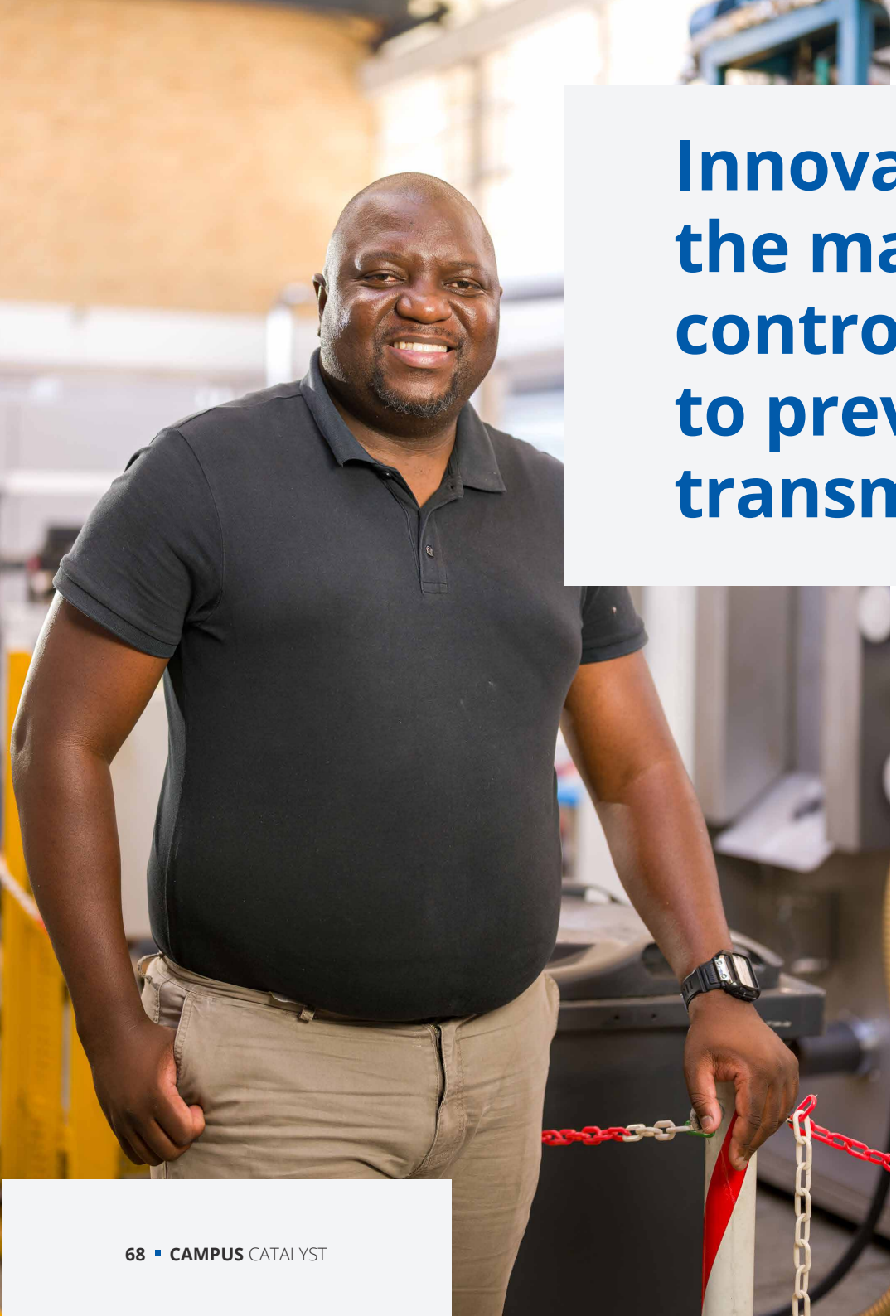


Innovator redefines the market for insect control products to prevent malaria transmission

Dr Mthokozisi Sibanda was a doctoral candidate in the University of Pretoria (UP)'s Institute of Applied Materials (IAM) under the supervision of Prof Walter Focke. During this time, he became part of the research team that developed patented composite polymer fibres that could be woven or knitted into textiles that contains a slow-release insect repellent. This proved to be the catalyst for his future career, and provided the encouragement to follow his calling.

He explains that he had always had aspirations of becoming an industrialist. “I knew I wanted to follow a career in which I could manufacture something. Although this is where I ended up, I followed a largely unconventional route to get there.” He says that when he graduated with his PhD in 2015, he received an offer of employment from the Council for Scientific and Industrial Research (CSIR), but he followed the advice of his supervisor and mentor, Prof Focke, to be brave enough to follow his dreams.

The technology that emanated from his PhD research is an innovative method of manufacturing textiles that are specially engineered to store large amounts of organic actives that are released into the atmosphere at a slow rate and in a controlled manner. This innovative technology extends the residual effectiveness of the volatile organic actives, reduces losses due to evaporation, reduces the overall cost of their use in practical applications, and enables the commercial manufacture of long-lasting insect-repellent textile-based products using fibres infused with insect repellent.

It was the commercialisation of this invention that led him to establish African Applied Chemical (AAC) as a private company in 2016. “It is a biotechnology company that utilises a combination of technology and science to provide simple lifestyle products and applications for malaria-stricken areas that could potentially save millions of lives,” he explains.

He co-founded the company with Dr Sthembile Sibanda, a medical researcher with six years’ experience in medical laboratories. She holds a PhD in Medicine from UP, and has been a shareholder and director of the company since 2019. Her focus at AAC is product design and packaging, and managing the company’s staff. Her mission is to protect the wellbeing of people by offering solutions to protect people in public and private spaces, and to transform people’s lives for the better by reducing the spread of malaria in urban and rural areas.

The advanced textile yarn the company manufactures using the proprietary Bi-Ko™ slow-release technology are made mainly from polypropylene homopolymer. The fibres are specially engineered to store a large amount of liquid within their matrix and to slowly release small amounts of this liquid over a long period of time. The technology was developed and patented by the University of Pretoria and is exclusively licensed to African Applied Chemical.

“We currently manufacture next-generation long-lasting insecticide-treated nets to control insecticide-resistant mosquitoes,” says Dr Sibanda. These products are marketed under the Vikela™ brand for the donor-driven market and under the NoBuzz® brand for the retail market.

He explains that the reason for developing the mosquito net product is that the World Health Organisation (WHO) had put out a call to innovators to come up with a ’next-generation‘ mosquito net designed to be effective against insecticide-resistant mosquitoes.

A 'next-generation' mosquito net is defined as a product that contains a pyrethroid insecticide and a secondary active, designed to increase the effectiveness of the mosquito net product against insecticide-resistant mosquitoes. The secondary active can be a synergist and/or a novel and safe insecticide that is not used in agriculture.

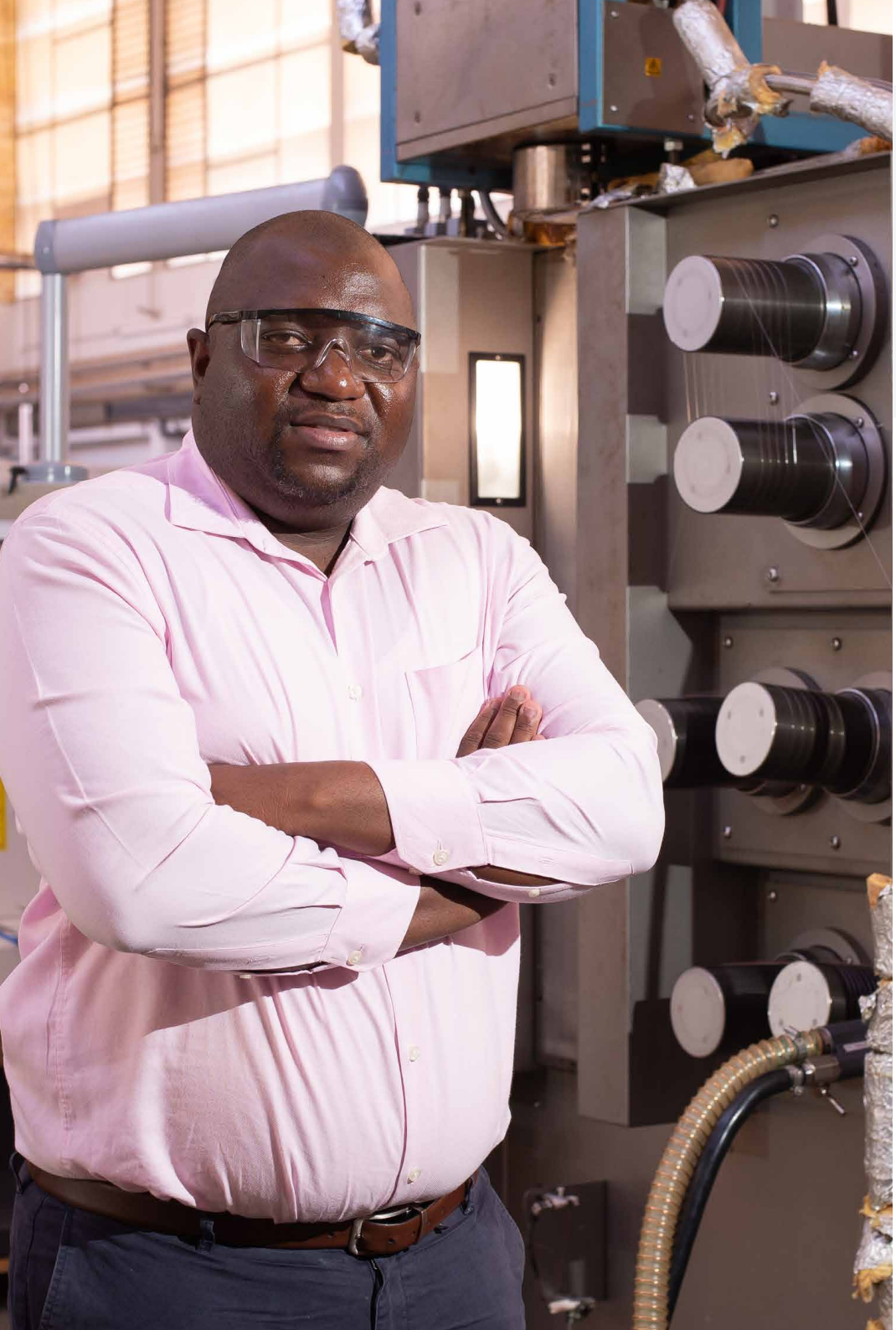
Such a long-lasting insecticidal net (LLIN) may be effective in controlling insecticide-resistant mosquitoes. The Vikela™ mosquito net incorporates beta-cyfluthrin, a piperonyl butoxide synergist and a nootkatone insecticide. The Bi-Ko™ slow-release fibre technology is used to store and slowly release the insecticide formulations over an extended period of time. This makes the mosquito net resistant to multiple launderings.

Nootkatone is a natural insecticide that is very effective against mosquitoes, including pyrethroid-resistant mosquitoes. Nootkatone is currently applied commercially as a food-flavouring agent. Since it is edible, it is also safe for exposure to human beings. It can therefore be used on mosquito nets. Safety of the insecticide to users is the most important aspect that is considered by LLIN regulators.

He says that the company has an ambitious product development pipeline that includes low-cost transdermal drug-dosing patches, slow-release pheromone traps for sustainable pest control in agriculture and advanced antimicrobial packaging for post-harvest fruit preservation. "I am passionate about applied science and the creation of cost-effective and innovative chemical products to solve pressing global problems."

Dr Sibanda points out that malaria kills hundreds of thousands of people in Africa each year, and new tools are needed to eliminate this disease. According to the WHO, there were an estimated 263 million malaria cases and 597 000 malaria deaths in 83 countries in 2023. Africa carries a disproportionately high share of the global malaria burden. In 2023 alone, the WHO's Africa Region was home to 94% of malaria cases (246 million) and 95% of malaria deaths (569 000). Children under five years of age accounted for about 76% of all malaria deaths in the region. Malaria has been estimated to cost Africa more than US$12 billion a year in lost gross domestic product (GDP).

The company currently employs 12 people full-time and is planning to build a new facility to start mass producing these mosquito nets for the donor market once the product achieves recommendation by the WHO. This manufacturing facility will potentially employ more than 500 people to produce more than 10 million mosquito nets per annum.



Profile of an innovative industrialist

Originally from Zimbabwe, Dr Sibanda graduated with a Bachelor of Engineering in Chemical Engineering (honours) degree from the National University of Science and Technology in Zimbabwe in 2008. During this time, he worked as a trainee engineer at the Triangle Sugar Corporation in Zimbabwe, a subsidiary of Tongaat Hulett Sugar.

In 2009, he enrolled for his master's degree in Chemical Engineering at the University of Pretoria (UP), which he obtained with distinction in 2011. This was followed by a PhD in Chemical Engineering specialising in polymers and chemical product design. He conducted research on the development of innovative vector control products for malaria vector control under the supervision of Prof Walter Focke. This gave rise to the products he is manufacturing under African Applied Chemical.

He explains that it all began when he was eight years old in Zimbabwe, and suffering from a repeat bout of malaria. "This was the beginning of my journey to find a solution for so many people living with the threat of malaria and sometimes even death."

Having lived through the ravages of malaria and seeing the unnecessary suffering of his community and so many others due to the disease, finding an effective solution became his driving force, and led to his research and ultimately an invention that he knows can simplify and cost-effectively manage the infection rates of malaria across the continent.

His supervisor, Prof Focke, had developed an interest in malaria transmission due to a similar experience that affected him personally when a close family member was diagnosed with cerebral malaria.

Prof Focke had already made contact with two researchers from the Leibniz Institute for Polymer Research in Dresden, Germany − Dr Andreas Leuteritz and Dr Harald Brünig − who were working in the field of synthetic yarn spinning. When he told Dr Sibanda about this, the seed was planted to investigate the application of mosquito-repellent technology to clothing items. This guided his postdoctoral research and development work for most of the following decade.

DOCTORAL RESEARCH

Dr Sibanda's PhD research sought to develop polyolefin co-polymers as controlled release devices for insecticides and repellents. With this research, his aim was to develop two cost-effective and innovative ideas to bridge the gap left by implementing current recommended vector control interventions. These ideas relied on the use of polymer matrices to stabilise and slowly release active agents used in malaria vector control, thereby increasing their residual effectiveness.

The first idea was to develop an insecticide-treated wall lining. He envisaged that the lining could be used instead of indoor residual spray and could complement the use of long-lasting insecticide-treated nets. This lining was produced using a simple extrusion of polyethylene master batches with a 1:1 polymer blend of high-density and low-density polyethylene containing concentrations of two pyrethroid insecticides to produce a Netlon® mesh.

The mesh linings were evaluated for acceptability, durability and perceived effectiveness in field trials carried out in the Vhembe district of Limpopo. The majority of the participants perceived the Netlon® lining to be effective and user friendly. The linings were stable to environmental elements that persisted inside the dwellings where they were installed; however, some rodent damage was observed. Standard bioassay tube tests indicated that these nets remained effective for at least 24 months in the field and 36 months after manufacture.

The second idea was to address the need for protection against mosquito bites outdoors. It entailed the use of polymer matrices to trap large amounts of a repellent and to release it slowly over an extended period. This could increase the residual effectiveness of volatile repellents. Possible future products based on this idea included long-life mosquito-repellent bracelets and low-cost rubber beach sandals (flip flops). The repellent DEET was incorporated into the polymer via the technique of spinodal decomposition. He found that it was possible to trap a proportion of the insecticide in a polymer matrix.

Further studies showed that the filled polymer matrix reduced the rate of release of the repellent. "Laboratory tests suggested that these bracelets may be effective in repelling mosquito bites for at least one month," he says. This suggested that low-cost bracelets and rubber beach sandals can be designed that would last that long. Future products based on this idea could help reduce infections due to ankle biting by *Anopheles gambiae* mosquitoes, which are responsible for many malaria infections in Africa.

FURTHER RESEARCH AND DEVELOPMENT

Prior to submitting his PhD thesis in December 2014, Dr Sibanda visited the Martin Luther University in Halle, Germany, for a month. It was at the end of this research stint that he visited the Institute for Polymer Research (IPF) in Dresden, and had the opportunity to meet Dr Andreas Leuteritz. The idea to use bi-component yarn to store and slowly release volatile actives was born. This discussion was followed by an offer to spend three months as a visiting scientist at the IPF to prove this concept. The progress to proof of concept was very swift, and by the end of 2016, there was a fully developed and tested prototype. A patent application was submitted to the South African Patent Office through the University of Pretoria.

When he returned to South Africa, Prof Focke alerted him to the fact that the equipment he had used in Germany to spin the Bi-Ko™ slow-release technology into yarn was also available on the premises of the CSIR in Gqeberha in the Eastern Cape. Although it was in a state of disrepair, it opened his path to becoming an innovator: he had the equipment and the technology to slowly release volatile and expensive insect repellents, making them last longer, now all he had to do was develop them into marketable products. He admits that this would not have been possible without the support of Prof Focke, who he considers to be his role model.

In 2016, he established African Applied Chemical as a private company. He obtained funding to repair the machinery at the CSIR, and in 2017 could start producing textiles on a small scale. After some pilot-scale studies, AAC started producing the insecticide-infused textiles. He was soon able to acquire more machines and to establish a manufacturing facility at the CSIR's Nanomaterials Industry Development Facility (NIDF) in Pretoria. AAC also rents office and manufacturing space at the Innovation Hub. He moved all his equipment to Pretoria when the Gqeberha facility closed down in 2018.

EARLY DAYS OF COMMERCIAL OPERATION

The company's Bi-Ko™ slow-release technology was licensed to AAC in 2018, and Dr Sibanda could start with the production of items manufactured with the insect-repellent textile infused with a long-lasting repellent. The company's first product was a hiking sock treated with the long-lasting insect repellent.

This product met the company's value proposition of manufacturing long-lasting insect-repellent textile-based products to meet customers' needs under the NoBuzz® brand using the Bi-Ko™ slow-release technology. The competitive advantage of AAC's products is that they use a natural insect repellent that renders products safe for the whole family, including toddlers. The textile-based products are washable for at least 25 washes or last for six months in the open.

The company started shipping its first orders at the end of February 2020. However, with the announcement of a nationwide lockdown in March 2020 following the COVID-19 pandemic, tourism experienced a downturn. As visitors to the Kruger National Park were the company's primary target market, this had a devastating effect on sales.

Although visitor numbers were limited when the park opened its gates to tourists again in September 2020, all AAC's product lines were sold out by the end of December 2020. This gave the company valuable sales data to test its sales assumptions. As the economy and travel started to open up again, AAC launched an aggressive sales acceleration campaign. The sale of the ankle bands and sprays increased. It also started exploring the regional export markets, and commenced exports during 2022.

Its products are currently distributed at the Kruger National Park under Tourvest Destination Retail, Mopani pharmacies in Nelspruit, the NoBuzz® online shop and through Takealot.com.

FUTURE PROSPECTS

As the sales of AAC's repellent product lines took off, the company's management adopted a strategy of developing new applications of the technology to ensure a sustained increase in income. Two new applications have been developed: next-generation long-lasting insecticide-treated mosquito nets for use against insecticide-resistant mosquitoes, and an anti-bedbug mattress cover. Research is also being conducted on the development of slow-release drug delivery patches and slow-release pheromone traps for sustainable pest control in agriculture. Development on the next-generation long-lasting insecticide-treated mosquito net is now complete and is undergoing product approval by the WHO. Once approved, the mosquito nets will become the company's flagship product.

Dr Sibanda engaged in further studies to improve his business management skills. He now also holds a Certificate in Entrepreneurship and Small Business Management from the University of South Africa (Unisa) and a Postgraduate Diploma in General Business Management from the Gordon Institute of Business Science (GIBS). His primary focus is product development.

His ambition for the company is to upscale production so that he can employ thousands of people. His driving force is to bring a new product or skill to the market. He acknowledges that the qualities of a successful innovator include determination and problem-solving abilities. The mentorship he received in applied science from his supervisor, Prof Focke, inspired him to look at the small details, and he passes this advice on to the scientists he mentors.

"We must realise that, even in Africa, we can come up with advanced and innovative products that compare well with products developed internationally. In some cases, these products are even more advanced than those on the global market."

LONG-LASTING INSECTICIDE-TREATED MOSQUITO NETS

Prior to 2018, the pyrethroid group of insecticides was the only insecticide approved for use on mosquito nets. However, mosquitoes quickly developed a resistance to pyrethroids. This resistance was reported in almost every country in sub-Saharan Africa. Although the widespread use of long-lasting insecticide-treated nets showed initial success in reducing malaria transmission, malaria cases started to increase again in 2016, despite the obedient use of these nets. There was therefore a desperate need for new innovative mosquito control products to effectively deal with insecticide-resistant mosquitoes.

The WHO suggested developing new insecticides with a different mode of action to pyrethroids. It put out a call to innovators to develop vector control products that contain novel actives that are safe and not used in agriculture, in addition to pyrethroids. The AAC responded to this call by trialling a novel insecticide active for use in long-lasting insecticide-treated nets to tackle insecticide resistance.

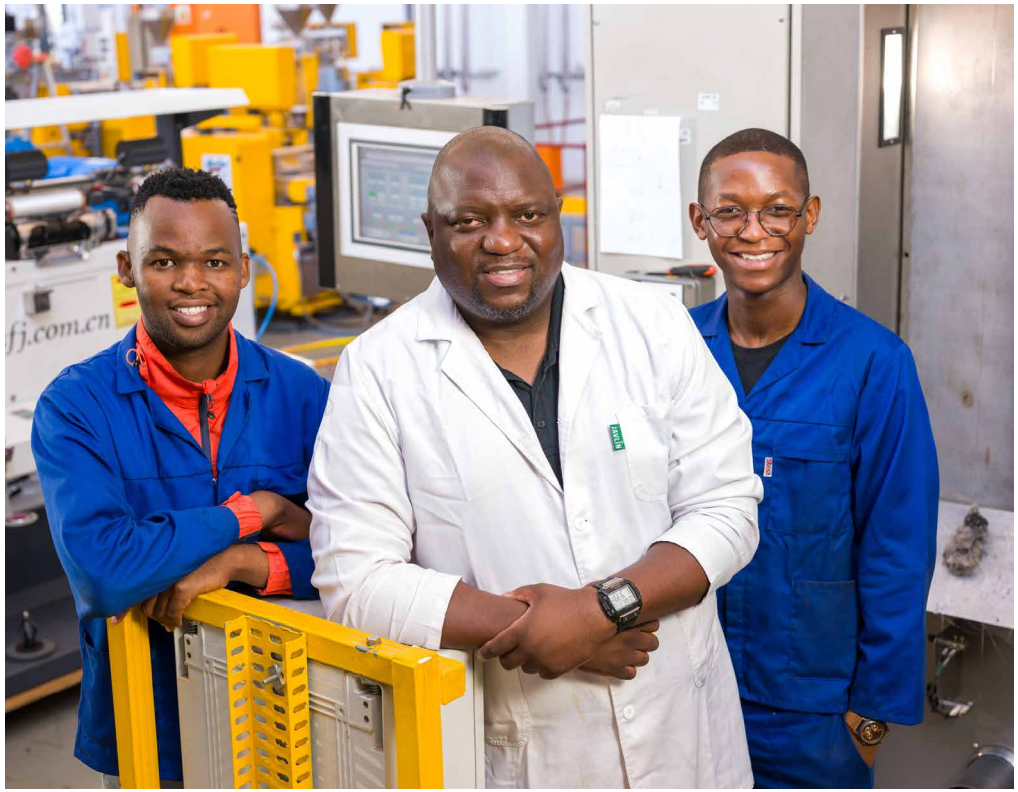
The new long-lasting insecticidal nets utilise the proprietary Bi-Ko™ slow-release technology to deliver small quantities of piperonyl butoxide (PBO) mixed as a novel natural insecticide called nootkatone. PBO is a synergistic chemical that prevents mosquitoes from resisting the effect of pyrethroid insecticides.

Studies by the Centres for Disease Control and Prevention (CDC) found nootkatone to be a very effective natural insecticide against mosquitoes as it seemed to make use of a different mode of action to pyrethroids. Nootkatone is a food-flavouring agent usually found in minute quantities in the skin of grapefruit. It is very toxic to insects such as mosquitoes. The safety of nootkatone to humans and the fact that it is not used in agriculture make nootkatone an excellent insecticide for mosquito nets, alongside the tried and trusted pyrethroid insecticides.

AAC's prototype long-lasting insecticidal net is currently undergoing testing using WHO standards for the purpose of product registration. If successful, the registration will open the

US$500 million per annum long-lasting insecticidal net donor market up to AAC. The participation of AAC in the mosquito net market will make it the first African company to manufacture mosquito nets, contributing to the growth of the South African textile industry.

SLOW-RELEASE PHEROMONE TRAPS FOR SUSTAINABLE AGRICULTURAL PEST CONTROL



The fruit-growing market is a vibrant sector of the economy. It exports a significant portion of its produce to Europe. However, this industry is facing a significant existential threat due to the banning of most synthetic insecticides by the European Union (EU). The industry desperately needs to control fruit flies and other pests that are responsible for the spoilage of produce. The EU demands very high standards in controlling fruit flies at the source. With the banning of synthetic insecticides, only a few tools are available to control the fruit fly menace. However, advances in technology have given this industry some hope.

Pheromones are odours released by female pests to attract male pests. The male follows this plume of odour until it finds a mate. The ability to produce pheromones industrially has given rise to their use to attract and trap male pests. If sufficient males are trapped and killed, females will not be able to produce fertilized eggs, leading to the collapse of the pest population without using synthetic insecticides.

Although this technology is applied in South Africa to control fruit flies, the pheromones are expensive (about R22 000 per kg).

AAC identified this gap in the market and entered into a strategic partnership with a major player in the industry to develop pheromone traps that incorporate the Bi-Ko™ slow-release technology in the manufacture of pheromone slow-release traps. AAC's slow-release technology will reduce the amount of pheromones required for their sustained release from traps in the field. The aim is to reduce the cost of the application by reducing the expensive pheromone needed for a season in the field. This cost saving will go directly to the farmer's bottom line.

The first prototypes of the slow-release articles have been completed.

Field testing is currently under way, after which it can be introduced to the market.

LOW-COST TRANSDERMAL DRUG-DOSING PATCHES

AAC's Bi-Ko™ slow-release technology has also been applied in the development of a slow-release cannabis patch, known as the CBDpatch™. It has been designed to slowly release controlled doses of Cannabidiol (CBD) under the skin.

Transdermal drug dosage is a useful way of introducing small amounts of drug actives into the body at a sustained rate. This increases the efficacy of the drug by directly introducing the active at the target site where action is required to bring rapid relief. Furthermore, bypassing the oral route reduces the loss of actives due to digestive processes, and ensures that all the actives are taken up in the bloodstream. The transdermal dosing of CBD also saves on the costs associated with using CBD for medical purposes.

A proof-of-concept study of the use of the proprietary Bi-Ko™ slow-release fibres indicated that a 20 cm^2 patch can dose approximately the maximum government-sanctioned rate of 20 mg per day. However, there are still questions that need to be answered before it can be released into the market. Most concerning is the lack of quantitative scientific evidence that clearly proves that CBD is of medical benefit. Once the anti-inflammatory action of CBD is proven beyond a doubt, the minimum dosage level would need to be determined to give adequate relief for acute and chronic conditions.

Once these questions have been answered, AAC will be perfectly positioned to claim market leadership for the transdermal CBD slow-release patch.

LONG-LASTING ANTI-BEDBUG MATTRESS COVER

The AAC's latest invention using its Bi-Ko™ slow-release technology is an anti-bedbug mattress cover, which is being marketed as NoBugs Nobites™. The product's effectiveness has already undergone independent evaluation by Clinvet International, a global veterinary contract research organisation.

The evaluation entailed the testing of both treated and untreated textile samples that had been exposed to the common bedbug, *Cimex lectularius*, for 240 minutes. After initial exposure, the insect was removed from the treated and untreated material, and knock-down (alive, but paralysed) was recorded at various time intervals.

Five minutes after exposure, the treated nets that had been washed 10 times produced the highest knock-down. After 60 minutes of initial exposure, the samples that had not been washed after application of the product achieved 100% knock-down. The samples that had been washed 20 times after application of the product achieved 100% knock-down after 120 minutes. After 24 hours of initial exposure, the samples that had not been washed after application of the product recorded 85% of dead bedbugs, while the samples that had been washed 20 times after application recorded 72% of dead bedbugs. All remaining bedbugs were still in a knock-down state and never recovered. None of the untreated samples induced more than 10% mortality. It is important to note that, in a knock-down state, the bedbugs are in a comatose state and cannot actively feed on their victims.

In real-life conditions of application, the knocked-down bedbugs will be continuously exposed to the treated material for only 240 minutes instead of 120 minutes as in the laboratory test, and will die in less than a day.

The results prove that the insecticide-infused mattress covers can be washed at least 20 times before they start to lose their effectiveness. The product is designed to be effective even on insecticide-resistant bedbugs.