

Innovation Awards 2020



Winners' supplement

Collaborate for change

Chemical collaboration remains a key driver to achieve sustainability goals

Collaboration and sustainability emerged as pillars of chemicals innovation in this year's ICIS Innovation Awards

Will Beacham Barcelona

We are delighted to announce that the winner of the 2020 ICIS Innovation Awards, sponsored by BASF, is Belgian small to medium-sized enterprise (SME) Qpinch, which has developed a heat recycling pump with the potential to save energy and reduce emissions across the entire petrochemicals sector.

The entry ticked all the boxes for the judges who were looking for an entry with standout potential to have the maximum impact on both the industry and the environment. If widely adopted this could save hundreds of thousand tonnes of CO2 emissions per year in global petrochemicals production.

The judges had a particularly tough time this year, sifting through a record number of entries from companies of all sizes from around the world. As chairman of the judging panel, I listened carefully to this year's online discussions and pinpoint the following as the most important criteria for success in this competition:

- Potential impact on the chemical industry
- Potential impact on society
- Size of potential market – how significantly could it impact the market?
- How novel is the chemistry/design – is it fundamentally new?
- What is the timeline to commercial launch?
- If already commercial, how successful is the product/service?

Innovation in chemicals is flourishing despite restrictions from the coronavirus pandemic. In fact, the outbreak may have accelerated certain lifestyle trends, which makes innovation even more important for the survival of the industry in the long term.

For example, because of the collapse in demand caused by lockdowns, demand patterns have now changed for good as consumers' lifestyles changed. At the same time regulatory pressure is increasing the need for chemicals that would help the world switch to low-carbon technologies.

Best Innovation by an SME/overall winner

The overall winner also picked up the Best Innovation by an SME award this year. Belgium's Qpinch has invented a new type of heat pump, which recycles waste heat from petrochemicals manufacturing back into the production process.

Qpinch has found a new way of upgrading



SME beats big boys to ICIS crown

this waste heat, turning it back into process heat through a reversible chemical reaction using phosphoric acid. The result is a heat transformer that brings double-digit energy savings to petrochemicals processes, according to Qpinch.

The company said its clients and prospects estimate that Qpinch can save 10% or more on energy use. It claimed savings of at least

2,100 tonnes of CO2 emissions per megawatt, and has potential for use across the industry, giving it a huge potential market and impact.

It has also been commercialised. Borealis, SABIC, and Kuraray are introducing the first units with the new process installed and intend on rolling out more of systems subsequently. Currently, Qpinch can process heat

Collaboration between large chemical companies was a standout feature in winning entries

up to 220 °C, enough for many chemical applications. At this stage – market introduction – the return on investment is between four and seven years, according to Qpinch.

Judges heap praise on Qpinch

According to Detlef Kratz, president of process research & chemical engineering at BASF: "This can be multiplied across many applications and could be a breakthrough to help companies grasp this residual heat that all of our plants have. This could save endless amounts of energy."

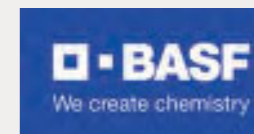
Mike McKenna, president and chief operating officer of US distributor Maroon Group said: "I like the fact it is commercialised with multiple companies – it seems like they have some really good partners to help them with this. Also it's great to see how this is a repurposing of older technology for a tangible benefit in the market."

Adrian Higson, director of UK bioeconomy

Overall sponsor **BASF**

We create chemistry for a sustainable future

Chemistry has always been an enabler for innovation as it provides solutions to meet 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, president for process research and chemical engineering at BASF.

"Looking at past years' 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, innovative battery materials and projects, which make a contribution to the circular economy and chemcycling.

And with its new strategy, the company goes one step further. Says Kratz: "We've set ourselves ambitious targets: As the leading chemical operator, we will grow our production volumes

significantly without adding further CO2 emissions until 2030. Our global carbon management programme will help us to live up to our commitment."

Speed and adaptation to change is a further challenge in today's multi-faceted 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 Curiosity is just one example how this is put into practice.

"We would like to share this spirit with those who work on innovations 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.

consultants NNFFCC added: "The widespread potential of this and where it could be used is really interesting. This could help the industry meet so many of its current targets around climate change, economics and energy use."

Paul Bjacek, principal director at Accenture said: "Anything that reduces heat will reduce emissions and Qpinch can be applied across many areas."

Best Product Innovation

Clariant picked up the Best Product Innovation award, sponsored by Accenture, for its new range of waxes made from the waste stream of rice bran oil production. Branded LICOCARE RBW Vita, these waxes are a bio-based alternative to petrochemical-based waxes.

The company claimed greenhouse gas reductions and the product also uses waste from bran oil production so it does not compete with food. The judges were impressed by the potential impact of this product as it could be used by a broad range of polymer compounders and masterbatch houses.

According to Janz: "It has interesting po-

tential as it uses a widely available biomass waste as input to make a commercially viable range of products. There is a big existing market here, which this product could access."

John Baker added: "This looks like it could be a drop in product for similar conventional products on the market. It's a good, solid commercial development from an interesting raw material."

Best Process Innovation

The judges remarked that there was a particularly strong list of entries in this category.

The winner of Best Process Innovation is The Dow Chemical Company for its new LP Oxo Isononyl Alcohol (INA) Technology.

The key step in INA production is the hydroformylation of mixed octenes comprised of branched internal olefins, which are quite challenging to convert. Traditionally the hydroformylation step has been conducted using cobalt catalysts at high temperatures and pressures.

Developed jointly with Johnson Matthey for third-party licensing, Dow said this new technology provides high conversion at lower

Category sponsor **Accenture**

Best Product Innovation

Accenture is pleased to sponsor the Best Product Innovation category of the 2020 ICIS Innovation Awards. In this period of epic disruption, the chemical industry faces profound change.

Opportunities abound for chemical companies, but they must build resilience and agility in order to reimagine their business for a sustainable future.

We continually look ahead to anticipate what's next and believe the future of the chemical industry is now. As a sector that can provide answers to some of the world's biggest challenges – from global health to environmental protection – chemical companies that

understand the forces reshaping the industry, embrace innovation and deploy it at scale can take the lead and accelerate growth.

With deep industry knowledge, strategic thinking and unparalleled technology expertise, we turn insights into action and collaborate with chemical companies to help them create value for their business, people and society.

Accenture's global chemicals practice works across the value chain in all industry segments, including basic and intermediate chemicals, polymers, fibres and elastomers, agrichemicals, paints and

coatings, industrial gases, and other specialty chemicals.

The depth and breadth of our capabilities allow us to help companies apply innovation, transformational strategies and digital enablement for growth, differentiation, sustainability and superior operations. With more than three decades of experience, we're helping to redefine the way the chemical industry works.

About Accenture

Accenture is a leading global professional services company, providing a broad range of services in strategy and consulting, interactive,

technology and operations, with digital capabilities across all of these services. We combine unmatched experience and specialised capabilities across more than 40 industries – powered by the world's largest network of Advanced Technology and Intelligent Operations centres. With 513,000 people serving clients in more than 120 countries, Accenture brings continuous innovation to help clients improve their performance and create lasting value across their enterprises.



Innovation continues to be a driving force in chemicals, despite the coronavirus pandemic

pressures (which saves capital), lower temperatures (which saves energy) and lower byproduct formation (which reduces waste). The product has already been commercialised: on 1 June, 2020, Zibo Qixiang Tengda Chemical Company announced plans to construct the first facility using LP Oxo SM INA Technology in Zibo City, China. Operation is anticipated to begin in 2023, with an annual production of 200,000 tonnes.

Judge Janz said: "I like this collaboration between a technology company and a chemical producer. Collaborations always score highly for me in achieving innovation success."

In Higson's view: "I like the fact that they have agreed a commercial licence deal, also its sustainability credentials and an interesting collaboration."

Kratz added: "I rank this highly because I know how difficult it is to change a fundamen-

tal process, and to do it with a catalyst at low pressure, which has commercial and sustainability benefits."

The judges wanted to make special mention of Genomatica for its plant-derived nylon 6, which is fully recyclable. The judges felt that this product has great potential with a big market and highly innovative process technology. However, the innovation is at an early stage on the route to commercial production, and so the judges would like to encourage the group to enter again next year, once more progress has been made.

Best sustainable product

Winner of Product with Best Benefit to the Environment and Sustainability, sponsored by Maroon Group, is Corteva Agriscience. It entered a new plant-derived herbicide called Loyant with an active ingredient known as Rinskor.

Corteva said the product has low toxicity, with little persistence in soil, water, and within plants. It also has little toxicity to birds, insects, fish and other aquatic organisms. This new, broad-spectrum herbicide is designed for use in seeded and transplanted rice and controls the most important weeds that rob rice farmers of yield.

It also claimed low application rates compared to older technologies. The company said the use rate is a fraction of rates commonly applied for comparable rice herbicide products and poses minimal risk to farmers, applicators and non-target organisms.

The formulation technology used in Loyant herbicide retains attributes historically associated with solvent-based emulsifiable concentrate (EC) formulations, but introduces a step-change

Category sponsor **Maroon Group**

Product with Best Benefit to the Environment and Sustainability

Maroon Group is a leading distributor of specialty chemicals and ingredients across North America and takes a proactive role in addressing corporate social responsibility and sustainability in the global supply chain.

Along with being recognised for adopting

international sustainable development standards by EcoVadis, Maroon Group is an active member of the National Association of Chemical Distributors (NACD) and holds ISO and Responsible Distribution certification.

NACD's verification of environmental, health,

safety and security programmes demonstrate our commitment to continuous performance improvement and responsible distribution in every phase of chemical storage, handling, transportation and disposal.





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Sustainability in chemicals has not been forgotten in today's market conditions

improvement in environmental favourability, said Corveta. The formulation's matrix is built upon co-formulants that are predominantly plant-derived and renewable, conferring attributes such as ease of measurement, mixing and application, as well as good transport and storage properties, according to the company.

Judge Baker said: "The very low application rate struck me, down to around 10% of other herbicides. It's not every day you get a full new active ingredient in the herbicide sector, and rice is a big market."

He added that if the application rate is mirrored in the cost to the farmer and environmental benefit then it offers quite a substantial improvement.

According to Bjacek: "I liked this one a lot – it's environmentally friendly, commercialised,

plant derived, and rice is a huge market."

McKenna pointed out that getting US Environmental Protection Agency registration is incredibly challenging, adding: "It's on the backbone of a chemistry that's been around for a couple of years. Taking that and evolving it for use on a broader scale for one of the biggest crops in the world is very interesting."

Kratz added: "Technically, compared to all the other agricultural submissions, it's the best, because they have gone through a tough approval process to put a completely new active ingredient onto the market."

Best sustainable process

Winner of the Best Sustainable Process category, sponsored by Deloitte, is AmoMax-Casale, a new ammonia synthesis catalyst that offers big CO2 savings by allowing a lower operating pressure. It was jointly developed by Swiss technology group Casale and Swiss catalyst producer Clariant particularly for use in Casale ammonia converters.

The technology is a customised evolution of the well-known, wustite-based catalyst, AmoMax 10. While retaining the same resistance to aging, poisoning, and mechanical strength, AmoMax-Casale is significantly more active, according to Casale and Clariant. By optimising the plant's overall efficiency, customers can generate higher profitability by either benefiting from energy savings and reducing the CO2 footprint or monetising its increased ammonia production.

The catalyst been recently proven in a world-scale commercial ammonia plant in the US.

The usage of AmoMax-Casale results in reduction of operating pressure of up to 10 bar, which can be converted in energy savings of approximately 0.1 GJ per produced tonne of ammonia. Over the typical catalyst lifetime (15 years/350 days production per year) this results in total energy savings corresponding to a reduction of 45,000 tonnes CO2 for a 1.5m

Innovation Awards 2020
Meet the judges



John Baker
Former global editor of Custom Publishing at ICIS



Paul Bjacek
Principal director
Accenture



Adrian Higson
Director
NNFCC



Just Janz
Founder and managing director
Expertise Beyond Borders



Detlef Kratz
President of process research and chemical engineering
BASF



Mike McKenna
President and chief operating officer
Maroon Group

tonne/year ammonia plant, the company said.

It added that AmoMax-Casale is an important step towards CO2 free ammonia. It opens the window for further optimisation of processes and catalysts, which will enable a profitable "blue" ammonia process. This includes CO2 capture and storage and paves the way to "green" ammonia starting from renewably produced hydrogen.

For McKenna: "Collaborations will be critical in driving innovation, especially when you get two really successful companies with their best minds and investment behind it."

According to Janz: "I really like collaborations and this has significant potential, including retrofitting of existing units, which broadens your addressable market – it ticks all the boxes."

Bjacek added: "I like the fact it offers less CO2, better energy efficiency and can be applied globally. It's also been proven on a commercial scale."

Higson said: "Its potential for saving greenhouse gas emissions are significant, given the market it's in. It's deployable and large scale." ■

Category sponsor Deloitte

Process with Best Benefit to the Environment and Sustainability

Deloitte provides industry-leading audit, consulting, tax and advisory services to many of the world's most admired brands, including nearly 90% of the Fortune 500® and more than 7,000 private companies. Our people work across the industry sectors that drive and shape today's marketplace – delivering measurable and lasting

results that help reinforce public trust in our capital markets, inspire clients to see challenges as opportunities to transform and thrive, and help lead the way toward a stronger economy and a healthy society. Deloitte is proud to be part of the largest global professional services network serving our clients in the markets that are most important to them.

Now celebrating 175 years of service, our network of member firms spans more than 150 countries and territories.

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Breakthrough for decarbonisation

Qpinch has developed a novel technology that transforms waste energy into process heat, which will enable companies to cut their energy consumption and carbon emissions while also generating significant savings

Elaine Burridge London

The germ of an idea often takes root at the most unlikely time and place. That was certainly the case for Wouter Ducheyne, co-founder, co-CEO and CTO at Qpinch, the winner of the Best Innovation by an SME category in this year's ICIS Innovation Awards, and the overall winner.

It was during his daily 15km cycle commute to and from his previous employer BASF's site in Antwerp, Belgium, which is also the site of the second-largest chemical cluster in the world, that the former process engineer noticed the huge volumes of waste heat being expelled from cooling towers.

Refineries and petrochemical plants consume large amounts of process heat, mostly in downstream operations, which eventually turns into waste, low-grade heat that has to be disposed of. Fossil fuels produce most of this heat and are the primary cause of the industry's share of more than a quarter of all global greenhouse gas emissions.

According to Qpinch, the production of process steam with natural gas – the cleanest of all fossil fuels – results in 2,100 tonnes of CO₂ emissions per year. A petrochemical plant requires up to hundreds of megawatts (MW) of process heat, with some of the biggest complexes integrated with refineries and requiring up to several gigawatts of duty.

Heat to energy

Ducheyne believed that this lost heat could be transformed into energy – the only question, was how? To exploit the waste heat, its temperature needed to rise substantially and existing technology was mostly unable to deliver the required temperature lifts.

Collaborating with Ghent University's professor Chris Stevens, the Qpinch team turned to a biological process, taking inspiration from the highly efficient adenosine triphosphate/adenosine diphosphate (ATP-ADP) cycle used by all living cells to create energy. This cycle uses a reversible chemical reaction but at shallow temperatures. Qpinch's re-

search focused on using a similar process that could be applied to the chemical industry.

Qpinch's technology is based on a chemical reaction with phosphoric acid in a closed loop between two reactors. On the cold side, the phosphoric acid is exposed indirectly to the waste heat and the ensuing endothermic reaction causes the phosphoric acid to oligomerise. In the hot reactor, the phosphoric acid is forced to return to its monomer state, which causes an exothermic reaction at high temperatures. The phosphoric acid is transferred back to the cold reactor and the cycle repeats.

Power of chemistry

"We use the power of chemistry and do not, like many traditional heat pumps, rely on mechanical compression," explains Erik Verdeyen, Qpinch's chief evangelist. "That tackles the problems that disqualify existing technologies for the job, either because they are technically insufficient or uneconomical."

The heat transformer operates between 30°C and 220°C and can achieve large temperature jumps of between 50°C to above 100°C. It can also handle fluctuations in input, variations in temperature and can exploit concurrent waste heat sources, making it very suitable for large-scale deployment to produce large, sustained output. Verdeyen says none of these vital points can be found combined in other solutions.

Another significant benefit of the Qpinch technology is the absence of large rotating equipment, which requires much maintenance and electrical power.

Verdeyen says the system can turn 50% of exploitable waste heat back into process

Erik Verdeyen
Chief evangelist, Qpinch

"We use the power of chemistry and do not, like many traditional heat pumps, rely on mechanical compression"

heat, resulting in less energy consumption and emissions with savings in the double-digit range. "With our system, petrochemicals have a new, large-scale tool with an excellent return on investment to curb their emissions and save energy costs." He adds that with a one-off capital expenditure, a Qpinch unit can deliver more than 30 years of free cashflow.

With energy a significant component of a plant's operating costs, together with rising CO₂ taxes in Europe, which are also emerging in many other regions, Qpinch says it can save tens to hundreds of thousand tonnes of CO₂ emissions every year in many of the world's petrochemical plants. For example, the company estimates the potential energy savings for a 500,000 bbl/day refinery at 100 MW, equivalent to a reduction of 200,000 tonnes/year of CO₂ emissions.

The technology can be installed as either a standalone unit to reduce local energy consumption or to produce heat for nearby processes or a steam network.

Unlimited scalability

Verdeyen says the modular nature of the unit means it has unlimited scalability. In addition, the unit uses standard components. In essence, it is a small chemical plant that, combined with the lack of major rotating equipment, means it does not require a lot of maintenance and has a lifespan of 30 years and more.

First commercial units are already under construction with clients Borealis, SABIC and Kuraray. The first plant is due to be commissioned by the beginning of 2021 for Borealis at Antwerp, where it will reduce the energy consumption of an exothermic reaction at the site's low-density polyethylene (LDPE) plant.

The other two units for SABIC and Kuraray are also due online in the first quarter of 2021. Verdeyen says the intention is to subsequently roll out more units. Qpinch is in open innovation with Borealis and other parties and work continues to extend the temperature range, both downwards (for specific chemical processes) and upwards (towards 250°C out-

put), which would open up the whole fertilizer market, says Verdeyen, adding that the company has seen much interest and additional customers in the past six months.

Some companies, he notes, are already planning to tie in the installation of a Qpinch unit in their maintenance cycles, while others have already put in connections to include a unit in future projects.

In addition, there are a couple of petrochemical companies that are interested in integrating a Qpinch unit with carbon capture and storage (CCS) projects. CCS technology uses low-temperature process heat and this market will be huge, says Verdeyen, as the global petrochemical industry needs CCS on a large scale to curb emissions. "This solution requires vast amounts of process heat that Qpinch is able to produce with the abundantly available low-temperature waste heat that is now lost. With our technology that provides carbon-neutral heat, CCS becomes cheaper and realises even more CO2 savings."

Energy

Green hydrogen and geothermal energy are other areas of potential interest for Qpinch. Production of green hydrogen is growing fast and the process, driven with carbon-neutral electricity, releases waste heat, which Qpinch can transform into process heat.

Geothermal energy is also not widely exploited due to its low temperatures or because many processes need steam. Verdeyen says Qpinch can change that by making geothermal heat an option for 24/7 sustainable process heat, specifically outside the petrochemical industry. The technology has also attracted interest from food and paper companies.

Looking ahead, Verdeyen says a move to larger-scale Qpinch implementation and market adoption will further lower the capital expenditure per MW and therefore also reduce the payback period.

The technology start-up is planning a series B funding round in the first half of 2021, aiming to raise between \$15m-20m. "We want to expand rapidly, invest in our research and development and roll out thousands of Qpinch units. We need to go big if we are to have an impact," Verdeyen says.

The company intends to remain a technology-based organisation, focused on process engineering and commissioning of the units and linking with other technology providers. The technology can be integrated with other process technologies, leading to huge opportunities ahead for the Qpinch team.

As Qpinch says, low temperatures are not an excuse anymore to waste heat, which is just energy waiting to be harvested, with the added benefits of free cashflow and a large-scale reservoir for reducing greenhouse gas emissions. ■



Qpinch's pumps are being added to a Borealis LDPE unit in Antwerp

Waxing lyrical on sustainability

Clariant creates a unique range of bio-based plastics additives that offers an effective and sustainable solution

Andy Brice London

Demand for recycled plastics and bio polymers is growing exponentially – and as plastics become greener and more advanced, so too must the additives used in those formulations.

Clariant's new Licocare RBW Vita wax additive range achieves the required levels of quality and performance by offering an eco-friendly solution with significant surface and processing improvements compared with conventional products.

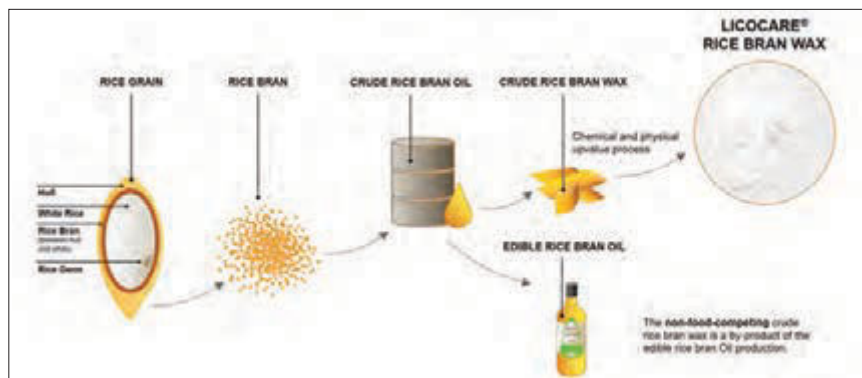
The bio-based additives are produced from rice bran wax, a by-product of rice bran oil. The Swiss specialty chemicals major uses proprietary technologies to transform this renewable raw material into high-performance processing aids for plastics compounders and masterbatch producers.

These plant-based waxes boast excellent lubrication and dispersion properties, as well as high thermal and colour stability, says Manuel Mueller, head of the plastics business within the Advanced Surface Solutions business line, and its global head of marketing and strategy covering plastics, coatings, inks, consumer, and agriculture segments.

"At Clariant, we take sustainability very seriously and it is one of our five strategic pillars," he said. "In some cases, we're being really radical and replacing certain products, while in others, we're offering greener alternatives."

"We find that our customers are increasingly asking for additives that have a better sustainability profile, with fewer CO2 emissions and less reliance on fossil-based materials. We're therefore pleased to introduce this new line to our portfolio – an alternative to our popular Montan waxes, a product we've had in the market for over 100 years."

The Licocare RBW Vita range significantly reduces greenhouse gas emissions, cuts water use in raw material production, and minimises



waste – which allows it to bear Clariant's Eco-Tain label, an indicator of its green credentials. TÜV Austria also certified the range as both biodegradable and compostable.

"Our customers like the fact that it is bio-based, non-food competing, and that it matches – or in many cases, is even better than – the performance of traditional, more established, products in the market," he said.

Licocare RBW Vita was launched in late 2017 and is now manufactured at an industrial scale exclusively in Germany at its Gersthofen site near Munich.

Development started in 2011 and within two years, Clariant had developed its first prototypes and application trials. It is now the world's only commercial producer of physically and chemically modified rice bran wax.

Although these waxes have been used in moderate quantities over the years, primarily in personal care applications, Clariant makes a physical chemical modification so they are suited to even the most demanding formulations required by its customers.

Huge volumes of rice are grown worldwide, particularly in Asia and North America.

Manuel Mueller
Head of the plastics business

"We're being really radical and replacing certain products, while in others, we're offering greener alternatives"



When the grain is harvested, the white rice within is used for food while the rice bran product is set aside. This generates over 1.5m tons of rice bran oil each year and is typically used as a deep-frying oil in Asia.

Impurities removed as part of the process leave behind rice bran wax, which is sent to landfill or used as animal feed. Clariant uses this – an almost unlimited, nearly 100% renewable resource – as the raw material for Licocare RBW Vita.

"We believe there is a huge amount of scope and opportunity for this," Mueller insisted. "We take this non-food competitive waste from rice production to manufacture high performance waxes that can be used for various plastics, coatings, and ink applications."

The resulting additives offer better internal and external lubrication, and make processing of plastics easier – for example, in injection moulding or extrusion. They also have enhanced pigment dispersion, leading to improved colour strength of finished goods, he says. Easier release from moulds means less scrap and waste too. Their optical characteristics also result in a superior finish.

Licocare RBW Vita is suitable for a range of polymers – whether polyamide and polyester, or biopolymers and polyolefins, said Mueller.

They are also excellent components for shoe creams to increase shine, for example, and can be used in surface coatings formulations because of their good slip properties. They are well suited to use in printing inks because of their excellent rub resistance, or as a matting agent in coatings applications, he adds. ■

Morgan Condon London

The barrier to entering the isononyl alcohol (INA) market had previously been set at a high level due to the significant level of investment needed to start and an energy-intensive production method.

This was not enough to de-incentivise the INA market – used to manufacture plasticizers with uses including medical, wire or automotive applications – but the traditional process needed to change.

It was this market demand that drove Dow and Johnson Matthey to develop new low-pressure technology which saves capital and energy while reducing waste in manufacturing the plasticizer alcohol.

Conventionally, cobalt catalysts are needed to react the double bonds of branched internal olefins in INA production, using high temperatures and pressure in the hydroformylation step.

The LP Oxo Technology uses lower pressure and temperature in INA production while providing lower by-product formation.

“It wasn’t a simple problem to solve, as they are quite tricky feedstocks to react,” said Johnson Matthey licensing manager Fraser Archibald. “One of the key things was to develop how to get this reaction to happen at these conditions, and to separate catalyst and product at the end.”

Speed, stability, selectivity and separation

The team used the four “S”s of catalyst production: speed, stability, selectivity and separation – as if you cannot separate the catalyst from the end-product then it is of no use.

And the work on the LP Oxo Technology has very much been a team effort between the two companies.

Development on this project began seven years ago and has been shaped by constant communication with their client base to provide the most competitive process.

“Customer feedback and interaction was one of the most important things we did on this development and the feedback was key in driving the development of low-pressure conditions,” said Archibald.

“Another thing to emphasise is sustainability. Clearly the industry and the market want a process with less potential impact to the environment,” said Dow Licensing and Catalyst Product Director Jeff Tang.

“The low pressure, low temperature process will need less capital to build but will also lower the environmental impact compared to high pressure processes.”

While precise conditions will vary, pressure is reduced to around 20 bars from 200 bars needed for traditional production, with temperatures below 100°C rather than above 120°C.



Wire is a traditional use for manufacturer plasticizers

The process of change

Collaborating to achieve a chemical breakthrough proves successful for Dow and Johnson Matthey

The new process will require roughly 33% less electricity and a reduction of 2.5 gallons/lb of product of cooling water required relative to some traditional cobalt-based processes.

There has already been significant interest in the technology, with one licence already issued to Zibo Qixiang Tengda Chemical and a world-scale 200,000 tonne/year plant in Zibo, China, set to come online by 2023.

The absence of a physical signing ceremony was the most significant change caused by the pandemic as customers and colleagues alike adapted to remote working.

Dow and Johnson Matthey were well placed for the transition, having an established business relationship from either side of the Atlantic.

This project builds on a 45-year shared history of working together, combining Dow’s

strength in chemicals and catalysts with Johnson Matthey’s expertise in engineering and process.

“We are constantly looking for new opportunities to expand technology driven by market needs and customer feedback,” said Tang.

“The knowledge that we could use to develop new products we are looking into, include high molecular weight olefins and branched internal olefins instead of alpha olefins, to get higher yield and selectivity.”

Already the market leader in low pressure oxo processes, the partnership could look to retrofitting this technology for existing producers depending on demand.

Whatever form the opportunities take, the collaboration between the Dow and Johnson Matthey looks set to continue for a long time to come. ■



Agrochemicals must become more sustainable to keep pace with customer needs

Farm fresh sustainability

With an ever-increasing global population and perpetual environmental challenges, there is escalating need for sustainable agrochemical products

Morgan Condon London

The pressure to balance farmer's yields with an environmentally friendly product remains prominent, but with the global rice herbicide market valued at an estimated \$2.5bn, so too is the reward.

Taking all of this into account, global agricultural science firm Corteva Agriscience has risen to the challenge on several fronts with the introduction of Loyant herbicide featuring Rinskor active.

Predominantly made of renewable, plant-derived co-formulant materials, Loyant is used to control invasive grasses, sedges, and broad-leaf weeds that compromise rice production.

"We see Rinskor as a long-term, versatile option in rice and other market areas because

of the unique plant-growth regulating mode of action it brings to weed control and because of its favourable environmental profile," said Corteva's Dennis Wujek.

The mode of action is how the herbicide controls weed growth, including select weed populations that have developed resistance to a number of existing primary modes of herbicide action, including acetolactate synthase-inhibitors (ALS) and acetyl CoA carboxylase-inhibitors (ACCCase).

Rinskor's environmental cache means it is already well decorated with awards, having won both the ACS Green Chemistry Challenge Award and the Agrow 100 Award for Best New Crop Protection Product in 2018.

Its effectiveness is only enhanced by its reduced environmental load. Much less materi-

al is necessary for efficient crop management – with use rates as low as one-half to one-tenth that of other commonly used products.

Experimental results indicate Rinskor active presents minimal threat to human health and low toxicity risk to birds, insects, fish, and other aquatic organisms. Its rapid degradation in the environment means there is less residual material left to impact other species.

All of this led to the United States Environmental Protection Agency (EPA) to designate Rinskor as a Reduced Risk Pesticide on rice and aquatics, exempting it from the requirement of a tolerance.

Corteva's ambitions for Loyant extend beyond the United States, as rice is a crop grown globally, throughout the Americas, Europe and holding strength in the Asia Pacific region.

Solid growth

Since its launch in 2018 Loyant has marked solid growth, with registrations received in 15 countries so far, and registrations pending elsewhere. Other formulations using Rinskor active are registered for commercial use in more than 20 countries with more pending.

Farmers need no special equipment to use the product so it can be successfully applied using existing applications equipment such as ground rigs or backpack sprayers.

In addition to standalone formulations like Loyant, Rinskor has been formulated in pre-mix form with other active ingredients and can be combined with other weed control agents in the field to provide a complementary blend of crop protection.

And Corteva is not interested in diversifying Rinskor from a merely geographic perspective, but it is looking into different crop protection applications beyond the rice market.

Formulations of Rinskor active have already seen successful commercial application in aquatics and pasture/land management areas with anticipated entry into corn and turf markets on the horizon.

"The collaborative effort with aquatic herbicide specialists SePRO to provide a formulation that could meet the needs of that market highlights the versatility and favoured environmental status of the active ingredient," said Wujek.

Joint projects

Corteva remains open to further joint projects of this type with a focus on reaping the benefits rooted in the sustainable science.

"We are always open to collaboration opportunities and look forward to more of the same in the future.

"In terms of manufacture of the active ingredient and related formulations, we continue to strive towards and monitor for getting the most sustainability out of every atom and molecule," said Wujek. ■



Decarbonisation remains a key driver for chemicals businesses in 2020

Catalyst tackles ammonia emissions

Clariant and Casale combine to create catalyst technology which cuts carbon dioxide emissions in ammonia manufacturing

Morgan Condon London

In an age of sustainability scrutiny and a further clamp down on carbon emissions, it is inevitable that technology tackling this head on piques industry interest.

This is exactly what has happened with the new ammonia synthesis catalyst titled AmoMax-Casale, jointly developed by Swiss specialty chemical producer Clariant and Swiss-headquartered Ammonia technology licensor Casale. The new development builds on existing wustite-catalyst technology which provides the advantage of combining long-term stability and good mechanical resistance, with an increased efficiency of 30% over traditional magnetite ones.

Combining Clariant's expertise in the catalyst technology with Casale's converter design know-how led to the development of a catalyst with higher activity thanks to a larger active surface area and other improvements.

This optimised activity of AmoMax®-Casale provides benefits from an increased ammonia production, and through the savings in energy and the consequent reduction in carbon dioxide (CO₂) emissions.

An increase in ammonia production of up to 5% is easily achievable with a significant energy consumption reduction.

In practical terms, a 1,600 tonnes/day plant would save up to \$300,000 a year in energy

costs and enable a reduction of up to 85,000 tonnes of CO₂ over the catalyst's lifetime.

"Part of the benefit of this technology is the emission saving, which is a topic point as ammonia production has a large carbon footprint," said Casale's Chief Technology Officer Ermano Filippi. "Better performing catalysts mean also less water consumption, and reduced modifications in the plant to increase capacity."

"The product combined with the design of converter internals makes the difference, and avoids the need for an expensive revamp," said Clariant Catalysts Head of R&D Marvin Estenfelder.

Already a 1,600 tonnes/day plant in Trinidad is operational, with performance already reportedly exceeding expectations, and the concept could be applied to hundreds of ammonia converters across the globe.

The solution is continuing to gain in popularity, with another client deciding to use the technology, and another 10 offers in the pipeline, some of which the team expects to confirm late 2020/early 2021.

The technology was quick to enter the market, bounding onto the scene in 2019 after only four years of development.

"You can improve the catalyst but if you cannot customise it to the process and vice versa there is no substantial benefit," said Estenfelder.

Those using ammonia in fertilizer production are the obvious beneficiaries from the

technology, but more competitive production could open the market to new and sustainable applications.

"We hope this will open up demand for ammonia to other markets. The saving which could be achieved will mean ammonia cost will be lower coupled with reduced emissions pave the way towards utilisation in the transport, energy and hydrogen storage sector," said Filippi.

Notable among these are the shipping industry and the power production industry, because if ammonia production were more competitive, it could play a prominent role in the transition to cleaner energy.

While the technology is specific to the ammonia market, it offers a suitable blueprint which could be transferred to other production processes.

While this innovation enables economic production of blue ammonia, the team is adamant that this technology would also facilitate the production of green ammonia.

"Building green ammonia plants is absolutely possible. We already know how, we just need a client to build the first plant," said Filippi. "If I have to bet, within five years we will see at least the first green ammonia plant in operation."

"Both of us are eager to continue with our collaboration and we are already working on further innovations, so you should expect another application for an award in the next four years!" said Estenfelder. ■

Sustainability continues to underpin innovation

Chemical companies have been expanding efforts in their journey towards more sustainable production

Elaine BurrIDGE London

The chemical industry as an enabler of a sustainable future is very evident in this year's submissions to the ICIS Innovation Awards.

Detlef Kratz, president of process research & chemical engineering at BASF and one of the judges, notes that entries spanned a huge breadth of focus, from circular economy and bio-based chemistry, improving energy efficiency and cutting CO2 emissions, to digitisation.

He adds too that the volume of submissions this year, which numbered above 100, is one of the highest since the awards were launched in 2003, clearly showcasing how innovative the chemical industry remains and which calls for appreciation to all those who have submitted proposals this year.

Unlike previous years, 2020 has been marked by the spread of the coronavirus around the world, but this appears not to have dampened innovative efforts. In fact, the opposite is true if you look at the pharmaceuti-

cals sector in particular, where the coronavirus is driving and accelerating research and innovation as drug companies race towards developing a vaccine.

Partnership model

What is perhaps interesting here, points out Kratz, is that in the race to find a solution to the coronavirus, pharma companies are collaborating and sharing information and expertise, and also pooling funds. Kratz sees this kind of partnership model as one of the solutions for the chemical industry going forward.

This is certainly evident in the area of chemical recycling, where several chemical companies are linking with plastics recyclers and the waste management industry to develop viable technology. "No one company will have one solution for chemical recycling and it will rely on changing the mindset from only eliminating waste to actually sourcing a (waste) feedstock to create a product of value. It needs the whole value chain to be involved. That is where the future will be," says Kratz.



Regulatory pressures continue to push forward sustainability initiatives despite the coronavirus pandemic

Like many of its peers, BASF has taken the partnership route in its chemical recycling project, ChemCycling, which was launched in 2018 with the aim of manufacturing products from chemically recycled plastic waste on an industrial scale. The Germany based multinational group has established partnerships with Quantafuel – a specialist for the pyrolysis of mixed plastic waste – and Pyrum and New Energy, both experts in the pyrolysis of end-of-life tyres.

Once again, sustainability and the circular economy were at the heart of many innovations this year, no doubt driven in part by the European Green Deal. As part of Europe's new growth strategy, the Green Deal sets out a path for the EU to become a sustainable, climate-neutral and circular economy by 2050.

In its Chemicals Strategy for Sustainability, released on 14 October 2020, the EU has called on innovation for the green transition of the chemical industry and its value chains to be stepped up in order to protect human health and the environment. The EU says that the shift to sustainable chemicals will be a key component of the economic bloc's recovery from the coronavirus crisis.

Kratz highlights the fact that the winners this year fit perfectly with several key sustainability

criteria. For example, Clariant's Licocare RBW Vita range of waxes – winner of the Best Product Innovation – is an alternative to fossil-based waxes. They are bio-based and their plant origin ensures a reduction in greenhouse gases on production. They also use less water during the manufacturing process and generate less waste. Corteva's Loyant rice herbicide, winner of the Best Sustainable Product award, has an enhanced environmental profile and exceptionally low-use rates.

Zero emissions

As the industry takes action to meet the EU's zero emissions target, moves to decarbonise production are taking centre stage. Announcements of new projects and capacity expansions go hand in hand with measures to reduce consumption of utilities and cut greenhouse gas emissions and waste products.

This area of focus is particularly illustrated by Belgian start-up Qpinch, the overall winner of the ICIS Innovations Awards, which has developed a unique process to recover waste heat and transform it to energy for reuse.

Improving the efficiency of chemical processes remains a permanent focal point for development work. The chemical industry has many processes but, as Kratz points out, they are never perfect, and companies are constantly innovating and taking steps to improve through operational excellence.

This not only occurs through direct process

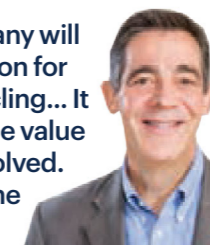
optimisation, as exemplified by Qpinch, but also in developing new catalysts to reduce energy use and improve yield, as highlighted by entries from Dow and Clariant/Casale, which won awards for Best Process and Best Sustainable Process, respectively. These catalyst developments are geared towards more sustainable production and thus contribute to improving our climate.

But innovation is not just centred on Europe, as illustrated by the wide geographical spread of companies that entered the awards this year. Typically, in previous years, the majority of applications have been from Western firms, but this time there are several from Asian companies, especially from India. This is a new trend, points out Kratz, showing that innovation is happening everywhere, fitting individual/local needs and challenges.

Digitalisation too is another enabler of

Detlef Kratz
President of process research & chemical engineering, BASF

"No one company will have one solution for chemical recycling... It needs the whole value chain to be involved. That is where the future will be"



chemical innovation, and one that Kratz believes will drive and accelerate the pace of research and development.

While it appears that digitalisation in the chemical industry has moved past the "nice-to-have" phase into a "must-have" phase, many argue that the sector has been slow to embrace digital methods.

According to a poll conducted in November 2019 by chemical digital marketplace CheMondis together with the German arm of statistics institute Statista, less than half of participants surveyed believed that the chemical industry is well prepared in a digital age.

There is no doubt that Industry 4.0 – or the automation of traditional manufacturing and industrial practices – can bring significant benefits, including cutting costs, improving efficiency, safety and security, minimising errors and giving insight into customer behaviours. And most importantly, it will allow maintaining the speed of innovation required to adapt to the changing dynamics of markets.

Digital operations

BASF is making big efforts in digitalising its operations. For example, it is looking to implement a system that can leverage the exchange of near real-time data with vendors, as well as setting up a digital procurement process.

With increasing attention being paid on sustainable chemistry, let us also not forget the consumer. End-consumers are expecting their products to be greener and kinder to both the environment and their health, and this will continue to set a path for future innovation and product scoping, says Kratz.

Here, BASF has broken new ground in becoming the first chemical company to provide its customers with total values of CO2 emissions for its products. Using data from BASF's Verbund network and a new digital application, the Product Carbon Footprint consists of all product-related greenhouse gas emissions that occur until the product leaves BASF's factory gate – from the purchased raw material to the use of energy in the production process.

BASF said it has been calculating PCFs for individual products since 2007 and aims to calculate the PCF for its entire portfolio of 45,000 products by the end of 2021. Next to the benefit for its direct customers to decide on the best and most ecofriendly product, BASF sees this transparency along the industry value chain as a key element to drive innovation. Kratz says the company can distinctly identify the levers for improvement in its own production processes, and can also seek cooperation between industries. Thinking this through to the final products that land on retailers' shelves, it will allow the consumer to make a conscious choice on climate friendly products, triggering sustainable purchasing habits. ■

Product carbon footprints create transparency for customers

Digital application to calculate greenhouse gas emissions of 45,000 sales products





Chemical companies are playing a key role in changing the way markets operate

Powering through the cycle

Sustained success depends on continued investment in innovation and sustainability – especially at the bottom of the cycle

Andy Brice London

For Maroon Group, innovation is a journey. It is not an initiative or a project; it is an ongoing process that has reshaped the business in recent years, helping it expand its portfolio, increase its offerings and better support its customers.

The past few years have seen a raft of acquisitions and now, the business is about to be bought by Netherlands-based Barentz – a leading global distributor of life science ingredients.

Just like the chemical industry itself, Maroon Group is constantly evolving and adapting to change, says president & chief operating officer, Mike McKenna.

Historically focused on factory-packed buy and resell distribution, with logistics and warehousing capabilities and just-in-time service, the Ohio-based supplier of specialty chemicals and ingredients has grown to become one of the largest players in North America. McKenna says

its innovative approach has helped it adjust its business model to provide even better value for its customers, suppliers, and employees.

“We’ve made many acquisitions over the last couple of years and our business has grown significantly. One of the great things about this is that we get to share best practices and change for the better.”

Maroon Group has drawn from these complementary product portfolios and synergies to move beyond its traditional markets and grow, he says. He points specifically to the recent purchase of J. Tech Sales, a national distributor of specialty chemicals in the HI&I space, as an example.

“They had an amazing laboratory and a business model where 75-80% of the products sold were touched or formulated in some way by their technical team. We wanted to expand on this. We’ve since built labs in our CARE and CASE businesses, and we’ve done

the same in our plastics segment and for our food business in Canada.”

“Our customers now look at us much more than a factory pack distributor; they call us for help formulating products that are cleaner, greener, and more environmentally friendly. We can even take that a step further and coordinate the production of those materials.”

Amid the coronavirus pandemic, with economies faltering and widespread uncertainty, it is arguably more important than ever for companies to focus on innovation and be forward looking, he suggests. Indeed, the current climate has forced companies to reset and reassess how they operate.

For Maroon Group, innovation extends far beyond the development of new products and processes.

“We’ve made some fantastic strides in the past few years, but we’ve got much more to do and achieve. We’ve got the foundations but we’re trying to take a much more holistic approach.”

“Innovation is not just about the chemical molecule in the lab,” he says. “It’s about looking at how you change the supply chain, how to become more efficient in how you store and supply product, how you reduce your carbon footprint, and minimise the amount of packaging so customers don’t have as much waste. It’s always thinking about creative solutions and different ways to conduct business.”

Social responsibility

McKenna is proud that sustainability and corporate social responsibility is central to the company’s ethos – particularly as this is vitally important for recruiting and retaining the next generation of talent.

Millennials are not looking at potential employers because of the salaries, he says. This generation is asking whether there is a sustainability programme in place, the extent of your recycling efforts and how you support the environment. They want to know more about the role they will play in shaping the future.

Earlier this year, Maroon Group published its first sustainability report to highlight its achievements and identify future areas of development.

“We want to be a market leader in the specialty chemical and ingredient distribution space – and for that to happen you have to invest in safety, compliance and sustainability, and build on it. This is part of the DNA and culture of our business.”

“We have been supporting the ICIS Innovation Awards for 12 years and think it’s really important as a market leader to support and drive innovation. When we sit alongside the other sponsors and judges on that panel, it sends a message to the market that innovation will continue to be a major focus for our organisation as we continue to evolve. This resonates with our customers, suppliers, and our employees.” ■

Waste opportunity for the West

The circular economy can change the West's falling commercialised process technology position

Elaine Burridge London

The circular economy and energy transition offer refining and petrochemical companies a unique growth opportunity. However, to take advantage of these key trends, companies in the West – notably Europe and North America – need to up their game in developing and installing the latest process technologies, reversing the trend of past decades.

Research by global professional services group Accenture of 196 process technologies covering 84 major products shows that north-east Asia holds by far the largest share – 70% of commercialised petrochemicals and plastics technologies after 1985, with North America at 9% and Europe at just 4%. In addition, emerging markets are gaining in competitiveness, as evidenced by plant age and size as well as technology, notes Paul Bjacek, principal director and lead of global resources research.

Although the latest technologies have been mostly developed in Europe and the US, they have been deployed in past years in Asia, especially China, as companies chase the returns from higher-growth markets. The emergence of shale gas, however, has improved competitiveness in North America, which has seen a

slate of new ethylene/polyethylene investments – incorporating the latest technologies – during the past couple of years or more.

Looking ahead, Bjacek says that Europe and North America could potentially see a new wave of future investment based on changing supply chains and harnessing developed countries' waste as feedstock.

He highlights that the circular economy will be particularly important for Europe in securing feedstock supply in the future as the region has a deficit of natural resources. Waste from landfills will become a necessary resource, providing companies with the opportunity to develop and commercialise new technologies.

This is already happening, with many companies such as BASF, INEOS, Versalis and Neste, to name a few, making serious moves on developing chemical recycling processes to treat waste plastic, such as pyrolysis, depolymerisation and gasification, all of which Bjacek says could be applied in the West again.

Accenture's research shows that in the US, 56% of the waste sent to landfill in 2017 was plastic. According to trade association Plastics-Europe, 29.1m tonnes of plastic waste were collected in the EU28 plus Norway and Switzerland for treatment in 2018, with 24.9% sent to landfill.

It is worth noting that this year there were several submissions to the ICIS Innovation Awards in the area of the circular economy, for example tracking waste, increasing efficiency, and making graphene from waste feedstock.

Currently, one of the main issues surrounding the new chemical recycling technologies is that they are all in the early stages of development and have not yet been tried at large scale, with commercialisation still some five years or more away.

Nevertheless, Bjacek says the number of announced projects and investments has significantly increased during the past 12-18 months, illustrating that there is a major focus within both the chemical industry and the waste management sector in finding a route to reuse discarded plastics and close the loop. However, most of the project capacities are still below 50,000 tonnes/year.



Circularity in plastics is the centre of many sustainability measures

"There is a new impetus today with 75% of company announcements on circular economy related investments made in the past year alone," says Bjacek.

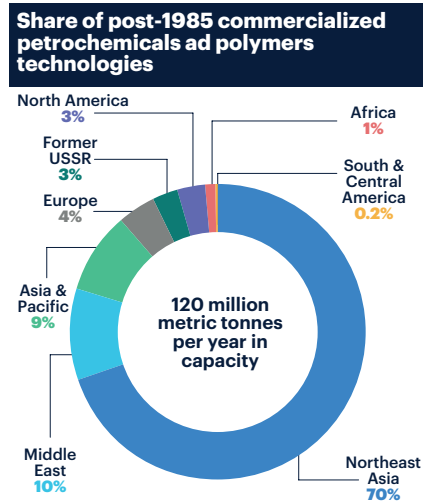
He adds that collaboration is a very key part of the solution, both in partnering with waste collection companies as well as governments and other technology providers. He adds that the refining industry in particular, more so perhaps than chemicals, has the most expertise in understanding how to optimise systems using different raw materials.

According to CICERONE, a European Horizon 2020 project, the annual generation of waste worldwide is predicted to increase by 70% by 2050.

As well as the shift to a circular economy, the coronavirus pandemic has highlighted the fragility of global supply chains, forcing companies to look at reshoring critical manufacturing closer to their domestic markets and becoming more self-sufficient.

As this reshoring is implemented, it will not make sense to use "old" technology, so there will be a move to greener and more sustainable operations, using the most modern processes.

For Bjacek, the winners in a circular and energy-efficient world will be those companies that have foresight, collaborate and are willing to take risks on new technologies and business models. ■



Source: Accenture Research analysis of ICIS Supply and Demand

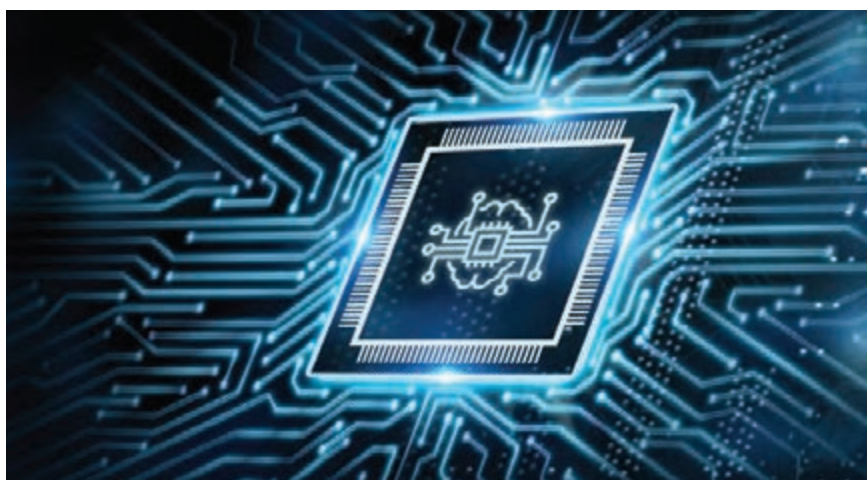
Choosing to create long-term value

Chemical companies that seek to survive the challenges ahead should rethink their traditional approaches to innovation, according to Deloitte

This rethink could entail capitalising on innovation by leveraging the advances in digital and materials science technology, collaborating with ecosystem partners, and focusing on business-model acuity.

One of the primary drivers of sustainable growth in the chemical industry continues to be innovation. However, chemical companies' age-old approach to innovation and the status quo might no longer be an option. This is because a staggering amount of change has taken place in the industry, and there may be more to come.

So, what has changed? The answer lies in the rise of digital technologies and open digital platforms used in material informatics. Value is migrating from the traditional research & development (R&D) departments of chemical companies to material informatics platforms. Until now, the process of discovering and developing new chemicals has remained largely unchanged and primarily lab-based. This made it difficult to predict the performance of materials under new conditions and required



Digitising chemical companies will be a key factor in innovation, according to Deloitte

many lab experiments, which were frequently expensive, unproductive, and time-consuming. There was often a disconnect between the accelerating pace of change in the marketplace and slowness of the innovation process.

To address this challenge, new startups that lie at the intersection of material science and computer science, called material informatics, are envisioning open digital platforms. These platforms have the capability to accumulate vast amounts of material knowledge from varied sources into a single, reliable, searchable format, and leverage machine learning algorithms to develop new innovations quickly and efficiently.

And more broadly, digital technologies are changing the basis of competition by unlocking potential value and making markets more accessible (figure 1). The applicability of advanced digital technologies assumes even greater importance in challenging scenarios such as the coronavirus pandemic. In response to the outbreak, digital technologies can help rapidly reengineer products to reduce costs in light of changing supply chains. For instance, startups using artificial intelligence (AI) to empower materials innovation are uncovering low-cost formulations in less than three months by evaluating, optimising, and assimilating ingredient recipes and domain knowledge.

Extended simulations and experiments can now be run on computers that digitally model

the product or process outcome, and help companies decide on the best combination of design, product, and process attributes that can make a solution highly functional. A few large chemical companies are heavily invested in such digital capabilities, allowing them to perform simulations costing a fraction of what actual experiments entail. Such simulations tend to help companies reduce failures during the product development phase and make physical laboratory tests more robust.

Therefore, to create sustainable long-term value, traditional chemical companies could consider leveraging advanced digital technologies and open platforms as well as collaboration and partnerships to reshape innovation. This may help in bringing and scaling new products and processes to market quickly and improve the return on innovation efforts. Industry leaders could begin by asking some key questions:

- Will the existing innovation strategies remain relevant, considering industry shifts?
- What strategic investments can be made now?
- Are there new business adjacencies, alternative revenue streams, or other new opportunities to consider?

Chemical companies that work to change established innovation practices and norms to navigate the innovation challenge most adeptly could be well-positioned to take full advantage of the opportunities to come. ■

Smart application development can help leverage existing materials to solve fragmented market needs



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