01-2019

Electropolymerization Applied to Biosensors

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Background

Biosensors are tools developed for the purpose of promoting analyte detection in complex media. They usually are a combination of a biological recognition element with a transducer capable of transforming the biological information received from the interaction of the analyte with the bioreceptor in a measurable signal. [1]

Escherichia coli is a species of gram-negative and rod-shaped bacteria. Detection of microorganisms via surface imprinted polymers (SIP) in combination with the Heat-Transfer-Method (HTM) appears as a promising alternative for more complex, expensive biosensors or laboratory techniques. [2,3]

Pyrrole Electropolymerization Mechanism

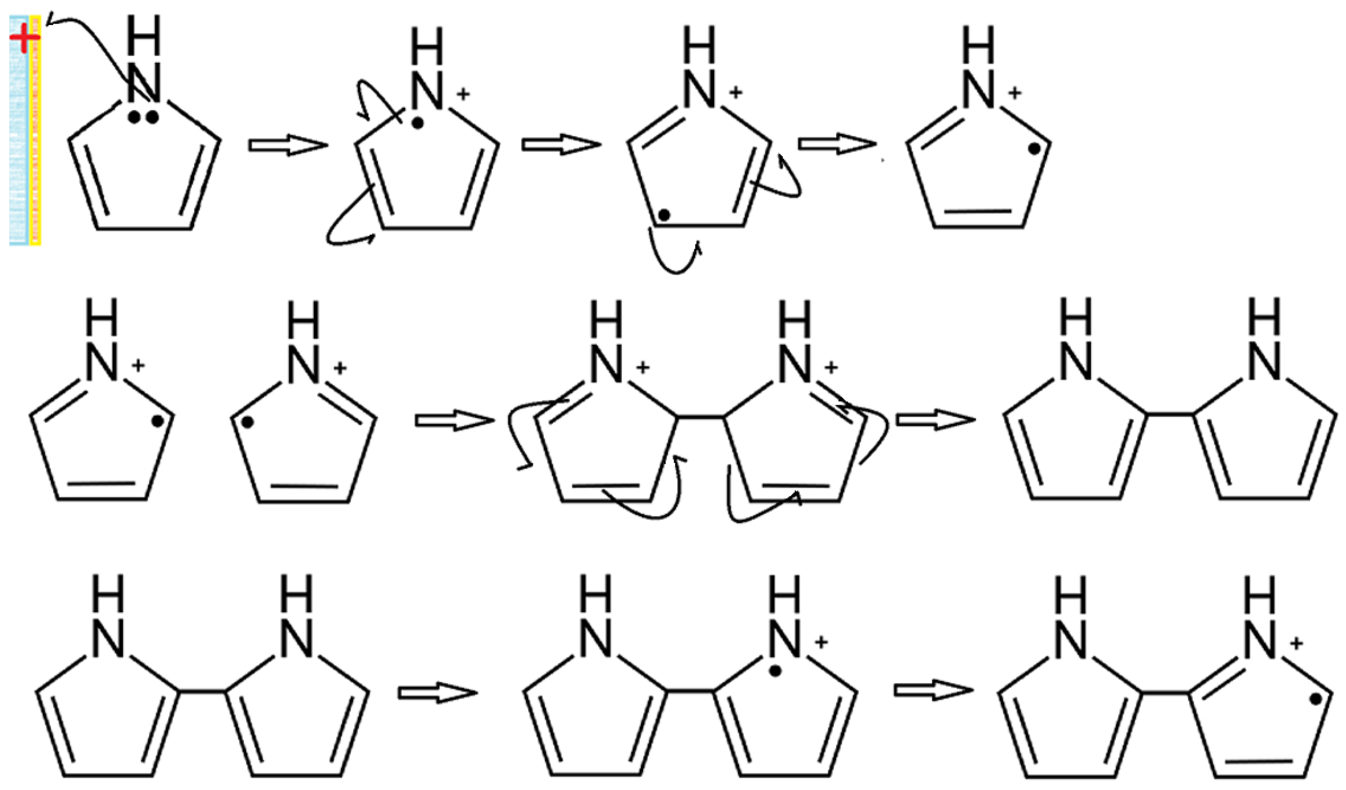

Figure 1. Pyrrole Electropolymerization Mechanism

Introduction

Artificial systems, such as those based on molecular imprinting, are an alternative to conventional biological receptor layers that are typically sensitive but unstable under non-physiological conditions. In addition, their synthesis can be complex and expensive. In previous work, SIPs were madeusing the microcontact imprinting method which gives good results, but because of the poor scalabillity and reproducibility, the method isn't ideal. Electropolymerization might be a tool to overcome this problem.

To carry out the electropolymerization it is necessary to have a solution containing the mold with the monomer. A suitable voltage will be applied to polymerize the mixture. The use of pyrrole as a monomer for electropolymerization results in a black polymer film. [4]

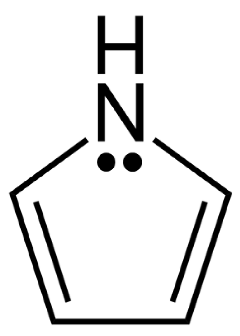

Figure 2. Estructural Formula of Pyrrole

Methodology

Creating a SIP based on the contact imprinting technique.

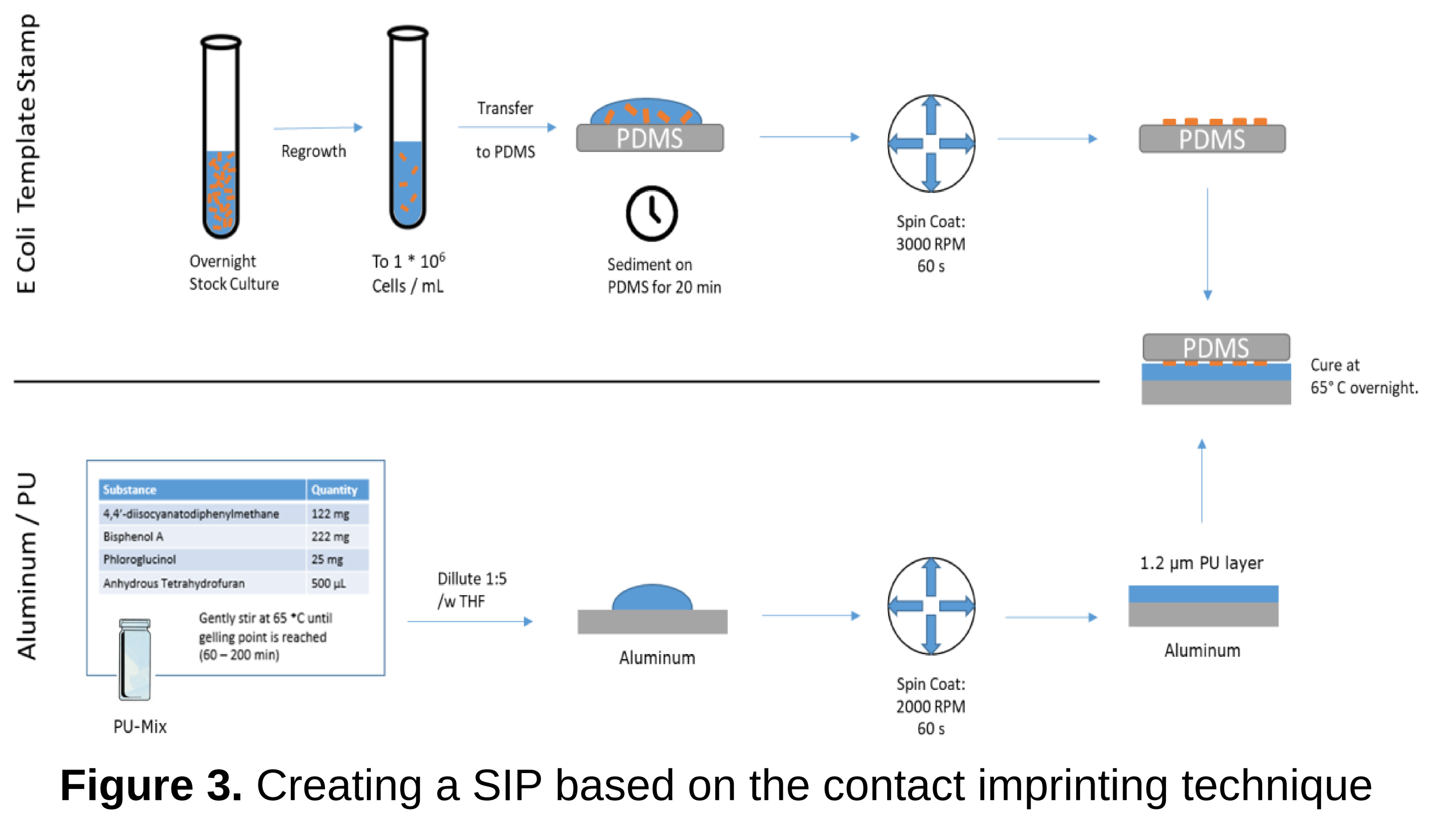

Figure 3. Creating a SIP based on the contact imprinting technique (reproduced with permission)

Creating a SIP using electropolymerization

- Suspend bacteria in the solution containing the pyrrole;
- Apply a current through the medium;
- Wash the SIP ethanol 70% and SDS.

Empty cavities are left behind and ready to rebind the bacteria. This rebinding can be measured with several different methods.

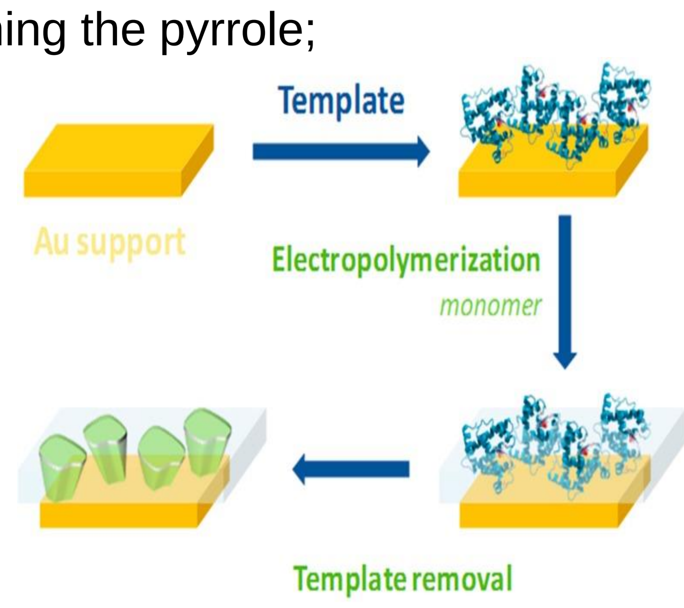

Figure 4. Creating a complementary cavity by Electropolymerization.

First evaluation

- Aluminum electrodes connected at the positive and negative poles of the power supply unit.
- Potential stable at 10V.
- Time of exposure: 6, 8, 10, 12, 20, 30, 40 s.
- Solution: 0.2 M pyrrole and 1.0 M PBS

Figure 5. Evaluation chambers

Second Evaluation

- Settings for the different sample:
  - 10V for 60s;
  - 1, 2, 5, 10 V for 90 s and
  - 5 V for 120 s.
- Solution: 0.2 M pyrrole and 1.0 M PBS

Evaluation of gold electrodes

- Work electrode: 10 x 25mm glass with gold deposited on top.
- Reference electrode: Ag/AgCl / 3M KCl
- Counter electrode: Graphite
- Applied current: 0,98 V.
- The time of exposure: 60, 90, and 150 s.
- Solution: 0.2 M pyrrole and 0.2 M PBS.

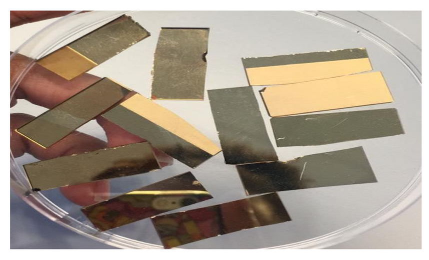

Figure 6. Work Electrodes

Results

- **Primary evaluations:** formation of a white solid layer.
- **Polymerization on gold work electrodes:** formation of a black, continuous and adhesive film.

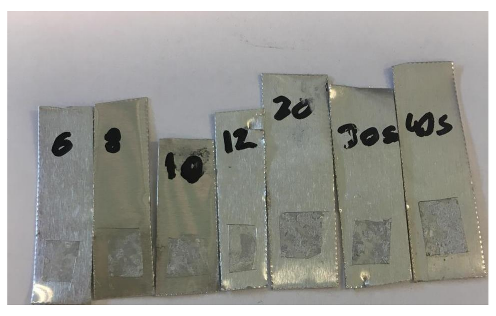

Figure 7. 1st evaluation samples.

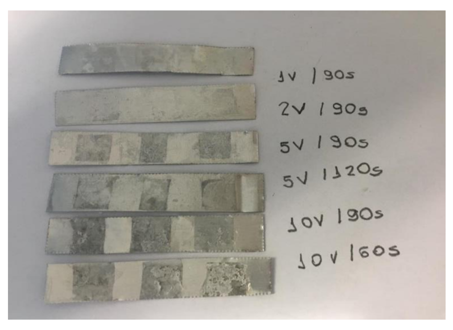

Figure 8. 2nd evaluation samples.

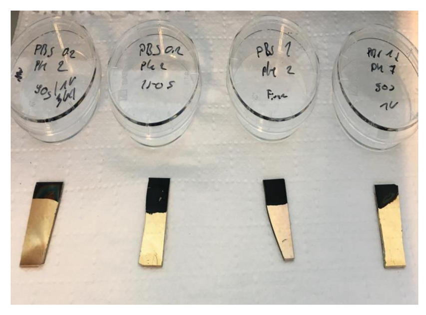

Figure 9. Black film deposited in gold electrodes.

Conclusions

- The electropolymerization was not successful in the primary evaluations because of aluminum electrodes, leading to oxidation of the material.
- Higher tensions and longer exposure times result in higher amounts of deposited product.
- Gold electrodes were efficient in the process of electropolymerization. This is mainly due to the greater stability of gold compared to aluminum.

References

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