Development of novel polymer electrocatalysts towards solving challenging environmental pollution phenomena

Priscilla G L Baker [a] and Pierre-Henri Aubert [b]

(a) SensorLab, Chemistry department, University of the Western Cape, PB X 17,Bellville, South Africa

(b) LPPI, Department of Chemistry, University Cergy Pontoise, 5 Mail Gay Lussac, 95031 Cergy Pontoise Cedex

Part I: Development of novel electrocatalysts

Conductive and semi-conductive polymers may be readily prepared from simple organic monomers in aqueous solutions using electrochemical polymerisation. Electrochemical polymerisation is uniquely capable of producing nanopolymers in situ in real time. Polymer composites with unique chemical and physical properties compared to that of the original parent polymer may be achieved in many ways including electrochemical polymerisation from a solution containing a mixture of monomers, chemical condensation reaction to functionalise or cross link short polymer chains and thus produce novel monomers for electropolymerisation as well as modification of the parent polymer by doping with metal nanoparticles, during electrochemical synthesis. The main objective being to produce semi conductive transducer platforms with unique electrochemistry that may be tailored to separate compounds in a family that are structurally closely related such as polycyclic aromatic hydrocarbons. In addition electrochemistry is a green technology, using small amounts of chemicals at a time and generating very little waste. Simplified instrumental configurations are required and many small electrochemical analysers i.e. PalmSens (USA) and Origalys (France) are available on the market for portable applications

Outcomes:

(i) Synthesis and characterisation of novel polymer composites through in situ electro-polymerisation of polypyrrole, polyamic acid acid, polysulfone and graphene oxide

(ii) Synthesis and characterisation of polymer nanocomposites through chemical condensation reaction to produce functionalised and crosslinked polymer composites;

(iii) Synthesis and characterisation of metal nanoparticle modified polymer nanocomposites for enhanced catalytic effect.

Part II: Development of portable multi-array ensembles for on-site measurement

Multi array ensembles may be prepared as individual consecutive electrochemical cell each with its own unique analytical transducer interface, exposed to the same sample in a flow through arrangement. It may also be prepared as individual wall jet electrochemical cells, in tandem but completely isolated from each other. Sample is brought to each individual cell by a series of peristaltic pumps and valves that control flow to and away from the analytical transducer. The advantage of the flow through method is that one can test for cross reactivity and co reactivity once the analytical parameters have been optimised. In the wall jet arrangement, cross contamination from one sample to another may be completely avoided, since each transducer is exposed to its own sample stream. Screen printed electrodes functionalised with the desired polymer nanocomposite will become the electrocatalyst for each specific analyte determined in the proposal. By training young researchers to design and control every aspect of the electroanalysis protocol, we encourage nano-chemical and engineering skills for innovative thinking, application and problem solving in the new generation of scientists, thus firmly entrenching a critical attitude towards knowledge.

Environmental challenges:

The polymer nanocomposites will act as the electrocatalysts for analysis of antibiotic residues of Norfloxacin, Penicillin, Sulfonamide and Neomycinin in drinking water. Similarly individual electrocatalysts may be produced for each of the 8 priority PAH compounds and analysed using a multi array ensemble for one stop analysis of PAHs in environmental water. The chemical sensors will be based on conducting polymer nanocomposites synthesised in situ to produce fresh electroanalytical interfaces for real time quantitative assessment of analytes in environmental water and drinking water.

Outcomes:

(i) Develop individual electrocatalysts for each of the antibiotic residues and PAHs identified in the scope of the study

(ii) Optimise individual analytical conditions and validate calibration curves for individual analysis

(iii) Assemble multi-array ensembles in flow through arrangement for evaluation of cross reactivity and interferences

(iv) Assemble multi array ensembles in wall jet arrangement for validation of calibration curves for each analyte in a mixture

UNIVERSITY *of the*
WESTERN CAPE

Faculty of Natural Science
Chemistry Department

Private Bag X17, Bellville, 7535
South Africa
Tel: +27 (0) 21 959-3051/3056
Fax: +27 (0) 21 959-1316
E-mail: pbaker@uwc.ac.za

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Re: visiting professor, 2016

Dear Prof Aubert

Thank you for extending the invitation to partner with LPPI (University Cergy Pontoise) for another year, in the capacity of visiting professor to your institution, in 2016.

To date we have achieved a noteworthy measure of success by working together under the visiting professor programme of the Institute of Advanced Studies (IEA, Institut d'Etudes Avancées). As visiting professor I have been afforded the opportunity to teach a module on Electrochemical Sensors to the Master in Engineering students enrolled on the Figure Reseau programme as well as participate in the evaluation process of MSc and PhD candidates under your supervision.

Together we have developed research concepts for funding proposals and planned very successful student exchange opportunities between SensorLab (University of the Western Cape, South Africa) and LPPI (University Cergy Pontoisee, France). With the financial support of the French Embassy (South Africa) and the Co-operation in Science and Technology (COST, South Africa) we have been able to co-supervise a MSc student who has now progressed to PhD under our joint supervision. We have captured the design, synthesis and characterization of the novel polymer composite polyphenazine-2,3-diimino(pyrrole-2-yl in a peer reviewed international scientific publication (Int. J. Electrochem. Sci., 9 (2014) 4776 – 4792).

I also wish to acknowledge your contribution to teaching and training of our postgraduate students here at SensorLab (University of the Western Cape, South Africa) during your researcher exchange visit in 2013. We look forward to strengthening the collaboration, by involving other researchers in our respective research laboratories as well.

Therefore it is with great pleasure that I accept the invitation to continue the visiting professor appointment in 2016.

Yours sincerely,

Prof. PGL Baker
Co-leader of SensorLab (UWC)
Deputy Chair: Electroanalytical division, International Society for Electrochemistry
Deputy Chair: Chemistry department, (UWC)
Chair: ElectrochemSA (South African Chemical Institute)