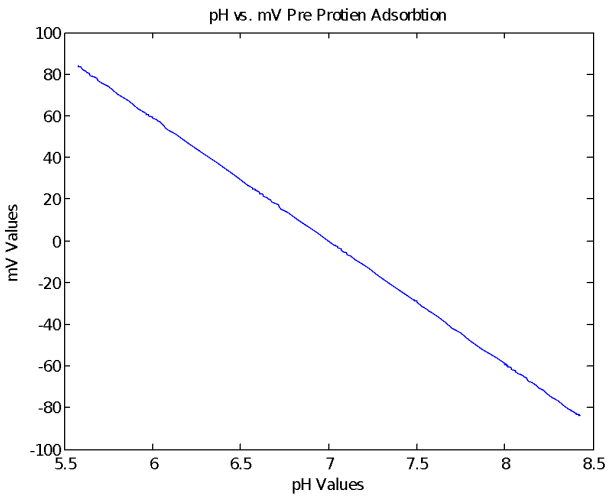

Figure (3) This figure shows the pH versus the mV measured pre protein adsorption.

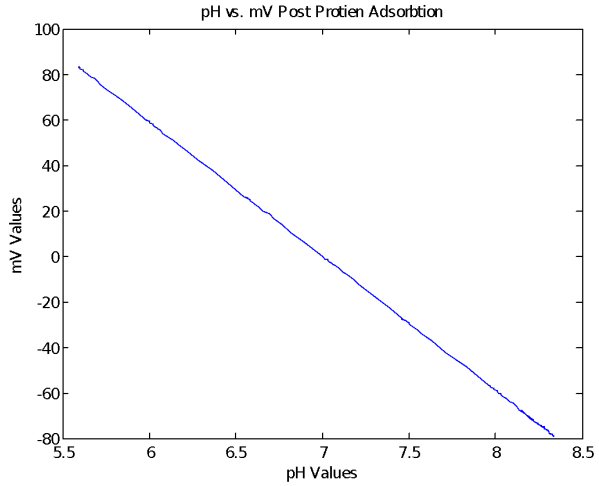

Figure (4) This figure shows the pH versus the mV measured post protein adsorption.

To calculate the sensor response time, the start time was subtracted from the time that the mV leveled off at each change in pH interval. According to the Jordan article, 63% of this value is the response time of the sensor, and so taking 63% of the value calculated as described before the response time at each change in pH is found.[3] The values that were calculated are shown in the tables below.

	Response Time Pre Protien Adsorption					
	Time at each pH value					
	8	7.5	7	6.5	6	5.5
start time	30	50	68	86	102	118
end time	35	53	70	89	105	120
difference	5	3	2	3	3	2
63% of that difference	3.15	1.89	1.26	1.89	1.89	1.26

Table 1. This table shows how the response time was calculated for pre protein adsorption.

	Response Time Post Protein Adsorption					
	Time at each pH value (in sec)					
	8	7.5	7	6.5	6	5.5
start time	45	73	97	121	142	160
end time	51	74	100	123	145	162
difference	6	1	3	2	3	2
63% of that difference	3.78	0.63	1.89	1.26	1.89	1.26

Table 2. This table shows how the response time was calculated for post protein adsorption.

Discussion

During this lab, the pH of a series of PBS buffer solutions was collected using a pH sensor. The data was collected using the SPARKvue software and was measured as mV over time in seconds. This part of the lab was done to have a control group to compare the effects of protein adsorption and thrombus formation on a pH sensor to a clean pH sensor.

When the pH sensor was soaked in goat blood and calcium chloride, then the pH values of the PBS buffer solutions were measured again. The purpose of soaking the pH sensor in the goat blood and calcium chloride was to observe the effect protein adsorption and thrombus formation would have on the response time of the pH sensor. The SPARKvue software again measured this data as mV over time in seconds.

Once MATLAB was used to plot the data collected during this experiment, the response times could be calculated for both pre protein adsorption and post protein adsorption.

When looking at the response times calculated in the tables above, it can be observed that the response time changes upon exposure to blood. The response times over all are longer post protein adsorption. This could be attributed to the protein adsorption on the pH sensor. Since there is a newly formed layer on the pH sensor, this could be slowing down the readings from the pH sensor.

Not only does the response time change before and after protein adsorption, but the steady state mV signals differ as well. This is shown in Figure (3) and Figure (4) in the results section. From these two plots, it is shown that post protein adsorption the mV values decrease with a changing pH value. For both of these trials, the mV values start around 83 mV and pre protein adsorption the ending mV value was about -85 mV. The ending mV value post protein adsorption was about -90 mV.

Conclusion

After conducting this experiment, it can be concluded that protein adsorption on the pH sensor can change the response time of the pH sensor and also the mV measurements of the pH sensor. Thrombus formation had no effect on the response times because the pH sensor wasn't soaked for long enough for thrombus formation to occur. These conclusions come from the graphs given above and also the tables that calculate the response times. Looking at the graphs of the pH vs. mV, it can be concluded that the mV values change before and after protein adsorption.

References

1) Kim, Jung-Hyan. "Protein Adsorption on Polymer Particles." *UCLA Chemistry*(n.d.): n. pag. University of California, Los Angeles,California,U.S.A. Web. 26 Oct. 2014.
2) "Thrombus." *Merriam-Webster.com*. Merriam-Webster, n.d. Web. 26 Oct. 2014. <http://www.merriam-webster.com/dictionary/thrombus>.
3) Jordan, David M., and David R. Walt. Max Tishler Laboratory for Organic Chemistry, n.d. Web. 26 Oct. 2014.