Biopolymer Based Sensors and Actuators

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Abstract

This research provides an electrochemical approach to sensing and detecting water contamination, such as Perfluorooctanesulfonate (PFOS), with Electrochemical Impedance Spectroscopy (EIS) technique. An environmentally benign composite biopolymer-based sensor was fabricated for PFOS detection. The preliminary experimental results demonstrate that the fabricated sensors showed a good response to the PFOS. Additionally, Electrical Technology is presently evolving in the same direction as the rapidly growing indispensability. A boat and electrical robot arm can be controlled by an outside user or pre-prepared commands. This research also presents a method of combining electrical embedded systems with sensors, making it much safer and more convenient for future research to be conducted in the related field.

Embedded System

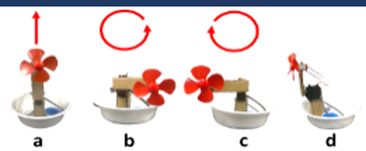

Fig. 1. Electrical Boat, the DC and Servo Motors controls the direction of the boat by exerting a torque on its frame;
(a) Boat moves forward without any rotational torque;
(b) Boat moves leftward then its arm is extended to the right, allowing torque to rotate the frame;
(c) Boat moves rightward when its arm is extended;
(d) a side view of the boat.

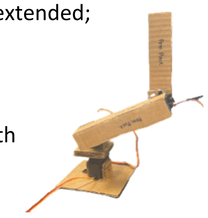

Fig. 2. Electric Robot Arm, constructed with cardboard and three servo motors.

- Biopolymer sensor will be used to test water quality.
- It can be further utilized to combine it with a boat design coupled with a robotic arm(with sensor attached).
- Purpose: be able to control the boat and robotic arm, collect and analyze water samples remotely.

EIS Experiment

Fabricated Sensor: The biopolymer sensor has mainly two parts: connection pad and interface pad, which are made of gold for its great conductivity. The connection pad (top) will be connected to the working electrode of the Impedance Analyzer, while the interface pad will be where the biopolymer (chitosan) layer is deposited.

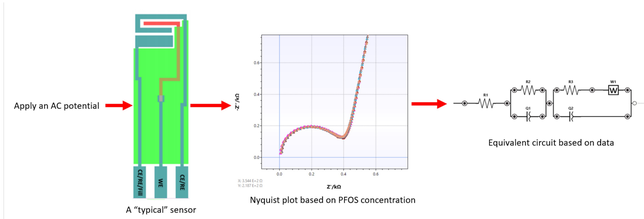

Fig.3. illustrates the procedure of PFOS detection using a fabricated commercial sensor.

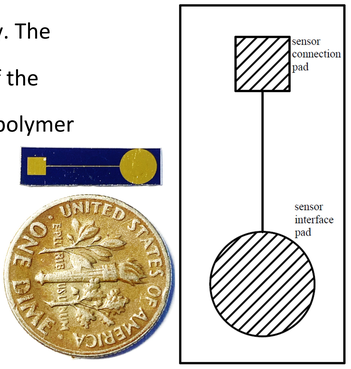

Fig.4. Illustrations of fabricated sensors; actual sensor(left) and designed sensor(right).

- PFOS is a chemical most common in the family of PFAS and suspected to be most toxic.
- The experiment utilizes standard three-electrode configuration, and various samples of chitosan solution were deposited as PFOS capturing mechanism for each experiment.
- Testing with an impedance analyzer, Nyquist Plot with sensor electrode impedance is shown.
- Different concentrations of PFOS will give different impedance curves. Based on this, PFOS can be analyzed using an equivalent circuit with varying resistance values.

Results

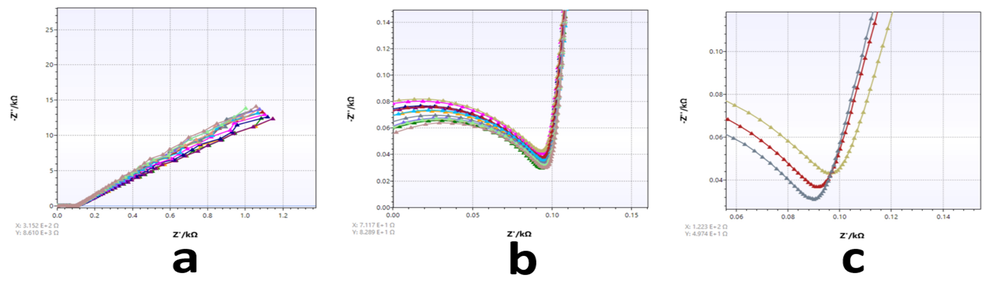

Fig. 5. Results for PFOS detection experiment; (a) Figure showing the whole Nyquist plot; (b) zoomed in view on the "tail" of the semi-circle; (c) Nyquist plot showing clearer zoomed in view of the semi-circle, with gold curve being baseline(0 ppb), maroon curve being 5 ppb, and gray curve being 10 ppb

- Testing with an impedance analyzer, Nyquist Plot with sensor electrode impedance is shown.
- Based on this, PFOS can be analyzed using equivalent circuit with varying resistance values.

Results cont.

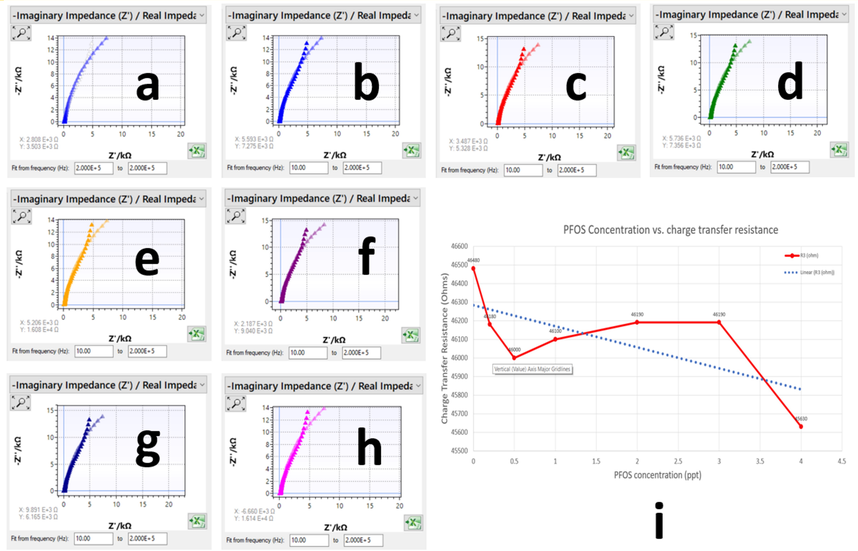

Fig. 6. Results for impedance analysis; (a) Actual data is hided, PFOS concentration =0 ppt; (b) Figure of both fitted curve and actual data, 0 ppt;
(c) PFOS concentration = 0.2 ppt; (d) 0.5 ppt; (e)1 ppt; (f)2 ppt; (g)3 ppt; (h)4 ppt; (i) Plot showing charge transfer resistance against PFOS concentration.

Conclusion

Electrochemical sensors are a promising method for contamination detection in water because of their low cost and portability. In this work, the biopolymer composite-based electrochemical sensor was fabricated, and its application for PFOS detection was demonstrated using impedance analysis. An equivalent circuit was designed and fitted to study the sensitivity of the fabricated sensor. Robotics is becoming more ubiquitous, and as a result, the work is now easier. The goal of this project's component is to give the moving electric robot arm and boat design control using an appropriate microcontroller and a Bluetooth module. With this technology, it can easily be utilized for more complicated and suitable work that can be extended to other areas of study such as this one.

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Acknowledgments

The support for this work was provided by the National Science Foundation REU program under Award No. 1852002. Any opinions, findings, and conclusions and recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.