

# Innovation Awards 2018

**INNOVATION FOR SUSTAINABILITY**

## **CRYO-GRINDING PUTS TYRE RECYCLING ON ROAD TO SUCCESS**

This year's winner is bringing the circular economy closer to reality for tyre makers



# Sustainability leads to winning ways

The winners of this year's ICIS Innovation Awards can now be revealed. All four enhance the sustainability performance of the industry through product and process improvement. ICIS congratulates Lehigh Technologies as the overall winner for 2018

JOHN BAKER LONDON

**S**ustainability was a strong theme throughout this year's ICIS Innovation Awards. Many entries detailed benefits arising from, for example, the use of renewable feedstocks, greater recyclability and/or reduced carbon footprint.

The four category winners and the overall winner certainly demonstrate how innovation can be a key driver in moving towards a more

sustainable future and a circular economy.

Between them, the winning innovations enable more effective recycling of tyres (Lehigh Technologies), the use of lignin as a chemical feedstock (Stora Enso), zero-carbon recovery of iron from process waste (Electrochem Technologies & Materials), and more environmentally friendly production of surfactants (Galaxy Surfactants).

ICIS congratulates these four worthy winners and especially US-based Lehigh Technologies, which not only won the Innovation with Best Benefit to Environment or Sustainability category, but was judged the overall winner in the ICIS Innovation Awards for 2018. Well done all!

The judges (see page 4) considered Lehigh's Technology's process to make micronised rubber powder (MRP) from end-of-life tyres as an outstanding technical and commercial innovation. It is now being used to help Michelin, Lehigh's parent company since 2017, meet ambitious targets for use of recycled rubber in new tyres and close the materials loop in tyre manufacture.

The judges were also very impressed with Stora Enso's entry, for extraction and treatment of lignin so it can be used as a renewable replacement for fossil-based materials. The Finnish company won the Best Product Innovation category and was a close runner up for the overall award.

The Best Process Innovation category was won by India's Galaxy Surfactants, for a novel catalytic route to amino acid surfactants, and the Best Innovation by an SME award went to Canada's Electrochem Technologies & Materials, for its electrolytic recovery of iron from copperas (ferrous sulphate heptahydrate) and ferrous sulphate solutions.

The locations of the four winners – they come from the US, Canada, Finland and India – illustrate the global nature of innovation in the chemical industry.

In their deliberations, the judges were par-

ticularly looking for commercial development of the innovation and the scale of actual or potential market impact as they assessed the short-listed entries in each category. The degree of innovation and problem-solving involved in the product or process were also criteria used in the assessment of each entry.

In these respects the Lehigh entry scored highly. It is a fully commercial process with a huge potential, given the 1bn tyres (25m tonnes of waste) that are discarded each year. The powder product is in a high-quality, easy-to-use form.

The patented manufacturing process for

**“Michelin recently announced its goals that by 2048 all new tyres will contain 80% renewable raw materials”**

micronised rubber powder (MRP) involves two key technologies: cryogenic freezing of correctly sized rubber granulate followed by high impact micronisation in a unique high-throughput turbo-mill. This, says Lehigh, yields a particle size distribution of micron-scale particles on an industrial scale.

Detlef Kratz of BASF, the overall sponsor of the awards, commented that Lehigh's development “closed the loop on the business case” for recycling. “In many recycling routes, quite often there are gaps but here we have a good combination of recycling and technology that produces an easily used product.”

Paul Bjacek of Accenture added that he considered the Lehigh development a significant advance in the circular economy. “Rubber from used vehicle tyres is tough to recycle, with most going into crumb for recreational surfaces and asphalt-modification applications. The use of cryo-freezing and micronisation enables it to be used again in new tyres, which is a big game-changer.” And, he added, reduces carbon dioxide emissions.

Mike McKenna of Maroon Group described

## THE WINNERS FOR 2018

### ■ OVERALL WINNER

#### Lehigh Technologies

Enabling the circular economy with micronised rubber powder

### ■ BEST PRODUCT INNOVATION

#### SPONSORED BY ACCENTURE

#### Stora Enso

Repurposing lignin as a renewable replacement for fossil-based materials

### ■ BEST PROCESS INNOVATION

#### Galaxy Surfactants

Green process for the manufacture of amino acid surfactants

### ■ INNOVATION WITH BEST BENEFIT TO ENVIRONMENT OR SUSTAINABILITY

#### SPONSORED BY MAROON GROUP

#### Lehigh Technologies

Enabling the circular economy with micronised rubber powder

### ■ BEST INNOVATION BY A SMALL OR MEDIUM-SIZED ENTERPRISE

#### SPONSORED BY EXXONMOBIL

#### CHEMICAL

#### Electrochem Technologies & Materials

Electrowinning iron from copperas: a zero-carbon iron-making process



Lehigh is helping parent company Michelin achieve its goals for use of recyclelate in tyres

the Lehigh development as “a fantastic innovation that will provide significant benefit for generations to come. It has been able to address a long-term challenge with a novel approach that provides a positive impact to our global economy.”

Since 2007, Lehigh has operated five production lines with an output of 60,000 tonnes/year in Tucker, Georgia, US, and has now started up a 10,000 tonne/year plant in Europe, in Navarra, Spain. Over 500m new tyres have been manufactured using Lehigh’s MRP product, which is marketed under the PolyDyne brand name.

This product and other variants are also in commercial use in markets as diverse as asphalt, plastics, construction and polyurethanes.

The potential of the technology certainly caught the attention of major tyre producer

Michelin, which last year acquired the company “to enhance its ‘4R’ strategy to reduce, reuse, recycle and renew materials.” Michelin recently announced its goals that by 2048 all new tyres will contain 80% renewable raw materials (including recyclelate), and that 100% of tyres will be recycled.

To put that in perspective, today the worldwide recovery rate for tyres is 70% and the recycling rate is 50% – the other 20% being accounted for by incineration with energy recovery.

Michelin tyres are currently made using 28% sustainable materials (natural rubber, sunflower oil, limonene, etc) – with 2% in the form of recycled materials such as steel and rubber. The aim is to increase this recyclelate content to 30% by 2048.

The Lehigh entry was considered by the judging panel to be a clear winner in the

Innovation with Best Benefit for Environment or Sustainability category, easing out entries from DSM (a circular economy approach to carpet recycling), U.S. Water (non-phosphorus containing water treatment) and Dow Chemical (a textile treatment to reduce water, energy and dye use in dyeing cotton).

### BEST PRODUCT INNOVATION

Finnish paper maker Stora Enso has developed a process to extract lignin from wood pulp, where it accounts for 20-30% of the overall mass, and turn it into a usable powder form. Conventionally, the lignin is usually discarded or burned for energy during the pulp production process.

The finished form of the Stora Enso innovation – a dry, free-flowing lignin powder – also caught the judges’ eye, as did the fact that it is now in large-scale production, in a 50,000 tonnes/year plant at its Sunila paper mill.

The product is commercially available as *Lineo* by Stora Enso, a biobased replacement for fossil-based phenolic binders in wood products, such as plywood and oriented strand board (OSB), for example.

As Kratz noted, “This is the one that clearly stands out [in this category]... it’s commercial, biobased, high impact... and the development has made it available in a stable form.” Given its sustainability and abundance, he added, “use of lignin in any way would be a major breakthrough.”

The assessment was echoed by David Woods of ExxonMobil Chemical, bringing to bear his own experience in the biomass for chemicals area. Given its nature, he added “lignin is always a destroyer of economics. If

### OVERALL SPONSOR BASF

## WE CREATE CHEMISTRY FOR A SUSTAINABLE FUTURE

CHEMISTRY HAS always been an enabler for innovation as it provides solutions to the needs of our society, combining care for the environment and economic success.

Our growing population of an estimated 10bn people by 2050 will need access to affordable energy, housing, healthcare and quality of food. At the same time, we must strive to consume fewer resources.

“Driving sustainable solutions should be the ultimate goal for companies, start-ups and academia aiming for profitable growth based on innovative chemistry – both ecologically friendly as well as socially accepted,” states Detlef Kratz, senior vice president for technology and operational excellence.

“Looking at this year’s awards



this is clearly a driver of innovation, providing technologies that enable us to consume less with more efficient and better products.”

With this in mind, sustainability-driven innovation has always been a cornerstone of BASF’s strategy, leading to a unique track record of novel products and processes. Just to name a few, the range includes highly energy efficient industrial chemical processes, chemical solutions for water treatment and novel materials for batteries that give long-



er life and keep costs and weight low.

Speed and adaption to change is a further challenge in today’s multifaceted innovation landscape. BASF is committed to developing digital technologies and embraces data-driven research methods which have a rapidly expanding influence on R&D. Our supercomputer Quiriosity is just one example how this is put into practice.

“We would like to share this spirit with those who work on innova-

tions in the chemical industry and are honoured to support the ICIS Innovation Awards this year. Our recognition goes to all the teams and people behind contributions for a sustainable future,” adds Kratz.

“The projects nicely show that brilliant minds come up with outstanding ideas. Congratulations to all teams and especially to the selected winning projects!”

**For information on BASF and its innovations, go to [www.basf.com](http://www.basf.com)**

## THE JUDGES FOR 2018



**PAUL BJACEK**  
is a principal director and leads Accenture's chemicals and natural resources strategic research



**DETLEF KRATZ**  
is senior vice president for corporate technology and operational excellence at BASF



**MIKE MCKENNA**  
is chief operating officer for Maroon Group, a North American specialty chemical and ingredients distributor



**GODEFROY MOTTE**  
is founder and managing director of advisory firm Adrialis



**DAVID WOODS**  
is opportunity identification manager, new product platforms, at ExxonMobil Chemical

[Stora Enso] has truly developed a free-flowing powder, then this really is a game-changer."

And consultant Godefroy Motte added, "This is a big step and has a very large potential. If they can do it, it will solve a sustainability issue in the market [for phenolics and the like]."

Lignin is a complex aromatic macromolecule containing a high number of phenolic, aliphatic and carboxylic hydroxyl groups and as such can be used without further chemical treatment.

The lignin is separated during the kraft pulping process of Nordic softwood (spruce and pine), using the *LignoBoost* system developed originally developed by Innventia and Chalmers University of Technology in Sweden. This is coupled with a ring dryer to extract a high purity kraft lignin from the black liquor stream.

The *Lineo* product line consists of a free-flowing brown powder which Stora Enso says opens up new application opportunities in many industries. "Compared to phenol and formaldehyde it is more stable and safer alternative. It is easy to handle and has stable pricing due to backward integration, making it an ideal biobased, nontoxic alternative."

The powder has a high dry content and superior dispersibility and can be stored for an extended period. Stora Enso is already selling *Lineo* as a replacement for phenol and is look-

ing at many other applications, as well as at increased production with extraction units at its other pulp mills.

The other short-listed entries in this category were AkzoNobel's *Levasil* CC, a nano-scale colloidal silica for use in paint formulations to impart self-cleaning properties to the coating; Teijin's development of an injection-moulded polycarbonate car windscreen, with associated innovation in surface treatment to impart scratch resistance; and Applied Research & Photonic's scanning spectrometer for measuring surfaces at the nanoscale.

While not a chemical innovation as such, the latter was deemed worthy of mention for its technical excellence and potential usefulness as an analytical tool.

### BEST PROCESS INNOVATION

The Best Process Innovation category saw a number of strong entries on the shortlist but after a close discussion the judges elected to give the award to Galaxy Surfactants for its novel, environmentally friendly process to produce N-acyl amino acid surfactants.

These mild anionic surfactants find uses in personal care products such as skin care and hair care, providing cleansing as well as sensory benefits. Traditionally they are produced in a two-step synthesis – preparing a fatty acid chloride by halogenating a fatty acid in the presence of a catalyst, and then condensing this fatty acid chloride with an amino acid under typical Schotten Baumann conditions.

The problem comes when trying to isolate the fatty acid chloride from the catalyst reaction mixture. Also, the dimethyl formamide (DMF) catalyst is a toxic material – it is rated as a CMR in Annex VI of the ECHA CLP regulations.

Galaxy's brainwave was to catalyse the step 1 reaction by using an amino acid surfactant as the catalyst in a semi-heterogeneous process, so that it is not necessary to isolate the catalyst before moving on to step 2.

The advantages are several: the process

uses a completely degradable and non-toxic catalyst; the separation issues (distillation/crystallisation/phase separation) are eliminated – reducing batch time and giving a significant saving on energy and waste disposal; the overall process is "green", with the closed loop process causing no emissions to the environment; and the odour of the product is improved (due to elimination of DMF).

Galaxy estimates the market for the main N-acyl amino acid surfactants is around 113,000 tonnes/year and growing rapidly. Between 2013 and mid-2018, some 15,000 consumer products containing this type of surfactant have been launched on to the global market.

The innovation has recently been recognised by major personal care products Unilever with one of its "Partner to win" awards, citing Galaxy's innovation for its "Green catalysis & sustainability".

Godefroy Motte commented that he really liked the process for its "green" environmental aspects and its commercial potential in the personal care sector, "although the market size for these types of specialty surfactant is not huge." He also liked the confidence of Galaxy and the way it has been able to work with Unilever as a Partner to Win – "clearly a challenging task".

Two other entries in this category attracted positive comments from the judges. Second in the judges' mind was Greenyug's direct bioethanol to ethyl acetate route using reactive distillation. This has several advantages over conventional routes to the high-volume chemical, and is in the process of scale up to 50,000 tonnes/year. But the judges felt it just lacked that degree of impact and innovation to take the category award.

Grillo-Werke's sustainable direct route from methane to methanesulphonic acid (MSA) was described as a worthy process invention overcoming the great challenge of using methane as a feedstock, but one that was as-yet not commercialised and perhaps lacked large-scale market potential.

### CATEGORY SPONSOR EXXONMOBIL CHEMICAL

## BROAD PORTFOLIO OF EXPERTISE

EXXONMOBIL CHEMICAL is one of the largest chemical companies in the world. Our unique portfolio of commodity and specialty businesses generates annual sales of more than 24m tonnes of prime products.

The commitment by ExxonMobil Chemical to maintain a leadership position in technology is fundamental to our continued success. We have a broad portfolio of pro-

**ExxonMobil**

Energy lives here™

prietary process, product and product applications expertise. Now, more than ever, chemicals are the building blocks of modern life.

Chemicals play a key role in fields integral to human progress, including transportation, agriculture,

pharmaceuticals and medical equipment, as well as efficient manufacturing and packaging of a wide array of consumer goods.

As an organisation with technological achievements that have enriched the lives of people everywhere, ExxonMobil Chemical is pleased to sponsor the Best Innovation by a SME category of the 2018 ICIS Innovation Awards. ■

**CATEGORY SPONSOR ACCENTURE**

**HELPING CHEMICAL COMPANIES TRANSFORM**

ACCENTURE IS pleased to sponsor the Best Product Innovation category of the 2018 ICIS Innovation Awards. In today's business environment, companies need to continually reinvent themselves.

At Accenture, we take an innovation-led approach to help clients "imagine and invent" their future. We are always looking ahead to anticipate what's next.

From research, ventures and labs to studios, innovation centres and delivery centres, we help companies imagine the future and bring it to life.

Accenture's chemical industry group helps chemical companies apply innovation,



transformational strategies and digital enablement for growth, differentiation and superior operations.

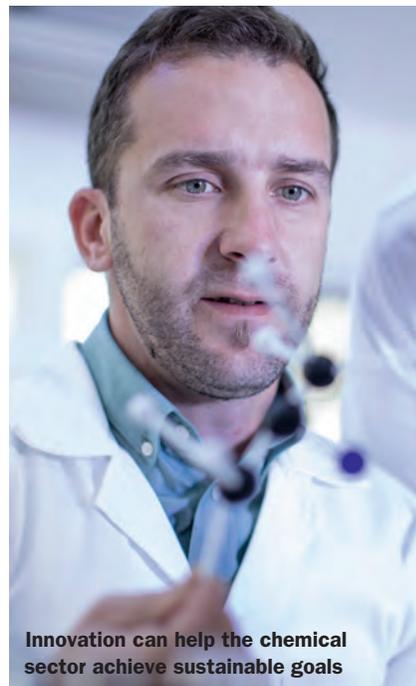
We have over 30 years of experience working in all segments of the chemical industry — including basic and intermediate chemicals, polymers, fibres and elastomers, agricultural chemicals, paints and coatings, industrial gases, and other specialty chemicals — across the value chain.

**About Accenture**

Accenture is a leading global

professional services company, providing a broad range of services and solutions in strategy, consulting, digital, technology and operations. Combining unmatched experience and specialised skills across more than 40 industries and all business functions – underpinned by the world's largest delivery network – Accenture works at the intersection of business and technology to help clients improve their performance and create sustainable value for their stakeholders. With 449,000 people serving clients in more than 120 countries, Accenture drives innovation to improve the way the world works and lives. ■

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**Innovation can help the chemical sector achieve sustainable goals**

Image Source: REY/Shutterstock

**BEST INNOVATION BY AN SME**

Only two entries made it on to the short-list for this category – with the winner judged to be Electrochem Technologies & Materials for its electrochemical process for recovery of iron from certain process wastes. In this case, the judges based their decision on the potential for the technology, given that it is still in the demonstration phase.

The runner up was Enerkem, for its development of a high octane biofuel using its municipal waste to bio-DME via biomethanol process and subsequent catalytic conversion to a paraffin-rich gasoline.

The market potential for the Electrochem development is indeed large. The technology enables recovery of iron from copperas, a by-product of titanium dioxide pigment produc-

tion, and copperas equivalent – mainly spent pickling liquors from the metallurgical and pickling industries. These wastes account for 8.8m tonnes/year annual in the case of TiO2 pigment production and 16m tonnes/year from the pickling sector.

The company – established in Canada in 2010 – claims the electrowinning of copperas produces iron with lower energy requirement per tonne of iron than conventional steel-making by smelting, and also requires lower capital and operational expenditures.

Additionally, by avoiding the use of a carbon reducing agent and by using green electricity (hydro- or nuclear), it operates with a zero CO2 footprint. The process also produces sulphuric acid (30%) and oxygen gas as by-products of the electrolysis.

The electrolytic iron produced can be in several forms – notably flakes, nodules, powder or plates, suitable for use directly or in sintering/melting processes for high quality steels.

Interest in the process is increasing, given the pressure on producers to manage and reduce waste streams around the world, especially with the move away from landfilling of wastes and increasing pressure to recycle.

Full details of all the winning entries can be found in the following pages, which also include interviews with the Awards sponsors – BASF, Maroon Group, Accenture and ExxonMobil Chemical – in which they discuss aspects of innovation and its importance in the profitability and sustainability of the chemical industry. ICIS thanks all the sponsors and judges for their support this year. ■

**CATEGORY SPONSOR MAROON GROUP**

**TAKING A PRIDE IN SUSTAINABILITY**

MAROON GROUP is a leading distributor of specialty chemicals and ingredients across North America that continually strives to improve its corporate social responsibility, including all aspects related to the environment, social, ethics and global supply chain. We take pride in associating with companies that value sustainability and environmental responsibility and that share these values by supplying safe



and consistent products.

Through our dedication as a responsible organisation, we are proud to sponsor the Innovation with Best Benefit to the Environment or Sustainability category of the ICIS Innovation Awards.

Maroon Group is an active member of the National Association of

Chemical Distributors (NACD) and holds a Responsible Distribution certification. This third-party verification of environmental, health, safety and security programmes demonstrates our commitment to continuous performance improvement and responsible distribution in every phase of chemical storage, handling, transportation and disposal.

Furthermore, our ISO 9001 certification reaffirms this commitment via our policies and procedures.

**About Maroon Group LLC**

Maroon Group is one of the fastest growing specialty chemical and ingredient distributors in North America. Our operating verticals focus on end markets which include CARE, CASE, HI&I, Plastics and Specialty Intermediates. We leverage a common infrastructure of industry leading technology, value-add services, global sourcing & logistics network, and a commitment to Creating Customer Success®. ■



# Closing the loop in tyre manufacturing

Greatly increased recycling of end-of-life tyres is a major goal in the automotive industry. Lehigh Technologies believes it has an answer with its cryogenic approach

JANE GIBSON LONDON

**A**round the world, some 1bn tyres reach the end of their useful lives each year, with around half burned for their fuel value. For the industry, transforming these tyres into a sustainable, high-performance material has long been an objective.

Lehigh Technologies has found a way to give new life to old tyres by producing micronised rubber powder (MRP) from them – a material that can be fed back into tyre production as well as a host of other end uses.

“The main driver behind the development was the belief that there had to be something better to do with the tyres than to simply burn them,” says Lehigh CEO Alan Barton. “The MRPs we produce are what they say on the tin – end-of-life tyre materials.”

The Georgia, US-based company has developed two types of MRP – *PolyDyne*, which has been designed specifically for the tyre and rubber industries, and *MicroDyne*, a rubber additive which is used in plastics, asphalt, construction, coatings, polyurethanes and other applications.

The idea was born in 2003 and the technology and finances to develop the product were secured in 2007. Since 2007, over 500m new tyres have been manufactured using Lehigh’s MRP product – half way to the company’s

goal of producing 1bn “green tyres”.

*PolyDyne* is available in a variety of sizes from 40 to 200 mesh, depending on the requirements of the application. End uses include OEM and replacement passenger car and truck tyres, retreads, and off-road construction and agriculture tyres.

Beyond tyres, it is used in anti-vibration mounts, seals, hoses and gaskets as well as natural rubber, EPDM rubber, nitrile rubber and other rubber polymer products.

*Microdyne* is also made in a range of particle sizes—from 830 microns (20 mesh) to 50 microns (300 mesh). It offers water resistance, energy savings, durability, flexibility, sound dampening, heat absorption and vibration dampening, and is found in end uses such as waterproofing systems, construction products, plastics and membranes.

In the US, the biggest market for *Microdyne* is modifying asphalt for road maintenance. This market is not yet so large in Europe, but

**ALAN BARTON**  
CEO, Lehigh Technologies

**“We fully expect that other people will start to come into the market – but that’s a good thing”**



the potential could get there, Barton says.

Particle size control is the key to delivering a high performance product to the markets the company serves. “People have had the concept of making small-sized particles before and the tyre industry can make larger particles with old fashioned technology – but they can’t make it in bulk.”

### THREE REASONS FOR SUCCESS

Barton says that the company had to develop a grinding system to produce the MRP that could deliver several significant features. “There are three reasons that we have been successful – our technology is capable of making very small particle sizes; we can make it in large quantities at an economical cost; and our products are of a consistent quality.” Barton says that the MRP can offer up to 50% lower cost per unit than oil-based materials.

Another leg to the technology is the R&D and technical support capability that Lehigh offers. This has led the company to understand what the powders do in different systems and then recognise how to manipulate them for other end uses, says Barton.

“The recycled tyre industry itself began from a waste management mindset, but we have a chemical management mindset and our team illustrates that – we are all refugees from the chemical industry.”

The patent-protected manufacturing process for MRP combines two key technologies: cryogenic freezing of the correctly sized rubber granulate followed by high impact micronisation in a unique, high-throughput, turbo-mill.

This combination yields a particle size distribution of micron scale particles on an industrial scale. “You take the granules of rubber and freeze them with liquid nitrogen to turn them into marble/glass granules,” says Barton. “This is then placed into a turbo mill where the marble shatters instantly into the powder. Then we separate the nitrogen from the rubber powder and split it into the different particles depending on the end use.”

The company has a chain of suppliers who collect and shred the used tyres to deliver the feedstock.

Lehigh’s Tucker, Georgia, plant, in operation since 2007, has a capacity of 60,000 tonnes/year using five production lines. The company has been regularly exporting to Europe, Asia and Latin America out of the facility.

#### **EUROPEAN CAPACITY ADDED**

As a result of good demand from Europe, Lehigh has built and recently started up a plant in Spain and is currently in the process of having material approved by customers. The Murillo el Fruto plant in Navarra has one production line and can produce 10,000 tonnes/year of MRP, but as demand increases, the site can be expanded to accommodate additional production lines, says Barton.

The plant is co-located on the Hera Holdings site and Hera will provide the feedstock for the MRP.

“For the European market the value proposition is that the MRP can be produced at a lower cost than the material it replaces, it offers equal or better performance and it is ‘green for free’. We were happy with the uptake of our product in Europe and that is why we decided to build a plant in Spain.

“We export to Latin American and Asia markets from the US at present – so we are working hard to build up our business in these areas so that we can justify building a plant there – I expect that within five years there will be some action from us in one of these regions.

“There is not really that much competition out there at the moment – we don’t see anybody doing it in the same way as us. We fully expect that other people will start to come into the market – but that’s a good thing.”

Barton admits that when developing the technology, the company faced several challenges. “Internally we had to master the manufacturing process and we also had to understand the chemistry and physics of MRP. Externally there have been challenges per-

suading companies to try something new in what is a conservative industry – we were faced with a ‘why should we try it?’ attitude. Another external challenge was to make sure we had something coming through the pipeline during the development process – which generally takes 1-3 years for new products.”

The green tyre story so far has tended to focus on creating better rolling resistance, with 5-15% of fuel consumed to overcome this. Low rolling resistance decreases the energy used per tyre roll, improving fuel efficiency. However now the tyre industry is increasingly turning its focus towards the role of sustainable raw materials in tyre production.

In 2017, the tyre manufacturer Michelin acquired Lehigh Technologies to enhance its “4R strategy” – to reduce, reuse, recycle and renew materials. Both companies recently celebrated the 10-year anniversary of the closed-loop process in the retread tyre market and Michelin’s North American retread facilities are now zero waste operations as a result of this closed loop model.

“The company is under the Michelin umbrella and we fit well with their innovation and sustainability profile. We think it’s a great home – we like the culture and it’s global,” says Barton.

Michelin recently announced its 2048 goal of new tyres containing 80% of renew-

able raw materials. Lehigh’s technology is an important component of this strategic objective enabling the use of MRP in high performance tyres without any compromise on performance.

Michelin tyres are currently produced using 28% sustainable materials. This includes 26% bio-sourced materials like natural rubber, sunflower oil, limonene etc, and 2% recycled materials such as steel or recycled powdered tyres – for example MRP-based tyres.

#### **RECYCLING TARGETS**

Michelin has also said it wants to recycle 100% of its tyres by 2018 – the world-wide recovery rate for tyres is currently 70% and the recycling rate is 50%. Barton says that most end of life tyres are recycled in some form or another – those that aren’t burnt for energy are transformed into playground materials or used for sport fields for example. MRP forms a small part of the total now, but its use is growing quickly.

Barton says that they are finding new applications for MRP in a broad range of places and the company is currently in the lab carrying out research as to where else it could be used. Lehigh has created an Application & Development Centre (ADC) at its headquarters to collaborate with customers to develop new MRP formulations.

“There is potential to develop the technology further and the company is currently looking at de-vulcanising – unzipping the polymers present in the rubber. It is also analysing how the rubber powder could be compounded with other materials so that it could find and add value to other end uses.

“We are still working hard to ensure that the product is taken up, which is not always easy in a risk-averse industry. And unless companies like ours can actually make money out of a green technology, then it won’t be developed.” ■

#### **KEY FACTS**

##### **MRP ENVIRONMENTAL BENEFITS**

Every pound of Lehigh’s MRP helps save:

- 10 kWh of energy in comparison with traditional alternatives
- 40% of the CO2 produced with traditional alternatives
- Tyres and post-industrial rubber from landfills



**The cryo-grinding stage is key to the Lehigh recycling technology**

# BASF pushes digitalisation in R&D worldwide

The chemical industry's largest supercomputer creates new opportunities for researchers and developers to carry out complex modelling

**B**ASF's strategic goal is to decisively take advantage of the enormous opportunities that digitalisation offers along the entire value chain. In doing so, research and development (R&D) plays a key role when it comes to further increasing innovative strength and competitiveness by using new technologies.

"With the increased use of digital technologies in research and development, we are strengthening BASF's position as the world's most innovative company in the chemical industry," says Dr. Martin Bruder Müller, chairman of the board of executive directors

and chief technology officer of BASF.

A key element is the supercomputer called Curiosity, so-named following an online contest among employees, which was put into operation in October 2017. With 1.75 petaflops, it offers around 10 times the computing power previously available to the global BASF R&D community.

In the ranking of the 500 largest computing systems in the world, BASF's supercomputer Curiosity debuted in June 2017 at position 65 and is currently number 94 in this ranking.

In particular, says Bruder Müller, the supercomputer will enable BASF experts to very

efficiently investigate complex questions and further shorten the time it takes to launch new products, according to. "We will thus be even better able to meet our customers' demands for tailor-made innovations based on chemistry."

## VIRTUAL AND REAL-LIFE EXPERIMENTS COMPLEMENT EACH OTHER

Digital technologies have a rapidly expanding influence on R&D. Managing large quantities of data has become a decisive factor for future scientific and economic success. With BASF's digital approach, virtual modelling and computer simulation go hand in hand with physi-

### RESEARCH AND DEVELOPMENT CURRENT PROJECTS

## INNOVATIONS FOR THE FUTURE IN FARMING, NUTRITION AND CATALYSIS

### AGRONOMIC MODELS SUPPORT FARMERS

BASF is playing an important role in the digital transformation of agriculture, where it relies on internal and external cooperation. The online application *Maglis*® helps farmers use available information more efficiently and make better decisions regarding the cultivation of their fields.

The firm ZedX, which BASF acquired at the end of May, specialises in developing agronomic models for weather, plant growth and infestation with diseases, weeds and pests.

BASF and ZedX have already jointly developed a model that, based on weather and environmental conditions, identifies the right window of application for a BASF herbicide.

### WHITE BIOTECHNOLOGY: THERMOSTABLE ENZYME FOR ANIMAL NUTRITION

BASF researchers from the research platform Bioscience Research have developed improved phytase (*Natuphos*® E) for animal nutrition. Phytase is an enzyme that helps animals to better digest the phosphate contained in plants.

But many enzymes are heat-sensitive and can be destroyed by the high temperatures in the pelleting process used to make animal feed, thus rendering the enzymes ineffective. To develop an effective, thermostable phytase, BASF researchers examined numerous different phytases that exist in bacteria and then developed the best possible hybrid from these using biotechnological methods.

This was then further improved

and an appropriate production strain based on the fungus *Aspergillus niger* was developed for the fermentation (biotechnological production) of the enzyme.

### CATALYSTS: ADDED VALUE FOR EXHAUST GAS CLEANING AND REFINERIES

The research platform Process Research & Chemical Engineering works on specialty zeolites, such as BASF's copper chabazite, which play a vital role in emission-control catalysts for diesel engines because they are especially efficient at removing nitrogen oxides from exhaust gas.

Demand for modern catalyst systems for cars is growing steadily thanks to increasingly stringent emission regulations. To meet this demand, BASF researchers are con-

tinually working on developing the next generation of specialty zeolites. Using sophisticated raw materials and processes, they can adjust the size of the pores in order to make particles that are more consistent.

BASF has also developed a boron-based catalyst technology (*BoroCat*™) that enables refineries to increase yields of valuable products like gasoline, diesel and other fuels from crude oil. The nickel contained in crude oil presents a particular challenge to further processing, as it significantly increases the generation of undesirable by-products like petroleum coke and hydrogen.

Containing an optimised pore structure, the new *BoroCat* Fluid Catalytic Cracking (FCC) catalyst intercepts nickel in processing, thus preventing undesirable chemical reactions. ■



**BASF's supercomputer Quiriosity is now in operation. With a computing power of 1.75 petaflops (1.75 quadrillion floating point operations/second), it offers around 10x the overall computing power previously available to BASF researchers. This could result in substantially reduced development times and recognition and exploitation of previously unknown relationships**

duction of the intermediate product ethylene oxide. The investigation found correlations between the formulations and the application properties of the catalysts, which enabled their performance and lifetime to be predicted more accurately and faster.

cal experiments in the laboratory – they complement each other.

Simulations help with the design of experiments and facilitate forecasting, while experiments deliver measurable results and evaluate the computer models. This results in a better understanding of chemical products and processes, and thus enables greater innovation to

**DR. MARTIN BRUDERMÜLLER**

Chairman of the board of executive directors and CTO, BASF

**“We will... be even better able to meet our customers' demands for tailor-made innovations”**



be achieved in a shorter period of time.

Digitalisation gives researchers additional opportunities to implement their creative ideas and to collaborate intensively with others around the world. A key element is to integrate digital technologies directly into the daily work of the R&D units. Direct access to knowledge-based systems is necessary to enable effective problem-solving and it opens up new horizons. A cloud-based app platform, for example, makes it considerably easier for all researchers and developers to expand knowledge networks.

Successful projects have already demonstrated the enormous potential that digitalisation offers in R&D. For example, researchers were able to conduct a systematic investigation of the data on catalysts used in the pro-

**TARGETED SEARCHING THROUGH LARGE VOLUMES OF DATA**

Digital technologies also played a vital role in the modelling of a new functional polymer for the stable formulation of an active ingredient. From more than 10,000 possibilities, BASF experts were able to work out the appropriate polymer structure. The subsequent synthesis resulted in the desired formulation polymer, which enabled the creation of a significantly more concentrated emulsion.

With “data mining”, it is possible to extract useful knowledge from very large quantities of existing data. When it comes to product or process development in the field of biotechnology, for instance, this can include the accelerated identification of promising enzymes or the discovery of suitable bacteria. ■

**INTERVIEW DR. MARTIN STROHRMANN**

**CHALLENGE OF INTEGRATING DIGITAL TECHNOLOGY**

BASF HAS established a department for “Digitalization in R&D”, to support the integration of digital technologies into BASF's everyday R&D operations. We asked department head, Dr. Martin Strohrmann, how they are going about this challenge.

**Why is digitalisation important for R&D?**

Digitalisation in R&D is a major opportunity for BASF. It aims at accelerating R&D, boosting innovative power, achieving competitive differentiation and creating new top line value.

Digitalisation in R&D includes building up IT infrastructure for data and knowledge management as well as the systematic application of digital tools, cognitive sciences and high-performance computing.

By steering our R&D effort by scientific multiscale modelling and implementing cognitive systems to derive knowledge from internal and external sources we will boost effectiveness.

Reducing the number of experiments and allowing faster and better decision making following systematic use of experimental design and statistical modelling along with widespread sharing of insights will help us to further increase the efficiency of research.

And new innovation opportuni-

ties will be opened up by new pattern recognition technologies and new insights along and across value chains.

**How does digitalisation change the working process?**

Not all the details of our mission, our methods and our challenges can be defined even now. In order to manoeuvre in this world of uncertainty, ambiguity and change we adapt in part agile ways of working developed in the software industry.

Empowerment of self-organised teams is key to success here. This allows us to move fast, continuously cross-check with our partners, learn from mistakes, flexibly adjust our solution and quickly get to a tangible prototype.

In R&D in general, digitalisation allows us to explore the solution space in a much more comprehensive way and reach targets faster and with higher probability of success. But this also brings a lot of change in the R&D process at a speed by far superior to the usual change in qualification.

Professional training on all levels and a systematic change management are needed to address this challenge. As you can see, we embrace both, the technical and the people side of the digital transformation. ■

**DR. MARTIN STROHRMANN**

Senior vice president digitalization in R&D, BASF

**“Digitalisation allows us to explore the solution space in a more comprehensive way and reach targets faster”**



# A change of R&D focus

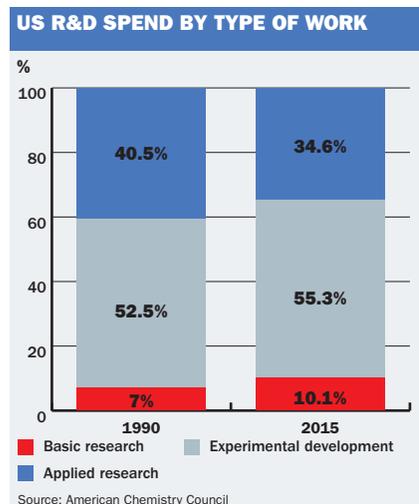
Innovation remains a key priority for chemical producers but attention is now being turned to new areas of development

ANDY BRICE LONDON

Recent research suggests R&D trends in the chemical industry are changing. Indeed, according to Paul Bjacek, principal director and global resources research lead at global consultancy Accenture, there is a noticeable push towards multi-discipline inventions, and a greater willingness to expand and offer new systems and services to customers.

Statistics from the American Chemistry Council show that R&D spend in the US on both basic research and so-called “experimental developments” – the targeting of new materials, products and processes, or the significant improvement of existing products – climbed by around three percentage points from 1990 to 2015. Conversely, there was almost a six percentage point decline in applied research.

Bjacek notes that a soon-to-be published Accenture survey shows that of the 120 firms questioned (36 specialty and 84 commodity companies), some 97% of the performance leaders – those with the highest revenues and profit growth – indicated they would increase investment in innovation areas outside their core business over the next three years.



PAUL BJACEK

Principal director and global resources research lead, Accenture

**“We’re seeing that more companies are using technologies to reach customers further downstream”**



The report also found that more than half (56%) of these performance leaders prioritise investment in products that use new technologies so they can meet their customers’ changing requirements. “We’re seeing that more companies are using technologies to reach customers further downstream,” notes Bjacek.

## COMPETITIVE ENGAGEMENT

Interestingly, those questioned also say they view mineral companies as rising new competitors in the next five years. Bjacek suggests they were ranked highly largely because of recent advances in 3D printing, which is gaining popularity and prevalence. There is a certain degree of crossover with this new technology, he says, noting the print heads used in industrial printing employ materials such as metals, plastics, cement and graphene.

“These are areas where I think we’re going to see a convergence – companies selling a variety of materials for use in the same products or by the same processes. We call this technology fusion – using a broader range of technologies rather than just chemistry,” he says. “It won’t happen overnight but we may start seeing some competition with mineral companies.”

A separate analysis of patents has also shown that chemical companies referenced more non-chemical areas over the past decade, adds Bjacek. In fact, an analysis of the patents of 82 global chemical companies in the 10 years to 2016 showed a share increase of seven percentage points in non-chemical disciplines.

Some companies are beginning to use technologies to sell services, instead of products such as chemicals. For instance, applying the

use of consumer interface apps to help visualise the results of paints or cosmetics. Or the use of electronic sensors in food packaging to monitor temperature, moisture and other environmental histories of the package.

“These are perfect examples of how digital and chemical technologies are now working together,” says Bjacek. “We’ve particularly noticed that chemical companies are seeking more patents in the electricity and transportation sectors, for applications such as battery technology and solar cells.” Accenture observed that from 2007 to 2016, the share of patents for electricity and transportation grew far more than for other segments, climbing to 23% (up 5%) and 28% (up 4%), respectively.

## LOCALISATION A PRIORITY

In the mentioned survey, when asked to rank various categories on a scale of 1-5, performance leaders rated “localisation” as their main focus with a 4.6 score. This is where companies develop their products to suit the needs of a specific local market, he says.

“Large industrial customers may move to a geographic area because of new technologies enabling them to customise their products to the local market,” says Bjacek. “As technologies in robotics, automation, 3D printing, lasers and sensors continue to evolve and be assimilated into manufacturing processes, so customisation/localisation trends will increasingly be seen in downstream manufacturing.

Bjacek adds, “a good example is the adidas Speedfactory. There is one in Ansbach, Germany, and one in Atlanta, US. They are producing athletic shoes with the aim to provide custom footwear with a short turnaround.”

The survey also highlighted that respondents see the circular economy as increasingly relevant to their plans. Establishing alternative, more efficient production methods to serve customers ranked among the top two most favoured innovation areas for the next three years by commodity chemical executives – with 86% of those questioned selecting it.

“The circular economy is no longer a backroom issue,” he says. “It’s now a top priority for chemical companies, thanks to increased consumer awareness and the recent voluntary and regulatory recycling measures that have happened in the past year.”

Bjacek notes that circularity was a common theme among the submissions for this year’s ICIS Innovation Awards. “There really were some quality entries this year and it was amazing how much is being done to try to significantly reduce the environmental footprint.

“This is definitely something leading companies are working towards: producing valuable new products and processes that at the same time reduce energy consumption, use environmentally sustainable products and lean towards applications that are more circular.” ■

# Dry powder expands lignin range

By extracting lignin from wood pulp and converting it into a dry, free-flowing powder Stora Enso is offering an alternative to the use of phenolics

Stora Enso

JANE GIBSON LONDON

In a drive to move beyond pulp and paper and become a renewable materials company, Finland's Stora Enso has invested in new technologies which allow the extraction of hemicellulose, sugars and lignin from non-food competing biomass more efficiently.

This has allowed new, value-added products to be created from these different sources, such as *Lineo* by Stora Enso, which is a versatile and non-toxic renewable replacement for oil-based phenolic materials.

*Lineo* is made of lignin, which is found in wood and is the most abundant natural aromatic macromolecule in the world. It is one of the main building blocks of a tree, making up 20-30% of wood's composition – yet it is usually discarded or burned for energy during the pulp production process.

"*Lineo* is able to replace many oil-based phenolic materials, which are used as adhesives in plywood, oriented strand board (OSB), laminated veneer lumber (LVL), paper lamination and insulation material," says David Almqvist, business development director, biomaterials at Stora Enso. The company is continuing to research how to use *Lineo* for many other applications in the future, including carbon fibre and energy storage applications.

"We began commercialising dried kraft lignin in 2015, after investing €32m in new lignin separation technology at our Sunila Mill in Finland," Almqvist says. "Sunila's lignin capacity of 50,000 tonnes/year makes it the largest lignin extraction unit in the world."

Almqvist explains that in a pulp mill, process chemicals are used to separate cellulose

fibres from other wood components such as hemicellulose and lignin. After the separation, you get a black liquor which contains the components separated from cellulose. In the recovery line, the process chemicals can be recycled and lignin can be extracted.

At Sunila, part of the lignin is extracted from the black liquor using *LignoBoost* technology, which enables the production of a consistent, high-quality lignin. After lignin has been extracted, it is then put in a dryer, which means it is possible for the company to offer *Lineo* with up to 97% dry content. The product is a free-flowing brown powder.

## HIGH POTENTIAL, STABLE PRICING

"Lignin extraction is not new," remarks Almqvist, "however, our installation is the only one in the world that can industrially produce lignin with such a high dry content, suitable for many different end applications where its unique, rigid chemical structure will provide the highest potential value."

In terms of cost, Almqvist points out that because Stora Enso's lignin production is backward integrated, the company can offer very

**DAVID ALMQVIST**  
Business development director,  
biomaterials, Stora Enso

**"Our customers have been able to replace up to 50% of the phenol content in industrial phenolic materials with lignin"**



stable pricing compared to phenol, which is tied to oil prices, which are often volatile.

"Lignin is not the same material as phenol. However, together with support from us, our customers have been able to replace up to 50% of the phenol content in industrial phenolic materials with lignin."

Installing a completely new technology, and one which is closely connected to the rest of the process in an existing pulp mill, naturally comes with some challenges. "It was important to define how to install the technology without disturbing the mill's pulp operations, the chemical recovery and the energy balance of the mill."

Another top priority was quality, says Almqvist. Using *LignoBoost* technology and Stora Enso's technical know-how, the company is able to produce *Lineo* to a narrow technical specification, which can be tailor-made for specific end applications.

"When introducing a totally new material to the market you need to allow time for all stakeholders in the value chain to fully understand its potential. However, we know brand owners are becoming increasingly aware of the possibilities *Lineo* offers as a sustainable and efficient product with a predictable cost structure," says Almqvist.

## GREEN CREDENTIALS

*Lineo* offers a host of green credentials. As a biobased product made from wood, which comes from sustainably managed forests, it has a range of environmental and safety advantages.

"Compared to phenol and formaldehyde, lignin is a more sustainable, stable and safer alternative," argues Almqvist. "Phenol has many issues – it is hazardous and difficult to handle and store. Phenol's smell and toxicity also cause issues in manufacturing facilities."

Almqvist says that for the company, innovation means translating ideas into new value for customers. At the same time, innovation is supporting the transformation of Stora Enso into a renewable materials company – and lignin is one of the areas aiding this transformation.

Research into lignin and other biobased chemicals is run from the Innovation Centre for Biomaterials based in Stockholm, Sweden. The centre identifies business opportunities in renewable materials markets and links them with leading innovation and research centres in business and academia.

"As a company, our goal is to help society decarbonise by replacing fossil-based materials with renewable solutions and we cannot do that without sustainable, profitable growth," Almqvist argues. "This strategy seems to be working as we recently reported six consecutive quarters of sales growth. Guided by our motto 'everything made from fossil-based materials today can be made from a tree tomorrow', we are confident that sustainable solutions will provide inspiration to keep innovating." ■

# Innovation brings competitive edge

Maroon Group's successful strategy proves it pays to build an integrated organisation that is sustainable, scalable and innovative

ANDY BRICE LONDON

Despite continued consolidation within the chemical industry and an increasingly competitive marketplace, Maroon Group has cemented its status as one of the most successful and fastest growing specialty chemical and ingredient distributors in North America.

The supplier of specialty chemicals and ingredients, based in Avon, Ohio, has completed no less than eight acquisitions over the past four years, more than quadrupling its revenues and securing its position as the third largest specialty chemical distributor in the region.

This flurry of activity has afforded the business the opportunity to expand beyond its traditional coatings, adhesives, sealants, and elastomers (CASE) and plastics markets.

It has built upon its existing position, increased its value-add offering and diversified – gaining a significant presence in the personal care, pharmaceuticals, food, household, industrial & institutional (HI&I), and specialty intermediates segments.

“For our business to be successful and sustainable long term, it was critical we proactively looked at growing and diversifying,” says Mike McKenna, chief operating officer.

“Our broad portfolio of products, synergies and infrastructure now gives us a competitive advantage. And now more than ever, we recognise that our customers are counting on us as a supplier to offer innovative solutions.

“Becoming more innovative is not only central to Maroon Group's strategy but it's becoming even more relevant. If you don't do it, you risk being left behind or standing still; you risk your product portfolio becoming commoditised. You have to bring value to your customers, otherwise they will go and buy those products from someone else. Innovation is a differentiator.”

It is for that very reason, says McKenna, that Maroon Group remains a staunch supporter of the ICIS Innovation Awards. This marks the 10th consecutive year it is sponsoring the Innovation with Best Benefit to Environment or Sustainability category.

“We've been a long-term supporter of ICIS and the Innovation Awards via our legacy U.S. Chemicals business. Innovation is driving the growth of our industry so being able to participate in this process is really important.

“It's been amazing to be involved in the judging and see the various types of submissions and technologies that these companies are working on – to see these theoretical ideas being taken to full commercialisation.

“There are so many opportunities with energy savings and new applications – and it's important to support the creation of innovative solutions rather than the conversation that chemicals are bad or harmful to the environment.”

McKenna points to Maroon Group's collaboration with Denmark's Novozymes as an example of how the business itself has benefited by breaking into new growth markets through innovation.

“For the HI&I and beverage markets, we're proud to partner with Novozymes – an incredibly innovative company. We're taking their enzymes and finding new applications for them in North America,” he says. “We've been able to successfully drive the growth of those products – where enzymes can be used in commercial or household laundry applications, detergents and cleaning products, as well as in beverages and distilling. It's now one of the fastest growing parts of our business.

“We strategically looked to partner with them a couple of years ago and have been making significant investments in that business. We've got highly-trained technical experts on our team who are in the labs at the forefront of these formulations and processes. We do all

**MIKE MCKENNA**  
 Chief operating office, Maroon Group

**“It's important to support the creation of innovative solutions rather than the conversation that chemicals are bad or harmful”**



**Maroon is partnered with Novozymes to bring its enzyme technology to US markets**

the application testing and then take them to launch. A lot of this is uncharted waters – but this is what really differentiates us. It's an area that's been extremely successful for us and shows our broad capabilities.”

While Maroon Group's business model has certainly evolved over the years, shifting from being a factory-packed regional distributor to becoming much more diverse with value-add service offerings, its success is testament to a continued focus on the customer and enhancing products and processes through innovation.

The structure of the business, with its various end market verticals, is the perfect environment to encourage R&D, he says. “We're now more heavily involved with custom blending, repackaging, etc, and have very extensive laboratory and formulation capabilities with technical experts who are always working on new products and applications.

It's not outsourced, but a full-blown R&D lab within our portfolio. We recognise the value of bringing innovation to our customers and suppliers, and that's why we're investing to diversify and accelerate growth.” ■

# Smart chemistry pays dividends

A novel approach to catalysis in the production of amino acid surfactants has enabled Galaxy Surfactants to produce a greener, more economic product

**JANE GIBSON** LONDON

**D**r Nirmal Koshti, director, innovation process, at Indian company Galaxy Surfactants, believes that if a product is not good for the environment, then it loses its charm. It is important that both the product and the process of making it are eco-friendly, he says.

This attitude was the main driver behind the company's search for a non-toxic catalyst in the production of amino acid surfactants (AASs) – which led to the discovery of a “smart” catalyst.

Koshti says the challenge was to find a catalyst for the chlorination of fatty acids that would be efficient, non-toxic and eco-friendly, and cost-effective. A second challenge was to develop an efficient catalyst that could be recycled several times before it was discarded.

“We started with the goal of designing a non-toxic catalyst that can be isolated and recycled. Two years of journey finally led us to invent the current smart catalysis.

## GREEN CHEMISTRY IN ACTION

“This smart chemistry meets all the norms of Green Chemistry. So Galaxy's green process brings down the cost of manufacture significantly, thereby making this class of surfactants available not only to the personal care industry, but other industries as well.”

Surfactants are bulk chemicals which find applications in a variety of fields, including personal care, home care, pharmaceuticals,

## NIRMAL KOSHTI

Director, innovation process,  
Galaxy Surfactants

**“It is not just about the bottom line... but about offering a good contribution to the science of biodegradable catalysis”**



paper, textile, paints, agrochemicals, foods and oil fields, to name a few. AASs are known for their mildness compared to other classes of surfactants and are therefore predominantly employed in the personal care industry.

The AASs are made from fatty acids of vegetable oil in a two-step procedure. The first step is the conversion of a fatty acid to a fatty acid chloride and the second step is the conversion of the fatty acid chloride with an amino acid (for example, glycine or glutamic acid) in an aqueous medium to produce the final AAS.

“The conventional process of manufacturing AASs uses the catalyst dimethyl formamide (DMF), a highly toxic substance. This process also results in significant loss of yield, higher energy consumption, longer batch cycle time and lower productivity. There are claims that phase separation can take out the toxic element – but it's not true,” says Koshti.

Galaxy's green process is based on smart chemistry wherein the surfactant is used to catalyse the synthesis of the precursor of the same surfactant. So an amino acid surfactant is used to catalyse the synthesis of an amino acid surfactant. “This is a case of ‘surfactant catalyses synthesis of surfactants’,” says Koshti.

Koshti adds that the use of an amino acid surfactant as a catalyst eradicates all the issues associated with the use of a toxic catalyst. “Since the catalysis is effected by the surfactant, which is non-toxic and biodegradable, one doesn't have to isolate it while going from Step 1 to Step 2. It therefore addresses all the woes of conventional manufacture of AASs.”

Koshti admits that the company faced challenges while developing the product. “It is never really a smooth ride. You always have your ups and downs. In an industrial set up there is a time line. You can't be without one and it can be frustrating keeping to this time line. But the highs and lows keep you going. Out of 10 good ideas, maybe three work and sometimes there needs to be a bit of serendipity involved. You have to get a bit lucky, which we did in this case.”

## KEY FACTS

### GALAXY SURFACTANTS' GREEN PROCESS BENEFITS

- 100% atom economy (quantitative conversion and yield)
- Use of non-hazardous chemicals
- Renewable source of raw materials
- Safe and biodegradable nature of final products
- Energy efficiency through a smart catalysis
- No waste generated

The process is now fully commercialised and Galaxy has been selling the amino acid surfactants successfully for the past three and half years. “The customers appreciated what we were doing. It is not just about the bottom line for us and for our customers, but about offering a good contribution to the science of biodegradable catalysis that can be extended to other industries.”

## UNILEVER RECOGNITION

The smart catalysis allowed the company to bring down the cost of manufacture significantly. Koshti says that one of its major customers, Unilever, recognised the importance of the innovation even before global patents were granted, presenting Galaxy with the “Innovation Award” for “Green Catalyst & Sustainability” in 2014.

In terms of developing the product further, Koshti says, “I think the goal is completely achieved with respect to surfactant manufacture – but this innovation is applicable to an entire family of amino acid-based surfactants and can be extended to other acid chlorides in general that are intermediates for a variety of other chemical industries.

“Now the entire class of AASs is coming into a more affordable zone, more industries (other than personal care) could certainly use it, for example the agrochemical industry, the paint industry and even the food sector.”

Koshti believes that sustainability achieved with an improved bottom line drives innovation today. “Cost-effectiveness is one thing but achieving cost-effectiveness by green/sustainable chemistry is something very holistic.” ■

# Taking the initiative to change

The world is moving fast and that creates tremendous opportunity to think outside the box and fuel change through innovation, says sponsor ExxonMobil Chemical

ANDY BRICE LONDON

To be a successful innovator in today's ever-changing chemical landscape, it is vitally important to allocate sufficient resources, not only in terms of funding, but in time and people. To succeed, you need the right attitude, appetite, drive and commitment.

Dave McConville, vice president, global chemicals technology at ExxonMobil, says the business has three distinct paths for delivering innovation. First, there is significant investment within the organisation itself, with a spend of around \$1bn/year directed not only at looking to new ideas but taking existing concepts and improving them, he says.

Collaboration is another important area, working with industry partners on joint developments where there are common interests and goals.

The third aspect is the corporation's commitment to supporting research with academic and non-governmental institutions. "We think this is particularly important because there are a lot of really excellent ideas within the academic community but what's often missing is the ability to scale up the technology," says McConville.

"That's where I think major corporations like us can play a big role, helping with the translation of that technology at the conceptual level to increase the impact it can have on society.

"In our business, we're continually trying to improve," he says. "Many of the processes we run are quite mature and the improvements we make tend to be incremental – but they're still extremely important. These help us to stay competitive, as well as helping to reduce our emissions, cut energy consumption, and improve our products and processes."

"Although it's about continuously improv-

ing the materials that we already sell into the market, we're also looking for opportunities for gamechangers – the really big ideas. You constantly have to ask whether you are working on the right things," he notes. "Are you looking at something that is really going to move the needle for your business and society?"

Sustainability and the drive towards greater efficiency is certainly stimulating R&D, he adds, and it is encouraging chemical players to break into new fields and explore new and exciting opportunities.

"I think there's a lot of out of the box thinking going on in our industry and sustainability is becoming a bigger driver for innovation. If you compare the type of work we're doing today to even 30 years ago, it's very different. There are just so many opportunities that are afforded by the drive for sustainability that it opens doors to things that simply would not have been pursued in the past."

McConville points to ExxonMobil's development of biofuels via algae and its partnership with California-based Synthetic Genomics. After some significant breakthroughs with the technology in June 2017, they announced in March this year that they were targeting a 10,000 bbl/day algae biofuel facility by 2025.

"That itself tells you that when you focus the research and investment you can achieve some pretty remarkable things. That development could be really important for the planet in the future."

**DAVE MCCONVILLE**  
 Vice president, global chemicals technology, ExxonMobil

**"The world is changing fast and I've never seen so many opportunities to innovate"**



Green algae offer a potentially attractive route to alternative fuels

Other examples, he says, are its halobutyl rubber products, which improve air retention in tyres and improve fuel economy while reducing the CO<sub>2</sub> footprint, or the work taking place with Connecticut-based firm FuelCell Energy on carbonate fuel cells – a promising technology that makes it possible to capture CO<sub>2</sub> streams from power plants, run them through fuel cells and generate electricity.

A few years ago, ExxonMobil also launched *Exceed XP*, he adds, a new line of polyethylene (PE) that provided yet another "step change in performance". This new material enabled the next generation of downgauging of films for the flexible film packaging industry, he says.

In addition to reducing the amount of material needed to package the same application, this material significantly reduces leakage that sometimes occurs in so-called "bag in box" applications. "This is another example of continuous development in an area where we thought performance was beginning to flatline," he says.

Moving forward, recycling and life cycle assessment remains a key priority, he explains. While the benefits that plastics have brought to society are clear – from the lightweighting of cars to increasing the shelf life of food – the industry recognises that plastic waste is a major issue that needs to be addressed.

"Plastic is building up in the countryside and in our oceans because it's not properly recycled, but there's a lot of carbon and energy contained in that plastic, and a lot of opportunity," he says.

"The question is, do you continue to landfill or look for ways to turn it back into feed for a process you run? This is certainly something that we're all looking at and an area that I think is going to evolve quickly over the coming years.

"The world is changing fast and I've never seen so many opportunities to innovate." ■

# Electrolysis makes a winning solution

Electrochem's electrolytic approach to recovering pure iron from titanium dioxide waste and iron sulphate pickling solutions yields a cost-efficient recycling route

JANE GIBSON LONDON

**H**uge amounts of ferrous sulphate heptahydrate – known as copperas – and other ferrous sulphate-containing wastes are produced worldwide each year, amounting to around 22m tonnes in all. These are usually disposed of without any attempt to recycle them.

This was the main driving force behind the development by Electrochem Technologies & Materials of a technology for producing electrolytic iron from copperas. “The technology, now patented worldwide, is an electrochemical process that transforms ferrous sulphate [into iron] using electricity,” says Dr Francois Cardarelli, president of the Canadian firm.

Electrolysis takes place inside an electrolyser and reduces ferrous cations at the cathode, while sulphate anions cross a membrane towards the anode where oxygen gas evolves, leaving behind sulphuric acid.

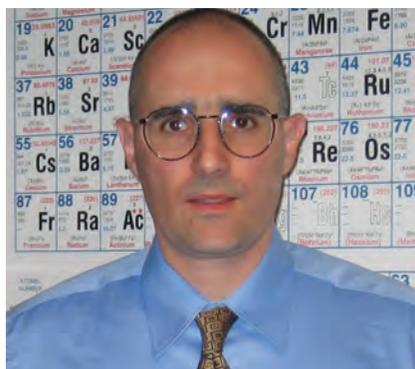
According to Cardarelli, the technology is simple and requires only existing and affordable equipment. It is also modular in design so that additional capacity on a greenfield plant can be obtained by adding more cells, making scale-up simple.

Moreover, he adds, the operating cost to produce a tonne of iron and the capital expenditure of an electrowinning plant are much more attractive than those of a new iron smelter.

“We have run several cost and benefit analyses for both greenfield and brownfield installations in various jurisdictions [where the patent is now enforced and where suitable economic factors such as cheap electricity and skilled labour are available] and the preliminary financial analysis reveals net present values and an internal rate of return that are very attractive.”

Another driver behind the innovation was recent industry interest in finding an alternative and greener way to produce iron without using a carbon as a reducing agent, thereby avoiding the release of greenhouse gases. In short, an alternative solution to the blast furnace.

According to Cardarelli, the energy consumption required to produce electrolytic



**FRANCOIS CARDARELLI**  
 President, Electrochem Technologies & Materials

**“Now that the technology is de-risked we are being approached by parties interested in purchasing licences, rather than the other way around”**

iron is half that of the conventional process and rather than emitting 1.8 tonnes of carbon dioxide per tonne of steel, the process releases oxygen. A final advantage is that the regenerated sulphuric acid can be reused upstream or further concentrated, making the entire process a recycling loop.

The pure electrolytic iron can be produced in various forms: flakes, nodules, powder or plates. These can be used directly or sintered or melted for the production of high-quality steels. At present, electrolytic iron is mainly used in the magnet and food industries and is considered somewhat niche. But that could change given the economics of the new technology.

“It’s a high quality product that you can melt – the iron is so pure that you can do whatever you want with it. But it’s very competitive – you can produce pure iron at lower price than pig iron. That’s why it makes sense – it doesn’t just work technically, but commercially too,” maintains Cardarelli.

Cardarelli says the company started developing the product eight years ago. Suitable

electrode and membrane materials that could withstand the operating conditions had to be found and the developers had to determine suitable operating conditions compatible with maximum current efficiency and product yields. This had to be done while also obtaining the minimum specific energy consumption and maximum throughput to minimise the cell footprint and make it compatible with an industrial operation.

“It takes a long time and a lot of energy and money to promote a novel technology, even though it has been tested successfully by several industrial clients. The chemical and metallurgical industries are among the most conservative for good reason,” says Cardarelli.

“They always want to implement affordable technologies, relying on known equipment and most importantly with products which are technically simple to scale-up.

“We financially supported the entire project ourselves (development, patents, materials, piloting), using only the cash flow generated from Electrochem’s other activities. Now that the technology is de-risked we are being approached by parties interested in purchasing licences, rather than the other way around.”

Cardarelli points out that commercially, you must make more than 50,000 tonnes/year of electrolytic iron to become profitable. “It wasn’t our intention to do this in-house. It takes a larger multinational to do this, so the company favoured licensing the technology.

“Some clients have tested it with a commercial unit, but we did not build a big pilot installation – it was one-fiftieth the size of a commercial unit but it mimicked all that a full-scale plant would do, which meant we could test it at our site and also at the client location.”

There is the possibility to develop the technology further, says Cardarelli. “We also manufacture industrial electrodes and have been working to devise special formulations that will allow us to lower costs and increase the service life of the iron. This gives us a competitive advantage for future commercial deployment. We are also working to integrate this technology vertically with other technologies. ■

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