Conclusions and Future Perspectives

CONCLUSIONS

The synthesis of some novel metallophthalocyanine complexes notably; nanostructured iron and cobalt phthalocyanine (nanoMPc), iron and cobalt octabutylsulphonylphthalocyanine (MOBSPc) and iron tetrakis(diaquaplatinum)octa-carboxyphthalocyanine (PtFeOCPc) was described in this work. The microscopic, spectroscopic, electrochemical and electrocatalytic activities of these MPcs were also explored. The fabrication of an electrode by the 'drop-dry' method to produce a stable redox-active MPc complex integrated with multi-walled carbon nanotube on an edge plane pyrolytic graphite electrode surface was developed.

Some findings from this work are remarkable and these include the following: First, the electron transfer dynamics towards an outer-sphere redox probe at MPc/multi-walled carbon nanotubes composite supported on a edge plane pyrolytic electrode (EPPGE-MWCNT-MPc) have been investigated. Employing the Davies-Compton theoretical framework on the "diffusion domain approximation", cyclic voltammetric evolutions showed that the diffusion process occurring at these electrodes correspond to the type 3 behaviour of the voltammetry at spatially heterogeneous electrodes. The electrodes, like that of the MWCNTs alone, generated huge current response, possibly due to the redox chemistry of the redox species that might have been trapped within the porous layers of these high surface areas species.

Comparative electron transfer dynamics, using electrochemical impedance spectroscopy, showed that the electron transfer constants are in the order of 10^{-2} cm s^{-1}. EPPGE-MWCNT-MPc has demonstrated an outstanding role in facilitating the electron transfer process between the electrode and the electrolyte or redox probe species in solution.

Second, it has also been established that the MWCNT/MPc-based electrodes enhance electrocatalytic activity towards the detection of thiocyanate and nitrite in aqueous solutions compared to the MPc alone.

Third, the oxygen reduction reaction (ORR) in 0.1 M NaOH revealed that the MWCNT-FePc complexes gave the best response compared to the other electrodes, involving a direct 4-electron mechanism, with ORR onset potential that is comparable and even better than reported in literatures.

Fourth, one of the key findings in this work is the PtFeOCPc supported on a MWCNT platform (MWCNT-PtFeOCPc). It exhibited better electrochemical response in terms of catalytic rate constant and tolerance towards CO poisoning during formic acid oxidation. This catalyst is specific only to formic acid oxidation, as other analytes such as ethanol, methanol and ethylene glycol showed no response.Tafel analysis confirmed the porous structure and high electrocatalytic property of the electrode.

The results clearly indicate that the MWCNT/MPc complexes could serve as powerful organometallic functional materials for the development of sensors and electrocatalytic devices.

FUTURE PERSPECTIVES

Given the high number of existing MPc complexes and new ones constantly reported in the literature, and the importance of ORR and formic acid oxidation in fuel cell development, it is envision that this newest study may likely spark research interests in the electrocatalysis of the ORR and formic acid oxidation by MPc–CNT hybrid electrodes. Possible areas in which further studies can be carried out include:

- The use of the MPc-CNT hybrid in real fuel cell testing employing formic acid and molecular oxygen.
- The use of other nanocarbons such as mesoporous carbon, carbon fiber etc. co-immobilised with MPc
- The use of other functionalised MWCNT such as those containing amine or sulphonated groups
- The use of SWCNTs
- Trying out other transition metal phthalocyanine such as Mn, Pt, Ru-centred phthalocyanine etc.
- The stability and activity of the studied MPc complexes after heat-treatment.