Patterned electrode surfaces for sensing applications

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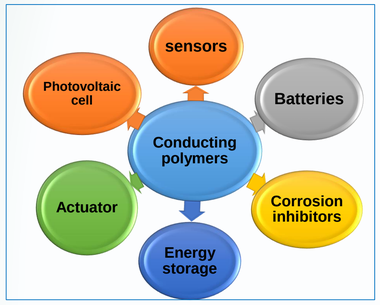
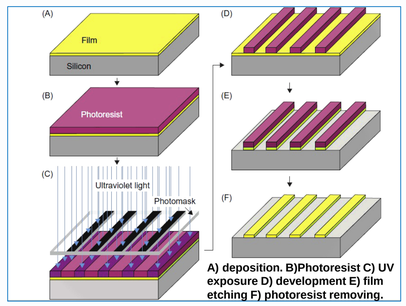
Background

Patterning of surfaces has become important in many research fields such as microelectronics, high selectivity sensors, drug delivery and catalysis. The capability to define spatial location for molecules on surfaces provides researchers with a strong tool to study the interaction between molecules and offer a chance to create heterogeneous films surface with diverse chemical functionalities.





A) deposition. B)Photoresist C) UV exposure D) development E) film etching F) photoresist removing.

Fig.1 Applications of conducting polymers and photolithographic steps.

In this study deposition of polymer films was controlled by using electrochemical techniques such as cyclic voltammetry. In addition, the Electrochemical Quartz Crystal Microbalance (EQCM) was used to determine the mass changes associated with film deposition and redox cycling. Morphology of the films was determined using 3D optical microscopy and Scanning Electron Microscopy (SEM). In this project we seek to pattern polymer surfaces laterally with different receptor sites which are capable of sensing different metal ions with improved sensitivity and selectivity.

Techniques

- **Cyclic voltammetry:** this technique was used to monitor the electrochemical reactions and involves applying a potential sweep to a system and measuring the resulting current. It gives information on thermodynamics, kinetics and mechanisms of redox reactions.

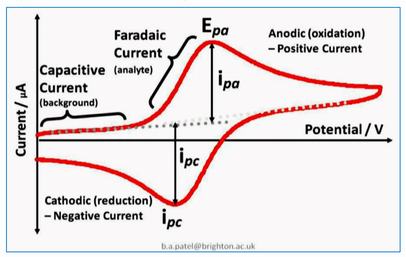


Fig.2 Cyclic voltammogram scheme.

- **Electrochemical Quartz Crystal Microbalance:** this technique was used to measure mass changes and viscoelastic properties of films. Changes of frequency of a piezoelectric crystal are proportional to mass changes in the film down nanogram range.

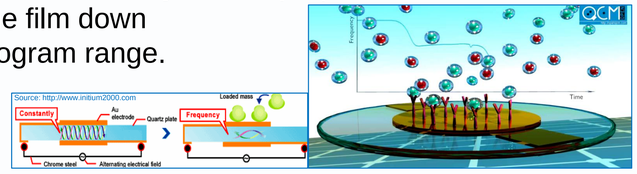


Fig. 3 QCM crystal and oscillating frequency of crystal.

- **Scanning Electron Microscopy:** this technique was used to investigate the surface structure for various materials. This device uses an electron beam to produce high resolution and three-dimensional pictures for samples.

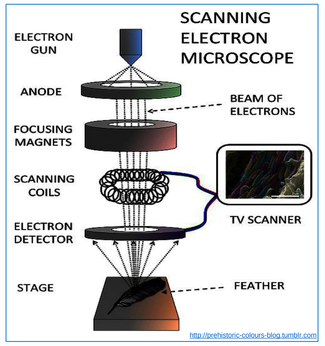


Fig.4 SEM diagram.

Results

1- Electrosynthesis of polypyrrole derivatives

Electropolymerization of pentafluorophenyl 3-(pyrrol-1-yl) propanoate (ester pyrrole) and (9H-fluoren-9-yl) methyl-3-(1H-pyrrol-1-yl)propylcarbamate (amide pyrrole) was performed using cyclic voltammetry as shown in figure 5.

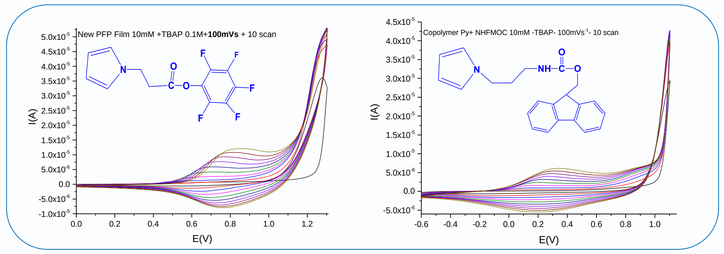


Fig.5 Cyclic voltammogram of ester and amide pyrrole.

2-Electrochemical Quartz Crystal Microbalance

The ester and amide films were precipitated on gold coated quartz crystal microbalance. Figure 6 illustrates how the mass of poly ester and amide pyrrole films increased with growth of polymer film on the electrode.

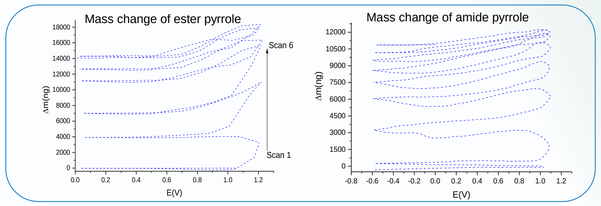


Fig.6 mass change of ester and amide pyrrole.

3- Hydrolysis study of films

The ester and amide films were hydrolysed to create voids in the polymer films to accommodate the new receptor units. The hydrolysis of films was monitored by:

- **Electrochemical Quartz Crystal Microbalance**

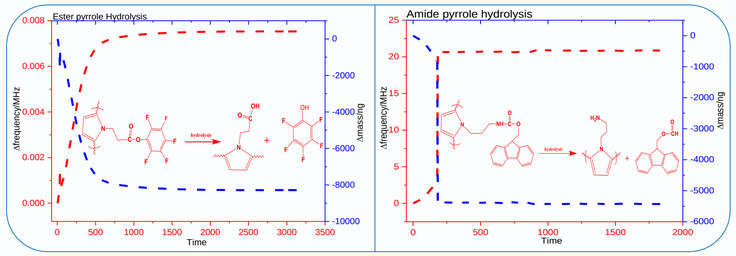


Fig.7 Hydrolysis monitoring of ester and amide pyrrole by QCM.

- **Fourier transform infrared spectroscopy**

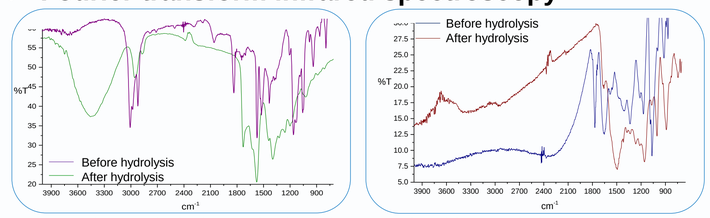


Fig.8 Hydrolysis monitoring of ester and amide pyrrole by FTIR.

- **Scanning Electron Microscopy**

Figure 9 illustrates SEM images of surface poly ester and amide pyrrole films before and after hydrolysis.

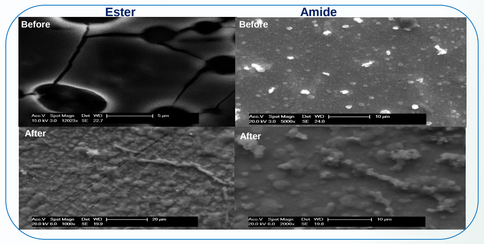


Fig.9 SEM of ester and amide pyrrole.

Conclusion

- Deposition of uniform polymer films with large labile groups was successful using cyclic voltammetry.
- The film's chemical structures and hydrolysis process of polymer films were deduced using QCM and FTIR techniques.
- SEM images confirm that polymer films did not collapse after hydrolysis.

References: 1-S. Prakash and J. Yeom, *Nanofluidics and Microfluidics: Systems and Applications*, 2014. **2**- Ratner D., Allan S., Frederick J., and Jack E. *Biomaterials science: an introduction to materials in medicine*., 2004. **3-** A. R. Hillman, *J Solid State Electrochem,* 2011, **15**, 1647-1660.