CONCLUSION

AND

RECOMMENDATIONS
CONCLUSION

This dissertation essentially describes the electrocatalytic properties of MPCAuNP, SWCNT-PABS and MPCAuNP, SWCNT-PABS functionalized with ironphthalocyanine complexes on gold electrode electrode towards the detection of hydrogen peroxide and epinephrine. The following important results obtained in this work should be emphasised:

• The electrochemical properties of DMAET SAM, with and without integration with SWCNT-PABS were probed for the first time. SWCNT-PABS was found to be irreversibly attached to the DMAET.
  * Electric field-induced protonation/deprotonation of the DMAET head group (\(-N(\text{H})^{+}(\text{CH}_3)_2\)) resulted in the well-defined reversible voltammetry observed for DMAET SAM.
  * The surface $pK_a$ of DMAET was examined for the first time and its value of $\sim7.6$ was found to be $\sim3\ pK_a$ units less than its solution $pK_a$.

• The integration of SWCNT-PABS and nanoparticles of redox-active FePc complex via electrostatic layer-by-layer assembly on Au-DMAET were explored for the first time.
  * The electron transfer kinetics of the ferricyaninde/ferrocyanide redox probe decreased with added alternating layers of SWCNT-PABS and nanoparticles of FePc.
Conclusion

* The reduction rate of hydrogen peroxide increased with added alternating layers of SWCNT-PABS and nanoparticles of FePc.
* DMAET-SWCNT-PABS SAM proved to be more efficient in epinephrine detection than the layer-by-layer nano-architectural assembly.

• The combined integration of FeTSPc complex and SWCNT-PABS investigated for the first time.
  * The nano-thin films of the combined redox-active species exhibited excellent electrochemical stability and showed faster electron transport in \([\text{Fe(CN)}_6]^{4−}/[\text{Fe(CN)}_6]^{3−}\) redox probe compared to the individual FeTSPc and SWCNT-PABS.
  * The combined species also showed enhanced detection towards epinephrine.

• The solid films exhibited excellent electrochemical stability. The SWCNT-PABS acts as efficient conducting species in the mixed hybrids (Au-DMAET-SWCNT-PABS/FeTSPc) thus facilitating electron transport between the integrated FeTSPc and the underlying gold substrate.

• For the first time the electron transfer dynamics of surface-confined gold nanoparticles involving different ratios of carboxylated- and hydroxyl-containing ligands has been fabricated and described.
Conclusion

* In both aqueous and nonaqueous solutions, there is electronic communication between the immobilized MPCAuNPs and the gold electrode, possibly from electron tunneling between these protecting ligands and the gold electrode.

* The electronic communication is strongly influenced by the hydrophilicity of the head groups (-OH and -COOH); in aqueous solution the electron transport of the -COOH based ligand is favoured, while in the nonaqueous medium the electron transport of the -OH based ligands is favoured.

* Au-DMAET-MPCAuNP-COOH$_{99\%}$ showed an excellent suppression of the voltammetric response of the ascorbic acid and an enhanced electrocatalytic activity towards the detection of epinephrine compared to other MPCAuNPs studied.

* Simply put, this study has provided some useful physical insights into the impact of different ratios of the protecting –OH and –COOH based monolayer ligands of redox-active gold nanoparticles on the dynamics of electron transport between solution species, in organic and aqueous media, and the electrode surface.
Recommendations

**RECOMMENDATIONS**

- The amplification of the electrochemical response to H$_2$O$_2$ detection suggests that this type of electrode could provide an important nano-architectural sensing platform for biosensor development.
- The extent to which the ratios of protecting ligands in MPCAuNP influence electron transport is crucial for the potential applications of such platforms in many areas such as in molecular electronics as well as chemical and biological sensing.
- Integration of *nano*FePc and MPCAuNP for the detection of H$_2$O$_2$.
- The use of HRP and Cyt C instead of FePc complexes for MPCAuNP studies.
- Other analytes and neurotoxins can be investigated using the modified electrodes.
- Interchange the order of the attached species in the assembly strategy by using charges opposite to that used in this work.
- Use of a negatively charged base monolayer.

It is envisaged that the results shown in this dissertation should provide some thoughts on the factors that should be considered when designing molecular-scale electronics or electrocatalytic sensing devices that employ these materials, and possibly for some other redox-active metal nanoparticles.
Appendix A: Peer-reviewed Articles Related:

(a) Directly to this Dissertation:


Appendix A.  


(b) INDIRECTLY TO THIS DISSERTATION:


Appendix A

impedimetric immunosensing platform for active tuberculosis”


APPENDIX B: LIST OF CONFERENCE PRESENTATIONS RELATED DIRECTLY TO THIS DISSERTATION:


Ozoemena, 39th National Convention of the South African Chemical Institute, Stellenbosch University, Stellenbosch, SOUTH AFRICA, November 30 – December 5, 2008 (ORAL PRESENTATION BY J. PILLAY).

