InnoVenton Times

January, 2017 041 504 3281 info.InnoVenton@nmmu.ac.za

2016—THE TIMES THEY ARE A CHANGING (BOB DYLAN)

Entrance to InnoVenton's new Administration Building on Gomery Avenue

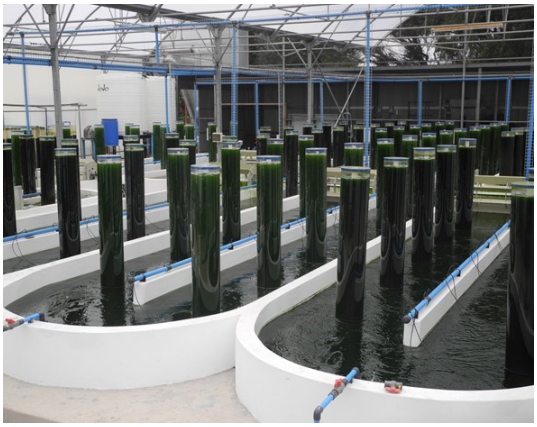
After an extremely long wait of close to 15 months, InnoVenton's new building and additions have finally been handed over. Now the big job of fitting the inside of the space with offices, laboratories, seminar facilities, common spaces, etc. awaits—No problem man.

Letter from the Editor.....

To all our readers, welcome to 2017 and wishing everybody a very happy new year. We trust that 2017 will start to see the fruits of all your labour in so many activities and projects. Some of these will be featured in this 2016 issue of our own InnoVenton Times so as to remind ourselves where we have come from in 2016 and also to show us where we plan to go to during 2017 and beyond. To each and everyone a very BIG thankyou for your contributions in 2016 in some very difficult circumstances. We trust that 2017 will bring us more work, but that it also brings us the joy of being able to do this for others. ———Melissa

Coalgae® Technical Demonstration

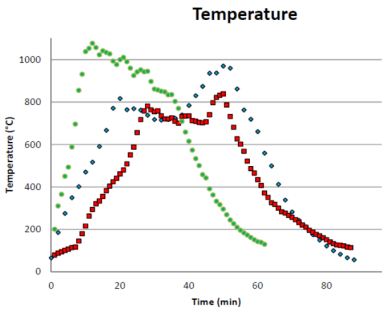
The start of 2016 saw the completion of the construction of the Coalgae® technical demonstration facility at a cost of some R2.4 million. The main purpose of the facility was to produce 5—6 tonnes Coalgae® product in a dedicated campaign in which all of the unit operations of the Coalgae® technology was integrated, obtain independent external testing of the product, and solicit interest from potential users of the technology or product. After some teething problems the facility started operating at the beginning of March and ran uninterrupted till the end of September when the campaign was stopped. During this period, some 5.2 tonnes of coal was processed through the facility. Some 200 Kg of the product was processed by means of pyrolytic topping into a bio-crude pyrolysis oil (~25 Kg) and which were sent for a crude oil assay by Intertek (UK). Other tests conducted on the product include mechanical resistance and weather resistance testing, and fixed-bed combustion testing (John Thompsons). Pulverised combustion testing is still to be conducted by Eskom.



The results obtained from the Coalgae® technical demonstration showed that the InnoVenton microalgae cultivation system performed better than its original design specification at a productivity rate that is close to double what the best large-scale cultivation systems produce internationally.

Combustion tests conducted by John Thompsons showed that Coalgae® is an excellent fuel for moving fixed-bed combustion systems (e.g. chain grate boilers) in view of its ease of ignition, significantly faster combustion rates, and producing higher

temperatures compared to the reference coal. One advantage of the improved combustion properties of Coalgae® relative to coal in moving fixed-bed combustion is the potential to significantly improve carbon-utilization efficiencies. Typically a chain-grate boiler leaves between 30—35 % of the available carbon as part of the ash at the end of the combustion process. With the improved combustion rates of Coalgae®, significantly less carbon will be left in the ash implying a significant reduction in fuel use rates for such boilers.



The results of the analysis on the Coalgae® pyrolysis oil showed that the oil may be an excellent feedstock for the production of kerosene and diesel in view of the significant proportions of these fuel petroleum fractions in the oil. Obviously a significant amount of work still needs to be done in order to convert the crude oil into a final fuel product.

Where to from here?

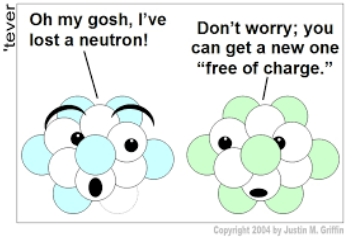
In view of the successes achieved to date, the Department of Science and Technology made additional funding available to expand the activities around the microalgae project with the view to develop either a Research Centre or Centre of Competence around the microalgae project. For this purpose, three distinct research themes will be developed within the overall microalgae technologies project, namely: Microalgae cultivation systems, Renewable Energy, and Biomass Processing. The first theme, Microalgae Cultivation Systems, will build on the current microalgae cultivation platform developed by InnoVenton so as to catalyse the establishment of large-scale microalgae cultivation farms. The Renewable Energy Theme will focus on the development of a suite of Renewable Energy technologies and products using microalgae as base. These include transport fuels, household solid fuels, synthetic natural gas, and chemicals. The Biomass Processing Theme will focus on the establishment of a full microalgae biomass biorefinery with a specific focus on the development of high-value products such as phycobilloproteins for the cosmetic industry, food supplements such as beta-carotene, astaxanthin, etc.

New Appointments

Dr Shaka Shabangu

Shaka Shabangu, appointed as the Renewable Energy Theme leader in the Microalgae Technologies Project, completed his PhD at Sheffield University in Chemical Engineering and Fuel Technology in 2005.after which he joined Cornell University for a post-doctoral fellowship and later worked as research associate. His doctoral research was on the development of a novel non-slagging gasification technology for both biomass and coal that can be used as part of the development of integrated gasification combined cycle (IGCC) to improve energy efficiency in power generation, as well as for syngas-to-liquid fuels.

As theme leader for the Renewable Energy Theme in the Microalgae Technology Project Shaka will be responsible for the development of technologies for the conversion of microalgae biomass—coal mixtures into a variety of renewable products that include liquid and solid fuels, renewable chemicals, and energy (heat and steam). His biggest challenge, however, will be the development of a technical demonstration facility for the conversion of Coalgae® into emissions-free lrenewable energy via gasification coupled with carbon capturing and storage/conversion. Shaka will also be responsible for the management and execution of one of two TIA Seed Fund projects, namely the development of a low smoke solid household fuel for low-income households (See elsewhere).



InnoVenton's New Buildings

At last the dream of sufficient space to bring all of InnoVenton's staff together in a single space is nearing reality. The concept of the new buildings at InnoVenton's Gomery Avenue site was first conceptualised in 2010 and took a very long and frustrating 6 years to complete. The plan involved regaining the second building, built in 2002 with a DTI grant for the use of the chemical Incubator, Chemin, and then linking the two buildings together on one side with an office/administrative wing. In view of the costs of construction of the entire facility, that also included the addition of a second storey on the existing ex-Chemin building, InnoVenton agreed to do most of the internal fittings itself using funding raised through its own activities. Once complete the new facility will house: A dedicated reception area for visitors and customers,;

A seminar facility that has a versatile 40—80 seater seminar room together with two smaller break-away meeting rooms;

Offices for all its staff; a Board Room and adjacent kitchen/seating area; An open-plan workstation area for post-graduate students; Three new laboratories; A process simulation computer laboratory; New store facilities, and a covered outdoor commons area for staff and students..

Doing the internal fittings in-house translates into substantive savings for the Institute and eventually the NMMU. As example, the cost of fitting two complete laboratories in a modern, open-plan style will cost an approximate R180 K, complete with individual work stations for 20 individual researchers,/post-graduate students. All of this work will commence immediately in the new year and we hope to complete the fittings of the new labs in a month.

More than R2.5 Million for student bursaries

During 2016 InnoVenton managed to raise and pay over R2.5 Million in bursaries to under-graduate and post-graduate bursaries. This amount excludes any amounts paid from NMMU Council funds through the NMMU's bursary Office.

The support for our students came from a wide variety of sources that include scholarships from industries, accommodation and study-fee support from the Chieta, bursaries through the NRF (specifically the RSES bursary scheme for support of post-graduate studies in the Microalgae to Energy project), and grants from a variety of sources such as industry, TIA, and internal InnoVenton funds.

Daniel Bothua and Seiyefa Otokolo (Interns) working with Dr Gary Dugmore. Saabier Mathews, Siyabonga Vusani and Candice Davison were also interns in 2016.

BASF sponsored students to complete their in-service training in 2016. Miss Aurora Bothua and Abongile Cutalele were also IST's in 2016 at InnoVenton.

New Appointments
Mr Brian Tait

Mr Brian Tait, previously Business Development Manager , Sasol Technology and more recently a self-employed consultant in the energy industry, has been appointed as InnoVenton's first Strategy and Operations Executive. With his vast experience in new business development and managing chemical businesses, Brian's primary role in InnoVenton will be to ensure the commercialization of technologies and products emanating from InnoVenton's research, and development activities. In addition, Brian will also assist the Institute to develop effective business operation systems to ensure the effective operation of, and future sustainability of the Institute. Commercialization activities will be undertaken in close collaboration with the NMMU's Innovation Office, the NMMU's IP holding company, Innovolve, and Propella Incubator. Much of the initial effort will be directed at commercializing products and technologies emanating from the microalgae project such as the low smoke fuel for low-income households.

Brian completed his MSc at the ex-UPE after which he completed an MBA at the University of the Witwatersrand and a general course in taxation through Unisa. He is an expert in techno-economic modelling of chemical/energy-related technologies and he will use this expertise to model new products/technologies at an early stage to drive research and development in the most promising directions. Brian will also train post-graduate students in the area of techno-economics.

Last-phase of Inulin production facility commissioned

The last phase of the Inulin production facility it Chicory SA in Alexandria, namely the ion-exchange facility for final product treatment, was commissioned during 2016. The process for the extraction of Inulin (a long-chain sugar used as pro-biotic) was developed in InnoVenton's pilot-plant facilities by Dr Gary Dugmore and the ion exchange facility is the last step required to reduce the ash content of the final product to meet customer specifications. The facility in Alexandria will start to produce market quantity samples for market penetration.

Ion Exchange columns showing feed entering on the left and clean product leaving on the right

Evaporator balance tank receiving clear inulin solution exiting the Ion exchange and de-colouring process

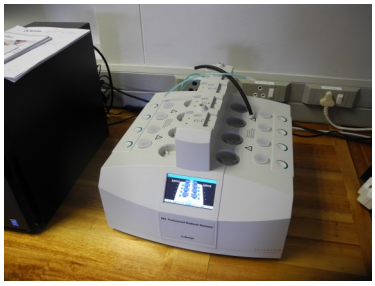
New Equipment Acquisitions

During 2016 the Technology Innovation Agency (TIA) provided some R2.4 million for the acquisition of three pieces of analytical and testing equipment, namely:

Thermal Desorption Unit for our Agilent GC x GC at a cost of approximately R1.7 million. This unit is used extensively for the analysis of VOC emissions from automotive materials used inside vehicle cabins such as carpets, seat coverings, dashboards, etc.

Cold Filter Plugging Point Apparatus, used for the measurement of the cold temperature behavior of fuels and oils. The instrument measures the highest temperature at which a specific fuel or oil blend will completely block a tube with a specified internal diameter. These measurements are especially important for fuels and oils used at high altitude (e.g. in aircraft) or very cold climates.

Oxidation stability meter— used for the measurement of stability to oxidation of fuels. Unsaturated compounds in fuels and biofuels are especially prone to oxidation, forming acidic groups that can lead to corrosion of pipes and components during transport, storage, and use.



Formulation reactors - Umicore donated eight formulation reactors complete with mixing and electronic control to InnoVenton. Two of the reactors are jacketed and may also be used as fermenters for bioprocessing. The reactors ranges in size from 100 L to 500 L. These reactors will be installed in the new laboratory space gained as part of the building expansions at InnoVenton. Apart from being used for scale-up of R&D technologies, the reactors will also be used for training of students from both the Diploma in Chemical Process Technology and the BSc Hons in Formulation Science.

New Appointments Dr Carla Kampman

Dr Carla Kampman has been appointed as theme leader for the Microalgae Cultivation Systems in the Microalgae Technologies project. Carla completed her PhD at NMMU in 2014 on the topic of large-scale cultivation of microalgae and since then worked as post-doctoral fellow as part of the Coalgae® technology technical demonstration where her responsibilities included the cultivation of microalgae for the project.

In her new role as theme leader for the Theme of Microalgae Cultivation Systems, Carla will focus on the continuing optimization of the InnoVenton integrated cultivation system as well as develop new cultivation systems for specific purposes, for example the development of a low-technology, low-cost microalgae cultivation system for subsistence farmers to produce their own bio-fertilizer. In addition, Carla will also be responsible for the development of cultivation protocols for specific microalgae strains to produce specific target products, for example astaxanthin, phycobilloproteins, stable isotope-labled amino acids, and more.

Given her background in formulation science, Carla will also lecture in the BSc Hons in Formulation Science program.

Renewable Energy Post Graduate Symposium 2016 (REPS 2016)

The annual renewable energy post graduate symposium, which up tp 2015 has been hosted by the Renewable Energy Hub at Stellenbosch University, was hosted by the University of Fort Hare as part of their Centenary Celebrations. Apart from being part of the organising committee for the symposium, InnoVenton participated in force with 7 oral and poster presentations as well as a full working exhibition on the cultivation of microalgae and the utilization of the biomass. The following presentations were presented during the two-day symposium:

- B Zeelie, Coalgae®: Coal Microalgae Composites,
- C Kampman, Large-scale cultivation of microalgae
- H Baloyi, Pyrolytic topping of Coal – microalgae composites,
- S Gaqa, Agglomeration of coal – microalgae mixtures
- N Magida, Greenhouse gas reductions through the combustion of coal-microalgae composites
- M Mambo, Treatment of municipal waste water through microalgae cultivation system,
- G Oghenekume, Soil remediation using microalgae

The working exhibition consisted of a 600 L microalgae integrated cultivation system containing actual microalgae, a small coal stove burning Coalgae® pellets to demonstrate the efficient combustion of pyrolysed Coalgae® and the low smoke properties of the pyrolysed Coalgae®, a gasifier for the generation of syngas connected to a 7.5 KW petrol generator for remote generation of electricity from Coalgae®, as well as several of product samples that included dried microalgae biomass, Coalgae® pellets, pyrolysed Coalgae® pellets, a bio-fertiliser produced from a blend of cow manure and microalgae biomass, and 25 L of bio-crude oil produced from the pyrolytic topping of Coalgae®. The exhibition was visited by over 1000 visitors ranging from National and Provincial Government Officials, symposium delegates, staff and students from Fort Hare University, and high school learners from the Alice—Fort Beaufort school districts. The exhibition got a special mention at the closing session of the symposium, especially the manner in which InnoVenton's post graduate students took spontaneous control of groups of people to take them through the exhibition and explaining the science and technology of the different exhibits. Great job guys—really great job.

New Appointments Mr Derek Hislop

Mr Derek Hislop has been appointed as instrument technician in InnoVenton to take responsibility for the repair and maintenance of InnoVenton's significant investments into equipment and instrumentation. Derek has many years of experience in instrument repairs and maintenance at companies such as Protea Medical, Ilex SA, and Beckman Coulter. Apart from taking responsibility for repairing instrumentation and equipment, Derek will play a crucial role in training staff and students in the proper use and operation of equipment.

Two TIA Seed Fund Projects Approved

Two additional Seed Fund proposals were approved for InnoVenton in October 2016. These proposal were:

Low Smoke Fuel for Low Income Households: The proposed project involves the development of a low-emission solid fuel, primarily aimed at developing a replacement fuel for the household use of coal and biomass (wood). While the concept of a "smokeless coal" is well known and such products are used extensively internationally, all attempts to introduce a low smoke fuel (LSF) into the RSA market have failed to date since, in most cases, alternatives did not meet the sociological and cultural requirements of consumers. Even the successful electrification of households across South Africa has made little impact on the rate at which coal is consumed by households (for cooking and space heating) due to the costs associated with electrical heating. The problem of pollution from emissions by coal and wood fires in homes are well recognised and have received massive funding for R&D since the mid 1990's. The fact remains that more than a million households are still using coal as their only form of household energy, and are paying the price for it, not necessarily in monetary terms, but by ill health, poor quality of life, and accidental death (CO poisoning and fires). It is rather sobering to consider that about 40% of all visible air pollution in South Africa is caused by households using coal. The goal of this project is to produce a low smoke fuel with identical end-use characteristics as coal, but without the negative pollution aspects, thereby alleviating the serous social impacts mentioned above.

Biological fertilisers and soil conditioners: The proposed project involves the development of three related product offerings using microalgae as the critical basic input. These product offerings are:

- Biological fertilizer produced by either blending animal manure with microalgae and optionally pelletizing said blends into a solid fertilizer,
- A low cost, low technology for growing microalgae in a wet bed of animal manure or other organic residue, and using said mixture directly as biological fertilizer; and
- A soil conditioner containing microalgae, bacteria, and humic acid substances.

The soil conditioning properties of microalgae have been known for several decades and are, for example, used extensively in rice cultivation in Asia. The main benefit of using microalgae as a soil conditioner is that they stimulate bacterial growth in soils, provide excellent soil structure properties that improve water and nutrient retention, and they also stimulate secretion of growth hormones. Studies conducted on the use of microalgae as soil conditioner have indicated substantial reductions in the rate of fertilizer (N and P) applications for maize of up to 60% whilst improving yields at the same time. In view of the high nitrogen content of microalgae being cultivated at the NMMU, the progression from soil conditioner to biological fertilizer seems obvious. In addition to the potential use of microalgae as substrate for biological fertilisers/soil conditioners, there also exists an opportunity to use microalgae for soil remediation purposes. As example, tests conducted at InnoVenton showed that microalgae concentrates are very effective of decomposing fuel and oil contamination. Thus, industrial oil contaminants are almost completely broken down after about six weeks of treatment. Similarly, fine coal contamination is broken down over a similar period and plant growth restored to its original state. Plans are underway to test this application on a larger scale on worked-out coal mines that typically take up to 15—20 years to regain normal productivity.

Advanced Weathering of Mine Tailings—Potential Grand Challenges Project Collaboration with Southampton University

Following a recent visit to the University of Southampton, InnoVenton has been approached to be the local (South African) partner in a very large Grand Challenges project submitted by the University of Southampton. The project will aim to capture and store excess carbon dioxide emissions by reaction with finely divided mine tailings (finely ground rock). The process will involve the dissolution of CO_2 in water, followed by treating mine tailings in situ with the acidic water to form a variety of carbonates, including carbonates of calcium, silicon, magnesium, etc.

InnoVenton's role in the proposed project would be to act as local analytical and monitoring support to the project. This involves detailed analysis of mine tailings prior to treatment, monitoring reactions during treatments, and analysis of the final products of the treatment.

In addition to the above, InnoVenton also plans to investigate the use of the mixed carbonates and bicarbonates produced during advanced weathering tests as source of CO_2 for microalgae cultivation.

Looking forward - 2017

Despite many uncertainties and a tight economic climate, the year 2017 promises to be another hectic year. The following are a few of the main activities planned for 2017:

Microalgae Technologies: Following the request by the Department of Science and Technology to expand the previous Microalgae to Energy Project into a much larger Microalgae Technologies project, a significant effort is going to be required for us to pass the Stage Gate set for the end of October 2017. Deliverables that has to be met by the end of October 2017 include 10 - 25 L of kerosene and diesel from Coalgae® pyrolysis, one example of a bio-fertiliser complete with external analysis certificate, one example of a soil conditioner with external analysis certificate, one example of a cattle feed formulation, low smoke solid fuel being sold in selected shops, a low-technology, low-cost microalgae cultivation system, and a heterotropic cultivation system to allow remote cultivation of microalgae for soil remediation purposes.

Fitting of new building space: As described elsewhere, this involves the construction of new offices inside the new administration building; assembling and installing all the laboratory benches, cupboards, plumbing and extraction in two new laboratories; construction of a computer-based process simulation laboratory; construction of a distillation laboratory; fitting new store space; construction and fitting of external commons area; and construction and fitting of open-plan post -graduate office area. Finally, all staff currently on North Campus will be relocated to Gomery Avenue together with InnoVenton equipment, and current space in the A-Block on North Campus returned to the Department of Chemistry.

TIA Seed Fund Projects: Both these projects require a relatively large amounts of microalgae biomass and we are currently looking for

space to construct our first out-door cultivation facility of some 2000 - 3000 m^2. This will allow the production of sufficient quantities of Coalgae® briquettes for conversion into a low smoke household fuel to supply to sufficient shops for consumer acceptance testing. In addition, such a facility will also be able to produce sufficient amounts of microalgae biomass to produce a bio-fertiliser and soil conditioner for testing in field trials.

Technology Station Projects: Several large Technology Station Projects are planned for 2017, including:

Cape Fynbos Preservation for NikwiFlora which will enable the company, based in the George - Mosselbay region, to expand their business substantially as they can reach markets much further away than is currently the case.

Cold Brew Coffee Extraction Process development for KAI Industries, a Pretoria-based company that imports coffee beans from a single region in Rwanda. The project will entail the development of the actual process, developing quality control procedures around the actual product, and ensuring an acceptable shelf-life for the product.

Wild Wall Garden Tiles project which involves assisting a prominent South African Artist to optimise her idea of a cement-based wall tile with a cup for growing small plants in (see picture). The project entails the design and manufacturing of a mould to allow production of sufficient quantities of tiles for testing, optimising the cement-based formulation from which the tiles are to produced, testing the tiles for water resistance, durability, freeze-thaw cycling resistance, and appearance. Finally, a 100 m^2 wall area is to be covered with the wall tiles to conduct comparative temperature studies on the covered and uncovered walls to test the hypothesis that the wall tiles/ garden will significantly reduce heat build-up in walls exposed to direct sunlight.

Agro-Refinery for the Sarah Baartman Municipal District - a joint project between InnoVenton and the Agrifood Technology Station at Cape Peninsula University of Technology. The development and implementation of South Africa's first Agro-Refinery will be based on exploiting the significant quantities of cactus pear populations in this District. While cactus pears are currently forming a significant informal business activity in this region, utilisation of the entire plant for the production of food products, cordials and drinks, high-value oils and chemicals for the personal care industry, can lead to significant economic development and skills training in this economically underdeveloped region. Some of the cactus pear plant components being targeted for development include fruits (pulp for cordials and drinks, and seeds for seed oil), flowers (for colourants), cladodes (for soluble fibre, food additives), and stems (fibres for water treatment, plant growth media).