Australian Synchrotron

FEATURE Case Study: Nano-active materials

Advanced manufacturing

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Principal investigator: Dr Mark Sceats, Executive Director and Chief Scientific Officer, Calix Limited

Lead organisation: Calix Limited

Company location: Pymble, NSW

Employees: ~30

International research collaborators: N/A

Industry or commercial partners: N/A

Paid or unpaid beamline time? Paid share: 100%

Access model/s: New South Wales Industry Synchrotron Access (NISA) scheme

Science and research priority: Advanced manufacturing

Intellectual property rights pending or granted: Granted

Beamline/s employed: Small and Wide Angle X-Ray Scattering (SAXS/WAXS) beamline

Time using beamline/s (hours): 36 (two sessions)

Multimedia provided: Available

Summary of key outcomes:

- Calix Limited accessed the Australian Synchrotron through the NISA scheme to investigate the properties of its nano-active powdered minerals – prepared through a patented process for a range of health, agricultural, energy and water management uses – to correlate changes in the nanoscale structure to observed improved product performance.
- Analysis using the Small and Wide Angle X-Ray Scattering (SAXS/WAXS) beamline identified the unique structures of Calix's minerals, at a characteristic length scale of about six nanometres, and showed that the structures' total surface area, including pores and internal chambers, changed in a predictable and controllable manner during production.
- The research confirmed Calix' patented techniques provide consistent and reliable production control over the nano-structures and confirm a measurement technique that can be used to correlate the nanostructures in the particles to the observed bioactivity of Calix products, aiding the development of powdered products to limit the spread of pathogens across biologically-sensitive industries in a way that is safe to humans and animals.

Background:

Calix is an Australian, NSW-based, minerals processing company, developing a range of applications of its patented Calix Flash Calciner technology. The applications range from the use of its process and products to capture CO_2 from industrial processes, such as lime and cement, to the use of the novel end-products across health, agriculture, aquaculture, and water treatment.

At Calix's plant in Bacchus Marsh, Victoria, powdered minerals are heated to about 800 degrees celsius to alter their composition and behaviour, losing approximately half their mass as pores

and internal chambers are created, enabling a range of new and enhanced industrial applications.

Traditional production processes use high temperatures which cause reacting particles to sinter, losing their surface area and reducing their surface energy; Calix has devised and patented a unique CFC processing approach that reduces sintering, producing new trademarked micron-sized powders that possess novel nano-structures.

An unlisted Australian public company, founded in 2005, Calix has committed more than $50 million to commercialise its processes, moving into full-scale production through its own facilities and in conjunction with partners. Calix is an integrated company owning mineral resources, processing facilities and joint ventures with downstream product manufacturers, enabling it to manage the full production lifecycle, from the extraction of minerals through to their processing and sale as final products.

Detailed case study:

Calix Limited is an Australian minerals processing company whose patented Calix Flash Calciner technology is guiding the development of powder-based approaches to safely controlling the spread of pathogens across biologically-sensitive industries, in health, food, agriculture and aquaculture.

Calix's operations are based on a fundamental principle of chemistry: the higher a product's particle surface area, the more effective the product is at performing its role.

Dr Mark Sceats, Executive Director and Chief Scientific Officer says Calix's patented Calix Flash Calciner technology allows for the processing of minerals with ten times the surface area of those produced using conventional approaches.

'Our processes create products that are typically ten times more reactive but, crucially, maintain the same bioactivity against pathogens as nanoparticles of the same composition. At about 50 microns in size, we call these 'nano-active' particles because they have all the benefits of nanoparticles, without the cost and handling issues associated with nanopowders.'

'As we refined our processes we saw a correlation between the preparation of our mineral powders and their eventual efficacy, but we needed the unprecedented detail of the Australian Synchrotron to visualise and accurately analyse the relationship between the nanostructures in the particles and product performance.'

Objective analysis performed on ten different samples using the Small and Wide Angle X-ray Scattering (SAXS/WAXS) beamline at the Australian Synchrotron showed predictable changes to the structure of samples' pores, confirming to Calix their patented techniques provide consistent and reliable production control over the surface areas of their powdered products.

Dr Sceats says the high intensity of the SAXS/WAXS beam allowed collection of high quality data in a short amount of time, enabling Calix to verifiably quantify their capacity to fine-tune the structure of materials at the nanoscale in a measured and controlled way, with a number of benefits to the business.

'There is a need for a broad based biocide that is low cost and non-toxic for applications in which traditional systemic toxic biocides quickly become resistant, and/or traditional contact biocides are toxic, and this information will help our work to address this need.

'Secondly, the findings gave us added confidence in the development of new products as the insight will help us minimise technical risk – if we set out to change our production process to

achieve a powdered mineral with a specific “nano-activity”, we know we can plan for, and predict this outcome.

‘It’s all about control – while the total surface area of the powder particles produced every year by our plant is about equal to the surface of Australia, about 7.7 million square kilometres, our goal is to predict, manage and deliver products in which the nano-activity is tightly controlled.’

In 2016, Calix won an Accelerating Commercialisation grant to apply the nano-active materials to agriculture through a series of field trials on various crops. Earlier trials had shown the nano-active products are non-toxic to humans, animals and plants, but inhibit the growth of bacteria, fungi and mites on plant leaves sprayed with the product.

Dr Sceats says it is an exciting time for innovation at the company.

‘Armed with new confidence in the reliability of our patented process, there is every reason to believe our reactor technology can be used to make a wide class of nano-functional products on a commercial scale.

‘The process also captures the CO_2 released from the minerals and the Calix Flash Calciner is now being developed in Europe by Calix in a consortium, LEILAC, with the lime and cement industriest – the one core technology can be used to make new nano-functional products, and reduce global warming caused by large industries.’