UNIVERSITY OF CAPE TOWN
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INNOVATION THROUGH SUSTAINABLE DEVELOPMENT

INNOVATION AT UCT 2019

RESEARCH CONTRACTS & INNOVATION

INNOVATION AT UCT **2019**

Introduction

As the theme for this year's publication, we have chosen, the United Nations' sustainable development goals (SDGs). The seventeen goals are wide-ranging and speak directly to critical problems for South-Africa and the continent.

The 2015/16 Research Report also focused on the SDGs and from that it was clear the strategic priorities of research at UCT closely match these goals, e.g. inequality, climate change, food and water insecurity, unemployment and safe cities, to mention a few. In this report we will highlight some of UCT's inventions that relate directly to SDGs.

For those of you who have followed this publication since it was first published 10 years ago, you may find some of the features familiar. It is interesting though to note how, through their development, some technologies now also address goals that were not necessarily originally foreseen. One such entity that was featured before is the spin-off company Strait Access Technologies (SAT), which has designed a device that can implant heart valves without the need for complicated surgery or high-tech operating theatres with advanced imaging systems and surgical teams, to address the impact of Rheumatic Heart Disease (RHD), a deadly disease affecting 70-100 million people worldwide (Goal 3 - Good Health & Wellbeing). Not only has SAT recently successfully done a 'first-in-man' operation, but currently the company also employs more than 60 people (Goal 8 – Decent work and economic growth) .

At the Partnership Practitioners Forum in 2017 Raj Kumar, the President and editor-and-chief of Devex said the following "I think in the end, that last goal, that 17th goal, is really the innovation goal...". This goal, *"Partnerships for Sustainable Development"*, is also considered by Research Contracts & Innovation (RC&I) as a very important activity for us to be able support the research community at UCT. Some of RC&I activities in support of this goal are also featured in this publication.

We gratefully acknowledge the funding provided by the Department of Science and Innovation (DSI)'s National IP Management Office (NIPMO) that provides up to 50% co-funding of the IP protection expenses incurred by the university and significantly supports other RC&I activities such as the Catalyst Lunch events that are profiled in this publication.

Fitness Test

Due to the nature of our bodies being unique, one of the more significant challenges of fitness assessment is normalising test results. An invention by UCT Professor Michael Lambert and the Sport Science Institute of South Africa's Justin Durandt is offering innovative individualisation for the assessment of fitness.

"The Fitness Test" (as it is currently being called) uses an adjustable step system and algorithm that correlates to the direct measure of VO2 Max (the maximum rate of oxygen consumption). Through this test, and the resulting VO2 Max score, an individual's fitness level can be assessed. The pace of the test is standardised to 20 steps per minute and the length of the test is thus determined by the mass of each participant. The step test is further individualised for each participant based on their height through a quick and easy notch adjustment built into the base of the structure.

The Fitness Test has many uses but among them is the potential use by biokineticists to assess athletes in school or professional sports teams, as well as individuals at a gym who may be concerned about their fitness level.

This technology has been successfully licensed to a leading South African financial/health insurance group who will use it within their member wellness programme.

Cheetah tail helps with motion tracking of humans

UCT senior lecturer from the Department of Electrical Engineering, Dr Amir Patel, first started investigating the properties of cheetahs' tails in relation to robotics. At the time, he was wholly unaware that his research would result in a whole new way of capturing the movement of the human body.

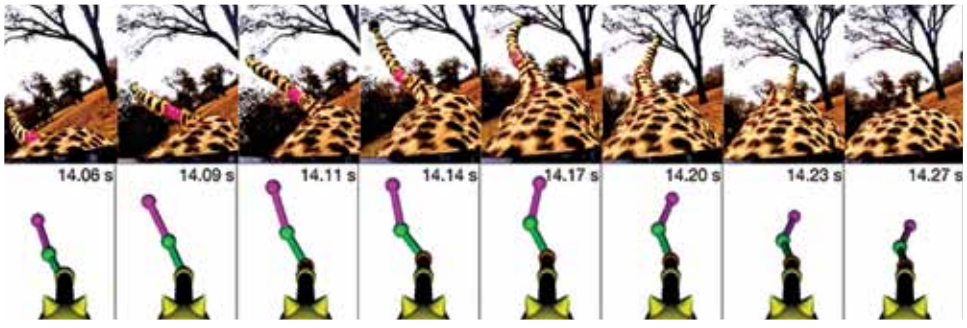
Patel, who graduated from UCT in 2008 after studying mechatronics engineering, spent several years working in the aerospace industry before returning to UCT to complete his PhD in 2015. He was fascinated with the idea of learning lessons from animals that evolved over millions of years and then applying those to new technologies.

Dr Patel remembers that "there were studies at the time that showed how lizards stabilised their movement when they jump using their tails. I started to wonder: if lizards used this technique, then what about an animal closer to home that moves much faster, the cheetah?"

Relying on his own resourcefulness, he wrote an algorithm that combined the disparate kinds of information available and pieced together a coherent model of the skeletal movement of a cheetah, including its spine and tail.

While discussing the invention with RC&I, they realised that this way of capturing movement could also be applied to the human body. Patel was introduced to scientists at the UCT Sports Science Institute who were keen to collaborate on the project.

With seed funding from RC&I, Patel and his team began to adapt their cheetah sensors to make them suitable for use on humans. "In essence, we have created a system of multiple sensors that are light-weight and economical, but can capture the movement of the human body very precisely". This 'democratisation' of motion capture technology could lead to additional innovations in capturing biomechanics as well as a potential bump for South Africa's burgeoning film industry as a low cost and accessible form of motion capture for feature films.



Biological Tendon to Combat Sleep Apnoea

Obstructive Sleep Apnoea (OSA) is a debilitating condition with significant morbidity and mortality characterized by blockage of the upper airway during sleep as a result of collapse of the soft tissues in the throat. OSA affects approximately 6-8.5% of the adult population in western countries.

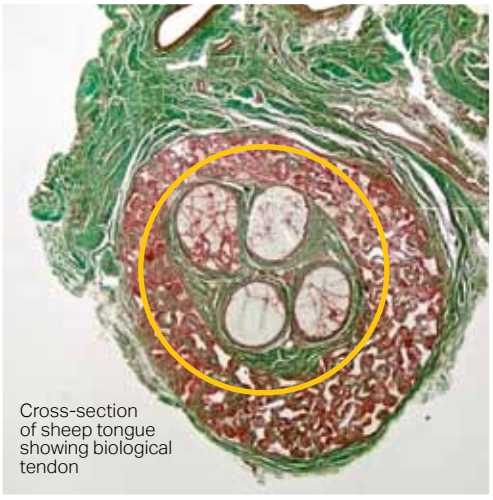
Left untreated, OSA can have serious health consequences in affected individuals. Related diseases include obesity, cardiovascular complications, cerebrovascular conditions, endocrine/metabolic challenges and premature death. Despite these devastating effects, current treatments for OSA are not effective, often involving invasive surgical procedures that do not provide suitable long-term solutions.

Maxillofacial surgeon Dr Rushdi Hendricks, and polymer expert Associate Professor Deon Bezuidenhout (both based at UCT), have developed a device that offers a less invasive, long-term solution for patients suffering from OSA.

A synthetic, porous scaffold made from a Thermoplastic Silicone Polycarbonate Polyurethane (TSPCU), called Carbosil is implanted into the base of the patient's tongue and coupled to an implanted bio-absorbable polydioxanone suture "vehicle" that holds the scaffold in place. The device enables a surgeon to advance the patient's tongue forward by about 10 mm at the base while secured to the inside of a patient's chin by means of a bio-absorbable screw on the opposing end.

UCT TIA Seed Funded animal trials proved that the scaffold incorporates with the muscle of the tongue and transforms itself into a "biological tendon" over a period of eight months. It also proved to be naturally strong and resistant to becoming infected. The tendon possesses double the capacity required to prevent the tongue from falling back and re-obstructing the patient's air passageway. As the product is bio-absorbable, the screw and vehicle disappear in time.

A first human patient trial has been planned and funds are being raised. This will provide the proof of concept and form the basis of a larger clinical trial with the ultimate objective being widespreasd implementation of the technology to sufferers of OSA in South Africa, as well as abroad.



Cross-section of sheep tongue showing biological tendon

A novel animal vaccine that could pack a double punch

Vaccination has long been an effective way to reduce disease burden in both human and domesticated animals. Historically, live attenuated vaccines have been considered the most effective – especially for the management of animal diseases. Attenuation takes an infectious agent and alters it so that it becomes harmless or less virulent. These vaccines contrast to inactive vaccines that are produced by "killing" the virus. Because attenuated live vaccines are so similar to the natural infection that they help prevent, they create a strong and long-lasting immune response.

However, there is always a risk that, through mutation, the attenuated live vaccines could revert to a virulent form in the vaccinated animal population. This is of particular concern in countries where a disease does not currently occur.

Professor Anna-Lise Williamson, Dr Nicola Douglass and Dr Henry Munyanduki from UCT's Division of Virology have been researching the use of recombinant vaccines. Recombinant vaccines utilise elements of different viruses that are genetically re-engineered to create vaccines that will elicit a protective immune response but that will not lead to disease.

The researchers identified superoxide dismutase homolog (SOD) as a gene that may influence immunogenicity of live virus vectors – poxviruses, in particular, which include Lumpy Skin Disease Virus (LSDV). Even though it has a relatively low mortality rate, the disease affects milk production, hides, causes abortions and temporary or permanent sterility in bulls, which could have a significant economic effect on the cattle industry.

With preliminary rabbit tests having been successfully completed, various vaccine constructs are soon to be tested in cattle. Whilst these could lead to improved vaccines against LSDV, they could also act as potential vector backbones for multivalent veterinary vaccines.

A current TIA-funded project is pursuing the development of the first dual recombinant vaccine that will target both LSDV and Bovine Ephemeral Fever (BEF).

AFFORDABLE AND CLEAN ENERGY

UCT takes the lead with clean energy innovations

A host of innovations are taking place in the affordable and clean energy space at UCT, primarily in the Departments of Electrical and Chemical Engineering.

The inventions of Professors Trevor Gaunt, Michel Malengret and their students are moving closer to commercial implementation through partnerships with an inverter manufacturer. One of the innovations their team has developed is an algorithm that can be applied to an inverter for power to either be injected into the network optimally or withdrawn.

This will become increasingly important as 'green' technologies such as wind farms and solar panels become connected to the grid. It can be applied to a single phase or multi-wire power network, ensuring that the power reaches the destination where it is consumed with minimal losses, thus increasing the efficiency of utility networks.

The HySA Catalysis Centre of Competence, funded by the Department of Science & Innovation, is producing hydrogen fuel cell components that capitalise on South Africa's platinum wealth, create 'clean energy' and reduce inequalities by providing power to remote off-grid users. This initiative is discussed elsewhere in section 8 of this publication.

Real-time health check for solar cells

Photovoltaics (PV) is a renewable energy method using solar cells to convert the sun's energy into electricity. South Africa averages about 2,500 hours of sunshine per year, making it one of the sunniest countries in the world. Solar is central to South Africa's renewable and sustainable energy strategy with several large solar energy projects, including PV, in various stages of development.

One of the challenges with PV cells is that they eventually degenerate and lose their effectiveness to capture electricity. It is important to monitor the State-of-Health (SOH) of PV cells to diagnose possible fault conditions and enable appropriate maintenance actions to be taken.

Prof Paul Barendse and Olufemi (Isaac) Olayiwola have developed has developed a technique whereby the SOH of PV cells may be determined in less than two seconds, making it ideal for real-time condition monitoring. The method, termed Optimised Broadband Impedance Spectroscopy (OBIS), involves injecting an optimised broadband signal that consists of multiple superimposed waveforms of different frequencies into the cell. OBIS has also proven to be applicable to fuel cells in an adapted form.

This is a substantial improvement on Electrical Impedance Spectroscopy (EIS), a well-known laboratory method for monitoring SOH, which is impractical for real-time, online condition monitoring because the total length of time required to complete the procedure is often longer than the rate of change in the cell's condition.

Sensors to detect early failure of utility poles

Worldwide, millions of wooden poles support utilities such as power distribution lines. Typically, they have a lifespan of about 40 years before succumbing to decay or fungal/insect attacks. Early failure may even occur due to unpredictable weather, environmental conditions or human activity. Apart from the threat to public safety, falling power lines have massive financial implications due to property damage, loss of sales and interrupted power delivery. In South Africa, where electricity supply is under severe pressure, effective pole maintenance is critical.

A new technology being developed at UCT by inventors Professor Ed Boje and Jason Hardy aims to measure the state of health of utility poles more efficiently using a sensing module, ensuring fast and appropriate maintenance and accurate fault reporting. The sensing module may include a vibration sensor and a magnetic field sensor, which can be used to determine changes in line and pole geometry. Characteristics of the magnetic fields associated with the lines that are held by a specific pole can be evaluated and compared to the situation of a sensor on the next pole.

This change in field orientation will indicate whether the poles have a similar alignment or if one has maybe fallen. By comparing measurements between nearby poles on the same line, differences and changes in the behaviour can be detected. Rot, insect attack, water logging, etc. cause changes in the modulus of elasticity of the pole and hence the vibration characteristic.

Importantly, data is analysed within the sensor module, rather than being relayed to a base station and only evaluated there, saving power.

Heart valve implant offers hope for rural RHD patients

Rheumatic Heart Disease (RHD) is a deadly disease affecting 70-100 million people worldwide. In 2017, the World Health Organisation (WHO) declared it a global health threat. RHD is a preventable condition triggered by streptococcal bacteria, but when left untreated can cause a patient's immune system to attack their own heart while fighting the infection. This leads to an acute inflammation of the heart and valves accompanied by a fever. Acute Rheumatic Fever primarily affects lower socioeconomic status people between the ages of 5 and 15. These individuals often lack access to suitable healthcare, further increasing their risk to this potentially fatal disease.

UCT spin-off company Strait Access Technologies (SAT) has designed a device that can implant heart valves without the need for complicated surgery or high-tech operating theatres with advanced imaging systems and surgical teams. Instead of open-heart surgery, which requires expensive machines and specialist hospitals and surgeons, the valve can be inserted at a rural hospital by a general surgeon through a small incision. SAT has also developed a polymer heart valve which is ideally suited to young patients, as it will last longer in their bodies, than the conventional valves that have a lifetime of around ten years. "A self-homing hollow balloon carries the valve into the heart," said Prof Peter Zilla, head of the Christiaan Barnard cardiothoracic surgery department at the University of Cape Town, who led the team that developed the valve and the insertion technique. The Dilatation Balloon clinical trial is currently in progress, with the first patient treated on 29 January 2019 by Dr Jacques Scherman at Groote Schuur Hospital.

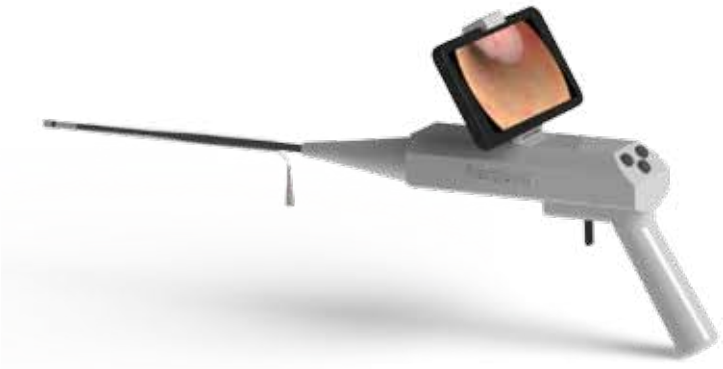
A flexible solution to hysteroscopy

Traditional hysteroscopy systems (most often used to treat uterine conditions) and the equipment required for its use are expensive. Furthermore, these systems employ rigid hysteroscopes that cause patient discomfort and require general anaesthesia, which in turn limits the procedures to the operating theatre.

Edmund Wessels and his supervisor, Sudesh Sivarasu - associate professor of biomedical engineering - have developed a reusable mobile hysteroscopy system for application outside of the operating room. The team has worked with some of the best gynaecologists in South Africa to understand their challenges and to co design the solution with their feedback in mind.

Their innovation, the FlexiGyn, is a system that consists of a handheld control base and a flexible rod, which can bend up to 180° in four directions through user-controlled input via its novel smart bending system powered by a rechargeable battery. A built-in, low power, integrated circuit camera and LED light source are located at the distal end of the flexible rod. The result is a system with controlled flexibility that ensures maximum patient comfort. With smartphone and tablet integration for visualisation, it also enables the user to save any videos or images. A significant benefit of the device is its application both inside and outside of the operating theatre, without the need for general anaesthesia.

The inventors have a working prototype, which has been demonstrated on test dummies. The user experience has also been validated by gynaecologists and urinary gynaecology specialists.



Hydrogen Fuel Cells power rural schools

Poelano High, a rural school in Goedgevonden, Ventersdorp in the North West Province, has benefitted from a hydrogen fuel cell system that will enable it to have access to low-cost, off-grid primary power/energy for its information and communication and technology (ICT) and lighting needs. The school's system uses solar photovoltaic (PV) panels to generate electricity, which is used to produce hydrogen via electrolysis.

This was accomplished through a collaboration between HySA Catalysis Centre of Competence, co-hosted at UCT, participating with the two other Department of Science & Innovation-funded HySA centres to demonstrate a hydrogen fuel cell system at the school. The Centre is one of the most prolific creators of intellectual property at UCT, resulting in a spin-off company, HyPlat (Pty) Ltd, that is already commercialising membrane electrode assembly (MEA) components that incorporate the platinum-containing catalysts.

HyPlat uniquely provides tailor-made MEA and catalyst products for their international clients (the fuel cell industry in South Africa is emerging) at cost competitive prices with rapid turnaround times. The MEAs are gaining significant traction in the market, as evidenced by the strong interest shown at the Hanover Fair, Europe's largest hydrogen and fuel cells exhibition.

INDUSTRY, INNOVATION AND INFRASTRUCTURE

Catalyst Lunches

As part of the office of UCT's Research Contracts and Innovation (RC&I) ongoing efforts to connect UCT's research community, we celebrated WIPO World IP Day during one of our Catalyst Lunches held last year. The theme was "Powering change: Women in innovation and creativity". This event was selected specifically to highlight how women at UCT (and across the world) are driving change through science, innovation and arts.

With more women seeking careers in fields traditionally filled by men, the importance of IP and IP protection are crucial. Understanding IP systems, and using them, is essential to keeping the current momentum of women joining tech, engineering and any other field that utilises IP as central to their business model.

The Catalyst Lunches, using funds provided by the National IP Management Office (NIPMO), have proven to be a success for RC&I, and UCT as a whole. These lunches facilitate engagement from a wide variety of faculties in an informal, relaxed environment. In addition to members from UCT faculties, industry representatives, as well as investors, are invited to allow direct interaction between industry and academia. Broad themes are selected for each lunch, with several being held during the year.

Through these events, and others like it, we hope to continue informing UCT researchers of industry trends, IP management and current innovation funding opportunities and specific funder requirements. Further, we hope to continue connecting relevant stakeholders to new technologies, research focuses and commercial opportunities.

Facilitating Innovation

To provide researchers with the tools to facilitate the production of knowledge and society improving innovations, it is essential to have a multi-pronged approach to funding that meets the needs of the researchers and entrepreneurs at multiple stages of a project.

With over a decade of existence, UCT's initial PreSeed Funding offering has evolved into a more comprehensive funding system meant to accommodate projects in various stages of development, ranging from initial prototyping to full commercial release. The allocation of the larger levels of funding, available from the Evergreen Fund is managed by the university's Intellectual Property Advisory Committee (IPAC). To help advise the committee, the Private Equity Advisory Group (PAG) was established. Composed of prominent members of the financial, legal and socio-investment sector, they are charged with providing strategic advice to IPAC.

The members of PAG operate on a voluntary basis and are Mr Chris Derksen (Chair), Mr Gasant Orrie, Mr Guy Harris, Mr AJ Nel and Mr Ashley Francis, UCT Executive Director Finance. UCT is appreciative of their time and efforts in assisting the university with this important work.

With UCTs current set of tools to provide funding for inventors, RC&I is well positioned to encourage creativity and bold ideas with the ultimate goal of benefiting not only UCT, but society as a whole. The emphasis on projects that improve quality of life and/or solve existing problems is central to the ethos of UCT in general, and RC&I specifically and will continue to guide the work in the coming years.

Funding Infrastructure

As part of a comprehensive funding strategy, UCT has rolled out several initiatives including the newest, the **UNIVERSITY TECHNOLOGY FUND (UTF)** which has been created by partnering with the SA SME Fund.

"The **SA SME FUND** was established by members of the CEO Initiative – a collaboration between government, labour and business to address some of the most pressing challenges to the country's economic growth – as an avenue of support for the SME sector". SA SME Fund (sasmefund.co.za)

The UTF will seek to provide very early-stage venture capital funding – unique in the South African space – and UCT will coinvest along with the Fund. A component of grant funding will also maintain the robustness of the UCT technology development pipeline. UCT and Stellenbosch University have been included for the UTF pilot phase.

The **INNOVATION BUILDER FUND**, recently established at UCT, exists to bridge funding gaps for projects prior to applying for the Evergreen Fund or University Technology Fund for larger levels of support. With awards totaling up to R500k per project, the fund will ensure projects are better positioned to qualify for subsequent stages of funding.

The **UCT EVERGREEN FUND** utilises a portion of alumni donations (roughly R4.5M), along with a capital injection of R60m of university funds, to make limited investments in private companies that are spin-offs of UCT. To date, four investments have been made totaling R34.2m. Future projects targeted include those in the health sector, with many more in the application stage.

App to support livelihood of artisanal fishers

Abalobi, led by Dr Serge Raemaekers, is a not for profit spin-off significantly impacting on the jobs of artisanal fishers.

The MarketPlace app links fishers to top local chefs who can put a QR code on their menus, allowing diners to trace when, where and by whom the fish on their plate was caught.

The ability to record daily catch and financial transactions has validated the income of the fishers and enaabled them to apply for loans from banks, delivering them from the clutches of loan sharks. This is an excellent example of technology being deployed to address SDG Goal 8 – Decent Work & Economic Growth.

Fishers are also able to sell an entire 'net' to a chef, so that bycatch species which are often discarded are now making it to the restaurant tables; ensuring that the fisheries are utilised more sustainably.

Visit http://abalobi.info/ for more information.

UCT SPIN-OFF COMPANIES

DRONESAR, Cell-Life, curitbiotech, ATTRI, Antrum Biotech, CapeRay, AngioDesign, tuluntulu, SAT, Nurture Restore Innovate, CAPE catalytiX, abalobi, HyPlat, IMPULSE, LUMKANI, sonic, PSTI, HPT HOT PLATINUM, Elemental NUMERICS, CAPE BIO PHARMS, CAPECAROTENE FISH FOOD

Since 2004, UCT has served as an incubator for 25 spin-off companies. Of these, 22 are still operating which is significant when one considers that only roughly 10% of start-ups survive.

Importantly, spin-off companies create highly-skilled opportunities within the South African job market. Cape Bio Pharms has employed five postgraduates, whilst Strait Access Technologies currently employs 60 people, many of whom are biomedical engineers or specialise in the production of advanced medical devices. Without these businesses, many skilled job seekers would be lost to off-shore employment.

DECENT WORK AND ECONOMIC GROWTH

Furthermore, since these companies rely on various support functions, e.g. financial, accounting, marketing, cleaning, etc., job creation extends way beyond the technical opportunities.

UCT's newest spin-off company, Nautilus, was founded by Associate Professor Co-Pierre Georg and PhD student Sabine Bertram. It is the first block-chain related company, as well as the first FinTech patent filed by UCT. Nautilus is based on Proof of Privacy, a novel cryptographic protocol that lets users control their private/personal data by granting others access for specific use cases – and only those.

In other words, you could release certain data to obtain a home loan or health insurance quote, but importantly, you can revoke the data access once you have obtained the quote.

It is anticipated that the number of spin-off companies will increase now that the Evergreen Fund and University Technology Fund have been established, so that funding is more readily available. These initiatives are covered elsewhere in the publication.

RESPONSIBLE CONSUMPTION AND PRODUCTION

RESEARCH CONTRACTS & INNOVATION

Green chemistry propelled forward by research group

The challenge for chemists is to develop products, processes and services in a sustainable manner to improve quality of life, the natural environment and industry competitiveness. Green chemistry, also called sustainable chemistry, is an area of chemistry and chemical engineering focused on the designing of products and processes that minimize or eliminate the use and generation of hazardous substances.

While environmental chemistry focuses on the effects of polluting chemicals on nature, green chemistry focuses on environmental impact and includes such concepts as waste minimisation, solvent selection, intensive processing and alternative synthetic routes from sustainable resources.

The overarching goals of green chemistry—namely, more resource-efficient and inherently safer design of molecules, materials, products, and processes—can be pursued in a wide range of contexts.

Inventor A/Prof Anwar Jardine of the Department of Chemistry and his research group, who are actively involved in green chemistry, have managed to reduce the number of process steps required in the conversion of insoluble chitin to soluble 6-deoxy-6-amino chitosan. The major benefits to this innovation include a reduction in processing waste, a reduction in the conversion time and, at scale, there is a potential to recycle the green solvents used in the process.

Conventional 'chitosan' is derived from chitin, a natural polymer found in the exoskeletons of invertebrates. It has various applications ranging from use in clarifiers, as a foliar spray in crop protection, as a co-polymer, as a safe antimicrobial and antifungal chemical treatment, as an ingredient in the cosmetics industry as well as for the encapsulation of drugs, chemicals and vaccines.

Research Contracts & Innovation
University of Cape Town
Allan Cormack House
2 Rhodes Avenue
Mowbray 7701
South Africa

Email innovation@uct.ac.za
Phone +27 21 650 4015
Twitter @UCT_RCI
Website www.rci.uct.ac.za

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Rethinking Petrochemicals

An invention with advantages over conventional industrial hydrocracking processes has been pioneered by Dr Roald Brosius of the Department of Chemical Engineering. It relates to a new process for the production of high yields of high-quality middle distillates.

The process involves hydrocracking a hydrocarbon feed stream at atmospheric pressure (as opposed to the usual pressure of up to 70 atmospheres) and temperatures around 200°C, (much lower than the conventional 360°C) in the presence of hydrogen, over a noble metal (platinum) containing FAU-type microporous zeolite catalyst.

The invention significantly reduces the investment hurdle for large green-field Gas-to-Liquid (GTL) hydrocracking units and it also facilitates the entry of small GTL units. These small GTL units aim to monetise natural gas resources, reducing gas flaring globally, which the global climate and clean air coalition considers to be the fastest and most cost-effective way of slowing global warming in the short term.

Hydrocracking remains the key technology for the production of gasoline and middle distillates (kerosene, aviation fuel, diesel and some lubricants), either from crude oil or from FT waxes. Companies such as Sasol operate hydrocracking processes to upgrade waxes from the low temperature GTL process to usable liquid fuels.

Also, in the Department of Chemical Engineering, Profs Michael Claeys and Eric Van Steen invented two processes where ammonia gas is added into the syngas from FT to either favour the production of specific olefin products or to create speciality nitrogen containing chemicals.

Small FT units are being developed in Europe (rather than the massive gas to liquid plants built historically) and use renewable hydrogen plus CO_2 or biogas as the raw material. These smaller plants lend themselves to the production of niche products in this new 'green' take on the petrochemical industry.