A love of research as the springboard for teaching

MechChem Africa profiles SAIChE IChemE's new president, David Lokhat, who is the academic leader for Chemical Engineering and head of the Reactor Technology Research Group at the University of KwaZulu-Natal (UKZN). With a BSc, MSc and PhD in chemical engineering, Lokhat is an active researcher in the field of chemical reactor design and optimisation; and chemical kinetics, with a focus on process intensification.

David Lokhat was schooled at a small community school in Durban North, where he grew to love science and mathematics "I lost my father when I was very young and my mother did everything she could to ensure that I had a proper foundation. She instilled in me a fascination for the natural, physical, scientific and technological worlds. I was always taking machines apart to see how they operated," he begins.

"When it came to my matric option choices in Grade 10, I decided on an S7 package that was available at our school, and which included maths and science as well as accountancy. I expected to follow in my sisters footsteps into chartered accountancy, but I had a much greater interest in maths and science than I did in accountancy, so I decided on taking up my hobbies as a career instead," he recalls.

Lokhat decided to apply for engineering at the University of Natal. "I had multi-disciplinary interests, though. I enjoyed chemistry, electricity and mechanics, so I was torn when choosing an engineering discipline. The new central applications system required us to make three choices, with one being awarded based on available space. I chose the courses in alphabetical order: chemical; electrical and mechanical engineering, and I got into chemical engineering, my first choice.

"I regard this as the best choice I ever made," Lokhat tells *MechChem Africa*. "The chemical engineering discipline is a massively broad one that has allowed me to regularly tap into classical engineering topics and other technological fields to bring solutions together, which was exactly what I was initially looking for," he adds.

David Lokhat in Kyoto as an invited speaker for the 2015 International Congress on Chemical, Biological and Environmental Sciences (ICCBES).

The Chemical Engineering laboratory at UKZN where David Lokhat is the Reactor Technology Research Group leader.

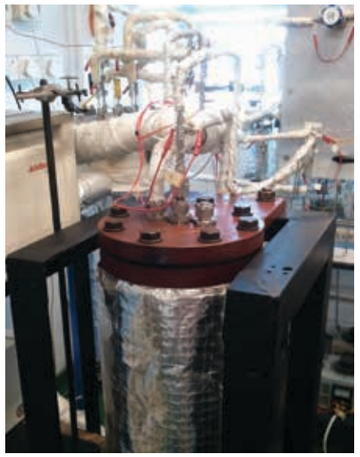
Lokhat's first few years at university were not easy. "I did OK in my first year, but the second year was challenging and I had to repeat two subjects," he says, adding that this opened up a lot more time in the following year, which enabled him to help the department with tutoring and research assistant work. "I can honestly say that this changed my whole life. Doors opened that would not have opened and I discovered research, which became my first love," he explains.

"I came to realise that the first few years of engineering courses are foundational, going back to the fundamentals of physics and mathematics that are essential foundation blocks. I was a late bloomer however, who only really began to enjoy the degree in my third year when we started to be exposed to the professional courses in chemical engineering. My results got better and better and I started to achieve the highest marks in class," he says.

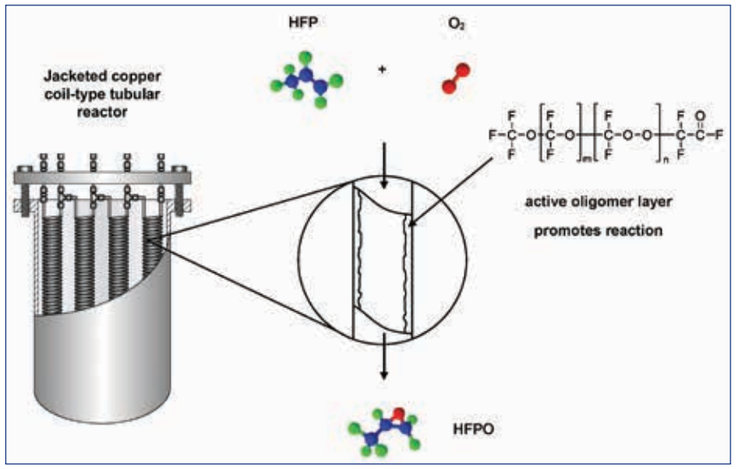
"As an academic, I have seen this happen time and time again with students at university. Students who have done well in school struggle initially but, once they find their interests, they start to excel," he adds.

In his final year of undergraduate studies, he was approached by Matthew Starzak, an associate professor in the area of optimisation and chemical reaction engineering at that time, to participate in a Sasol-supported industry project as his first semester project.

The project involved investigating metathesis (double decomposition) of 1-hexene, a chemical process involving the exchange of substituents in an unsaturated hydrocarbon resulting in the formation of longer chain molecules. "Organic chemistry was previously a challenge to me and I really wanted to make it my own by taking my module knowledge and applying it. By passing 1-hexene over a solid catalyst in a fixed bed chemical reactor at a high temperature, we were able to create 5-decene, a 10-chain hydrocarbon molecule that is used in the manufacture of surfactants," Lokhat explains.



The reactor developed at UKZN for the gas-phase production of HFPO from the reaction of hexafluoropropylene with molecular oxygen (O_2) under mild reaction conditions.



A schematic diagram summarising the award winning process developed by Lokhat for his PhD.

"Through this project, I had the wonderful opportunity to work for a short time at the Technical University of Lodz in Poland in a highly sophisticated laboratory with advanced analytical equipment. After Lodz, I knew research was what I wanted to do.

"Towards the end of the project, Prof Starzak came over to visit me in Poland and, while having a meal in the beautiful old capital, Krakow, he invited me to stay on to do an MSc with him after I graduated. I said yes immediately," he says.

David Lokhat completed his BSc in chemical engineering in 2006 and, after a short break, returned to start his MSc in April the following year.

Still based on the initial metathesis of 1-hexene, he set out to look at the fundamentals and reaction kinetics. "The MSc took another 18 months and helped me to hone my research skills. We commissioned an entirely new bench scale reactor for the work and my MSc was finally awarded cum laude in April 2009," he recalls.

Then, following the launch of the Fluorochemical Expansion Initiative (FEI) and establishment of the South African Research Chair for Fluorine Process Engineering and Separation Technology under the direction of Professor Deresh Ramjugernath, Professors Starzak and Ramjugernath identified an industry relevant PhD project for Lokhat: the production of hexafluoropropylene oxide (HFPO), a fluorochemical intermediate used to make ion exchange membranes for fuel cells. "I was tasked with developing a new cleaner and higher capacity process for the production of this chemical on a commercial scale," Lokhat informs *MechChem Africa*.

His final PhD details a continuous process for producing HPFO under mild reaction conditions (lower temperatures) that substantially reduce waste and are associated with a much smaller environmental footprint. As well as being accepted for his PhD, the work culminated in several journal articles, a patent and the commissioning of a 5.0 t/a onsite pilot facility at the DST funded Multipurpose Fluorination Pilot Plant (MFPP) at NECSA in Pelindaba.

The process? "HFPO used to be batch produced using a chemical solvent as the oxidiser. Unfortunately, this is not a selective process, so many other products are formed alongside HFPO, all of them unwanted and some of them dangerously toxic.

"We developed a gas-phase production system that involved the reaction of hexafluoropropylene with molecular oxygen (O_2), which eliminated the solvent and most of the by-products. The key problem we had to overcome was the high temperatures needed to activate this reaction, but by running the process under tightly controlled conditions and initially coating the inner surface of the reactor with a polymeric by-product (an oligomer) to catalyse the reaction, we were able to lower the temperature and make the process continuous," he explains. In addition the few gas-phase by-products produced are much more easily separated out.

The process Lokhat developed won him, together with co-investigators, the SAIChE Innovation Award in 2013 and is being commercialised through the DST for use by some multinational chemical producers. "In 2012, I was among the first doctoral graduates to emerge from the FEI programme and the research has since lead to the development of a whole new portfolio of products and processes," he adds.

Lokhat was then offered a lecturing post at UKZN. "This was a big decision for me, because of my love of research, but I eventually accepted the post and became a full time lecturer in 2013. I soon found I enjoyed teaching even more than research! There would be no researchers without teachers – and I have not had to give up on my research interests," he says.

Between 2013 and 2017, David Lokhat received numerous best lecturer and distinguished teacher awards for his work in chemical engineering at UKZN. He still spends half his time on research focused on process intensification and chemical reaction engineering. "I strive to make process units that are more efficient, have a smaller footprint, use fewer resources and produce less waste. In the process, I also get to explore various alternative technologies, such as ultrasound, microwave energy, centrifugal fields and advanced materials," he notes.

Prior to 2018, he has been credited with 25 journal papers and seven book chapters. He is rated as an emerging researcher (Y-rated) by the National Research Foundation and, in 2019, he became the academic leader for Chemical Engineering at UKZN.

As the Institute's new president he believes that SAIChE IChemE has a critical role to play, locally and globally. "Interesting things are happening in the world and we increasingly need strong technical and scientific voices. Global phenomena such as climate change, social cohesion and the 4th Industrial revolution are affecting the way things are done, who is doing them and their consequences. We as chemical engineers have a responsibility to become involved in identifying pathways through these challenges.

"As an institution representing engineers in South Africa, SAICHe IChemE is in an ideal position to interact on behalf of our membership with broader global communities: to mitigate against current challenges while continuing to secure our standards of living through advanced technologies," he concludes. ❑