FROM **HOPE** TO **ACTION** THROUGH **KNOWLEDGE**

The Renaissance of the
University of the Western Cape

2001 – 2014

Editors

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The South African Institute for Advanced Materials Chemistry (SAIAMC): from applied research to innovation – evolution of an engaged university

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Introduction

The South African Institute for Advanced Materials Chemistry (SAIAMC) originates from the research and development (R&D) activities of the Inorganic Porous Media Group (IPMG) started by Prof Vladimir (Vlad) Linkov in the Department of Chemistry shortly after joining UWC in 1997. In conducting ground-breaking research in electrochemically active and functional adsorption materials, IPMG was the first unit at UWC that focused on close collaboration with large industrial companies, initially Eskom, to deliver on the pressing technology development needs of South Africa in power generation and water treatment. In the late 1990s and early 2000s IPMG added significant value to Eskom's core R&D activities through the development of innovative technologies allowing the utilisation of South African coal resources with minimised impact on the environment. Development of gas treatment technologies for pre- and post-combustion emission control to address the environmental needs of Eskom and South Africa as a whole was the strategic focus area at that time for IPMG research, technological development and innovation. The arrival of Prof Brian O'Connell as Rector and Vice-Chancellor in 2001 generated new vigour and energy through his inspirational, visionary leadership.

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Initially, a small research grant from the Eskom Tertiary Education Support Programme (ESKOM TESP) was used to initiate postgraduate research in IPMG. With a firm desire to see developed technology applied into the South African industry, the Institute shifted its focus from R&D to innovation and added the motto “Making research work for industry” to its logo. Given that during these early years there was little emphasis on, and direct government support for, innovation and new product development at universities, the strategic decision was made to focus the research and innovation agenda on projects that were of national importance, as well as projects that addressed industrial challenges. It was only through the legislation on intellectual property rights of publicly funded research and development (IPR-PFRD Act 51 of 2008) that it became mandatory for universities to establish technology transfer offices, and innovation and technology transfer was incorporated into the core business of a university.

Within several years the ground-breaking and industrially relevant research programme of IPMG with cutting-edge technology – generously funded by Eskom, the DTI/NRF THRIP programme, the Water Research Commission, Shell South Africa and NRF support programmes – was consolidated by the inauguration of the Eskom Centre for Electro-Catalytic Research (ECER) in January 2003, which was incorporated into the IPMG.

With an ever-expanding R&D programme, IPMG applied in early 2004 for, and was granted, the status of an Institute by the University and renamed the South African Institute for Advanced Materials Chemistry (SAIAMC). At the same time Prof Linkov was seconded from the Department of Chemistry to lead SAIAMC as its permanent Director, with a replacement lecturer appointed in his place. The Faculty of Science financed the establishment of an additional academic post in SAIAMC at Senior Lecturer level in October 2004 to further support the development of the Institute. The post was later upgraded to Associate Professorship and is presently occupied by SAIAMC Deputy Director, Prof Bernard Bladergroen. These moves were strategically undertaken as part of Prof O’Connell’s drive to expand the national and international presence of the University underpinned by excellence and relevance.

The concept that inspired SAIAMC from its inception is that of a creative new interface between research activity and industrial development aimed at the utilisation of advanced materials and processes based on South Africa’s natural resources, in so doing bridging the innovation chasm. A series of successful THRIP applications have greatly assisted

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with the establishment of SAIAMC as an internationally acknowledged R&D institute (DTI/NRF THRIP, 2007-2019). A striking indicator of the profile and prestige that SAIAMC has established is its designation of by the South African Department of Science and Technology (DST) as the Competence Centre in Systems Analysis, Integration and Technology Validation for The Hydrogen and Fuel Cell National Flagship Programme (HySA Systems), as a part of the DST's National Hydrogen and Fuel Cell Technologies Research, Development and Innovation (RDI) Strategy.

The appointment of Prof Ramesh Bharuthram as Deputy Vice-Chancellor Academic in 2008 accelerated SAIAMC's presence and impact on the national science and innovation landscape. His deep knowledge and understanding of the innovation space and the need for responsive strategic decision making assured our partners of UWC's commitment and ability to deliver, thereby allaying the fears of potential funders. Various strategic partnerships with organisations besides Eskom were forged, in line with Prof O'Connell's vision that growth in external partnerships was essential for increasing UWC's resource base as well as for scholarly advancement. Paramount among these is PetroSA, a partner that funded the construction of the PetroSA Synthetic Fuels Innovation Centre (PSFIC) laboratory and provided funding for the SAIAMC Innovation Centre as a whole, along with the transfer of a significant portion of their R&D activities to UWC.

As UWC advanced under the leadership of Prof O'Connell and Prof Bharuthram, with its R&D gaining greater impact both nationally and internationally, so did the stature of SAIAMC. In 2011 SAIAMC moved to a brand-new home, the SAIAMC Innovation Centre. The funding for the construction of this R27.4 million state-of-the-art laboratory, technology development and office facility at the forefront of the UWC campus was made available by a generous contribution from PetroSA, co-funded by UWC. All R&D facilities of the Institute are designed to accommodate a wide range of activities that form the vanguard of modern technology development worldwide, aimed at producing commercially viable products with high levels of sophistication yet low cost in nature, scalability and ease of modification. These include advanced materials and processes in energy generation and the hydrogen economy, cleaner processing and chemicals production, and environmental remediation.

Today SAIAMC has firmly established itself as a local technology development and innovation leader founded on academic excellence and focused on solving problems specific to South African industry and society

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in fields ranging from energy generation and storage to water purification and effluent treatment. Working prototypes of various products, both materials and systems, developed at the Institute are being trialled by its industrial partners. Commercial relationships with several companies are being formed based on the intellectual property (IP) developed through the expertise in the Institute.

In 2014 SAIAMC's operational structure was re-organised into a coherent amalgamation of three innovation-driven programmes, namely HySA Systems, PSFIC and the newly established Energy Storage and Fluid Treatment Centre (ESFTC) programme. The revised structure allows for more streamlined and efficient planning and execution as well as daily operational support through the Institute's Management and Safety Committees to ensure that the programmes move rapidly along the innovation path. The technology development and product prototype outputs of the programmes are numerous and detailed elsewhere in this chapter. In May 2015 a specialised industry collaboration platform, the Energy Storage Innovation Laboratory (ESIL, part of ESFT) was launched; it is tailor-made for rapid transfer of IP and know-how to market-driven product development environments,. This new unit has already demonstrated its efficacy as a commercialisation environment and is currently involved in joint projects with several companies.

The success of the Institute is owned by its researchers, engineers, postdoctoral fellows, students and support staff, who are fully capable of developing world-class R&D concepts into commercially feasible IP, processes and prototypes, and together play a critical role in the establishment of UWC as an internationally recognised innovation hub in the strategic focus area of energy.

Technology Development

HYSA Systems

The Hydrogen and Fuel Cell Technologies RDI Strategy (HySA) launched by the DST in September 2008 focuses on applied, near-market research and development work with special emphasis on product development and its commercialisation, leading to the establishment of new high-tech industries based on minerals found in South African soil, specifically platinum-group metals (PGMs). Prof Bharuthram's strong leadership role in our engagements with the DST during the early years was most crucial.

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His professionalism in negotiations with the DST and bold strategic decision-making within UWC during the HySA launch phase resulted in rapid establishment of HySA Systems as the DST's leading centre of competence.

The main objective of HySA Systems is to develop components, integrate them into systems and validate these technologies within three key applications of hydrogen and fuel-cell technologies, namely combined heat and power, portable power, and fuel-cell-powered vehicles.

Figure 23.1 Aerial view of the integration and testing zone.

Over the past several years HySA Systems strengthened its manufacturing capabilities through the collaboration in the manufacturing of fuel-cell electrodes with a European company, FuMa-Tech, Germany, and the innovation project which integrated a fuel cell and metal hydride technologies into a forklift truck for a South African mining company, Impala Platinum, (Fuel Cells Bulletin, 2013). Currently, HySA Systems focuses on establishing partnerships with private sector partners that will utilise the products and prototypes developed by the Institute. The Institute also initiated a joint R&D project with Airbus (UK), in which the

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performance and durability of PEM fuel cells for aeronautic applications is being investigated. HySA Systems achievements are highlighted below.

- o A Gen 2 HFC generator providing 2.5kW electric power was installed at UWC Nature Reserve in November 2014 and has clocked over 10 000 hours of running time. [<https://bit.ly/3ineUO1>]
- o A semi-automatic pilot scale MEA fabrication line was commissioned and MEA prototypes has been manufactured showing a performance comparable to the state-of-the-art commercial MEAs.
- o The first 2 kW HT-PEMFC stack comprised of components manufactured in South Africa was assembled, pre-tested and integrated into a CHP system.

The Institute initiated joint R&D project with Airbus.

[<https://bit.ly/3bzmd2o>]

- o A series of prototype metal hydride (MH) hydrogen storage and supply systems for LT-PEMFC applications was developed. The systems provide stable operation for stationary and mobile FC power modules (from a few watts to several kilowatts). [Hydrogen South Africa (HySA), 2014.]

Energy Storage and Fluid Treatment Centre (ESFTC)

The former Eskom R&D thrust has been transformed into the Energy Storage and Fluid Treatment Centre (ESFT) and encompasses the Energy Storage Innovation Laboratory (ESIL) and fluid treatment (emission control and water treatment) projects funded by various government institutions and industries. ESIL is the culmination of many years of research, development and innovation at SAIAMC in the field of electrochemistry and particularly lithium-ion and sodium-halide battery technology.

Further incorporation of electronic engineering skills has led to the development of prototypes that drew the attention of industrial collaborators to a point where commercialisation of the technology is imminent. The partnerships created in this programme present a significant opportunity for UWC to become a truly 'engaged university', since the technology deployment is essential for cost-effective rural electrification and large-scale energy storage applications. Furthermore, this technology has rapidly become a critical part of South Africa's response to climate change and the attempt to achieve a stable electricity supply for the benefit of all South Africans and the country's economy as a whole.

Figure 23.2 Equipment within the lithium-ion battery assembly facility.

Within the area of fluid treatment, the technological output is related to the development of electrodes for the capacitive deionisation (CDI) process and membrane module manufacturing, where the manufacturing process includes winding, potting and cutting of membranes. During the last three-year period, the following technology outputs were successfully demonstrated:

- o UWC-Alphadot agreement towards the commercialisation of Modular Battery System technology;
- o 500Wh CombiLit battery pack for use with Hydrogen Fuel Cells;
- o 1000Wh battery pack using high-energy pouch cells;
- o High-voltage & high-energy (13.3 kWh) mining vehicle battery;
- o 150Ah Na-NiCl₂ thermal battery cell;
- o 2.5kWh Li-ion battery pack;
- o Membrane module containing 1 km-long hollow fibre membrane for the recovery of water from the dry-cooled coal-fired power stations using the wet-flue-gas-desulphurisation process; and
- o CDI-stack for low-energy intensive desalination of water.

PetroSA Synthetic Fuels Innovation Centre (PSFIC)

The PetroSA Synthetic Fuels Innovation Centre (PSFIC) project, as indicated earlier, is a significant collaboration between UWC and the national oil company of South Africa (PetroSA). Its primary objective is the relocation and development of PetroSA's R&D efforts to improve COD (conversion of olefins to distillate) technology to improve the supply of synthetic fuels in South Africa.

The diminishing offshore gas reserves at Mossel Bay make the search for alternative COD feedstock an urgent necessity, as the GTL (gas to liquids) plant producing olefins cannot ensure supply without adequate sources of offshore gas. Thus the PSFIC is investigating alternative feedstocks from anthropogenic sources connected to the oil and gas industry worldwide. These include alcohols (including other oxygenate mixtures), and paraffinic naphthas. Also under investigation is the utilisation of new zeolitic materials as COD oligomerisation catalysts. The PSFIC has developed equipment resources capable of up scaling all R&D on COD from bench scale reactor rigs, to micro-scale reactors up to pilot scale.

Support for plant operations at Mossel Bay has become an important PSFIC activity in the area of applications of separation technology to product and waste-water purification. Some PSFIC achievements are highlighted below:

- o Agreement between PetroSA and UWC to fund the project for a further five years from 2015 to 2020 (contractual agreement signed on 27 January 2015 and effective till 26 January 2020, a new agreement/addendum is in progress);
- o COD pilot plant operating with high selectivity for diesel production (SANEDI newsletter 2018/2019);
- o Micro-reactor systems (3) capable of duplicating the high pressure and temperature conditions used in the PetroSA plant at Mossel Bay; and
- o Nano filtration membrane unit to remove discolouration from certain petroleum products.

SAIAMC Management Structure

The organogram of SAIAMC below represents three programmes (HySA Systems, ESFTC and PSFIC) that are supported by centralised safety, administration and finance structures. The SAIAMC Advisory Board provides strategic guidance to the Institute Director, who chairs the Institute's management committee, which deals with all major aspect of day-to-day operation.

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Human capital development

Human capital development (HCD) towards the next generation of R&D leaders is an integral component of SAIAMC's mandate and plays an important role in the operation of all three programmes.

Postgraduate education

A major objective of the Institute is to increase the number of South African graduates in the postgraduate pipeline, from master's to doctoral to postdoctoral levels, with specific research and technological skills relevant to industry requirements.

Currently the training is carried out under co-supervision of international experts, local experienced scientists and engineers and postdoctoral fellows who are continuously recruited by the Institute. As the new qualified specialists emerge through this process, they will undertake the supervision, thus gradually replacing some of the invited foreign specialists. All research projects at the Institute have clearly stated goals and objectives, which are used to drive and help develop an innovative postgraduate training and education environment.

Undergraduate student training

SAIAMC's efforts to promote postgraduate research supervision in applied technological disciplines is focused primarily on South African students, while its research and technology development agenda is highly relevant to the real needs of the country. These conditions require adequate academic and technical qualifications of the undergraduate students as prerequisites to enter the MSc and PhD programmes in the Faculty of Science in which SAIAMC is located. The Institute has two full-time academics funded by the University (Institute Director and Deputy Director), who have full teaching loads in the undergraduate programmes. Special attention is paid to the introduction of practical technical knowledge and market orientation in the third-year BSc and the BSc Hons academic modules with the purpose of bringing students closer to understanding the industry and marketplace requirements, both to increase students' immediate employment opportunities and to demonstrate the advantages of continuing their education into the postgraduate stream. In addition, more than 10 Honours students from the Physics and Computer Science Departments are educated in product development and more than 10 in-service students are trained in advanced manufacturing techniques annually.

The BSc Hons Product Development Programme run by the Institute in collaboration with Departments of Physics and Computer Science deserves special mention. It is aimed at exposing BSc Hons students to the principles of product development, so that they are challenged to extend their research beyond the laboratory into its commercial or societal use. It is through the practical application in industry-related projects that the students develop skills and attitudes that make them more employable as well as to venture into entrepreneurship. The ultimate outcome would be to positively impact on the range of technologies that are commercialised in South Africa, thereby enhancing employment opportunities in this sector.

Research and development outputs and future directions

SAIAMC has been one of the leading entities within the Faculty of Science with regard to research publication outputs and graduating students. The Institute's philosophy is underpinned by an emphasis on excellence in research as a precursor to advanced innovation and technology transfer. Consequently, SAIAMC has maintained a high level of research output in the form of journal articles and graduating students. However, in terms of its

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mandate as per funding from the University and external sources, SAIAMC has to shift more towards innovation and new product development.

SAIAMC has an important role in the Faculty and UWC as a whole in generating tangible research and innovation outputs. At the same time, with the Institute's focus on technology development and innovation, it has to focus on product development and pilot manufacturing, which was always regarded by donors – both government and industry – as the ultimate purpose of making available to the Institute the extremely high levels of resources over many years.

This new phase of the Institute's existence involves almost all of SAIAMC resources, in a number of separate high-impact projects. The deadlines, responsibilities and levels of potential exposure for pre-commercialisation delivery are a lot more significant and stricter than during the early years after its inception. With the significant advancements made in the innovation space, SAIAMC's senior researchers are today much more involved in the pilot manufacturing, testing and validation trials.

Nonetheless, it is recognised that fundamental research, along with with human capital development, are integral components of SAIAMC's core business in order to contribute to the realisation of the University's vision and mission, and in so doing strengthening UWC's presence on the national and international platforms. A brief summary is presented below of the strategic plans of the Institute's three R&D programmes.

HySA Systems

The HySA programme is solely designed to perform applied near-market research and product development, with special emphasis on new product development that can be commercialised, resulting in the establishment of a vibrant hydrogen and fuel-cell industry in South Africa. Targeted human capital development as well as publishing in peer-reviewed journals will be integral components of the competence centre.

ESFTC

The Energy Storage and Fluid Treatment Centre (ESFTC) programme has two main focus areas. The Energy Storage Innovation Laboratory (ESIL) focuses on commercialisation of newly developed energy-storage products and processes. As 'know-how' protection is important, patenting will be done wherever applicable. The activities of the fluid treatment

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component encompass prototype development and technology implementation, specifically for industrial applications and as such is also involved in human capital development and research publications.

PSFIC

The PSFIC project plan places an emphasis on patent outputs for PetroSA based on development of COD technology. Human capital development for the oil and gas industry in South Africa and publications emanating from ground-breaking research are also part of the PSFIC workplan. Hence, in spite of having to absorb a funding contraction during the current 2015 to 2020 funding cycle, the PSFIC envisages R&D outputs will not shrink, including patents.

Conclusion

The South African Institute of Advanced Materials Chemistry (SAIAMC) at the University of the Western Cape has developed a respected track record in research and innovation, with an advanced technology base emanating from international partnerships and new knowledge generation and generous support from government departments and the parastatal and private sectors.

SAIAMC brings return to all stakeholders in the form of world-class technological solutions in various critical areas of the energy sector, as well as developing the next generation of R&D specialists. The Institute's meteoric rise in the period after 2001 was inspired by the visionary leadership of Prof Brian O'Connell and a dynamic Executive Management Team.

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