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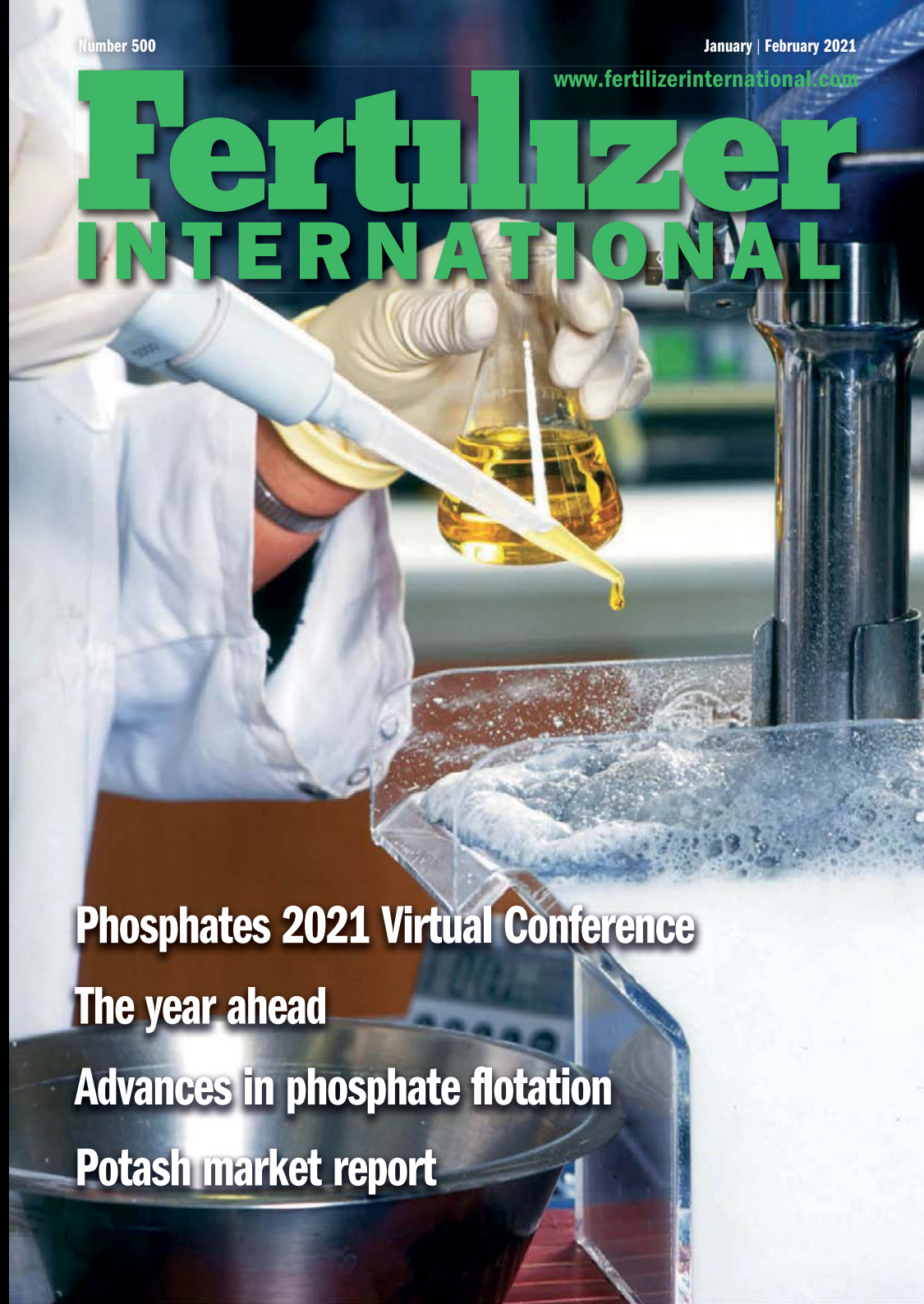
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Phosphates 2021 Virtual Conference

The year ahead

Advances in phosphate flotation

Potash market report



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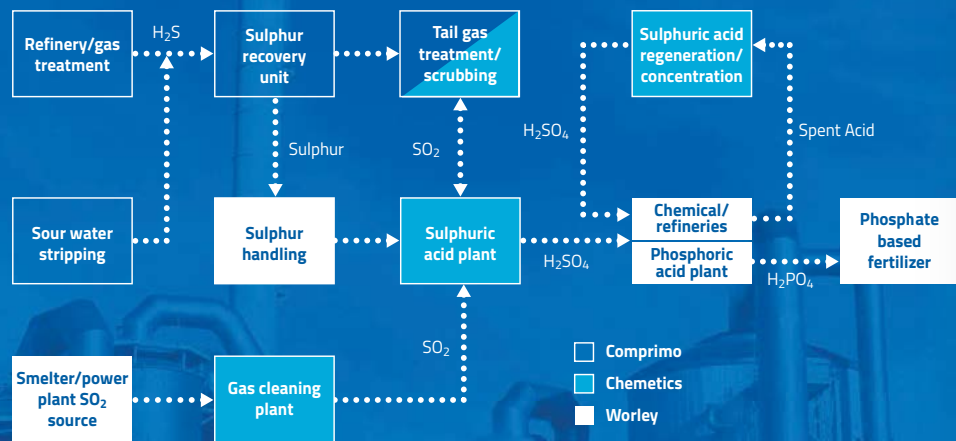
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Cover: Laboratory benefication test with a Denver flotation machine. Nouryon.



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The high stakes phosphate game



No one in this industry should ever need a reminder that commodity markets are cyclical. The corollary of that is – every once in a while – markets can, and will, abruptly change direction.

But, to paraphrase Kierkegaard, while life is lived forwards, it's understood backwards. Practically, this means that sea changes in commodity markets are usually only recognised months after they actually occur.

With the focus falling on the phosphates sector, ahead of CRU's *Phosphates 2021 Virtual Conference* in March, it is now apparent, with hindsight, that phosphate market fundamentals did shift over the summer of 2020. The year-and-a-half prior to last summer had been a largely bleak period, in terms of phosphate pricing and production economics, particularly for North American producers.

Take the Tampa diammonium phosphate (DAP) price, for example. Having reached a three-year high of \$438/t f.o.b. in August 2018, this major benchmark subsequently underwent a sustained 18 month slide. This lasted through the second-half 2018 and the whole of 2019, to finally reach a nadir of \$265/t in the first week of 2020. This price level marked a 10-year low-point, plumbing depths not seen since the notorious commodity crash of 2008/2009.

How to explain it? Well, oversupply and high import availability in 2019 certainly acted as major triggers for this price decline. While, conversely, it's been the tightening in the market since mid-2020, by prompting a substantial shift in the supply/demand balance, that has driven prices higher over the last eight months. The Tampa DAP price, for example, has recovered by more than \$110/t since May 2020 to \$390/t f.o.b. at the time of writing – and has even been selling at a premium of around \$20-50/t above the Indian DAP price.

Last year's rise in demand and fall in availability has been global in scope, acting across four key phosphate producing and consuming countries. US phosphate imports for the first nine months of 2020 (Q1-Q3) were down 820,000 tonnes, around one-third lower year-on-year (y-o-y). China's Q1-Q3 phosphate exports, meanwhile, were around 980,000 tonnes lower y-o-y in 2020, equivalent to a 13 per cent fall.

Elsewhere, resurgent phosphate demand in Brazil in 2020 boosted its Q1-Q3 imports by almost half a million tonnes, a y-o-y rise of close to 10 percent. India was also on the look-out for more phosphate imports last year, due to a shortfall in domestically-

produced DAP. The subcontinent's DAP production in Q1-Q3 was down by 450,000 tonnes in 2020.

Government intervention in the market has been another factor. North American producer Mosaic firmly believes the catalyst for the current price rally was its successful petitioning of the US government last summer. This move prompted the US Department of Commerce to impose duties on Russian and Moroccan phosphate imports from November (p8).

The introduction of these duties has certainly been a harbinger of change. Their imposition has already prompted dramatic shifts in global phosphate trade flows, as CRU's phosphates analyst Glen Kurokawa reports:

"Price spreads in the global and North American markets will change as a result. These duty rates are preliminary... [but have] potentially big consequences for the future of US and global phosphate trade – the stakes are big."

Looking ahead at the chances of further phosphates price recovery, the messages are distinctly mixed.

In the short term, Mosaic expected a \$50/t price uplift in 2020's final quarter. Yet other players are not so optimistic, especially when looking further ahead. Rival producer Nutrien, having written down the value of its US phosphate assets by \$760 million in November (p8), believes the phosphates market is fundamentally oversupplied – a fact that could limit the potential for price gains for years to come.

"We have a view that the market has a lot of fundamental oversupply in low-cost jurisdictions around the world," said Chuck Magro, Nutrien's president and CEO. "And that supply will only continue to increase."

Mosaic, however, offered a different perspective. Joc O'Rourke, its president and CEO, said: "It is very difficult for me to see how the long-term phosphate outlook was the triggering event for this write-down."

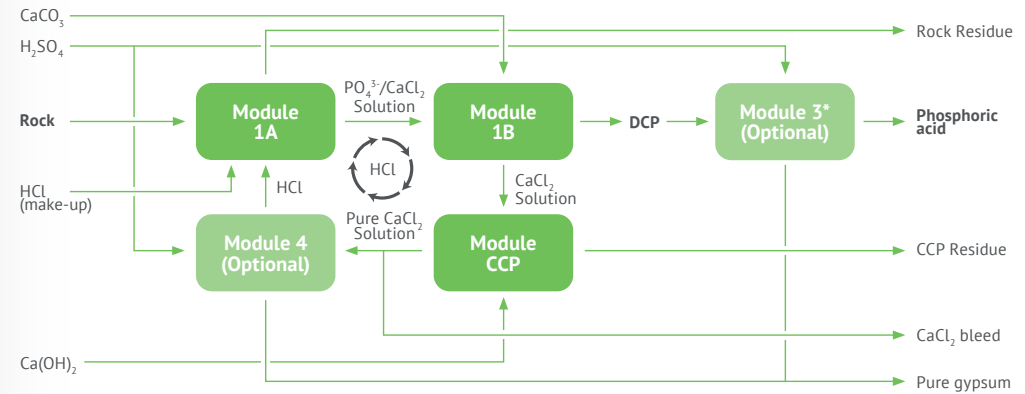
With such high stakes, the future of global phosphates production and trade will no doubt be a major talking point during CRU's forthcoming *Phosphates 2021* virtual event in late March. CRU's authoritative annual phosphates market outlook will no doubt offer-up some answers – providing another reason to attend what is always a lively, well-organised and informative conference.

S. Inglethorpe
Simon Inglethorpe, Editor



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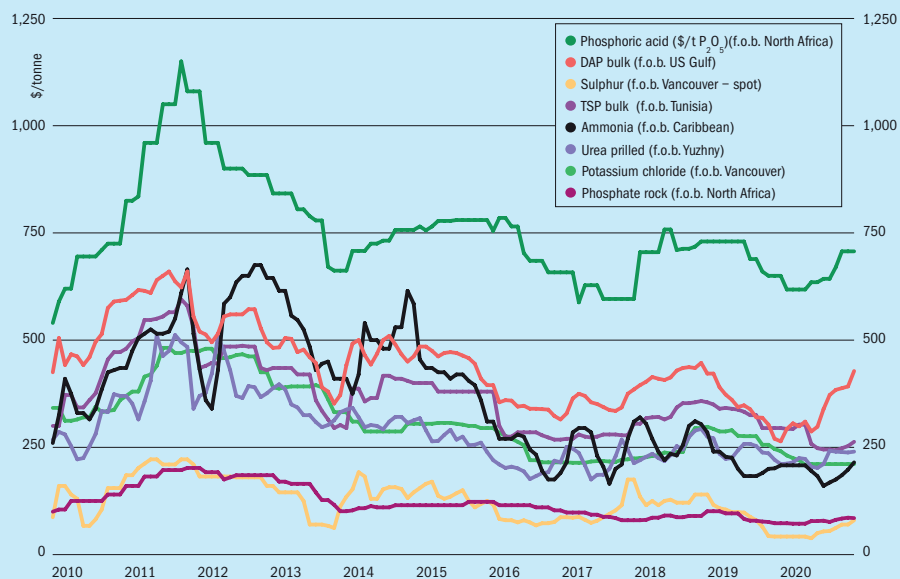
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Historical price trends \$/tonne



Source: BCInsight

Market Insight courtesy of Argus Media

PRICE TRENDS

Urea: The market started 2021 in a bullish mood, similar to where it left off last year. Market sentiment is being shaped by factors such as China's continued absence from the export market, the prospect of European and Turkish price, and US grain prices rises boosting US spring hopes. Most attention has been on markets west of Suez. US Barge prices have risen over \$20/st since Christmas, for example, supported by a grain price rally. Last minute seasonal buying in Brazil also saw granular prices there climb to over \$290/t cfr in early January. Suppliers, in general, have benefited from the firmer sentiment. Egypt has been forward selling into European markets in the range \$290-300/t f.o.b., with other sellers also adjusting their price targets higher.

East of Suez, meanwhile, price rises have been prompted by supply cuts rather than rising demand. Indonesia has sold in the range \$276-278/t f.o.b., a sharp jump

on previous business, benefitting from the lack of Chinese exports and reduced Malaysian supply.

Phosphates: The market, both east and west of Suez, began 2021 with price jumps of up to \$50/t. In Pakistan, a buyer bought a vessel of Chinese DAP at \$425/t cfr, significantly up on the mid-\$370s/t cfr price range of early December. Chinese export prices also rose, amid sales to Bangladesh and the fulfilment of South-east Asian tenders.

Importers in northwest Europe are now paying in the mid-\$330s/t fca for DAP, up almost \$20/t on December. Brazilian buyers are purchasing MAP from Morocco's OCP at \$420-430/t cfr, up from \$405-410/t cfr pre-Christmas levels. US DAP barge prices, in contrast, having first rallied and then stabilised, ultimately slid by \$4-5/st in mid-January.

Availability remains generally tight, with most global output already allocated

throughout the first-quarter. Low stock levels in India and Pakistan, plus out-of-season buying in Brazil, are exacerbating this global supply/demand imbalance.

NPKs: NPK and NPS prices mostly held level in early January on thin trading. However, market participants do expect strong gains when liquidity returns, given the leap in raw material prices since December.

Ukraine has been a notable source of demand. In December, 12,000 tonnes split across four Bulgarian cargoes (20-20-0+13S) were sold for January delivery to the Ukraine in the range \$305-320/t f.o.b. Varna. Additional Ukrainian demand for up to 30,000-40,000 tonnes of this grade is also possible for February-March delivery, one market participant said, although no deal has been closed.

The focus of Greek and Turkish producers on domestic markets has limited export capacity. A tender by Turkey's Pankobirlik to buy over 40,000 tonnes of NPKs and

Market price summary \$/tonne – Start January 2021

| Nitrogen | Ammonia | Urea | Ammonium Sulphate | Phosphates | DAP | TSP | Phos Acid |
|-----------------------|--------------|--------------------------------|--------------------------|------------------|------------------|----------|-----------|
| f.o.b. Caribbean | 205-230 | - | f.o.b. E. Europe 100-120 | f.o.b. US Gulf | 427-435 | - | - |
| f.o.b. Yuzhny | 204-230 | 240-260 | - | f.o.b. N. Africa | 375-405 | 250-275 | 654-759 |
| f.o.b. Middle East | 230-260 | 270-295** | - | cfr India | 365-385 | - | 689* |
| Potash | KCI Standard | K ₂ SO ₄ | Sulphuric Acid | Sulphur | | | |
| f.o.b. Vancouver | 182-240 | - | cfr US Gulf | 55-70 | f.o.b. Vancouver | 80-99 | - |
| f.o.b. Middle East | 180-240 | - | - | - | f.o.b. Arab Gulf | 98-106 | - |
| f.o.b. Western Europe | - | 470-550 | - | - | cfr N. Africa | 90-110 | - |
| f.o.b. Baltic | 180-240 | - | - | - | cfr India | 108-120+ | - |

Prices are on a bulk, spot basis, unless otherwise stated. (* = contract ** = granular). Phosphoric acid is in terms of \$/t P₂O₅ for merchant-grade (54% P₂O₅) product. Sulphur prices are for dry material. (+ Quotes for product ex-Arab Gulf). n.a. = not available.

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21,000 tonnes of nitrogen products closed on 15th January. This follows its November tender for almost 47,000 tonnes (12-32-12) awarded to a local producer at the end of last year.

Russian producers are set to load around 80,000 tonnes of NPKs in January for shipment to Thailand. Some crop sowing and fertilizer applications have already begun in north Thailand, ahead of the start of the country's main application season in May.

Sulphur: A number of contracts have been concluded for shipment during the first-quarter. Sulphur is being supplied to Morocco in the range \$78-94/t cfr, an increase of \$14-15/t on 2020's fourth-quarter. Tampa liquid sulphur sales have also been concluded recently at \$96/t Tampa Bay, a jump of \$27/t on the previous quarter. Middle East prices trended upwards in January. The market overall has been affected by demand outstripping supply.

OUTLOOK

Urea: Current firm demand west of Suez should carry the market over until the start of Australian and Thai purchasing later in the first-quarter. European and US buying is also ramping up. While Europe's buyers are playing catch-up after low autumn activity, the surge in US prices in late December is now making Nola an attractive spot market for urea.

Indian urea sales have fallen below expectations since August. Although the country is unlikely to tender again before late March/April, this will add support when it finally arrives. Reduced Chinese production and exports, plus production issues in some other countries, have mitigated this loss of demand.

Phosphates: The current upwards price momentum is set to continue throughout the first-quarter. With stock levels in India

and Pakistan falling to recent lows, resurgent DAP import demand in both countries is likely to tighten the market further. Elsewhere, continuing market firmness in the US has seen traders there scrambling to source product.

NPKs: The lack of loadings at Jorf Lasfar due to recent poor weather and the continuing climb of raw material prices have been the main factors shaping the market. Looking ahead, supply tightness is expected to continue, while European demand is set to ramp-up.

Sulphur: The market is expected to follow its usual pattern of softening prices as we move towards the summer months. But the expected price easing could be amplified in 2021, both by the emergence of new Middle Eastern capacity and the potential for rising refinery rates as quotas are eased.



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Fertilizer Industry News

UNITED STATES

US imposes phosphate import duties

The United States has imposed duties on Russian and Moroccan phosphate imports.

The following preliminary import duties were set by the US Department of Commerce (DOC) on 24th November:

- 20.94 percent on Russia's PhosAgro
- 23.46 percent on Morocco's OCP
- 72.5 percent on Russia's EuroChem.

At current price levels, these duties are expected to halt Russian and Moroccan phosphate shipments to the US, reports Argus Media, by returning the US Gulf coast to a net discount to Brazil on a cfr basis.

NOLA phosphate prices immediately leapt by \$10/st on the news, with February futures at \$380/st f.o.b. and March futures at \$384/st f.o.b., Argus reported.

US phosphate producer Mosaic had petitioned US authorities to impose import duties in July (*Fertilizer International* 497, p8).

"We appreciate the Commerce Department's diligent work on our countervailing duty petitions," said Mosaic's president and CEO Joc O'Rourke. "Mosaic believes in vigorous competition and free and fair trade, and that these foreign government subsidies must be addressed in order to level the playing field in the US market."

Import duties on Moroccan phosphate were subsequently corrected downwards from 23.46 percent to 16.88 percent by the DOC in January. This was due to an arithmetic error in the department's original calculation.

"We are gratified that the Department of Commerce has acknowledged and now corrected the error in the calculation of the provisional rate," OCP said in a statement. "OCP and

the Government of Morocco will continue to cooperate with US authorities to establish that there are no grounds for countervailing duties."

The currently imposed import duties are an interim measure and subject to change. The DOC is scheduled to make a final determination on these countervailing duties (CVDs) on 8th February. This will be followed by a decision by the US International Trade Commission on 25th March 2021 – with the whole matter due to be finally concluded by the start of April 2021.

US buyers had been reluctant to commit to large volume phosphate purchases during the autumn season. This was due to the perceived risk of carrying high-priced inventory into 2021, given that a resurgence of Moroccan and Russian shipments could have seen prices slide downwards.

Glen Kurokawa, CRU Group's phosphate analyst, commented: "We had been anticipating CVD orders to be imposed on OCP, PhosAgro, and EuroChem, and the DOC preliminary determination is certainly consistent with that view."

"Mosaic and other US phosphate fertilizer producers should be pleased with the result. The decision increases the likelihood they will receive some protection from imports from lower cost producers entering their home market."

Kurokawa added: "We've already seen dramatic changes in global phosphate flows since Mosaic filed its trade petition in July, and those changes could be cemented going forward. Price spreads in the global and North American markets will change as a result."

"These duty rates are preliminary so may yet change. However, they indicate potentially big consequences for the future of US and global phosphate trade. The stakes are big." ■

Nutrien writes down US phosphates assets

Canadian fertilizer giant Nutrien wrote down the combined value of its US phosphate plants at Aurora, North Carolina, and White Springs, Florida, by \$760 million in November.

The move followed a market reassessment by the company which resulted in a downwards revision to its long-term phosphates price forecast. Nutrien described the phosphates market as "fundamentally oversupplied" adding that this could limit the potential for price gains for years ahead.

"The reason for the impairment, to be very candid... is that we have a view that the market has a lot of fundamental oversupply in low-cost jurisdictions around the world," Chuck Magro, Nutrien's president and CEO, said in an investor call. "And that supply will only continue to increase."

Nutrien is North America's second largest phosphates manufacturer, after Mosaic, with a market share of around 25

percent. The company produced 354,000 tonnes of phosphate products (P₂O₅ basis) in the third-quarter of 2020, a year-on-year fall of five percent.

"Nutrien sees a bleak future for phosphate producers, adjusting lower the estimated value of its primary US phosphate assets as a result," commented Argus Media.

Nevertheless, Nutrien expects that improved farm economics will support fertilizer demand in the Americas in the short-term. The early US harvest in 2020 also provided a longer-than-usual time period for fall fertilizer applications.

The US phosphate industry has been convulsed by periodic mergers and plant closures stretching back several decades. This has seen the industry consolidate from 18 companies operating 22 production sites in 1990 to just four companies operating from 10 production sites currently (*Fertilizer International* 496, p40).

Nutrien ended phosphates production at the former Agrium-owned Redwater phosphates plant in 2017, a non-integrated

operation in Alberta, Canada. Despite this, the company still has the capacity to produce around five million tonnes of phosphate fertilizers annually in North America. While the Aurora plant could run for several decades ahead, Nutrien's White Springs operation is expected to exhaust its phosphate reserves by 2029.

Cronus extends EPC contract

US project developer Cronus Fertilizers has extended its engineering, procurement and construction (EPC) contract with thyssenkrupp Industrial Solutions (tkIS). The original turnkey contract, for the construction of the Tuscola, Illinois, ammonia plant, dates from October 2018. It will now run until the end of June.

Cronus is also finalising an additional operations and maintenance (O&M) agreement with tkIS. This will ensure thyssenkrupp is involved in keeping the plant up and running once it enters production.

The new contractual arrangements were announced on 15th December. tkIS also revealed that will become a minority

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shareholder in Cronus Fertilizers, as part of a strengthened partnership between the two companies.

Construction of the much-delayed 2,300 t/d capacity, \$1.7 billion Tuscola ammonia plant is currently scheduled to begin in the second half of 2021. Its completion would provide a major new source of locally-produced ammonia for the Midwest Corn Belt.

"We are looking forward to working in partnership with the Cronus team to realize this world-scale ammonia plant," said Dr Sami Pelkonen, CEO of the chemical & process technologies business unit at tkIS. "Our investment in Cronus Fertilizers demonstrates our commitment to this project and to Cronus' success in particular."

"We are developing one of the largest fertilizer facilities in the US and bringing together global experts to ensure the highest quality in both the construction and operations of the Cronus plant," said Meilih Keyman, chairman of Cronus Fertilizers. "We are proud to expand our partnership with tkIS on this important project."

Cronus says it will update the project's timeline as development proceeds. The project has missed a number of construction start dates since it was announced in October 2014.

CANADA

Nutrien launches carbon reduction programme for farmers

Nutrien has launched a pilot carbon reduction scheme in North America as part of a new sustainability partnership with its farm customers.

The scheme is aiming to embed and track sustainable farming practices and improve on-farm carbon performance. As part of this, Nutrien will help farmers to monetise their carbon performance by acting as a go-between in the buying and selling of carbon credits.

The new carbon reduction programme will help to reduce greenhouse gas (GHG) emissions and sequester carbon by promoting climate-smart products and sustainable practices. Nutrien, which operates an industry-leading digital platform, says it is well-equipped to measure the resulting improvements in financial, productivity and environmental performance.

Nutrien provides crop inputs and farm services to more than 200,000 growers worldwide, making it "uniquely positioned" to create a carbon reduction programme

at scale. Farmers will also have access to the expertise of Nutrien's in-house agronomy team. The new carbon programme will be piloted across North America in 2021 before being expanded to South America and Australia in future years.

Chuck Magro, Nutrien's president and CEO, said the new carbon programme would help farmers to practice and profit from sustainability:

"Nutrien is working to solve some of the world's biggest challenges: producing more food with less land, water and environmental impact. Our aim is to... help our growers benefit from sustainable practices and enable the purchase and sale of their carbon credits, while partnering with governments to help meet public environmental goals."

Looking ahead, the carbon offsets market is expected to grow by between 40-100 times globally by 2050, according to some estimates, due to the increasing focus on climate action. Agriculture is expected to be a leading participant in this growing market.

"Carbon has the potential to become a substantial economy that will go a long way towards realizing net zero agriculture. Our direct relationship with our growers will help them to be early movers in this space and see financial value from farming sustainably," concludes Magro.

NORWAY

Yara targets full-scale green ammonia production by 2026

Yara is planning to scale-up 'green' ammonia production from renewable energy.

The company announced plans to completely electrify its Porsgrunn ammonia production plant in Norway at an online investor seminar on 7th December.

Yara is aiming to eliminate CO₂ emissions from the 500,000 t/a capacity Porsgrunn plant and at the same time dedicate its output to emissions-free shipping fuel, carbon-free fertilizer production and green ammonia for industrial purposes.

Complete electrification of Porsgrunn has the potential to cut 800,000 tonnes of CO₂ annually, equivalent to the emissions generated by 300,000 cars each year. By eliminating one of Norway's largest static CO₂ sources, the project would also make a major contribution to Norway's Paris Agreement climate commitments.

Yara has set itself the goal of reducing its Scope 1 and Scope 2 emissions by 30 percent by 2030. It is also collaborating with Nutrien and the World Business

Council for Sustainable Development on a sector-wide approach to nitrogen industry decarbonisation.

Completely electric production of ammonia at Porsgrunn could commence by 2026, according to Yara, although this is conditional on public co-funding and a supportive regulatory framework.

The full-scale green ammonia project is part of a wider Yara strategy to broaden its core business to encompass the hydrogen economy, as well as crop nutrient markets.

"Ammonia is the most promising hydrogen carrier and zero-carbon shipping fuel, and Yara is the global ammonia champion – a leader within production, logistics and trade," said Svein Tore Holsether, Yara's president and CEO. "I am excited to announce that a full-scale green ammonia project is possible in Norway, where we can fully electrify our Porsgrunn ammonia plant."

Yara is hoping to capitalise on its leading position as an international ammonia producer and trader to capture emerging low-carbon shipping, agriculture and industrial opportunities. This market is expected to grow by 60 percent over the next two decades. The company is actively seeking partners and government support to turn its vision of zero-emission ammonia production in Norway into reality.

In recent months, rival ammonia producers such as Nutrien (*Fertilizer International* 499, p8) and Fertiherbia (*Fertilizer International* 499, p9) have also committed to producing green ammonia at scale.

Yara also wants to use its large global presence to improve on-farm carbon management and cut crop-related emissions.

"Yara is uniquely positioned to help decarbonise the food chain, with trusted relationships with millions of farmers in 65 countries," said Terje Knutsen, the company's executive vice president for farming. "We see a clear opportunity to contribute to sustainable agriculture, while at the same building new business for both farmers and for Yara. As an example, we can directly address 70 percent of corn crop emissions with optimal crop nutrition and soil health measures."

RUSSIA

PhosAgro expands digital farming project

PhosAgro-Region, Russia's largest fertilizer distributor, will expand the domestic use of digital farming to cover more than 100,000 hectares in 2021.

The expansion of digital services to Russian farmers was unveiled as part of a new cooperation agreement with Exact Farming. This will build on an existing joint project that is piloting Exact Farming's digital app for remotely monitoring fertilizer use.

The digital system developed by both companies automatically records fertilizer data from tags on PhosAgro fertilizer bags. The data are read by mobile phones and automatically transmitted to Exact Farming's agronomic satellite monitoring system. Precise volumes and grades of fertilizer are then allocated to specific geographical coordinates. In the future, this system will track crop growth/health alongside data on the crop nutrients applied.

PhosAgro's current digital farming pilot project covers more than 23,000 hectares in 20 Russian regions. As a result of remote monitoring and changes to crop nutrient plans, the project has already increased crop yields by 10 percent in 2020. This generated additional profits of around RUB 5,000/hectare for participating agricultural producers.

The new automated services offered by PhosAgro and Exact Farming will improve agronomic support for users by including soil analyses and fertilizer recommendations. A constantly updated database will also provide more accurate information on how fertilizers perform under various agronomic and meteorological conditions.

Uralchem acquires a controlling stake in Uralkali

Major Russian nitrogen producer Uralchem has finally acquired a controlling interest in Uralkali, one of the world's largest potash producers.

The purchase of a new tranche of shares, announced on 2nd December, increased Uralchem's ownership stake in Uralkali to more than 75 percent. This was financed through a long-term loan with Russia's Sberbank.

The controlling interest will allow both companies to improve "the efficiency of production, logistics, and sales", Uralchem said in a statement. This includes jointly providing customers with combined "nitrogen, potassium, and phosphorus" product packages in "key consumer markets around the world".

Dmitry Mazepin, Uralchem's chairman, said: "[The] acquisition of a controlling stake in Uralkali is a commercial project based on the high marginality of the pot-

ash fertilizer market, confidence in its further growth, and stable demand for the company's products. We see the potential for increasing the efficiency of Uralchem and Uralkali due to shared experience, standardization of processes, and joint application of the best practices."

SUDAN

Uralchem and Uralkali in talks to jointly supply Sudan

Uralchem and Uralkali plan to start supplying Sudan with fertilizers in 2021. The two companies already have an export partnership, jointly supplying products to Zimbabwe, Zambia, Kenya, Angola and Mozambique.

Closer business ties with Sudan were unveiled by Dmitry Mazepin during a visit to Khartoum in early December. Mazepin, who is also a leading member of Russian business group RSP, held talks with Sudanese vice president lieutenant general Mohamed Hamdan Dagalo and the country's prime minister Abdalla Hamdok during the visit.

"We believe that Sudan can become the platform in the Eastern part of Africa where we can significantly increase our position as a fertilizer seller," Mazepin said. "Uralchem and Uralkali, for their part, will do their best to promote mutually beneficial and friendly relations between Russia and Sudan. We plan to start supplying fertilizers to the country in 2021".

Lieutenant general Mohamed Hamdan Dagalo said: "Sudan has large areas of land and is interested in developing agriculture and attracting foreign investors. Uralchem can show by its example that our country is ready and open to long-term cooperation with Russia. And the new government will do everything possible for this."

CHINA

Forbon and OCP launch joint R&D venture

China's Hubei Forbon Technology has entered into a 50/50 joint venture (JV) with Moroccan phosphate giant OCP. This will allow both companies to collaborate on research and development (R&D) to develop the next generation of fertilizers products and 'smart' agricultural technologies.

Forbon is a leading Chinese fertilizer additives manufacturer and is also highly active in digital agriculture. The new JV, announced in early January, will be located in the East Lake New Technology Development Zone in Wuhan, China.

"OCP has put innovation as a cornerstone of its growth strategy," said Soufiane El Kassi, OCP's chief growth officer. "Being located in the East Lake New Technology Development Zone in Wuhan, the JV will have access to one of the largest and most dynamic network of professionals involved in innovation, as well as leading universities and research centers in China working on the future of agriculture."

Wang Renzong, chairman & CEO of Forbon, said: "OCP and Forbon have the same vision and ambition for the future of agriculture. With its expertise in artificial intelligence, sensors, precision equipment, the internet-of-things and digital technology, Forbon together with OCP could bring to farmers the best customized solutions for a sustainable and innovative agriculture."

Closure of the new JV agreement is subject to customary conditions and regulatory approvals.

SAUDI ARABIA

Ma'aden renews agreement to supply Bangladesh

Saudi Arabia's Ma'aden has signed a year-long phosphate fertilizer supply agreement with the Bangladesh Agricultural Development Corporation (BADC) for 2021.

State-owned BADC works with the Bangladesh Ministry of Agriculture to manage the country's agricultural imports.

Ma'aden will supply BADC with diammonium phosphate (DAP) under a renewed contract agreed at the end of December. The terms of the contract, including the tonnages to be supplied, have not been disclosed.

Mosaed Al Ohali, Ma'aden's CEO, said: "We are pleased to build on our strong partnership with BADC to supply the agricultural industry in Bangladesh with the fertilizer products local farmers need to make the most of their crops. This new agreement will play an important role in boosting crop output and contributing to stable food supplies in the country."

He added: "With the natural phosphate deposits in the north of Saudi Arabia and proximity to promising markets in South Asia and East Africa, we are in a strong position to serve the globally growing need for fertilizer products. By 2025, we estimate reaching a phosphate fertilizer production capacity of nine million tonnes."

In 2019, Ma'aden strengthened its access to the African market via the acquisition of fertilizer distribution company Meridian Group. ■

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People

Alexander Prygunkov became Uralchem's new CEO on the 4th December. Mr Prygunkov, who was formerly PIK Group's chief operating officer, will focus on the digital transformation of the company. He is also expected to strengthen Uralchem's position in the chemicals and agricultural industries, and introduce a more modern approach to business management.

Alexander has occupied a number of high-level operational and financial management positions. During a successful career at PIK, he notably implemented a digital strategy and helped create Russia's largest residential real estate management company. Mr Prygunkov holds an honours degree in finance from Volgograd State University.

Vitaly Lauk was appointed as Uralkali's new CEO on 4th December. Vitaly was previously Uralkali's technical director. He succeeds **Dmitry Osipov** who has stood down to focus on other projects at the company.

Dmitry Mazepin, the chairman of Uralchem and deputy chairman of Uralkali, thanked outgoing CEO Dmitry Osipov: "We are grateful for the significant contribution he has made to Uralkali's development. Under his leadership the company has retained its leading position in the global potash market."

"I would like to express my gratitude to the shareholders, the board of directors, the management team and employees of Uralkali for their help and support," replied Dmitry Osipov: "My work at Uralkali has enabled me to gain invaluable managerial experience, new skills and expertise,

which has been possible largely due to the company's effective positioning in key potash markets."

Incoming CEO Vitaly Lauk said: "I recognise that my appointment reflects a deep level of trust on the part of both our shareholders and the board of directors. Supported by the longstanding expertise and professionalism of the management team and employees, the company will continue its strategic development aimed at maintaining its leading position in the sector."

Mr Lauk holds a degree in underground mining from Perm State Technical University and an MBA from the St Petersburg International Institute of Management. He joined Uralkali in 1990 as a mine worker before being appointed deputy technical director in 2016. Vitaly has been the company's technical director and a member of Uralkali's management board since 2017.

Itafos appointed **G David Delaney** as CEO at the end of November. Mr Delaney has been an independent company director at Itafos since February 2017. He succeeds **Dr Mhamed Ibnabdeljalil** who has served as CEO since May 2019.

Mr Delaney is a senior business executive with over 30 years' experience in fertilizer and agricultural industry leadership roles. He was previously the chief commercial officer of the Farmer's Business Network, an independent group that links together thousands of North American farmers. Prior to that, Mr Delaney was a strategic advisor to Paine Schwartz Partners, a private equity firm with interests in the food and agricultural sectors. Before

that, he was chief operating officer and executive vice president at Potash Corp.

"The board is extremely pleased to have David as CEO. David is highly respected within our industry and has been an independent director of the company for several years," said Anthony Cina, the chairman of Itafos. "His in-depth knowledge of both the industry and company, combined with his collaborative leadership style and adaptability, will serve both him and the company well."

BASF CEO **Dr Martin Brudermüller** was elected as the new president of Cefic in October 2020. He succeeds **Daniel Ferrari**, the CEO of Versalis, who was president for the previous two years.

Marco Mensink, Cefic's director general, welcomed Dr Brudermüller's election: "With more than 30 years' experience in various roles in the chemical industry, he will be able to lead us to deliver on the Green Deal objectives. Additionally, his strong belief in cooperation with stakeholders will help Cefic to continue to act as a dialogue partner with the European institutions and societal actors."

Dr Brudermüller set out his ambitions for Cefic: "The EU chemical industry has the capability, know-how and is developing the innovative technologies to deliver on the challenges we are facing today and in the future. The Green Deal is designed as a turning point for Europe and the chemical industry stands ready to support its objectives. The pandemic is one of many instances where we have shown that our sector is resilient and reliable." ■

The year ahead:

resilient but not immune



PHOTO: US NAVY MEDICINE

As the Covid-19 pandemic continues, we look ahead at fertilizer industry prospects for the next 12 months, including the key economic and agricultural drivers likely to shape the market during 2021.

Economic backdrop

The exceptional contraction in economic activity triggered by the Covid-19 pandemic in 2020 looks like being far worse than the Great Recession of 2009. The world economy is currently projected to shrink by 4.4 percent in 2020, according to the latest International Monetary Fund (IMF) forecast. Although world-wide growth is expected to rebound sharply this year, rising by 5.2 percent overall in 2021, the extent and speed of this recovery, for individual countries and from region-to-region, remains unpredictable.

Alongside the headline economic impacts, the pandemic's signature features – widespread and intermittent national lockdowns, disruptions to international trade and travel bans – have created paralysing business uncertainty. These disruptions have also been accompanied by alarming levels of foreign exchange rate and commodity price volatility.

Oil prices, for example, collapsed by two-third during the first-half of 2020 before rallying in the year's second-half. Brent crude, which dropped from \$68 to \$23 between January and May, ended 2020

at \$50 a barrel – a remarkable rally that few predicted would happen so soon. Food commodity prices have been on a similar rollercoaster ride, having fallen to three-year lows in May 2020 before rallying to six-year highs by the year's end.

The fertilizer market, while not immune from the pandemic and its consequences, has proved to be remarkably resilient during 2020 – faring much better than originally expected. This reflects the better-than-average performance of the wider agricultural sector, as the International Fertilizer Association (IFA) recently reported:

"Food and agriculture are essential sectors, in which production and transportation continued during lockdowns. Moreover, bulk shipping, the main transport mode for agricultural goods, has been far less affected by restrictions than other forms of transport.

"In addition to categorising agriculture and fertilizers as essential, major jurisdictions have moved swiftly to support their agriculture and fertilizer sectors."

As the time of writing, business and financial markets are operating under the assumption that the pandemic will be brought under control by the end of 2021,

Above: Covid-19 vaccination at the Naval Medical Center, San Diego.

Calendar 2021

FEBRUARY

16-18

CRU Nitrogen+Syngas USA, TULSA, Oklahoma, USA

Contact: CRU Events

Tel: +44 (0) 20 7903 2444

Email: conferences@crugroup.com

MARCH

1-3

CRU Nitrogen+Syngas 2021

Virtual event

Contact: CRU Events

Tel: +44 (0) 20 7903 2444

Email: conferences@crugroup.com

! The following events may be subject to postponement or cancellation due to the global coronavirus pandemic. Please check the status of individual events with organisers.

8-12

IFA Global Stewardship Conference,

Virtual event

Contact: IFA Conference Service

Tel: +33 1 53 93 05 00

Email: ifa@fertilizer.org

23-25

CRU Phosphates 2021, Virtual event

Contact: CRU Events

Tel: +44 (0) 20 7903 2444

Email: conferences@crugroup.com

MAY

26-28

IFA Plant Nutrition Solutions Conference

Virtual event

Contact: IFA Conference Service

Tel: +33 1 53 93 05 00

Email: ifa@fertilizer.org

JUNE

11-12

AICHe Annual Clearwater Conference,

CLEARWATER, Florida, USA

Contact: Miguel Bravo, AICHe Central

Florida Section

Email: vicechair@aiche-cf.org

28-30

IFA Annual Conference,

LISBON, Portugal

Contact: IFA Conference Service

Tel: +33 1 53 93 05 00

Email: ifa@fertilizer.org

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although uncertainty remains about the speed of both vaccine development and immunisation (see main photo).

While the lingering effects of Covid-19 are not expected to cause major disruption to fertilizer supply and distribution during 2021, there are concerns that advanced purchases made by farmers at the height of the pandemic could lessen fertilizer sales this year and into next¹.

Global growth – calamity, not catastrophe

Despite a recent upgrade to its growth forecast, the International Monetary Fund (IMF) is sticking by its forecast of a deep global recession, and currently expects the world economy to shrink by 4.4 percent in 2020.

This latest forecast bleakly illustrates the complete reversal of fortune that Covid-19 has inflicted on the world economy, given that the IMF was forecasting a global economic expansion of three percent for 2020 just 12 months ago (*Fertilizer International* 494, p22).

Gita Gopinath the IMF's chief economist, did not pull her punches – calling last year's economic collapse a calamity:

"This is the worst crisis since the Great Depression, and it will take significant innovation on the policy front, at both the national and international levels to recover from this calamity. The challenges are daunting. But there are reasons to be hopeful."

She added: "The ascent out of this calamity is likely to be long, uneven, and highly uncertain. It is essential that fiscal

and monetary policy support are not prematurely withdrawn."

Nevertheless, Ms Gopinath singled out for praise "the exceptional policy response" of governments during the Covid-19 pandemic, saying this was "a powerful reminder that well-designed policies protect people and collective economic wellbeing".

Timely government intervention during 2020 had "saved lives and livelihoods and prevented a financial catastrophe" in her view. Global fiscal support of nearly \$12 trillion, extensive interest rate cuts, injections of liquidity, and asset purchases by central banks have all helped to lessen effects of the Covid-19 pandemic.

The IMF is currently forecasting a strong rebound in global growth of 5.2 percent in 2021. Following a healthy recovery this year, the IMF expects annual global growth to then slow to around 3.5 percent over the medium term. The economic prospects of the advanced economies also look set to diverge from those of emerging and developing nations.

Advanced economies, which are projected to contract by 5.8 percent in 2020, look set to rebound with 3.9 percent growth in 2021. Emerging market and developing countries, meanwhile, which are projected to contract by 5.7 percent in 2020, are forecast to recover faster with five percent growth this year.

The pandemic will result in a cumulative loss in global output costing 11 trillion dollars over the short-term (2020-2021), according to the IMF, rising to 28 trillion over the medium-term (2020-2025).

"This represents a severe setback to the improvement in average living standards across all country groups," it comments.

The IMF warns of the "tremendous uncertainty" surrounding the world economic outlook due to both downside and upside risks.

A resurgence of the virus, further lockdowns, and a deterioration in the prospects for treatments and vaccines all carry downside risks, in the IMF's view: "The toll on economic activity would be severe, and likely amplified by severe financial market turmoil. Growing restrictions on trade and investment and rising geopolitical uncertainty could harm the recovery."

While on the upside, faster and more widespread Covid-19 testing, when combined with effective treatments and vaccines, could significantly improve economic outcomes this year, concludes the IMF, especially when coupled to extra policy stimulus.

Food prices reach six-year high

As 2020 drew to a close, the FAO's Food Price Index (FPI) reached its highest level since the end of 2014, averaging 105.0 points in November, nearly seven percent (6.4 points) higher than a year ago. November's gains were driven by across-the-board price rises, led by vegetable oils followed by sugar, cereals, dairy and meat.

The November 2020 vegetable oil price index (121.9 points) reached its highest level since March 2014, after a stunning month-on-month gain of nearly 15 percent (15.4 points). The rally was driven by the combination of a spike in palm oil prices and

markets. **Farm economics** and attendant issues such as credit availability and barter ratios have a more direct impact on the ability of farmers to purchase fertilizers.

Crop prices and fertilizer-to-crop price ratios act as key controls on crop nutrient demand as they play a critical role in determining farm buying power and fertilizer affordability. Crop prices in turn are driven by the **harvest size** annually, **stock levels** and **demand** for agricultural commodities. Fertilizer industry analysts pay particularly close attention to the prices of cereals, oilseeds, cotton, sugar and palm oil, the main fertilizer-consuming crop types globally.

The **biofuels market** is also an important driver of fertilizer demand due to large-scale cultivation of maize and sugarcane for ethanol and oilseed rape (canola) for biodiesel (*Fertilizer International* 474, p22). Crop failures due to extreme weather events such as the **El Niño** (*Fertilizer International* 475, p38) and **La Niña** can also affect fertilizer demand in the short-term. ■

Table 1: Global fertilizer demand forecast, million nutrient tonnes*

| Nutrient | 2021/2022f | 2020/2021f (million tonnes) | 2019/2020e (million tonnes) | 2018/2019 (million tonnes) | 2017/2018 (million tonnes) |
|-------------------------------|---------------|--------------------------------|--------------------------------|-------------------------------|-------------------------------|
| N | 109.5 (+1.0%) | 108.4 (+1.6%) | 106.7 (+2.7%) | 103.8 (-1.9%) | 105.8 |
| P ₂ O ₅ | 49.0 (+0.9%) | 48.6 (+3.2%) | 47.1 (+2.5%) | 45.9 (-1.3%) | 46.5 |
| K ₂ O | 37.0 (+1.3%) | 36.6 (+1.4%) | 36.1 (-2.8%) | 37.1 (-1.6%) | 37.7 |
| Total | 195.6 (+1.1%) | 193.5 (+2.0) | 189.8 (+1.6%) | 186.8 (-1.7%) | 190.0 |

* Year-on-year percentage increase in parentheses. e = estimate, f = forecast

risers in soy, rapeseed and sunflower seed oil values. International palm oil price quotations rose for a sixth consecutive month in November, linked to falling world inventory levels and firm global import demand.

The cereal price index (114.4 points) has risen by 20 percent (19.0 points) since November 2019, having increased for five consecutive months in a row. Wheat export prices have edged upwards on the prospects of tighter export supplies and a reduced Argentinian harvest. Maize prices have been supported by large Chinese purchases and cuts to US and Ukraine production estimates. Firm demand has continued to push up barley and sorghum prices, while international rice prices have held steady.

The sugar price index rose by three percent (2.8 points) in November to reach 87.5 points, its second consecutive monthly increase. A forecast fall in 2020/21 global production, due to weaker crop yields in the EU, Thailand and Russia, have driven up international sugar quotations. Sugar prices have also been supported by hurricane damage to sugarcane crops in Nicaragua, Honduras and Guatemala.

Agricultural commodities: bull run defies expectations

The rally in agricultural commodity prices in 2020 has confounded expectations, according to Rabobank's latest annual outlook.

"The 2020 bull run in agri commodities defied all expectations and proved immune to Covid-19's economic and social consequences," says Rabobank: "While coffee and cocoa suffered, grains & oilseeds reached multi-year highs. Even palm oil and sugar – commodities closely associated with the energy market and therefore GDP growth – performed remarkably well."

The bank identified a number of factors behind the price rally of the last 12 months, including:

- Speculators buying record amounts of agricultural commodity futures in 2020 as investment assets, amplifying the price upside
- Very resilient demand – particularly from China – resulting in only a small global wheat surplus and dwindling stocks of corn and soybeans
- Many countries seeking to guarantee their domestic supplies of agricultural commodities – particularly for wheat – leading to a scramble for available stocks.
- La Niña affecting farmers across the globe, worsening the availability of a range of agricultural commodities.

The "very visible" consequences of La Niña will continue to drive up prices in 2021, according to Rabobank. Risks are elevated in South America due to the start of key crop periods there. Dryness in the south of Brazil and parts of Argentina, for example, has already affected sugarcane and wheat harvests and soybean planting. A lack of snow cover this winter, again linked to La Niña, could negatively affect the wheat crop in both the US Midwest and Russia, potentially leading to much lower exportable availability.

Rising food prices have been at the top of the list of concerns for many governments, according to Rabobank: "Dry weather events and speculations have been driving prices higher over 2020, with the Bloomberg Agriculture Spot Index, based on nine crop prices, rising 28 percent since late April, to its highest level in more than four years, led by increases in wheat, corn, soybeans, and sugar."

As a consequence, Rabobank expects to see greater stock piling of agricultural commodities by importing countries accompanied by diminishing stock levels in the countries of origin.

Resilience has been global agriculture's defining characteristic during 2020, reports Rabobank: "Agricultural supply

chains have shown incredible resilience in 2020, with only minor delays at certain ports and very few localized issues. Agriculture was mostly spared from the global slump in international trade."

Despite bucking the general trend last year, agriculture faces an uncertain outlook in 2021, with US-China relations, in particular, likely to remain tense. While Rabobank expects a strengthening US dollar to result in weaker prices for US agricultural commodities in 2021, it does not expect Brazil's currency to return to the weaker levels seen last year.

Fertilizer demand

Disruption – initially by extreme weather and then by the Covid-19 pandemic – has undoubtedly been the key watchword governing the fertilizer market over the last two years. This could well continue too, given the likely prospect of La Niña effects next year.

Fertilizer demand has yo-yoed in recent years. Going back to 2019, Nutrien infamously described the spring that year as "the worst US planting season in history" after record rainfall prevented crop planting across 10 million acres – a new US record. This followed and compounded a poor US fall application season for fertilizers in 2018.

These unfavourable North American market conditions actually tipped world fertilizer demand into reverse in 2018/19. Global fertilizer consumption did, however, subsequently recover by 1.6 percent in 2019/20 to reach 189.8 million nutrient tonnes, according to the International Fertilizer Association (IFA), almost reversing the contraction of the previous year (Table 1, Figure 1).

The global recovery in fertilizer use seen in 2019/20 was led by India, which enjoyed abundant monsoon rains, and the US, which, at long last, benefitted from

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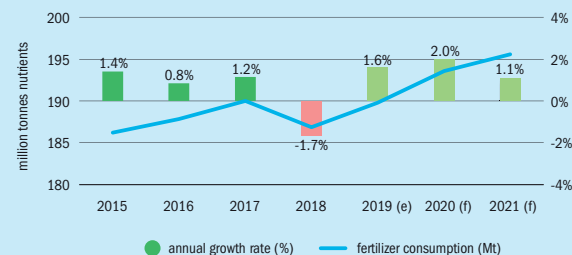
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Fig. 1: World fertilizer consumption (nutrient tonnes) and annual growth rate: 2015/16-2020/21



Note: 2019/20 = estimated. 2020/21 & 2021/22 = forecast. Source: IFA (November 2020)

favourable weather conditions. As a consequence, South Asian and North American fertilizer use both increased by almost six percent in 2019/20, each region adding 2.0 million tonnes and 1.4 million tonnes to nutrient demand, respectively¹.

Then Covid-19 happened. With the pandemic's arrival in March 2020 further large-scale disruption to the fertilizer market looked almost inevitable, given the unprecedented damage inflicted on other parts of the world economy. As late as May 2020, IFA was forecasting a three percent year-on-year decline in global fertilizer demand in 2020. This would have been the largest contraction in the fertilizer market since the eight percent drop that occurred during the global financial crisis more than a decade ago.

When the Covid-19 crisis began last spring, potash and phosphate consumption were thought to be particularly vulnerable to supply disruption and falling demand. This reflected the reliance on imports in key consuming countries, as well as the expected negative impact of the pandemic on potash- and phosphate-hungry crops such as fruit and vegetables, sugar and palm oil. Nitrogen consumption, in contrast, was expected to be more robust and inelastic. Nitrogen demand was known to have held up well during past economic downturns, due to its association with broad acre agriculture and the production of food staples.

Contrary to initial forebodings, the fertilizer market proved to be remarkably resilient as 2020 progressed, bucking the general economic trend and confounding the original downbeat expectations. The fertilizer sector instead overcame the

widespread economic paralysis from Covid-19 lockdowns to rebound strongly during 2020. Indeed, IFA currently expects world fertilizer demand to grow by two percent in 2020/21 to reach 193.5 million nutrient tonnes¹, boosted by a particularly healthy year-on-year rise in phosphate consumption (Table 1).

A number of factors have sustained fertilizer demand during the pandemic (see box). In particular, national governments moved quickly to prioritise food supplies – introducing mitigation measures that supported and protected the fertilizer industry and the wider agricultural sector. Demand has also been bolstered by attractive fertilizer-to-crop price ratios in 2020 and favourable weather conditions in key end-markets. Weakening of domestic currencies, versus the US dollar, has also boosted profits in key agricultural exporting countries¹.

Indian agriculture again enjoyed a good monsoon in 2020. As a consequence, *Kharif* season sowings have increased, with prospects for the *Rabi* season looking similarly good. The subcontinent has emerged as the single biggest contributor to global growth in fertilizer demand last year, according to IFA, with India alone expected to account for over half the world's total extra consumption during 2020/21. Higher consumption in the Americas (Brazil, United States, Argentina, Mexico, Canada), Asia-Pacific (Pakistan, Bangladesh, Australia, Philippines) and Russia also look set to contribute to rising global demand over this period.

IFA expects fertilizer demand growth to slow this year and into next. The association is currently forecasting an increase of one percent in global fertilizer demand in

2021/22 – equivalent to a 2.1 million tonnage rise to 195.6 million nutrient tonnes (Table 1). Regionally, sizable increases in fertilizer consumption are still expected in South Asia, Eastern Europe, Central Asia, Latin America and Africa. Such gains could be partly countered by a range of negative factors, suggests IFA, including¹:

- The likelihood of La Niña weather events
- Lower demand due to advance fertilizer purchases in 2020
- The effects of a patchy and uneven global economic recovery in 2021 on fertilizer purchasing behaviour and financing, as well as overall consumer food demand
- Introduction of new regulations that limit fertilizer use in China, Europe and New Zealand.

More positively, IFA notes that fertilizer usage is being underpinned by last year's strong recovery in crop prices, and supported by the rebuilding of the Chinese swine herd, which should improve feed demand¹.

Fertilizer production and trade

Urea: Preliminary estimates suggest world urea production was particularly resilient in 2020, increasing by almost three percent to 182 million tonnes (+ 5 million tonnes). Similarly, global urea exports – equivalent to almost 30 percent of world production – also increased vigorously last year (+3.4% to 52 million tonnes).

Three countries combined – India, Brazil and the US – accounted for more than forty percent of global urea imports during the year. Thailand, Australia and Vietnam were the other major import destinations. Ukraine's return as a major exporter, after four preceding years of decline, was a notable feature of last year's urea market feature. Urea exports to Indonesia also increased significantly in 2020¹.

World urea capacity is projected to grow by three percent in 2020 and 2021 to reach 223 million tonnes (+14 million tonnes). New urea capacity is expected in India (+5.0 million tonnes), Nigeria (+2.6 million tonnes) and Iran (+1.1 million tonnes), as well as Azerbaijan, Uzbekistan and Russia (+2.5 million tonnes) in 2020 and 2021¹.

Phosphates: Global production of finished phosphates in 2020 is expected to remain flat at 69 million tonnes, according to preliminary IFA estimates. Monoammonium

phosphate (MAP) output grew strongly (+4% year-on-year), while diammonium phosphate (DAP) production fell (-3%).

DAP exports last year expanded by almost two percent year-on-year to reach 18 million tonnes. More than half of DAP production in 2020 (34 million tonnes) was traded internationally. Five destination countries (India, Pakistan, the US, Bangladesh and Turkey) accounted for more than fifty percent of global DAP exports. While DAP imports to Pakistan and Bangladesh increased in 2020, lower US, Indian and Turkish imports are anticipated.

Globally, finished phosphates capacity is forecast to increase by 2.4 million product tonnes in 2021 (+2.5% to 47.3 million tonnes P₂O₅), driven upwards by new projects in Brazil (Serra do Salitre), India (Tuiticorin), Kazakhstan (Taraz) and Tunisia (M'dhilla), alongside an expansion in existing Russian capacity (Volkhov).

Potash: Following a fall in output in 2019 (-3.3%), world muriate of potash

(MOP) production is expected to increase by just under one percent year-on-year in 2020 (+600,000 tonnes) to 67 million tonnes, with rising output in the Americas offsetting decreases elsewhere.

Preliminary estimates suggest worldwide MOP trade grew rapidly last year (+5.8% to 51.4 million tonnes). Higher imports to the US, Brazil and India more than offset slight import decreases into China, Indonesia and Malaysia¹.

World potash capacity is forecast to rise by just over six percent (+3.7 million tonnes K₂O) during 2020 and 2021 to reach 63.6 million tonnes K₂O. This will be driven mainly by the entrance of new MOP projects in Russia and Belarus. These are expected to add around 2.4 million tonnes of extra MOP product capacity in 2020 alone. In a landmark development, the commissioning of two projects in Australia is also expected to bring extra primary sulphate of potash (SOP) capacity (+0.3 million tonnes) on-stream this year¹.

Resilience to Covid-19: mitigation measures, good logistics and favourable economics

Fertilizer production and supply – an essential industry

Actions taken by national governments to limit the spread of Covid-19 through enforced lockdowns had only a limited effect on fertilizer sales, distribution and farm deliveries during 2020. This was because:

- Almost every country globally protected their agricultural and food supply sectors – including fertilizer production and distribution – by classing these as essential industries.
- Many governments across Asia, Europe and the Americas have strongly backed their agricultural industries – by providing monetary support for farmers, easing commodity import/export flows, and ensuring labour availability.
- Restrictions to fertilizer trade and export mostly proved short-lived.
- The global movement of fertilizers via bulk shipping was much less affected by the pandemic, relative to sectors that relied on air transport.
- Fertilizer purchases for 2020 had also already been completed and delivered in key countries prior to the pandemic.
- The fertilizer industry – and food and agriculture as a whole – was largely successful at overcoming supply and distribution challenges.
- There is evidence that farmers in some markets purchased fertilizers early to guard against potential delivery delays and/or currency weakening.

Farm economics

These remained largely favourable as 2020 progressed:

- Crop prices recovered strongly from mid-year falls seen to reach six-year highs by the year's end
- This helped keep fertilizer-to-crop price ratios attractive
- Falls in local currencies against the US dollar improved returns on crop exports in major agricultural-exporting countries such as Brazil and Argentina.

Price outlook

Urea: Prices varied between \$260-280/tonne in major end-markets during the second half of 2020, supported by record demand in India and Brazil. Looking ahead, Rabobank expects new production capacity to weigh on the market in 2021. Prices could come under pressure in the second quarter, as soon as US and European demand wanes, potentially settling slightly below \$200/t².

Phosphates: Falling demand in South America at the end of 2020 is likely to pressure prices in the short-term. Phosphate prices should, however, find support due to better farm economics – the result of higher international wheat, soybean, corn and cotton prices. The prospect of new import tariffs on Russian and Moroccan phosphate imports is also likely to create a premium on cfr prices in the US, and on f.o.b. prices in selected exporting countries such as Mexico, Australia and Saudi Arabia².

Potash: Weak trading conditions in the first-half of 2020 saw prices reach their lowest levels in a decade. These subsequently recovered in the year's second-half on the back of resurgent demand. Prices are likely to continue to increase at a slow but constant pace in the next six months, predicts Rabobank, as the market tightens. Factors such as improving US farm demand and higher import demand from Brazil should act to support prices in the first-half of 2021. On the supply side, the potential for disruption from the political crisis in Belarus, the world's second largest potash exporter, remains a wildcard factor².

Author's note

Please note that the FAO's Food Price Index (FPI) was expanded in July 2020 and its base period revised to 2014-2016. Values are therefore not directly comparable with those quoted in last year's market outlook (*Fertilizer International* 494, p22).

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Soybean seedling.

PHOTO: ANGLO-AMERICAN GROUP NUTRIENTS

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Dust and moisture control agents

The quality of finished fertilizers can be maintained during transport, handling and storage by protecting the surfaces of granules and prills with coating agents. We survey the range of anti-caking, water repellent and anti-dusting additives currently on the market.

Preventing degradation, preserving value

Granular fertilizers can be protected through the addition of anti-caking and dust control agents (*Fertilizer International* 492, p28; *Fertilizer International* 477, p28; *Fertilizer International* 464, p32; *Fertilizer International* 453, p26). These agents are usually applied as surface coatings and help prevent dust formation and caking by reducing water absorption under humid conditions. They include both synthetic and natural compounds. These need to be harmless to soil, plants and humans. Coating chemicals generally function by:

- Controlling dust formation
- Minimising caking and particle bridging
- Enhancing powder flow
- Reducing moisture absorption
- Enhancing appearance
- Regulating nutrient release.

They are often combined with a pigment to introduce colour.

The caking of fertilizers, if not prevented, can be a major headache during storage,

transport and field application. It can destroy the value of fertilizers, halt loading and unloading, damage handling equipment and be a safety hazard.

Urea, urea-based NPKs, ammonium nitrate, calcium nitrate and other NPK fertilizers are more hygroscopic – due to their lower critical relative humidity (CRH) – and therefore often benefit the most from the addition of anti-caking agents (Figure 1). In comparison, the need for anti-caking treatment in other types of fertilizers, such as phosphates and ammonium sulphate, can be lower if they are less hygroscopic.

Selected products and producers

Arkema-ArrMaz has been a leading provider of coatings and process control chemicals to the fertilizer industry since the late 1960s. The new company was formed when Florida-based ArrMaz was acquired by French-headquartered Arkema Group in 2019.

Some of the world's major fertilizer producers treat tens of million tonnes of fertilizers every year with the company's *DUSTROL*® and *Fluidiram*® range of anti-

caking and dust control agents. These tailor-made agents are generally suitable for all solid fertilizers including granules, prills and powders. They reduce airborne dust and minimise product losses and can be applied to a variety of fertilizers. These include diammonium phosphate (DAP), monoammonium phosphate (MAP), ammonium nitrate (AN) and NPKs.

Treatment with Arkema-ArrMaz coatings:

- Reduces caking of prills or granules
- Provides dust control for ease of handling and storage
- Benefits flow properties, colour, appearance and product marketability
- Improves workplace safety and compliance with environmental, health and safety (EHS) regulations
- Promotes better environmental stewardship.

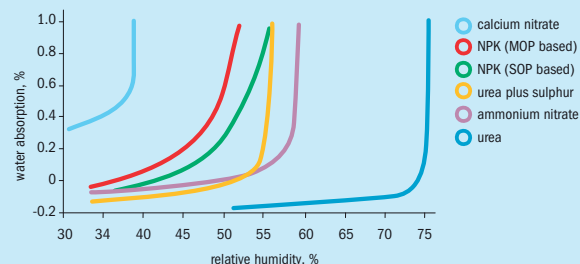
DUSTROL coatings suppress dust by forming a barrier around granular products and also adsorb dust after it is generated.

The *Fluidiram* product range successfully keeps fertilizers free-flowing by preventing caking, dusting and moisture uptake, and is available globally.

Arkema-ArrMaz also offers sustainable fertilizer coatings (see accompanying article on page 24). These fully bio-renewable and biodegradable products deliver comparable dust, moisture and caking control performance to traditional coatings. Coating products offered include REACH-compliant, organic (OMRI listed) and water-soluble types.

Arkema-ArrMaz's expertise is not limited to coating products alone. The company also offers its customers safe, effective and easy-to-operate systems for applying coatings to fertilizers. Coating equipment can be designed, engineered, constructed and installed as part of a comprehensive service package.

Fig. 1: Critical relative humidity (CRH) of various fertilizers at 25°C



Source: Yara



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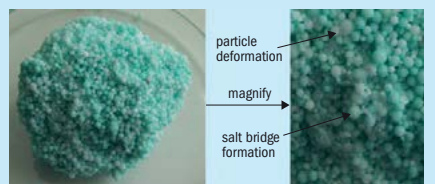
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Sustainable solutions to dust and caking in fertilizers

NAQ Global is well known for its advanced and innovative fertilizer additives sourced from crop-based materials. **Prakash Mathur** and **Anmol Mathur** explain the company's commitment to sustainability.

Fig. 2: Hard cake of uncoated ammonium nitrate phosphate (ANP) fertilizer (left) with a magnified image (right) showing salt bridge formation and particle deformation.



Source: NAQ Global

led to the creation of the company's highly efficient and cost-effective *Green Technology* product line for the fertilizer industry.

At NAQ Global, innovation was – and remains – the key to addressing this challenge. The need to nourish the world in a safe, responsible and sustainable way is central part of the company's purpose and way of doing business. We believe that sustainability and agricultural development go together hand-in-hand and can thrive simultaneously. We are therefore committed to finding innovative solutions that, as well as being economically viable for fertilizer producers and farmers, still protect our planet.

Biodegradable, environment-friendly coating agents

The company's commitment to sustainability led it to delve deeper and look at the potential for developing advanced and innovative additive technologies derived from crop-based source materials. The most esoteric but promising of these involved the catalysis of a waste by-product from the vegetable oil industry. We subsequently incorporated this as an important functional constituent in our dust control and moisture control agents.

NAQ Global's innovative moisture control agents are easy to apply, biodegradable and environment-friendly. Crucially, they provide long-lasting caking control in fertilizers by effectively preventing the formation of salt bridges between granules.

For dust and caking control under standard conditions, our analyses indicate that NAQ Global's new generation of anti-dusting and anti-caking agents are much more efficient, compared to other common phosphate fertilizer coating products on the market. These advanced coating solutions – because of the unique adhesive properties of the vegetable fats they contain – offer long-term anti-caking and anti-dusting protection.

Going further...

But we did not stop there. Our commitment to sustainability drove us further onwards – to look for even more innovative ways to drastically reduce our environmental footprint. Today, NAQ Global offers a complete range of eco-friendly products for the entire fertilizer supply chain. From mining, to phosphoric acid production, to granulation, and, finally, to retailing and distribution, NAQ Global's comprehensive *Green Technology* range is able to optimise product performance, improve process efficiency, and help produce superior quality products.

While dust and caking in fertilizers have been significant long-term challenges for the industry, advanced and environmentally-friendly solutions that address both these problems are now available – doing so both efficiently and cost-effectively. The pioneering use of vegetable oils and by-products for fertilizer additives is just one example of how our industry can harness innovation to deliver on its mission to provide farmers with affordable, safe and sustainable crop nutrient products. ■

Netherlands-based speciality chemicals company **Holland Novochem** has been a leading global supplier of anti-caking, moisture repellents and de-dusting agents to the fertilizer industry since the early 1990s. It currently serves customers in more than 90 countries through four branch offices located across Eastern and Western Europe.

The company is well-known for its extensive range of Novo-branded fertilizer additives. These low-toxicity, environmentally-friendly products successfully address many of the problems associated with the production, storage and transportation of fertilizers (see accompanying article on page 26). The Novo product range includes:

- **NovoFlow** anti-caking and moisture repellent coatings: these provide protection against caking and moisture uptake. They are suitable for all major types of fertilizers. Formulations are custom-made – according to the specific needs of fertilizer producers – to reduce caking and/or moisture.
- **NovoDust** anti-dust coatings: these substantially reduce dust generation during the handling and storage of fertilizers. This is becoming increasingly important

due to the introduction of ever more stringent environmental and safety regulations – and the general requirement for cleaner workplaces.

- **NovoTec** granulation additive: this granulation enhancer can optimise the production process and/or improve the quality of fertilizer granules for a variety of fertilizer grades, especially AN, CAN and NPKs.

The **CHEMISIL** range of additives offered by Spanish firm **Chemipol** are designed to prevent fertilizer caking during manufacture and storage. They are based on two main formulations. **CHEMISIL NS** is a soluble sulphonated coating agent designed to prevent caking in bagged fertilizers stored under load on pallets. The anti-caking agent **CHEMISIL AG**, in contrast, is a highly-absorbent form of silica dioxide used to prevent agglomeration during the manufacture of powdered fertilizers.

China's biggest fertilizer additive producer **Forbon Technology** manufactures four anti-caking agents for urea, phosphates and compound fertilizers under the *Hisoft* brand name. These oil-based and powder-form coating agents are designed to solve fertilizer quality problems such as caking, dust generation and weak granule strength.

India's **Neelam Aqua & Speciality Chem Ltd** markets the **NEELCOAT** range of anti-caking agents for granular NPK, ammonium phosphate (DAP/MAP), and calcium ammonium nitrate fertilizers. The company's **NEELCOAT DS** products combine anti-caking behaviour with dust suppressant properties. They are derived from plant extracts and are fully biodegradable. Neelam Aqua also offers three **URECOAT** anti-caking formulations for urea, the first designed for prills, the second incorporating neem oil and the third including an urease inhibitor.

Fertibon Products manufactures a wide range of fertilizer additives, including anti-caking agents and colourants, at its production site in Maharashtra, India. These are non-toxic and also designed to protect conveyor belt systems as they are inert when in contact with rubber.

Kao Global Chemicals sells paste and powder anti-caking agents for a wide range of fertilizers (AN, CAN, DAP and NPKs) under the **SK FERT** marque. It also offers the liquid anionic surfactant product **URE-SOFT A-10**, a low-toxicity anti-caking agent designed especially for urea and ammonium sulphate. ■



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Laboratory testing is vital when it comes to measuring the sustainability of fertilizer coatings.



PHOTO: ARKEMA-ARRMAZ

Is your fertilizer coating sustainable?

Fertilizer coatings play an integral role in minimising the degradation of fertilizers during transport, handling and storage. Increasingly, customers also want to know if the coatings they buy are sustainable too. But what exactly is a sustainable fertilizer coating – and how can its sustainability be properly defined and measured? **Lucas Moore**, director of coatings technology at Arkema-ArrMaz, weighs up these thorny questions and provides some clear-cut answers.

With the world's growing population raising demand for food, the fertilizer industry is finding new ways to utilise our limited natural resources responsibly and sustainably. To meet industry needs, many fertilizer coatings manufacturers have developed new and innovative products that are marketed as sustainable. But how can you be sure that a fertilizer coating is truly sustainable and isn't just green-washed?

Defining sustainability

According to the Oxford English Dictionary (OED), being sustainable simply means "to be capable of enduring". The OED also defines "environmental sustainability" as

"the degree to which a process or enterprise is able to be maintained or continued while avoiding the long-term depletion of natural resources".

For products, the definition of sustainability is inextricably linked to the concept of stewardship. This requires producers to take responsibility for their products from 'cradle-to-grave'. Stewardship encompasses where and how a product was created, where and when it will end up, and its end-of-life condition.

Therefore, taking all of the above considerations into account, to be truly sustainable, fertilizer coatings ideally need to be:

- Produced from biorenewable resources
- Designed not to bioaccumulate, i.e. should biodegrade

- Developed to minimise waste generation.

So, how can these criteria be evaluated effectively for a fertilizer coating?

Measuring fertilizer coating sustainability

At Arkema-ArrMaz, we recommend that sustainability be measured by asking critical questions that check for three key criteria:

Biorenewability: Are the raw materials used to formulate the coating produced or extracted from natural and renewable feedstocks? A resource is classed as 'biorenewable' if it can be replenished within a single human lifetime. Biorenewability can be evaluated using a standard

ASTM D6866 method¹. This radiocarbon test detects if the naturally-occurring isotope carbon-14 (¹⁴C) is present by comparing samples with a reference standard. Because fossil-fuel carbon does not contain any ¹⁴C, its absence verifies that the resource is not truly biorenewable.

Biodegradability: How much does the coating biodegrade in the environment? Biodegradability can be evaluated using the OECD 301 method². This determines biodegradation by measuring the loss of carbon dioxide (CO₂ respiration). Using this method, a product is considered biodegradable if it achieves greater than 60 percent biodegradation within a 28-day interval, counting onwards from the day that 10 percent degradation is first achieved.

Waste Prevention: Does the coating help prevent or minimise waste? While ensuring product coatings are biorenewable and biodegradable are important considerations, the prevention of product losses in the supply chain is another way in which the fertilizer industry has become more environmentally sustainable. Innovations in coatings technology have supported industry sustainability by protecting fertilizer products, thereby preventing or minimising the generation of waste. To be effective, coatings need to reduce the amount of waste generated during fertilizer handling – otherwise granules can lose their integrity and strength and generate fugitive dust. Unless they are properly coated, fertilizers can also agglomerate and cake in response to changes in ambient temperature and moisture.

Dust generation and caking both lead to significant and costly fertilizer product losses and the unwanted generation of waste. Also, to be considered effective and sustainable, the dust control coatings used at a fertilizer processing plant – in addition to minimising waste – must contribute to a cleaner work environment, improve equipment efficiency, ensure worker safety, and support the development of better quality fertilizer products for farmers.

True sustainability

Once it has been established that a fertilizer coating is truly sustainable, based on an evaluation of the above criteria, it is essential to determine whether the coatings also perform well – delivering the necessary reductions in dust, caking and moisture absorption required. Coating technologies, such as those available in Arkema-ArrMaz's *DUSTROL*[®] and *Fluidiran*[®] product lines, deliver on both sustainability and on performance.

So, in your next conversation with a coatings producer, be sure to request dust, caking and moisture absorption data to assess coating performance. But also remember to discuss the above mentioned sustainability criteria, and request appropriate data, so you can accurately evaluate if the fertilizer coating offered is truly sustainable as well. ■

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Caking of granulated fertilizer during bulk storage.



PHOTO: HOLLAND NOVOCHEM

Tailor-made additives: keeping fertilizers in shape

The degradation of fertilizer granules during handling and storage can be economically-costly and therefore needs to be avoided. Preventing unwanted caking and dust formation requires tailor-made coatings, as **Kim ten Wolde**, product manager at Holland Novochem, explains.

Holland Novochem B.V. has been helping the fertilizer industry to maintain the quality of fertilizer granules and keep these in good shape since its establishment in 1992. The company, working in collaboration with its customers, manufactures tailor-made additives specifically designed for fertilizer granules and the granulation process.

Different fertilizers, different coatings

In our view, there is no such thing as a 'one-size-fits-all' approach when it comes to coatings. All fertilizer granules are physically and compositionally different, having been produced from different raw materials and by different production processes. Handling conditions and storage environments for fertilizers also vary widely. Consequently, the problems that require prevention – from dust formation to caking

and moisture uptake – are never exactly the same.

The selection of the wrong coating agent can also cause problems. This may increase dust formation, for example, or allow the take-up of moisture from surroundings to continue – leading to caking and ultimately the complete disintegration of granules.

Moisture holds the key

Fertilizers and water are not friends and should never be allowed to meet, except for the final moment when the product is applied to agricultural land. This is the precise moment when water is required to release valuable nutrients to the soil and crops.

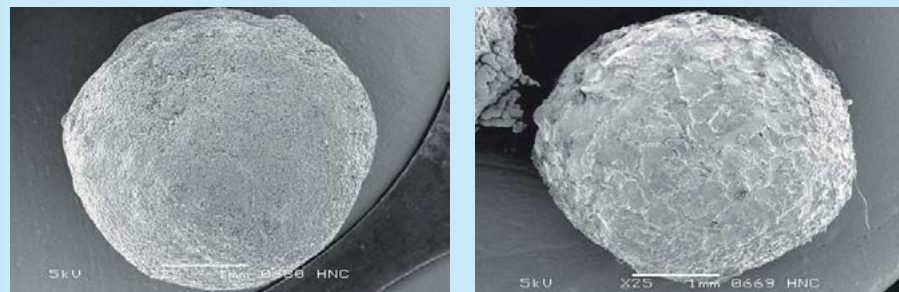
Fertilizers are generally hygroscopic, being prone to the absorption of water to a greater or lesser extent. Their behaviour generally varies from very hygroscopic (e.g. magnesium-stabilised ammonium nitrate)

to moderately hygroscopic (e.g. urea). Therefore, every effort needs to be taken to prevent contact between fertilizers and moisture, especially when granules are stored and handled in bulk. Almost everyone within the fertilizer industry has seen unfortunate examples of what happens after exposure to moisture – and the huge hard compact lumps that can result from the caking of bulk materials (see photo).

Moisture, the main culprit and cause of such lumping, can originate either from within the fertilizer or be introduced through uptake from the external environment. It is therefore crucial to look at both of the following factors:

- The innate/original moisture content of the fertilizer granule (product quality)
- The tendency of the fertilizer granule to take up moisture from the environment, expressed as critical relative humidity (CRH).

Fig. 1: Uncoated NPK granule: before (left) and after (right) moisture uptake and drying



Source: Holland Novochem

External moisture

Fertilizer granules will absorb water when the relative humidity of the surrounding air, at a given temperature, is higher than their CRH. When fertilizer granules are stored above their CRH for prolonged periods of time, undesirable dissolution and recrystallisation of solids can occur – resulting in crystal bridge formation and caking.

Fertilizer granules are significantly affected by moisture uptake, as can be seen clearly in Figure 1. The uptake of moisture, as well as resulting in caking,

can also trigger extreme dust formation in some fertilizer types such as urea. This happens when the original smooth surface of the granule dissolves completely to be replaced by hollow tubes of recrystallised tetragonal urea crystals (Figure 2). These hollow tubes have an even stronger attraction for water due to capillary action. The presence of such crystals ultimately leads to extreme dust formation when granules are subsequently handled.

The take-up of external moisture occurs most readily in the exposed uppermost layer of piled bulk materials, eventually

leading to the creation of strong crusts. These surface crusts are often so hard and impervious that they act as an effective seal, completely preventing any water uptake by the underlying fertilizer granules.

For other fertilizer grades only a very thin crust forms on the surface of piles. Upon shipment, this fragile crust can be easily pierced – allowing access to the underlying free-flowing granules.

That is not always the case, though. For other multi-component fertilizers such as calcium ammonium nitrate (CAN), for example, exposure to moisture leads to the creation of ammonium nitrate crystals in the top of stored piles, significantly increasing the amount of dust formed. By increasing the specific surface area, this creates a vicious circle by triggering repeated cycles of moisture uptake, caking and dust formation.

Internal moisture

As well as external uptake, the migration of internal moisture held within fertilizer granules can also result in significant recrystallisation and caking. Temperature differences can promote this by triggering the transfer of moisture from the interior to the surface of granules.

Consequently, when stored without sufficient drying, mobilisation of moisture within the fertilizer itself, as well as water absorption from the external environment, can create problems. Under these conditions, stalactites can form from fertilizer salts due to a dissolution-precipitation process. These stalactites can be very hard and large, making it difficult to handle and reclaim fertilizer piles from bulk storage. Scraping with large

Fig. 2: Dust formation on the surface of urea granules due to the recrystallisation of tetragonal crystals



Source: Holland Novochem

Figs 3 & 4: Moisture uptake test on calcium ammonium nitrate (CAN) granules. Results for (from left to right) untreated, anti-caking coated and anti-moisture coated samples



Note: Samples exposed to moisture in a climate-controlled cabinet at 80 percent relative humidity for 72 hours at 20°C.

Source: Holland Novochem

machinery, such as a wheel-loader bucket, is often necessary – although this inevitably generates a large amount of dust.

It is clear from the above discussion that there are many different factors determining the origin and effects of moisture on fertilizer granules. It is equally clear that preventing moisture uptake is vital for maintaining good fertilizer handling properties. For that reason, the continuous development of coating agents – capable of reducing the uptake of moisture as much as possible – has always been a major priority at Holland Novochem.

Moisture protection: the key to fertilizer integrity

Over the years, fertilizer producers and coatings/additives manufacturers have been quite successful at minimising moisture uptake by taking various measures. Chemically, there have been several improvements. Moisture migration in ammonium nitrate can be prevented, for example, by adding salts such as aluminium sulphate and magnesium sulphate to improve stability. This improves the strength of ammonium nitrate granules by preventing volume changes from occurring under normal storage conditions. Technical improvements in the granulation process have also helped. The ability to create smoother and more uniform granules has reduced both moisture uptake and the number of contact points – the two factors that promote moisture migration and caking.

However, the critical relative humidity of a fertilizer – a key indicator of suscep-

tibility to moisture – is an inherent property that cannot be changed or increased. Fortunately, however, it can be effectively mitigated against by the application of a surface coating.

Indeed, it is common practice for fertilizer producers to apply coatings to fertilizer granules to prevent moisture uptake, caking and dust formation. The general function of a fertilizer coating is very simple: it provides granules with a protective layer, so reducing both granule-to-granule and granule-to-air interactions.

Traditional coatings are composed of oils, paraffins, alkylamine and other special additives. Viscous oils, in particular, have proven to be very effective against dust formation, while the use of alkylamines significantly inhibits the caking tendency of fertilizers.

Nevertheless, Holland Novochem believes that a more sophisticated customised approach is necessary to achieve consistent moisture protection, as each type of fertilizer – manufactured via a specific production process – requires its own individual and custom-blended coating mixture. Such tailored coatings also need to take account of the caking tendency of the fertilizer. Fortunately, coatings with good water repellent properties generally possess moderate anti-caking properties, and vice versa.

Holland Novochem's extensive range of moisture protection coatings have been widely-used globally for many years, ensuring consistent fertilizer quality for the company's clients. These products are able to keep fertilizers free-flowing by offering reductions in moisture uptake of up to 75 percent.

Controlled moisture exposure tests help illustrate how coatings protect fertilizers. In one test, equal amounts of three calcium ammonium nitrate (CAN) samples – untreated, anti-caking treated and anti-moisture treated CAN – were weighed into cups, and then exposed to moisture by placing in a climate-controlled cabinet at 80 percent relative humidity (RH) for 72 hours at 20°C. The untreated sample has the highest moisture uptake, as can clearly be seen, while the anti-moisture coated sample remains free flowing (Figures 3 and 4).

In another test, a single layer of untreated and anti-moisture treated CAN granules were exposed to moisture in a climate-controlled cabinet at 80 percent RH for one hour at 20°C. The untreated granules absorbed moisture and partly dissolved on the surface, while the integrity of treated granules clearly benefitted from their protective surface coating (Figures 5 and 6).

While every fertilizer has different susceptibilities, anti-caking coatings are unable to completely prevent moisture uptake, as can be seen from the above photos. This is what makes tailor-made coatings, that combine both anticaking and moisture control properties, so essential. The performance of different coatings formulations for moisture control are shown in Figure 7. These results demonstrate that, in practice, not all anti-moisture coatings provide the same levels of protection, with small changes in their formulation creating large differences. This reinforces how necessary it is for coatings providers, such as Holland Novochem, to work together with fertilizer



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Following the great success of the inaugural Global Stewardship Conference last year, IFA's Agriculture, Communications & Public Affairs and Technical & Safety-Health-Environment Committees will bring together another exciting range of speakers from international governmental and non-governmental organizations, policymakers, academia, multi-sectorial business development and engineering to take a comprehensive look at corporate Sustainable Development Goals (SDGs) implementation.



"It was an honor to speak about best sustainable business practices at the Global Stewardship Conference."

"I thoroughly enjoyed the 2020 Global Stewardship Conference. High level, productive teaching. Well done!"

Is social and environmental sustainability on track to become as important as market share and shareholder value? New business models and new value propositions integrating sustainability are appearing around the world, securing not only the reputations of companies, but also their ability to attract and maintain staff, as well as access finance and new business opportunities.

The IFA Global Stewardship Conference is the place to hear more about innovative stewardship initiatives, learn more about sustainability reporting, get inspired by sustainability programs within the fertilizer industry and understand expectations from UN agencies, the finance community, and leading voices in the NGO community. Through a focus on the fertilizer industry's stewardship priorities, this event will present innovations and investments in areas of environmental protection and climate change and inform on critical outcomes of the most recent UN reports and resolutions for nutrient management.

Figs 5 & 6: Single-layer moisture uptake test on calcium ammonium nitrate (CAN) granules. Results for untreated CAN (left) and anti-moisture coated CAN (right)



Note: Samples exposed to moisture in a climate-controlled cabinet at 80 percent relative humidity for one hour at 20°C.

Source: Holland Novochem

producers to formulate the most effective coating solution.

The future outlook for coatings

The fertilizer industry can expect the future to herald major changes. A variety of different pressures are affecting the current business operating environment, including new legislation and a shift in public opinion on fertilizers, pesticides, climate change and renewable energy. The fertilizer industry is changing quickly in response to such pressures, especially in Europe. Newly-introduced EU fertilizer market regulations, for example, will promote both the use of biostimulants and the recovery of nutrients from waste streams. Importantly, they will also require fertilizer coatings to be biodegradable in future.

This biodegradability requirement has prompted fertilizer coatings and additives producers to look beyond mineral oils and paraffin waxes, which have a very limited biodegradability, and seek out alternative bio-based raw materials instead. This is necessary as polymer-based coatings such as PE-waxes will be fully outlawed because of the EU's ban on microplastics in fertilizer coatings.

Bio-based anti-caking and anti-dust agents have already been rolled-out into the market with great success. Yet there is still a need to close the performance gap between some new bio-based products and traditional coatings. While variations in bio-based raw materials can still cause performance issues, big steps are being made at the moment to place products on

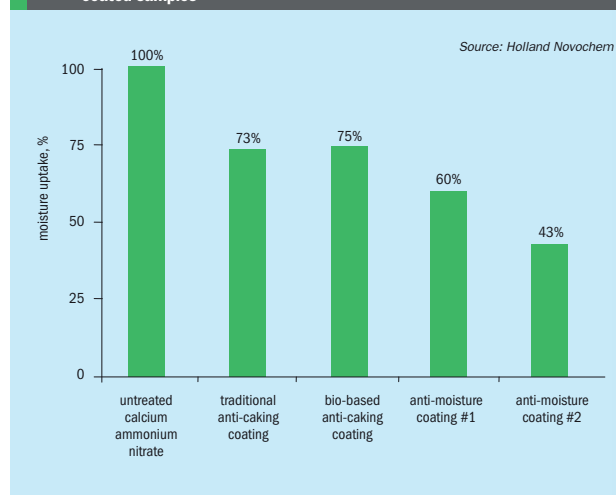
the market that deliver even higher anti-moisture performance.

These shifts in the fertilizer coatings market are part of wider changes to the whole of agriculture. Ongoing restrictions on fertilizer use and nitrogen emissions will require a major rethink by the farming industry globally. This will make both the quality of fertilizers and their use efficiency ever more important in future.

Against this backdrop, innovations at Holland Novochem are helping to bring innovative, more efficient and value-added

fertilizers to market – by adding micronutrients to coatings and developing coatings with nitrification and urease inhibitors. Such coatings add significant value, both to the coating products themselves and the fertilizers they are coated with. The adoption of controlled-release fertilizers (CRFs), by allowing fertilizers to do more from less, is another important development that should not be overlooked. The future outlook for added-value coatings in the fertilizer market is very bright in our view!

Fig. 7: Calcium ammonium nitrate: Moisture uptake results for untreated versus coated samples



Source: Holland Novochem

phosphates & potash

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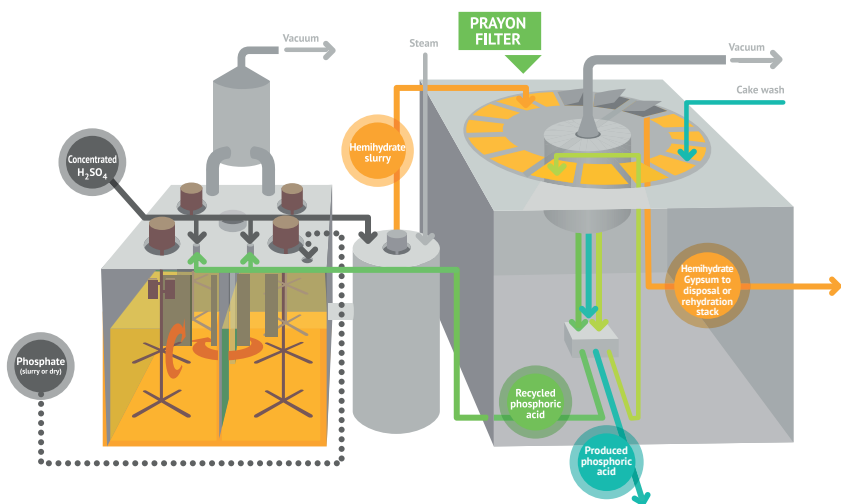
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CRU Phosphates 2021 goes virtual!

During this time of disruption, keeping connected and informed has never been more important. While the in-person events the industry usually relies on are not possible, CRU's Phosphates 2021 Virtual Conference, 23-25 March, offers exceptional information sharing and networking opportunities.

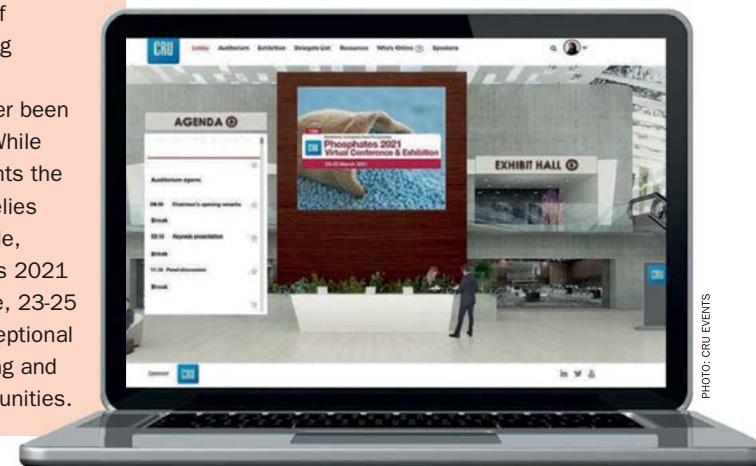


PHOTO: CRU EVENTS

Attending virtually and flexibly

CRU Phosphates, the annual international meeting for the global phosphates industry, has reinvented itself this year as a virtual event. In normal times, this well-established and must-attend event regularly attracts more than 400 delegates from over 40 countries.

Running this year's phosphates sector gathering as a virtual event has more advantages than disadvantages, as Nicola Coslett, CEO of CRU Events explains:

"We have had to completely reimagine our conference offerings in light of the pandemic. Many of our clients – when they see what these events have to offer – are shocked and surprised by how good the virtual conference experience can be.

"In fact, as word has spread, we are actually seeing the size of our audiences growing. It's been great to see how the convenience, efficiency and cost-effectiveness of virtual participation means that we are able to reach new delegates from across the fertilizer industry."

In the last six months, CRU Events have successfully run more than a dozen virtual conferences. One of the primary benefits of the virtual event format is its flexibility and the bespoke, tailor-made experience it offers.

Virtual delegates can schedule their attendance around work and home commitments, while still taking full advantage of all the conference has to offer. That includes a mix of on-demand presentations and live interactive sessions such as Q&A and panel debates.

Having access to content on-demand for 30 days after the conference is also an added benefit – as presentations can be viewed at your leisure whenever most convenient.

CRU Events know that attending the exhibition is an essential part of the conference experience, for the networking it provides and the chance to meet with technical experts. The immersive virtual platform therefore offers networking at

any time throughout the event. Attendees can search or browse the delegate list and interact with other delegates via chat, video call or by scheduling a private meeting.

"Many participants cite the speed networking function as the highlight of our virtual conferences. By joining a large video call and being placed into smaller break-out chats with a handful of other participants, you can catch up with old friends and make new contacts," comments Nicola.

Timed for convenience

Spread over three days, presentations at CRU Phosphates 2021 will primarily run between 14:00-18:00 CET – as this time zone allows European- and US-based attendees to engage in the scheduled interactive live sessions. The virtual platform still provides 24/7 accessibility for all delegates, though, offering full access to on-demand content and the ability to network at all times – not only throughout the three-day conference but for 30 days afterwards.

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A typically strong commercial agenda

Uniquely, CRU Phosphates 2021 combines a commercial agenda with a technical agenda in one single event. This enables the conference to cover the entire value chain of the phosphate industry – including the fertilizer, feed and industrial segments – from both an operational and market perspective.

This year's conference features a typically strong commercial programme, including market outlooks from CRU's leading analysts and presentations from the world's major phosphates producers. Project updates and key insights on phosphates production, trade, and products will also feature strongly. Notably, in-house analyst Glen Kurokawa will provide the 'CRU View' on key factors likely to shape phosphate market supply, demand and prices globally in 2021 and beyond.

While the agenda provides a truly global market perspective, this year's event is devoting a special spotlight session to China. CRU analyst Isabel Chen will highlight the latest in Chinese fertilizer supply and demand, while Rosa Wang, an analyst with Shanghai JC Intelligence, will cover developments in Chinese agricultural commodity markets.

Technical programme for production professionals

The event also offers a separate but equally strong technical and operational programme. This has been put together with operations, maintenance and production professionals in mind. At least 15 presentations will be devoted to operational experience and new developments in phosphates technology, processes, materials and equipment.

The technical agenda provides industry operatives with an ideal opportunity for professional development. Attendees will also have plenty of chances to share their practical experiences with other operators, and meet with leading technology and engineering suppliers in our large-scale exhibition.

CRU are also pleased to announce that personnel working in an operations, maintenance, engineering or plant management role may be eligible to attend **free of charge!** This offer applies to employees of phosphate rock, fertilizer and feed producers. Please visit the conference website for full details and information on how to apply. ■

Technical programme highlights

A selection of CRU Phosphates 2021 abstracts from the conference's technical and operational programme.

Gemini collectors – novel phosphate flotation surfactants

Results are presented for a novel family of anionic Gemini surfactants from **Nouryon**. These environmentally-friendly dimeric compounds have been developed and evaluated as collectors in the direct flotation of apatite from carbonate-rich and siliceous phosphate ores. Using these novel dimeric collectors, it was found that a significant reduction in dosage (half or more) is achievable, in comparison to currently-used monomeric collectors. Gemini surfactants are not only more dose-efficient, they also show outstanding selectivity for apatite in phosphate/carbonate/silicate systems.

Beneficiation of phosphate rock by X-Ray sorting

TOMRA Sorting shares the lessons learnt from two-years of operational experience at the Ma'aden Wa'ad al Shamal Phosphate Company (MWSPC). TOMRA's sorting machines are installed at MWSPC's 13.5 million t/a capacity beneficiation plant where they pre-process run-of-mine (ROM) ore using XRT (X-Ray transmission) technology. TOMRA's machines can treat 1,800-2,000 t/h of feed material, about 50-60 percent of the total ROM. The machines, which recognise and separate materials based on differences in atomic density, reduce silicon content by removing unwanted chert from phosphate (apatite). Importantly, XRT technology achieves a high apatite recovery during the sorting process. Eliminating chert also realises substantial cost savings for MWSPC – by reducing flotation reagent consumption and downstream equipment wear and maintenance.

What is eco-friendly and sustainable?

In fertilizer production, it is important to understand exactly what being sustainable or eco-friendly entails. In this presentation, **Arkema-ArrMaz** take a deep dive into sustainable chemistry – what it is, how it can be applied, and what it means for the fertilizer industry. Case study results are presented for eco-friendly Arkema-ArrMaz coatings. These renewable and biodegradable coatings generate zero or minimal waste during production. They are suitable for phosphates and other industry substrates such as nitrogen- and potash-based fertilizers.

Solving foaming problems in phosphoric acid production

Managing the formation of foam is a common challenge in the phosphate production process. It can decrease production output and be a safety concern. Although foaming is a notable reactor problem, it can also occur in other parts of the process. Its downstream effects can also be widespread, with consequences for beneficiation, evaporation and granulation. In this presentation, **Nalco Water** will discuss its recent experience of solving foam problems in the phosphate production process. An effective approach that combines advanced chemistries with advanced application technologies is described.

Other technical presentations

Smartchem Technologies, a subsidiary of **Deepak Fertilisers**, will report on the importance of optimising reaction and filtration sections at phosphoric acid plants in their presentation. Sweden's **EasyMining**, meanwhile, will describe the *Ash®2Phos* process for recovering clean phosphate from sewage sludge ash. ■

Innovations in phosphate production

Prayon's **Hadrien Leruth** and **Marc Sonveaux** highlight the latest phosphate production developments at the company – and share their experience of how innovative ideas are validated, industrialised and turned into commercially-viable technologies.

Prayon rhymes with innovation

Prayon is renowned for its commitment to research and development. The Belgium-headquartered company constantly invests in innovation to maintain its status as a global leader in technical- and food-grade phosphate production and phosphoric acid technologies. In the current world context – especially in

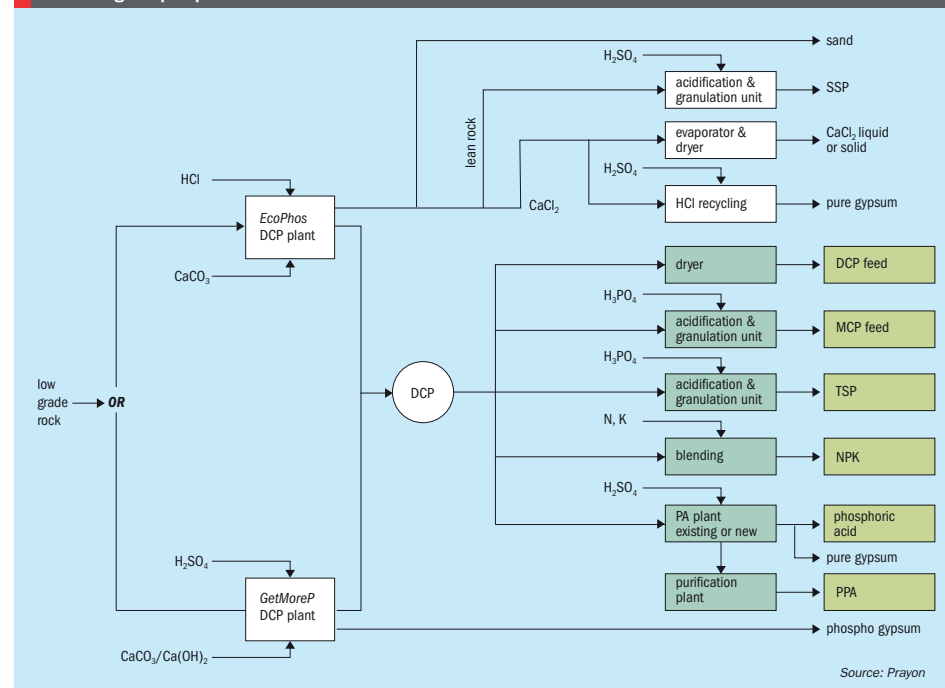
the phosphates market – Prayon believes that innovation is a must, if we are to tackle present and future planetary challenges.

The company invests more than €10 million in innovation each year. This spending is funnelled through Prayon's R&D centre in Belgium, where it is used to develop and validate new technologies for the phosphates industry.

New to the technology portfolio

Prayon also pursues innovation through acquisitions, most notably the recent purchase of the technology patents and know-how from EcoPhos. Importantly, the acquisition of the EcoPhos brand also included full ownership of its Bulgarian R&D site – which includes the Technophos

Fig. 1: The *EcoPhos* and *GetMoreP* DCP processes from Prayon. Both can generate a wide range of downstream products from low-grade phosphate rock



Source: Prayon

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Table 1: The *EcoPhos* and *GetMoreP* processes: main inputs and outputs

| | <i>EcoPhos</i> process | <i>GetMoreP</i> process |
|-----------------------|--|---|
| | Module 1A (+ option) | Module 2A (+ option) |
| Digestion | | |
| Inputs | Low-grade phosphate Diluted hydrochloric acid (+ additives) | Low-grade phosphate Diluted sulfuric acid (+ calcium carbonate, additives) |
| Outputs | Solution of $\text{HPO}_4^{2-}/\text{Ca}^{2+}/\text{Cl}^-$ Rock residue (sand, gypsum, iron, aluminium, fluorides, heavy metals) | Solution of $\text{HPO}_4^{2-}/\text{Ca}^{2+}$ Gypsum residue (sand, iron, aluminium, fluorides, heavy metals) |
| | Module 1B | Module 2B |
| Neutralisation | | |
| Inputs | Solution of $\text{HPO}_4^{2-}/\text{Ca}^{2+}/\text{Cl}^-$ Calcium carbonate | Solution of $\text{HPO}_4^{2-}/\text{Ca}^{2+}$ Calcium carbonate/hydroxide |
| Outputs | Dicalcium phosphate (DCP) Solution of $\text{Ca}^{2+}/\text{Cl}^-$ with residual impurities (Mg^{2+} , Cd^{2+}) | Dicalcium phosphate (DCP) Water with residual impurities (Mg^{2+}) |
| | Module CCP | Module WT (optional) |
| Post-Treatment | | |
| Inputs | Solution of $\text{Ca}^{2+}/\text{Cl}^-$ with residual impurities (Mg^{2+} , Cd^{2+}) Calcium hydroxide | Water with residual impurities (Mg^{2+}) Calcium hydroxide |
| Outputs | CCP residue ($\text{Mg}(\text{OH})_2$, $\text{Cd}(\text{OH})_2$) Pure CaCl_2 product or recycled | WT residue ($\text{Mg}(\text{OH})_2$) Pure filtrate to recycle |

Source: Prayon

pilot and demonstration plants.

The purchase of *EcoPhos* has enabled Prayon to extend its technology portfolio into new market areas. Indeed, the company – through its Prayon Technologies licensing division – plans to introduce a raft of new technologies to complement its famed and widely-used phosphoric acid production processes.

The new technologies include:

- The chemical beneficiation of low-grade phosphate rock
- Secondary phosphate recovery/recycling processes
- The PUMA membrane purification system
- The new DA-HF phosphoric acid production process.

Each of these innovations are described below. Bringing these to market will help Prayon Technologies achieve its mission to deliver the best technical solutions to customers by meeting two targets: making production sustainable while at the same time boosting its profitability.

Chemical beneficiation technologies

Prayon has recently shown a huge interest in developing and acquiring new technologies that are capable of recovering phosphate commercially from low-grade deposits. This has become an imperative,

given the steady decline in both the size and quality of phosphate rock resources globally.

It has become clear that chemical beneficiation, when applied to low-grade phosphate rock, is potentially more profitable than traditional physical beneficiation techniques as it is more efficient and consumes less energy.

With this in mind, Prayon now offers two chemical processes (Figure 1) in its portfolio for beneficiating low-grade phosphate rock:

- The recently-acquired *EcoPhos* process – an innovative technology based on the use of dilute hydrochloric acid
- *GetMoreP*, a similar in-house technology developed by Prayon based on the use of dilute sulphuric acid.

Both processes generate dicalcium phosphate (DCP). This flexible end-product can be directly marketed as an animal feed additive. Alternatively, it can be used as a high purity intermediate feedstock (39-41% P_2O_5 and 32-34% CaO) for phosphoric acid plants, enabling the manufacture of a range of other phosphate products.

The *EcoPhos* and *GetMoreP* processes have a number of similarities:

- They are both modular (Figure 2)
- They generate the same quality DCP product
- Each are capable of consuming low-grade phosphate rock.

Their main differences are:

- The stages at which impurities are removed
- Different co-products are generated due to the use of different types of acid to digest phosphate rock.

Individual modules for both processes with their contrasting inputs and outputs are shown in Table 1.

The *EcoPhos* process

The *EcoPhos* process has four main modules (Figure 2).

- Module 1A
- Module 1B
- Module CCP
- Module 4.

Each of the above modules, by combining a reaction step with a filtration step, generates a filtrate (solution) and a filter cake (solids).

In the first process step, **Module 1A**, phosphate rock is digested using dilute hydrochloric acid. These benign process conditions enable the selective digestion of phosphate. Many impurities (silica, gypsum, iron, aluminium, most heavy metals and fluoride), meanwhile, are directly eliminated at this stage as a rock residue. This insoluble fraction is removed by filtration, yielding a clear phosphate solution.

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This filtrate consists of soluble monocalcium phosphate (MCP), phosphoric acid and calcium chloride, together with some residual impurities such as magnesium or cadmium.

In the next step, **Module 1B**, by adding calcium carbonate or limestone, the pH of the solution is gradually increased to recover the phosphate from the filtrate. This crystallises as DCP and is recovered as a solid cake by filtration.

In **Module CCP**, the pH of the solution is again raised to precipitate any remaining heavy metals as part of a solid residue. The remaining soluble calcium chloride solution is very pure. It can be crystallised and dried and directly sold as a de-icing or de-dusting product, as a setting agent for the concrete industry, or marketed at the oil industry.

Alternatively, using **Module 4**, calcium chloride can be recycled to the process by adding sulphuric acid to convert it back into hydrochloric acid. This final module, by closing the loop, decreases hydrochloric acid consumption in Module 1A while, valuably, also precipitating gypsum as a very pure co-product.

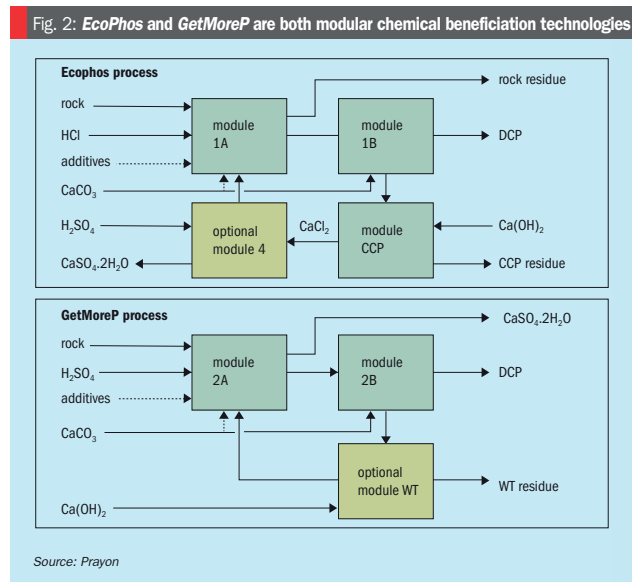
The GetMoreP process

The *GetMoreP* process, similar to the *EcoPhos* process, selectively digests phosphate from low-grade rock – this time using dilute sulphuric acid instead of hydrochloric acid. In the initial process step, **Module 2A**, phosphate is digested with sulphuric acid and enters solution, while calcium, alongside other impurities such as silica, iron, and aluminium, precipitates as gypsum. A further adjustment to pH removes even more impurities – mainly fluorides and heavy metals – leaving a relatively pure filtrate of soluble monocalcium phosphate (MCP) and phosphoric acid.

In **Module 2B**, phosphate is crystallised as DCP by neutralising the solution with calcium carbonate or limestone. This generates a reasonably clean filtrate with only limited levels of dissolved impurities. This can be further polished, if required, using an optional water treatment module (**Module WT**) to eliminate magnesium and other remaining contaminants.

Secondary phosphate technologies

The medium- to long-term scarcity of phosphorus raises questions about security of supply, especially in Europe. However, dependence on external primary phosphate



Source: Prayon

resources in Europe, and other phosphate rock deficient regions, could be reduced by the large-scale recovery of phosphorus from waste streams. This has dual benefits as it would also cut global phosphate losses.

The following technology options from Prayon are capable of recovering phosphorus commercially from various secondary/waste sources:

- Recovery from phosphate beneficiation wastes (slimes, rejected rock) using the *EcoPhos* or *GetMoreP* processes
- Recycling industrial phosphoric acid waste by membrane purification
- Recovering phosphate from sewage sludge fly ash.

Recovering phosphorus via sewage sludge incineration is highly challenging due to the complexity and composition of the iron- and aluminium-rich fly ashes obtained – these typically containing up to nine percent and eight percent iron and aluminium, respectively.

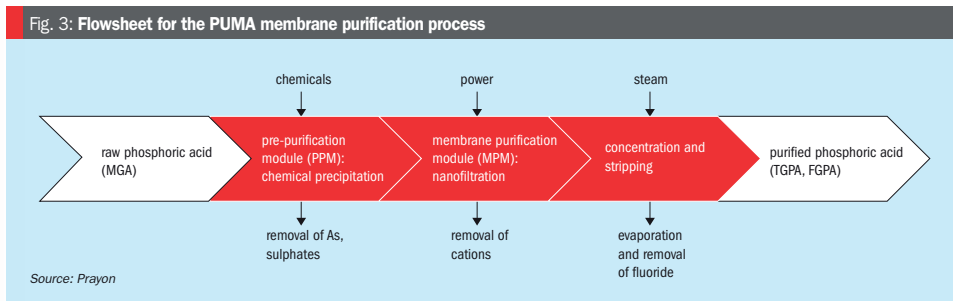
Prayon offers two types of recovery technologies for sewage sludge fly ash. These are selected according to the composition of the fly ash, its location and the required end-product:

- **Technical-grade phosphoric acid production.** This two-stage process firstly involves the digestion of fly ash in

phosphoric acid, followed by the purification of the resulting solution by ion exchange and, optionally, nanofiltration. Phosphoric acid is partly recovered as the final product and partly recycled to digest more fly ash. The ion exchange resin is regenerated by hydrochloric acid. Depending on their composition, the solutions arising from regeneration can be valorised as a de-icing product (Ca/Mg Cl solutions) or sent for wastewater treatment (Al/Fe Cl solutions). This process is safe, performed at reasonably low temperatures, and can be easily installed at sewage sludge incineration sites.

- **Fertilizer-grade dicalcium phosphate (DCP) production.** This process is very close to those used to digest low-grade phosphate rock described above. The main difference is that, due to their high concentration in filtrates, both aluminium and iron need to be removed by ion exchange to obtain high-quality DCP. The DCP product can be used directly as fertilizer or converted into triple superphosphate (TSP) instead.

Process selection depends on the installation location (at the incinerator or not) and the target product (DCP, TSP or phosphoric acid) – and, of course, fly ash composition.



PUMA membrane purification

This innovative purification system from Prayon converts merchant-grade phosphoric acid (MGA) into technical- or food-grade phosphoric acid. The technology has been validated at the Technophos semi-industrial plant in Bulgaria (see below). Achieving food-grade quality from raw phosphoric acid requires three modules used in combination (Figure 3):

- **The pre-purification module (PPM).** This preliminary stage improves phosphoric acid quality to a suitable level for subsequent purification. Selected elements (As, F, SO₄ etc.) are precipitated and organic matter is removed.
- **The membrane purification module (MPM).** This purifies phosphoric acid by removing impurities. It can be combined with an ion exchange resin finishing step, if required.
- **The concentration module.** The desired P₂O₅ content is achieved in an evaporator and fluoride is removed.

This new purification technology offers the following advantages:

- The small size of the units means they can be delivered partially containerised in a skid – thereby limiting construction time and lowering installation costs
- The modular process is easy to install, simple to operate and only requires limited maintenance
- The highly-resistant membrane (Figure 4) developed for the process has a lifetime of more than 700 days
- It is solvent-free, making the process safe and environmentally-friendly.

PUMA membrane purification technology is perfectly practical at small- to medium-scale (typically 10,000-40,000 t/a P₂O₅ capacity) and can be fully integrated within an operational phosphoric acid or fertilizer plant. Effluent and retentate streams can also be recycled to avoid almost all phosphate losses. Installation at an MGA or fertilizer production plant not only avoids water emissions it achieves yields of close



Source: Prayon

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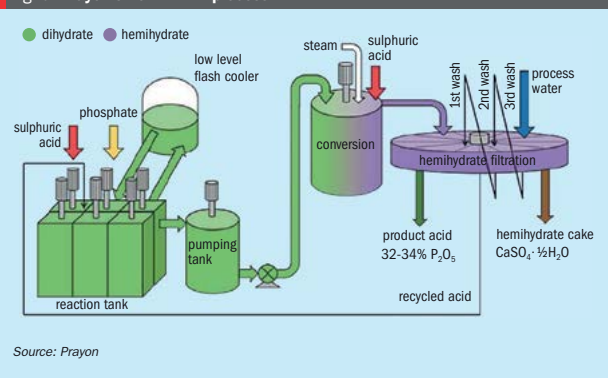
Advances in phosphate flotation

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Fig. 5: Prayon's new DA-HF process



Source: Prayon

- The quality of the calcium sulphate by-product

Unlike the very high efficiency CPP (Central Prayon Process) operated by Prayon in Engis, Belgium, only one single filtration stage is required in DA-HF. This makes DA-HF simpler and easier to operate compared to CPP. Beneficially, the process also removes undesirable cadmium at the concentration stage.

Process validation at Technophos

In addition to its R&D centre in Belgium, Prayon owns the Technophos testing site in Varna, Bulgaria (Figure 6). This centre of excellence, which originally opened in 2016, can validate most of Prayon's innovative technologies at pilot or semi-industrial scale.

Fig. 6: Technophos semi-industrial plant, Varna, Bulgaria



Source: Prayon

Technophos is able to mimic full-scale industrial plant conditions, housing a large array of scaled-down equipment items within in a modern 3,000 square metre building. The available items include press-filters, reactors fitted with agitators, vacuum belt filters (Figure 7), hoppers, buffer tanks, granulators, dryers, multiple conveyors etc.

While Technophos was originally designed for the EcoPhos hydrochloric acid based process, it is also perfectly suited to running the GetMoreP process at semi-industrial scale. Both processes can be operated at feed capacities of up to 500 kg/h (Modules 1A or 2A).

Additionally, Technophos also offers several pilot-scale units that allow process parameters to be adjusted and validated before scaling-up to semi-industrial capac-

ity. This has allowed the PUMA purification process to be demonstrated at pilot-scale with the testing of specific membrane configurations to optimise purity.

Technophos is also a training centre where future plant operators can learn about production processes first-hand by operating the semi-industrial plant on their own. An experienced team of 35 staff are also on site to offer their guidance and coaching to trainees.

Conclusions

The phosphate technologies described in this article are the tip of the iceberg – being just the latest innovations to emerge from continuous large-scale investment in research and development. Indeed, with its expanded portfolio, Prayon is able to match the most suitable technology, both economically and environmentally, with individual project requirements.

Prayon's business activities are unusually broad – encompassing process technology and licencing, projects, equipment manufacture, production and products. Such wide-ranging phosphate industry expertise is beneficial, as it allows the company to offer customers unrivalled support, both on operational improvements and the installation of new technologies. Prayon itself has been an international producer of high-quality phosphates for many decades, operating four plants in Belgium, France and the United States. Collectively, the breadth and depth of its expertise allows Prayon to take innovative ideas, validate and test these at scale, and transform them into commercially-viable technologies. ■

Fig. 7: Filtration at the Technophos semi-industrial plant



Source: Prayon



Advances in phosphate flotation

DELKOR BQR MAXGen flotation cells manufactured in Bengaluru, India, awaiting shipment to Spain.

PHOTO: DELKOR (TAKRAF GROUP)

Newly-developed froth flotation equipment and reagents are improving selectivity and the grade and recovery of phosphate concentrates.

Mined phosphate rock generally needs to be processed and upgraded to meet the downstream requirements of phosphoric acid production and fertilizer manufacture. The industry requires apatite-rich rock concentrates with a high P₂O₅ content and low levels of gangue minerals (silicates, carbonates and clays).

Froth flotation has become widely-adopted globally as the most effective beneficiation method for phosphate rock, since its adoption commercially in the first half of the last century. More than half of the world's marketable phosphate, for example, and two-thirds of Florida phosphate rock, is upgraded by froth flotation (*Fertilizer International* 480, p53).

Flotation technologies typically fall into one of three types – mechanical, pneumatic and column flotation. Nevertheless, conventional Denver-type mechanical cells remain the most popular and well-established choice in phosphate processing plants worldwide.

Maximising the extraction of P₂O₅ from phosphate rock is increasingly critical – as more efficient and less wasteful phosphate recovery from lower-grade ores has become a key challenge for the industry. This has spurred interest in new flotation technologies and reagents.

Major equipment manufacturers have responded to mining industry demands by improving the design of flotation equipment. Innovative flotation cells recently introduced by TAKRAF Group (DELKOR),

FLSmidth, Eriez and others all offer attractive performance advantages – in terms of operational cost, energy consumption and process efficiency.

DELKOR's BQR MAXGen flotation cell

TAKRAF Group launched a new type of BQR flotation cell (Figure 1) at the end of last year through its well-known DELKOR brand of liquid/solid separation and beneficiation equipment. By incorporating a new proprietary MAXGen mechanism, these latest BQR cells offer best-in-class flotation

performance, according to the company.

This new mechanism, which offers both superior recoveries and higher grades, represents the culmination of extensive R&D and demonstration trials at bench-, pilot- and plant-scale.

Dr Venkoba Rao, general manager, process R&D, at DELKOR explains the benefits:

"MAXGen generates a swarm of air bubbles with an optimum size distribution. This enables the flotation of both fine and coarse particles equally. It is also highly efficient at keeping solids in suspension,

Fig. 1: Computer-generated image of an array of three DELKOR BQR MAXGen flotation cells



Source: Tenova Delkor (Takraf Group)

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so maximising the probability of bubble-particle interaction.

"The cell's distinctive design configuration, meanwhile, enables the rotor to operate at a lower tip speed. This delivers operational cost savings by lowering power consumption and reducing wear."

The *BQR MAXGen* cell also incorporates practical features that should improve how flotation circuits are installed, maintained and operated. One of these design features, a 'by-pass ready' tank, allows the easy installation of cell by-pass systems during upgrade projects, without compromising the original circuit layout or requiring modifications to the tank shell. Two of the cell's other features – a deeper launder and higher slope – also enable froth to be evacuated quickly.

The latest *MAXGen* flotation cells should be well-suited to phosphate benefi-

ciation, according to Rajiv Krishnamurthy, DELKOR's sales manager for Europe:

"The flotation process is perhaps one of the more important operational processes within the phosphate beneficiation flowsheet. Phosphate is liberated in different size fractions depending on the specific ore deposit – with most phosphate ores demanding a flotation process for particle-size fractions between 500 µm to 45 µm.

"Second generation *BQR* flotation cells equipped with the proprietary *MAXGen* mechanism are capable of generating a suitable bubble size distribution for this particle range – and providing an optimum agitation level. These second generation cells are suitable for direct flotation of phosphate minerals or the reverse flotation of silica in the froth."

FLSmidth's REFLUX™ flotation cell

FLSmidth is currently developing a revolutionary *REFLUX™* flotation cell (RFC) with Australia's Newcastle University. Its unique design is capable of achieving higher grades, recoveries and throughputs than any other flotation cell currently on the market, according to the company.

"We believe the whole system is unique in its design and mechanics," says Lance Christodoulou, FLSmidth's, global product manager for *REFLUX™* technologies¹. "You are essentially dealing with a form of staged flotation."

He continues: "The feed makes contact with air in an environment where there is high energy density and high shear rates, effectively increasing the probability of collision and attachment. This bubbly

mixture is then passed down into a chamber which operates at a very high air fraction – much higher than anything currently available in the market and approaching what we would call flooding conditions."

The incorporation of lamella plates and the enclosure of the system improves flotation kinetics in comparison to conventional cells – improving both grade and recovery at the same time. Christodoulou explains how this new design operates in practice¹:

"Having [lamella plates] allows for advanced bubble slurry segregation, enabling the RFC to operate in higher air fractions with higher air flux and higher throughput. The RFC's lamella plates allow you to achieve the segregation – and therefore operate with a smaller bubble diameter – as well as higher superficial bubble

surface area flux which then allows for better recoveries.

"We have enclosed the system... and that allows us to operate with very high wash water fluxes and very high gas fluxes, pushing us out into operating ranges that are not possible in open cell systems... simultaneously achieving higher grade and higher recovery."

FLSmidth has already demonstrated the RFC at pilot-scale system on a continuous basis using a constant supply of feed. In addition, the company and the University of Newcastle are currently trialling a two-metre RFC machine on Australian coal. This full-scale evaluation is due to be completed in early 2021.

FLSmidth is also conducting trials on mined fertilizer raw minerals, and is confident about how its new *REFLUX™* flotation

cell technology will perform.

"A test is scheduled in early January on phosphate," Christodoulou told *Fertilizer International*. "Based on other work we have performed, we expect the RFC to be a good candidate for treating finer phosphate feeds to produce high recovery and enhanced rejection of gangue materials, consequently providing a low MER (minor element ratio) product."

Other flotation advances from FLSmidth

FLSmidth recently launched two other new flotation products able to enhance recovery. The company's innovative *mixedROW™* flotation system was released alongside a new 'froth recovery upgrade package' at the end of 2019.

Column flotation revolutionises Brazilian phosphate beneficiation

Erich Dohm and Eric Wasmund of Eriez Flotation outline the major performance benefits achieved at phosphate plants in Brazil by replacing mechanical cells with flotation columns.

Brazil's igneous phosphate deposits contain valuable apatite as well as impurities such as barite, hematite, calcite, alumina and silicates. These ore types are typically processed in two stages. A milling circuit is firstly used to liberate the target mineral (apatite) which is then subsequently recovered by coarse and fine flotation circuits.

Mechanical versus column flotation

In Brazil, mechanically-agitated cells were the standard choice in flotation circuits for many years. However, due to the presence of finely-sized particles, mechanical cells often struggle to produce high-grade concentrates. Fine impurities such as magnetite and silica are a particular problem, as these are easily carried into the froth by hydraulic entrainment, thus lowering the quality of the final concentrate. The attrition effect within mechanical cells is also deleterious as this continuously generates and releases fresh fines into the circuit. As a result, conventional mechanical flotation usually requires chemical depressants and multiple cleaning stages to achieve acceptable grades.

Column flotation cells, in contrast, are well suited to the processing of Brazilian phosphate ore – having become a popular choice throughout the phosphate industry for the selective flotation of fine particles. Flotation columns, when equipped with well-designed froth washing systems, enhance the overall quality of the froth concentrate by minimising the carryover of fine impurities into the floated product. Accordingly, one highly efficient column flotation stage can often replace three stages of cleaning in mechanical cells. In some cases, the wash water can also lower chemical dosage rates by partially offsetting the need for depressants. Additionally, columns cells do not generate fine slimes as they do not create the intense agitation associated with the rotor/stator in conventional mechanical cells.

Brazilian phosphate producers began replacing conventional flotation machines with column cells in the mid-1990s. These upgrades were driven by a desire to improve separation performance, reduce operating costs, and simplify plant circuitry. In fact, two phosphate beneficiation plants in Brazil have replaced their entire mechanical flotation circuit with columns cells.

Effective bubble generation essential

While columns offer many potential performance benefits, some commercial installations have failed to meet expectations due to ineffective bubble generation (gas sparging) systems. However, the Cavita-

tion-Tube sparger in Eriez flotation columns (Figure 2) is one of the most effective sparging systems on the market – being perfectly capable of meeting the rigorous reliability standards demanded by industrial operations.

The Eriez sparger is an hour-glass shaped tubular device constructed of wear-resistant material. A centrifugal pump circulates a mixture of flotation pulp and compressed gas through the device during operation. The use of a circulation system avoids the need to introduce additional fresh or clarified water during bubble generation. Within the sparger, cavitation is induced by the higher flow velocity and lower pressure of the slurry-gas mixture in the cylindrical throat, relative to the mixture in the cylinder entrance. A network of distribution pipes is used to disperse this slurry-gas mixture throughout the flotation tank.

Benefits of column flotation technology

A real example of the performance benefits delivered by column flotation technology is shown in Table 1. This compares phosphate beneficiation results obtained after mechanical cells were replaced with columns during an upgrade at a major phosphate plant in Brazil. The upgrade reduced the number of cells in the plant from 66 mechanically-agitated machines down to just six columns.

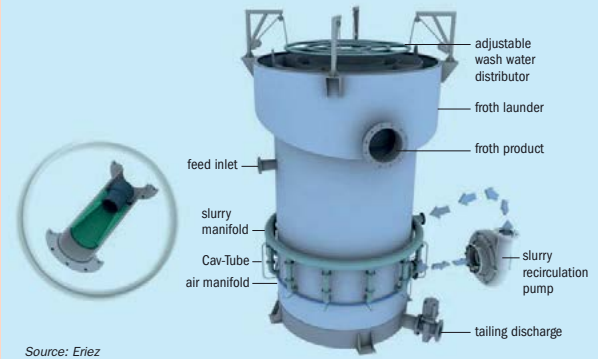
Installing column cells has proven to be extremely effective for upgrading fine

material into saleable products. Indeed, the recovery of fine apatite improved markedly despite the use of less equipment. Recovery increased by 56 percent for the natural fines in the feed, for example, and by 18 percent for fines generated by the grinding circuit. The retrofit also reduced power costs by six percent, and lowered collector demand for barite and apatite by 70 percent and 86 percent, respectively.

Column flotation widely adopted

Eriez, a proven leader in column flotation, has become a trusted partner for the phosphates industry due to its ability to deliver innovative flotation technologies that reduce production costs and cut reagent and power demand. The company has installed 50 column flotation cells in Brazilian phosphate applications to date. Eriez also continues to work closely on new projects using this technology – notably Aguiá Resources' Tres Estradas phosphate project in southern Brazil (*Fertilizer International* 495, p46). Eriez has also piloted *StackCell®* two-stage flotation with Brazilian phosphate producers. This innovative technology offers additional efficiency gains, in comparison to conventional mechanical cells and columns cells. Furthermore, Eriez customers also benefit from its full in-house metallurgical testing and analytical capabilities. These are invaluable when it comes to flow-sheet development, equipment sizing, and understanding and evaluating flotation circuit options.

Fig. 2: Typical Eriez column flotation cell with Cavitation-Tube sparging system



Source: Eriez

Table 1: Comparison of mechanical and column flotation cells

| | | Mech. Cell | Column Cell | Change % |
|-------------------------|--------------------------------|------------|-------------|----------|
| Circuitry data | Number Cells | 66 | 6 | -91 |
| | Power (kWh/t) | 108 | 100 | -7 |
| Collector (g/t) | Barite Circuit | 567 | 170 | -70 |
| | Apatite Circuit | 2,803 | 404 | -86 |
| Barite recovery | | 95 | 97 | 2 |
| | Natural fines | 50 | 78 | 56 |
| Apatite recovery | Generated fines | 65 | 77 | 18 |
| | Coarse/regrind | 71 | 72 | 1 |
| Fine product | P ₂ O ₅ | 33.5 | 34.7 | 4 |
| | Fe ₂ O ₃ | 6.1 | 5.8 | -5 |
| Coarse product | P ₂ O ₅ | 36.2 | 35.9 | -1 |
| | Fe ₂ O ₃ | 3.1 | 3.1 | 0 |

Source: Eriez

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Both innovations address a pressing need, according to FLSmidth.

"Flotation systems are a vital technology in minerals processing and extraction. But despite their overall effectiveness, particles of valuable ore still get disposed of along with waste material. Additionally, the energy consumption that flotation systems require to function effectively is high. So while flotation systems are necessary when recovering ore, making them more sustainable and energy-efficient has been a challenge."

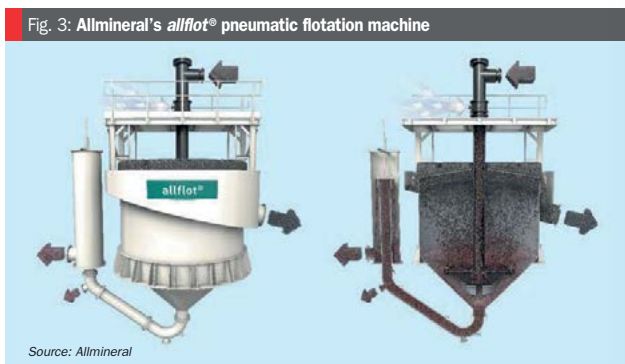
The first-of-its-kind *mixedROW* system combines two flotation machines – the *nextSTEP*™ forced air cell and the *Wemco*® self-aspirating cell – as a way of boosting flotation recovery while reducing environmental footprint and increasing profitability.

nextSTEP machines are placed at the beginning of the flotation circuit to recover coarse material using the least amount of energy possible. This positioning lowers energy consumption by between 15-40 percent and increases recovery by up to five percent. In contrast, the *Wemco* machines – which are capable of treating a wider range of particle sizes – are placed at the end of the circuit to increase both coarse and fine particle recovery. The elevated rotor position within *Wemco* machines also cuts energy consumption by reducing the distance the froth has to travel.

The improvements in recovery possible with the *mixedROW* flotation system – although not large in numerical terms – can still translate into very large economic gains, potentially equal to tens of millions of dollars. Although only officially launched in 2019, the *mixedROW* concept has already been successfully applied in both new installations and retrofits.

Until recently, flotation circuit losses in the mining industry were substantial, typically around 50 percent, and even running as high as 90 percent for coarse particles in some instances. FLSmidth's 'froth recovery upgrade package' is designed to minimise the loss of these valuable particles, while also improving control of the froth recovery process. It does this by combining four design features:

- **Adjustable radial froth crowders (ARFCs):** developed in-house by FLSmidth, these mechanical devices increase either recovery or grade, regardless of the amount of froth formed at the top of the machine. They permit much higher pulling rates (to improve recovery) or much deeper froth (to boost grade).



Source: Allmineral

- **Advanced froth cameras:** provided in cooperation with Stone Three, a market leader in vision equipment, these allow precise monitoring of the froth phase.
- **Redesigned actuators:** provided in cooperation with Festo, these control the position of modified dart valves inside the flotation cell.
- **New and improved level sensor:** provided in cooperation with HyControl, the solid state MultiSense probes accurately monitor both the slurry level and froth position.

By harnessing the combined benefits of crowders, froth cameras and actuators, processing plant operators are able to make quicker adjustments to the flotation circuit in response to changes in flow and slurry density – dramatically boosting the performance of flotation machines.

The most difficult part of the flotation process is often froth recovery in cells located at the end of the row. At this stage, because there is not enough hydrophobic particles to form a stable and deep froth, a large percentage of these can fail to be recovered. FLSmidth's new upgrade package helps resolve this problem. Not only does it increase recovery of these particles, it also enables precise control of recovery and grade in this part of the flotation circuit.

In summary, the new upgrade package provides two major flotation process improvements – firstly, precise control of froth depth and, secondly, the choice of increasing pulling rate or froth depth. Because of this, the package can deliver either better recovery at the same grade or increased grade at the same recovery. The package can also be retrofitted into

existing plants regardless of the type of mechanical cell (forced air or self-aspirated).

Pneumatic flotation

The German company EKOF manufactured the first pneumatic cell for coal flotation in 1987. The innovative design incorporated an energy saving, self-aspirating, venturi-based aerator.

The *allflot*® pneumatic flotation machine from Düsseldorf-based manufacturer Allmineral (Figure 3) offers several potential benefits for phosphate ore flotation. It can either function as a scavenger cell to increase recovery and/or as a cleaner cell to improve grade.

The *allflot* machine operates as a high-intensity flotation cell – with a flotation throughput 2-4 times greater than an equivalent mechanical flotation cell. The machine brings mineral particles into close contact with fine bubbles within an external aerator/contactor. The external contactor uses either pressurised air or air entrained in a fluid jet. The contactor/aerator functions as the primary collection zone while the main tank acts as the disengagement zone.

The power consumption of *allflot*® pneumatic flotation cells are 40 percent lower than conventional mechanical agitator cells. Their installation footprint is also smaller. Phosphate flotation experience with the machine dates back to 1996, and includes detailed test work at JPMC in Jordan, Simplot in the US and Kazphosphate in Kazakhstan. Results have demonstrated the ability of the *allflot*® machine to produce marketable phosphate grades and achieve high recoveries (*Fertilizer International* 495, p48).

Collector reagents

Clariant offers the *Flotinor* and *Flotigam* range of collectors for direct and reverse flotation of phosphate ores. The company's *Flotigam 3135* proprietary reagent – an ether propyl di-amine – has long been used as a standard collector by a leading global sedimentary phosphate mine. This mine produces nearly four million tonnes of concentrate by processing around six million tonnes of ore feed using multiple flotation cells. For 30 years, the high production mine has used *Flotigam 3135* as its benchmark collector due to its ability to deliver consistently high-grade concentrates ($\geq 32\%$ P_2O_5 and $< 3\%$ SiO_2) at recovery rates in excess of 80%.

High-grade phosphate ores which are most amenable to fatty acid flotation are becoming exhausted. As a consequence, reverse flotation using amines and specialised anionic collectors will become increasingly necessary in some parts of the world, suggests Clariant, particularly for difficult-to-float ores where carbonates are present as gangue. This is true in Florida, where ores are becoming more dolomite-rich as extraction moves southwards. High levels of carbonate minerals are also present in new South American and African phosphate deposits.

Clariant is highly active globally, having successfully conducted direct and reverse flotation trials on a wide range of different phosphate ores from Africa and North and South America. In recent case studies, the company has been able to demonstrate how difficult-to-float ores – which do not respond to conventional low-cost anionic collectors – can be effectively benefited with new anionic and cationic collectors (*Fertilizer International* 480, p53). Clariant says its expertise in reverse flotation collectors for phosphate is helping to make these reagents the preferred choice for ores with high carbonate contents.

Arkema-ArrMaz is a leading global provider of speciality chemicals to the global phosphate mining and industrial minerals sectors. Its participation in the phosphates industry dates back to 1967, when the company pioneered phosphate flotation chemistry in Florida's bone valley.

There is no universal reagent scheme or flowsheet for phosphate flotation.

Arkema-ArrMaz therefore recommends an individually tailored approach, given that every ore is different.

Increasing phosphate recovery or grade through the flotation process is a balancing act, suggests Arkema-ArrMaz, as improving one is difficult to achieve without detrimentally affecting the other. Indeed, in the company's view, a true positive shift in the grade-recovery curve can only be achieved by integrating flowsheet design with reagent formulation. Arkema-ArrMaz therefore advises developing the reagent scheme and the process flowsheet together from the outset. This holistic approach recovers more higher-grade phosphate during flotation, while at the same time consuming less energy, fewer resources and extending mine life.

The company individually formulates its standard flotation reagents according to each customer's unique ore characteristics (*Fertilizer International* 480, p53). Available product lines include:

- *CustoFloat*® and *CustAmine*® anionic and cationic collectors
- *CustoFroth*® frothers/surfactants
- Depressants
- Defoamers
- Flocculants
- Filtration aids
- Float oils
- pH modifiers.

CustoFloat and *CustAmine* reagents are specially formulated to handle clays and multiple size fractions. These collectors can successfully reject carbonate and silica in clay-laden feeds, while also maximizing grade and recovering more phosphate in finer size fractions (*Fertilizer International* 480, p53). The end result is the generation of more tonnes of higher-grade

Modifiers

The demand for flotation reagents capable of improving selectivity and recovery during phosphate ore processing is becoming more widespread, as high-grade deposits have become depleted. The use of additives to modify fatty acid collector systems is one area where significant advances have been made in recent years. These secondary

collectors/modifiers – typically anionic or non-ionic surfactants – have a critical effect on flotation performance, especially in acidic reverse carbonate flotation.

Since the mid-1990s, **BASF Mining Solutions** has developed and introduced a range of non-ionic modifiers in mineral processing applications. These are marketed as safe, biodegradable and non-toxic alternatives to alkylphenol ethoxylates (APEOs) and nonylphenol ethoxylates (NPEOs). The range includes *Lupromin FP A 105*, a non-ionic modifier for standard fatty acid collectors. This modifier is recommended for the direct flotation of both oxidised and un-oxidised igneous phosphate ores, and has been shown to improve selectivity and increase recovery compared to conventional APEO modifiers (*Fertilizer International* 480, p53).

Depressants

Phosphoric acid and its derivatives have long been used as depressants for apatite in phosphate flotation. Although an effective reagent, dosage levels are normally quite high (1-5 kg/t), making the use of phosphoric acid a costly option. This depressant is also usually sourced from downstream phosphoric acid production, leaving less P_2O_5 for onward fertilizer manufacture.

Nalco Water recently trialled a new depressant reagent which, says the company, should help phosphate process engineers maximise P_2O_5 recovery and increasing profitability. Test results show that the new reagent can cut phosphoric acid dosage requirements by as much as 50 percent, and increase phosphate recovery by as much as three percent, without any decline in concentrate grade (*Fertilizer International* 480, p53).

Further reading

A more comprehensive introduction to phosphate flotation flowsheets and reagents can be found in our March/April 2017 issue (*Fertilizer International* 480, p53). Flowsheet, equipment and reagent options were also discussed in our March/April 2020 magazine (*Fertilizer International* 495, p44).

References

1. Moore, P., 2020. FLSmidth's flotation REFLUX™ revolution. *International Mining*, 16 September 2020.
2. Moore, P., 2019. New flotation innovations from FLSmidth. *International Mining*, 2 October 2019.

Gemini surfactants: novel phosphate flotation collectors



PHOTO: NOURYON

Nouryon is introducing a new anionic 'gemini' collector for phosphate flotation under the product name *Phospholan G10*. These novel dimeric reagents offer distinct performance advantages over conventional fatty acid collectors.

Above: Laboratory beneficiation test with a Denver flotation machine.

Nouryon is a global manufacturer of flotation collectors for phosphate ores. These reagents are designed for the direct flotation of apatite or the reverse flotation of silica and carbonate (Table 1).

Nouryon's collectors are specifically tailored and optimised for different customer needs. This is necessary to match reagents to individual beneficiation requirements – particularly variations in ore type, process water quality, flotation temperature, impurities, particle-size distribution, etc.

Novel 'gemini' surfactants

Nouryon is working to continuously improve its flotation process reagents for mining customers globally. The company recently developed a new range of 'gemini' surfactants for the flotation of apatite, as briefly reported last year (*Fertilizer International* 495, p44).

These novel ionic surfactants are dimeric. They were originally developed a few decades ago as more efficient alternatives to existing monomeric surfactants. The high efficiency of gemini surfactants is linked to their critical micelle concentration (CMC). This can be up to 100 times lower than their monomeric counterparts (Figure 1).

CMC represents the critical concentration at which surfactants in solution start to form micelles. At the CMC, surfactant solutions show a drastic decrease in sur-

face tension. The phenomenon of much lower CMC exhibited by gemini surfactants is connected to their unusual structure. Uniquely, they contain two ionic groups which, being covalently-bound, cannot repel each other (Figure 2).

Key advantages

Currently, fatty acids are the most commonly used type of collector in the direct flotation of apatite from sedimentary phosphate ores. However, their flotation performance usually needs to be enhanced by the addition of other reagents. These typically include a non-polar hydrophobicity enhancer (commonly diesel) and a saponification agent (commonly NaOH). Total reagent dosage rates are often high and can reach 4-6 kg/t.

The use of novel gemini-type apatite collectors, in contrast, offers three specific advantages over fatty acids:

- They lower overall consumption of reagents
- Flotation circuits can run at natural pH
- These lower pH operating conditions allow vegetable oils to substitute as an enhancer for diesel, a known environmental and human health hazard.

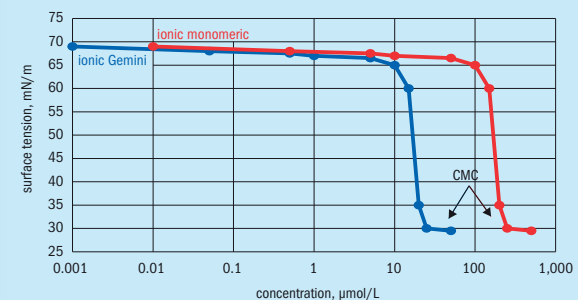
Previously, the hydrolysis of vegetable oils at high pH, together with their relatively high price, have limited their use in the direct flotation of apatite. The option with gemini

Table 1: Nouryon's collectors for phosphate ores – including *Phospholan G10*, the new gemini-based reagent

| Flotation type | Product name | Comment |
|----------------|-------------------------------------|---|
| Direct | <i>Phospholan PE-65</i> | Boosters for complex difficult to float ores and/or hard process water, perform over wide temperature range |
| | <i>Berol 8305, Berol 8313</i> | Fatty acid special formulations |
| | <i>Atrac 922, Berol 912L</i> | Carbonate selective surfactants, proprietary formulations, primary collectors |
| | <i>Atrac 2600</i> | Synthetic anionic collector with improved selectivity for siliceous gangue minerals |
| | <i>Phospholan G10</i> | New gemini-based collector |
| Reverse | <i>Armoflote 465, Armoflote ECO</i> | Low toxic and readily biodegradable cationic collectors for silica removal |
| | <i>Atrac 50L</i> | Anionic collector for carbonate removal |

Source: Nouryon

Fig. 1: Critical micelle concentration (CMC) of dimeric 'gemini' surfactants vs monomeric surfactants



Source: Nouryon

Table 2: Direct flotation of apatite: Denver cell laboratory test results for a conventional fatty acid collector versus a novel 'gemini' collector. Diesel and crude soybean oil (CSO) enhancers are also compared.

| Reagents | Test 1* Fatty acid + diesel | Test 2 Gemini + diesel | Test 3 Gemini + CSO |
|---|-----------------------------------|------------------------------|---------------------------------|
| Reagent dosage (g/t) | | | |
| Fatty acid | 2,400 | 0 | 0 |
| Diesel | 7,900 | 7,900 | 0 |
| Gemini | 0 | 1,800 | 1,250 |
| CSO | 0 | 0 | 4,725 |
| Total | 10,300 | 9,700 | 5,975 (42% reduction) |
| pH | 9 | Natural | Natural |
| Concentrate grade (% P ₂ O ₅) | 35.5 | 35.3 | 36.0 (Highest grade) |
| Concentrate recovery (% P ₂ O ₅) | 96.6 | 96.6 | 96.6 |
| Concentrate SiO ₂ content (%) | 6.6 | 6.5 | 5.1 (20% lower) |

*Reference collector test.

Source: Nouryon

collectors to replace diesel with vegetable oils (triglycerides) is therefore an important operational health and safety improvement. Triglycerides – similar to diesel – are non-polar substances with hydrophobicity enhancing properties. Vegetable oils such as soybean, rapeseed, olive and palm are also more sustainable, being naturally-occurring and renewable raw materials.

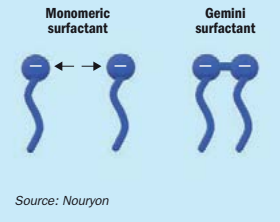
Gemini flotation case study

Flotation tests were performed on a sedimentary phosphate ore from Western Africa using a Denver laboratory flotation

machine. These tests compared the performance of gemini ionic surfactants as collectors, versus fatty acids, in the direct flotation of apatite.

The main purpose of this laboratory investigation was to confirm the higher efficiency of the new gemini surfactant and evaluate its dependency on pH. Unlike with fatty acid collectors, the gemini flotation tests were carried at natural pH. This allowed the potential of crude soybean oil (CSO), a replacement for diesel enhancers, to also be evaluated as part the tests. Flotation results are shown in Table 2.

Fig. 2: Packing of ionic surfactants in solution



Source: Nouryon

The results demonstrate that the new gemini collector is 25 percent more efficient than the fatty acid, when both use a diesel enhancer (Test 2 vs Test 1), even at natural pH. Commenting on the overall results, Dr Natalija Smolko Schwarzmayr, senior scientist at Nouryon, observes:

"We can see an outstanding synergistic effect between the gemini collector and crude soybean oil. This combination led to levels of P₂O₅ recovery as high as those achieved with the reference collector but with enhanced capacity to remove silica, with SiO₂ levels over 20 percent lower in the concentrate. Additionally, the new collector system is way more efficient, leading to 42 percent reduction in the total consumption of reagents."

Commercialisation

This novel ionic gemini collector from Nouryon will be made available under the product name *Phospholan G10*. This belongs to a family of pyrophosphate esters. Such phosphorus-based anionic surfactants make a good choice from a product life cycle perspective. This is because any phosphorus present in the surfactant will be recovered to the apatite concentrate, and not lost to waste waters. It will therefore be captured in the manufacture of phosphoric acid and be ultimately consumed in the production of the fertilizer end product.

"At Nouryon we provide essential chemistry for a sustainable future. When it comes to mining chemicals, we develop and offer products that will improve the performance of your mineral beneficiation process leading to a high-quality concentrate," comments Dr Odair Lima, Nouryon's global strategic marketing manager for mining.

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Phosphates project listing 2021

Fertilizer International presents a global round-up of phosphate rock, phosphoric acid and finished phosphates projects.



PHOTO: EAK ANAH KAEWTHIP/SHUTTERSTOCK.COM

Phosphate rock*

| Plant/project | Company | Location | capacity ('000 t) | Status | Start-up date |
|--------------------------|-------------------|---------------|-------------------|--------|---------------|
| CANADA | | | | | |
| Lac-à-Paul | Arianne Phosphate | Quebec | 3,000 | FS | n.a. |
| Sept-Iles | Mine Arnaud/Yara | Quebec | 1,500 | FS | n.a. |
| REPUBLIC OF CONGO | | | | | |
| Hinda | Kropz | Hinda | 1,200 | FS | n.a. |
| GUINEA-BISSAU | | | | | |
| Farim | Itafos | Guinea-Bissau | 1,300 | FS | n.a. |
| SENEGAL | | | | | |
| Baobab | Agrifos | Gadde Bissik | 1,000 | FS | n.a. |
| SOUTH AFRICA | | | | | |
| Elandsfontein | Kropz | Elandsfontein | 1,000 | C | n.a. |

*Excluding China. Standalone, non-integrated projects only. At present, there are tens of junior phosphate mining projects globally. However, only capacity developments with a published feasibility study are listed here. In general, these projects have yet to secure the necessary finance and, consequently, none have committed to a firm construction schedule and start-up date currently. Africa is undoubtedly the region with the most potential for phosphate rock expansion – although large uncertainties over individual projects and their timescales remain. OCP Group is, however, pressing on with ambitious plans to increase phosphate rock capacity at Khouribga and Meskala in Morocco. The restart of Kropz's Elandsfontein project in South Africa is dependent on its water permitting issues being resolved. Major expansions in phosphate rock capacity are also expected out to 2024 from established phosphate producers in Russia and Kazakhstan (Acron, EuroChem, PhosAgro), Brazil (Yara, Itafos) and Mexico (Fertinal). This extra supply will be largely consumed in integrated, downstream operations.

Phosphate fertilizer, phosphoric acid and integrated phosphate rock projects**

| Plant/project | Company | Location | Product | capacity ('000 t) | Status | Start-up date |
|----------------------------|----------------------|--------------------------|--|-------------------|--------|---------------|
| BRAZIL | | | | | | |
| Serra do Salitre | Yara | Patrocinio, Minas Gerais | Phosphoric acid (P ₂ O ₅) | 250 | UC | 2021 |
| Serra do Salitre | Yara | Patrocinio, Minas Gerais | SSP | 650 | UC | 2021 |
| Serra do Salitre | Yara | Patrocinio, Minas Gerais | DAP/MAP | 350 | UC | 2021 |
| EGYPT | | | | | | |
| El Wadi | WAPHCO | Abu Tartur | Phosphate rock | 3,000 | UC | 2021 |
| El Wadi | WAPHCO | Abu Tartur | Phosphoric acid (P ₂ O ₅) | 500 | UC | 2021 |
| El Wadi | WAPHCO | Abu Tartur | DAP/MAP | 800 | UC | 2021 |
| El Wadi | WAPHCO | Abu Tartur | TSP | 600 | UC | 2021 |
| INDIA | | | | | | |
| Krishnapatnam | KRIBHCO/OCP | Krishnapatnam | DAP/NPK | 1,200 | n.a. | 2023 |
| Orissa expansion | Paradeep Phosphates | Paradeep | DAP/NPK | 400 | n.a. | 2023-2024 |
| Tuticorin expansion | Greenstar Fertilizer | Tuticorin | Phosphoric acid (P ₂ O ₅) | 216 | UC | 2021 |
| Tuticorin expansion | Greenstar Fertilizer | Tuticorin | DAP | 650 | UC | 2021 |
| KAZAKHSTAN | | | | | | |
| Karatau | EuroChem | Zhambyl | Finished phosphates | 1,000 | PL | 2021 |
| Taraz | Kazphosphate | Taraz | PPA (P ₂ O ₅) | 240 | PL | 2021 |
| Taraz | Kazphosphate | Taraz | MAP | 460 | PL | 2021 |
| MOROCCO | | | | | | |
| Various | OCP Group | Various | Phosphoric acid (P ₂ O ₅) | 2,000 | UC | 2019-2022 |
| Various | OCP Group | Various | Finished phosphates | 4,000 | UC | 2019-2022 |
| NIGERIA | | | | | | |
| Lekki | OCP/Nigeria | Lekki | DAP/NPK | 650 | PL | post-2024 |
| RUSSIA | | | | | | |
| Cherepovets expansion | PhosAgro | Cherepovets | Phosphoric acid (P ₂ O ₅) | 10 | C | 2020 |
| Cherepovets expansion | PhosAgro | Cherepovets | DAP/MAP/NPK | 110 | C | 2020 |
| Dorogobuzh | Acron | Dorogobuzh | Phosphoric acid (P ₂ O ₅) | 400 | PL | 2024 |
| Dorogobuzh | Acron | Dorogobuzh | DAP/MAP/NPK | 1,000 | PL | 2024 |
| Volkhov expansion | PhosAgro | Volkhov | Phosphoric acid (P ₂ O ₅) | 500 | UC | 2023 |
| Volkhov expansion | PhosAgro | Volkhov | DAP/MAP | 800 | UC | 2023 |
| SAUDI ARABIA | | | | | | |
| 'Phosphate 3' mega project | MWSPC | Umm Wu'al | Phosphoric acid (P ₂ O ₅) | 1,500 | PL | post-2024 |
| 'Phosphate 3' mega project | MWSPC | Ras al Khair | Finished phosphates | 3,260 | PL | post-2024 |
| TOGO | | | | | | |
| n.a. | Dangote Group | n.a. | Finished phosphates | 1,000 | PL | n.a. |
| TUNISIA | | | | | | |
| M'dilla II | GCT | M'dilla | Phosphoric acid (P ₂ O ₅) | 180 | UC | 2020-2021 |
| M'dilla II | GCT | M'dilla | TSP | 500 | UC | 2020-2021 |

KEY FOR BOTH TABLES

FS Feasibility study complete
 PL Planned
 UC Under construction
 C Project completed
 n.a. Not available
 DAP Diammonium phosphate
 DCP Dicalcium phosphate
 MAP Monoammonium phosphate
 PPA Purified phosphoric acid
 SSP Single superphosphate
 TSP Triple superphosphate

**Excluding China. The International Fertilizer Association (IFA) expects various production investments by OCP Group to collectively add an additional four million t/a to Morocco's finished phosphates capacity out to 2022. OCP is also pursuing large-scale joint venture projects in both Nigeria and India. The third phosphates mega project announced by Ma'aden and its partners should eventually ramp-up product capacity in Saudi Arabia by a further 3,260 t/a. In Egypt, WAPHCO is currently constructing a major phosphate production complex at Abu Tartur.

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Phosphate technology and engineering profiles

JESA Technologies

JESA Technologies (JT), based in Lakeland, Florida, has proudly served the global phosphate industry for over a half century. The company, part of Worley Group, offers licensed technology to the phosphates industry covering the whole production process, from mine to market. The company is a leading licensor for three process steps in particular: phosphate rock beneficiation, phosphoric acid production and granular fertilizer manufacture.

Additionally, JT offers on-site pilot plants, for both beneficiation and phosphoric acid, supported by a fully equipped analytical laboratory. The ability to combine in-house technical and engineering design know-how – from mined rock all the way through to the finished product – with on-site pilot plants makes JT unique as a licensor.

Since its establishment in 1974, JT has been responsible for the design of over 150 process facilities for the phosphate fertilizer industry in 29 countries. The plants designed by JT include the largest single-train phosphate operations in the world. Notably, these include a phosphoric acid plant with a demonstrated capacity above 3,000 tonnes per day – plus numerous examples of DAP/NPK plants with capacities in excess of one million tonnes per year.

In addition to designing new plants, JT has an extensive track record in revamping operational plants. These revamps have successfully delivered a range of desired outcomes for customers – including increased production capacity, product quality improvements, energy savings and improved environmental performance.

Through its parent company Worley Group, JT is also backed by one of the world's largest engineering and project delivery firms, with proven strengths in resource, energy, and infrastructure markets globally. JT and Worley's combined capabilities offer clients a full spectrum of support covering all aspects of engineering, procurement, programme and construction management, as well as operations and maintenance.

JT's extensive test facilities in Lakeland, Florida, include:

- A comprehensively equipped analytical laboratory
- A bench-scale metallurgical laboratory, capable of testing ore samples obtained from core drilling or pits



Inspection of Ammaroo project phosphate core.

- A fully-equipped pilot plant capable of batch or continuous operation
- A continuous phosphoric acid pilot plant.

These test facilities make a vital contribution to feasibility studies. By developing process design data, they enable JT to offer its customers process guarantees. They are also engaged in contract research for clients.

Two case studies of phosphate industry projects recently awarded to JT are provided below:

Client: Verdant Minerals Ltd

Location: Northern Territory, Australia

Project: Ammaroo phosphate project: dihydrate phosphoric acid pilot plant testing.

Verdant is proposing to develop the Ammaroo phosphate project – the largest JORC-compliant phosphate rock resource in Australia and one of the world's largest undeveloped phosphate deposits. In the project's initial development phase, phosphate rock concentrate and associated merchant-grade phosphoric acid (MGA) will be produced for export to Asian markets through the Port of Darwin.

The proposed phosphate fertilizer com-

plex will produce a high-quality MGA product utilising the most modern equipment and technologies available. These must also provide optimal environmental safeguards. The project's phosphoric acid production capacity is initially set at approximately 500,000 t/a P₂O₅, equivalent to 1,600 t/d.

Client: Ma'aden

Location: Ras Al Khair, Saudi Arabia

Project: Front-end engineering design (FEED) for two large-scale granular fertilizer plants

JT has been selected as the licensor for a major granular fertilizer project as part of Phase 1 of Ma'aden's 'Phosphate 3' mega project. Two large-scale granulation plants, with a total annual production capacity of two million tonnes, will be designed to produce over 25 different fertilizer grades.

As licensor, JT will be involved throughout the life of the project – all the way through from technology and design to staff training and then plant commissioning and start-up, supporting the engineering, procurement and construction (EPC) contractor. JT's mission is to provide the client with reliable, efficient designs that demonstrate the excellence of its expertise and unrivalled leadership in the phosphate industry. ■

PHOTO: VERDANT MINERALS

An array of four TOMRA sorting machines at the MWSPC mega project in Saudi Arabia.



PHOTO: TOMRA

TOMRA: cutting the cost of phosphates processing

The use of TOMRA sorting machines at a major new phosphate mining and processing operation is showing how phosphorus can be extracted from ore with greater environmental and economic efficiency.

Transforming phosphate rock into a high-quality and commercially-usable concentrate can be costly, logistically-complex and technically-demanding. Fortunately, the introduction of innovative and pioneering sorting technology is now helping to improve the efficiency of phosphate fertilizer production.

Indeed, over the last two years, the installation of TOMRA sorting machines at a new large-scale phosphates mining and processing complex in Saudi Arabia has shown how it is possible to cut production costs – while at the same time turning traditionally discarded waste into usable phosphate.

The massive complex, located in the remote north of the Kingdom, is run by the Ma'aden Wa'ad al Shamal Phosphate Company (MWSPC), an \$8 billion joint venture between Saudi mining giant Ma'aden, Saudi Basic Industries Corporation (SABIC) and US-based Mosaic, a leading international fertilizer producer. The successful completion of the MWSPC project in 2018 has turned Saudi Arabia into the second-largest phosphate producer in the Middle East.

The biggest challenge at the MWSPC plant – in common with many other phosphate operations around the world – is removing significant amounts of unwanted silica, also known as flintstone or chert. This needs to be eliminated from run-of-mine material to improve its quality and ensure that phosphate rock concentrates are suitable for downstream chemical processing.

This challenge is even tougher for MWSPC. That's because contaminants are traditionally removed from phosphate ore using large quantities of water (and chemicals). Yet this is not possible at the company's arid inland desert location due to the lack of a natural rain-fed water supply.

TOMRA therefore collaborated closely with the designers of the MWSPC plant to find a way of reducing water (and electricity) consumption in downstream production processes. The installation of high-capacity TOMRA sorting machines emerged as the most viable and practical option. These machines are capable of efficiently identifying and ejecting unwanted silica from large volumes of phosphate feed materials.

Following their installation, TOMRA's XRT (X-Ray Transmission) machines are now pre-processing more than half of the total 13.5 million tonnes of phosphate ore handled by the MWSPC plant every year. Running at a rate of 1,800-2,000 tonnes per hour, the XRT machines recognise and separate materials according to their specific atomic density. Advantageously, this process is completely dry and avoids the need for wet, water-based cleaning of materials.

The sorting machines have performed remarkably well at the MWSPC plant, delivering large efficiency gains and cost savings.

"Now that this plant has been running for two years, the effectiveness of XRT sorting is clear," comments Jens-Michael Bergmann, TOMRA's area sales manager for Europe, MENA and India. "By making it possible to remove 98 percent or more of liberated silica contaminants, XRT has reduced the workload and costs of crushing by about 75 percent, reduced the costs of milling by 45 percent, and reduced water consumption by 45 percent."

He adds: "What's more, the ability to reduce the size of the flotation plant has saved millions of dollars in construction costs, and continues to save about \$10 million per year in the cost of flotation reagents alone."

XRT sorting technology can perform equally well at improving the phosphate-processing efficiencies of many other operations globally. That's the main lesson from the successful installation of TOMRA sorting machines at the MWSPC plant – in some of the most hostile working conditions on earth. ■

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Prayon Technologies (PRT)

Prayon Technologies (PRT) is the technology arm and subsidiary of parent company Prayon s.a. With experience dating back more than 60 years, PRT is a global leader in phosphoric acid production technology.

Uniquely, Prayon is both a leading commercial manufacturer of phosphoric acid and its derivatives – purified acid, technical- and food-grade phosphates – and a licensor of phosphoric acid production technology. This provides the Belgium-headquartered company with considerable advantages when it comes to understanding the needs of its technology customers.

A major proportion of the worldwide phosphoric acid production relies on Prayon's process technology. In fact, Prayon Technologies has designed, developed and helped construct more than 135 phosphoric acid plants in more than 30 different countries globally. These plants consume more than 40 different types of phosphate rock and have P₂O₅ production capacities ranging from 25 tonnes up to 2,000 tonnes per day.

Prayon offers flexible production technologies able to respond optimally to the requirements of phosphoric acid producers, offering:

- Reduced energy consumption
- Increased yield
- Lower production costs
- Excellent environmental performance.

Prayon Technologies essentially offers two types of service: technology licensing and consultancy. Its licensing activities cover:

- Phosphoric acid production – including a full range of processes (DH, HH, DA-HF, CPP, PH₂) producing hemihydrate or dihydrate calcium sulphate with one or two filtration step(s)
- Phosphoric acid concentration
- Fluorine recovery
- Gas scrubbing systems – for F, dust and H₂S reduction
- Phosphoric acid purification – SO₃, Cd, As, F, Al₂O₃, Fe₂O₃ and MgO reduction technologies
- Phosphogypsum purification
- Uranium recovery from phosphoric acid
- DCP production from low-grade rock and dilute sulphuric acid – the *GetMoreP* process.

Prayon's consultancy activities cover:

- Audits of existing plants with specific objectives
- Phosphate rock evaluations
- Plant operator training. ■

GEA Group

GEA is emerging as a leading technology and equipment provider to the phosphates industry. The Dusseldorf-headquartered group is one of the world's largest production technology and equipment suppliers and employs about 18,500 people across the globe. GEA generates around 70 percent of its revenues from the food and beverages sector – and is the technology leader in this market.

With more than 100 years of experience in crystallisation alone, the company offers a range of production plant technologies able to meet the diverse requirements of the phosphate and fertilizer industries. They include:

- Evaporators
- Crystallisers
- Membrane filtration units
- Centrifugal decanter and separators
- Spray and fluid bed dryers for drying crystals or granulation.

GEA specialises in the production of water-soluble monoammonium phosphate (MAP) from phosphoric acid. The innovative production technology offered by the company is capable of manufacturing high-quality water-soluble MAP from lower-quality merchant grade acid (MGA). This ground-breaking process reduces opex and/or capex costs as it avoids the need to purchase more expensive purified phosphoric acid (PPA), or integrate a purification line within the fertilizer production plant.

GEA's process firstly produces a clarified liquid stream after an initial reaction and filtration step. Dry, pure and highly water-soluble MAP crystals are eventually generated as an end-product, after a series of further crystallisation and purification steps. Waste from the various purification and filtration steps, in the form of sludges or purges, still contains some valuable P₂O₅. This can be captured by further processing – for example, via the fertilizer plant's blending or granulation units.

GEA's manufacturing process can typically deliver a yield (i.e. the amount P₂O₅ recovered to the crystalline end-



Operational GEA crystalliser at a fertilizer production plant.

product vs the P₂O₅ contained in the feed acid) of between 50-70 percent. The exact yield depends on the impurity levels in the MGA and the purity/quality requirements (non-soluble content) of the final MAP product.

GEA's technology for water-soluble MAP production has already been successfully implemented by an Eastern European customer. The new plant avoided considerable capital and operational expenditure by allowing non-purified MGA to be used as the phosphoric acid feed, while still delivering a pure MAP fertilizer with a high market value as the end-product. As a fertilizer, the crystalline end-product offers the following key benefits:

- High-quality fully water-soluble MAP (typically 12-61-0) with a low insoluble content
- Avoids clogging problems on spray systems and pumps
- Suitable for fertigation, foliar applications and the production of fertilizer blends and nutrient solutions
- Low turbidity after dissolution in water
- High-throughput processing
- Free of chlorine, sodium and other deleterious elements
- Moderate solution pH – safer and less corrosive
- Access to excellent laboratory backup, support and expertise. ■

Tenova Advanced Technologies (TAT)

Tenova Advanced Technologies (TAT) offers phosphate beneficiation process development and proprietary technologies for the purified phosphoric acid industry, complemented by in-house laboratory and pilot plant facilities.

Tenova provides a full suite of technologies for the beneficiation of phosphate rock. Its project services range from process development through to feasibility studies and complete turnkey solutions.

Tenova is proud of its modern in-house analytical laboratory and pilot plant capabilities for purified phosphoric acid (PPA), solvent extraction (SX), and wet and dry mineral beneficiation. These state-of-the-art R&D facilities are able to handle a wide range of phosphate rock materials, including:

- Sedimentary and igneous ores
- Carbonaceous and/or siliceous gangue
- Terrestrial and marine deposits
- Low-grade phosphates
- High impurity phosphates
- Reclamation of phosphate from tailings.

Tenova also provides the full spectrum of technologies required for producing PPA from phosphate rock and wet-process phosphoric acid (WPA) – including the SX, acid purification and concentration stages. These are well-suited to the production of high-quality food- or technical-grade phosphoric acid.

Ensuring reliable plant design requires continuous monitoring and the collation of information during process development. Each successive process stage has the following objectives:

- **Pre-treatment:** this stage removes common impurities such as sulphates, cadmium, fluorides and arsenic
- **Purification:** this is achieved via proprietary SX processes and involves the selection of the optimal solvent
- **Post-treatment:** this stage brings the product up to final specification through concentration, solvent recovery and the reduction of total organic carbon.

Tenova has an extensive track record of project implementation built on years of experience and know-how. The company adopts a step-by-step approach to project development. This guarantees the fulfilment of customer requirements and ensures successful project delivery. Selected project references are provided below.

Phosphate beneficiation:

- The Mosaic Company, Ona Phosphate, Florida: Process development, high magnesium ore

- Afrig SA, phosphate project, Senegal: one million t/a concentrator, process development
- Cominco Resources, Hinda phosphate project, Republic of Congo: four million t/a concentrator, process development (lab & pilot), ore variability study and pre-feasibility study
- Ma'aden Al Jalamid and Umm Wu'al projects, Saudi Arabia: 4.5 million t/a and five million t/a concentrators, process development (lab & pilot), basic engineering (BE) and front-end engineering design (FEED)

Purified phosphoric acid and chemical processing:

- Wengfu Phosphates, China: 100,000 t/a (P₂O₅) food-grade PPA from WPA, process development (lab & pilot), BE and FEED, SX design and supply
- Ma'aden, Wa'ad Al Shammal, Saudi Arabia: 50,000 t/a (P₂O₅) food grade PPA from WPA, process development (lab & pilot), BE and FEED, SX design and supply
- EuroChem, Karata, Kazakhstan: Phosphate chemical complex process selection study. ■

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PHOTO: MOSAIC

Potash players endure tumultuous 2020

Despite the unprecedented economic woes inflicted by the Covid-19 pandemic, the global MOP industry still managed to endure in 2020, says **Andy Hemphill**, senior editor for potash at ICIS Fertilizers, thanks to its 'essential' status.

2020 - a year without precedent

Unprecedented is a word that is bandied about with little care for its true meaning, which is 'never having happened or existed in the past'.

Nevertheless, by this definition, what happened to the global potash market during the whole of 2020 was truly unprecedented and completely unforeseen.

Even expert observers can get things wrong. With the benefit of hindsight, looking back at the article I wrote on the MOP (muriate of potash) market for this magazine in late 2019 (*Fertilizer International* 494, p59), the tone now appears almost laughably naïve:

"After a rocky second half of 2019, the global MOP industry limps into 2020 amid hopes that tight production control – and the potential for resurgent fertilizer demand – could spur trade and even, perhaps, a price recovery."

At that moment in time, little did the world suspect that the arrival of a global pandemic would derail and sweep aside all our plans. As we now know, Covid-19 subsequently touched every continent, even

Antarctica, inflicting untold economic damage and causing immeasurable human misery during its inexorable spread.

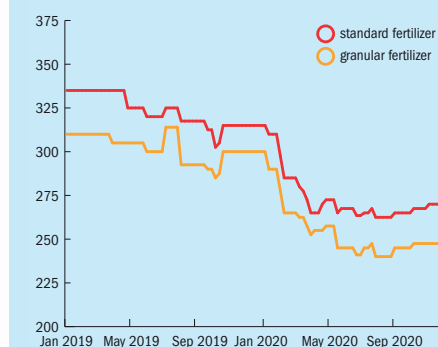
Against this backdrop, it will no doubt surprise some that the global MOP industry actually endured better than many other industries – including rival types of fertilizer manufacturing.

An essential industry

With a global nameplate production capacity above 69 million tonnes per annum, and with around 53 million t/a traded annually, potash is one of the world's most widely used stock fertilizers, trusted by agribusinesses across the globe. Yet, in stark contrast to its widespread use, deposits of this natural mineral fertilizer are concentrated in a just a handful of countries, notably Belarus, Canada, Germany, Israel, Jordan and Russia.

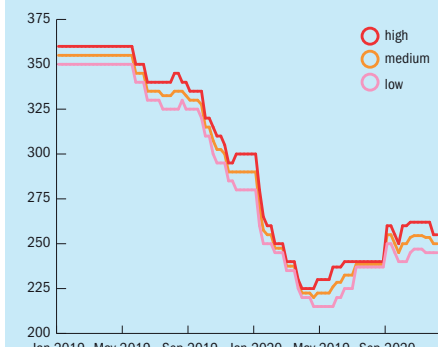
This contrast – between massive market size and the limited number of production centres – actually worked in the potash industry's favour as the coronavirus spread across the globe. Indeed, concentration of supply meant the potash

Fig. 1: Weekly Southeast Asia MOP cfr spot prices (\$/t), 2019-2020: granular and standard products



Source: ICIS

Fig. 2: Weekly Brazil granular MOP cfr spot prices (\$/t), 2019-2020: high, medium and low values



Source: ICIS

industry was better placed when it came to overcoming the logistical difficulties faced by rival fertilizer producers and many other industrial sectors.

Going back more than 12 months ago, prior to the pandemic, potash producers responded to difficult global market conditions by publicly announcing production cuts at the end of 2019 – a tried and trusted response to what is traditionally a period of slower of demand.

But did the potash majors act fast enough to curb production in late 2019? With hindsight, probably not, given the already high inventory levels in Brazil, a key importing nation – a situation that was compounded by the waiting game being played by Chinese buyers over their next long-term import contract.

That left the market somewhat long as 2020 approached. This was also the moment when coronavirus first appeared in Wuhan, China, and began to spread, fast. As 2019 ended and 2020 began, the general consensus – pre-pandemic – was the potash market would remain inactive until March, at least.

At the start of the 2020 calendar year, Southeast Asian buyers were stalling purchasing decisions, awaiting news of a new bellwether settlement from China. Meanwhile, key importing companies in India tired of waiting for China and instead settled their own supply contract at \$280/tonne cfr (cost & freight). This was a \$10/t decrease from the 2019 agreement, even if it only covered the first six months of 2020.

Soon after, the market began to show several signs of recovery – with Indian buyers purchasing cargoes, Southeast Asian powerhouse PT Pupuk Indonesia snatching up large tonnage volumes (albeit low-priced material from Laos) and Brazilian warehouse draw increasing.

But this recovery proved short-lived as Covid-19 began to take hold. Values quickly slipped again, depressed by weak demand, as nations awoke to the threat of the coronavirus in their midst. A blizzard of negative factors then hit – civilian lockdowns, plant closures, port *force majeure*s, workforce restrictions and fluctuating exchange rates – causing many months of previously unexpected disruption.

The 'new normal'

After the initial chaos, the classification of fertilizers as 'essential goods' by most governments proved to be a pivotal moment. By helping to strip out logistical snags, this declaration provided the clarity and impetus for potash trading to resume. The supply and distribution of potash, all the way from mine to field, improved as a result.

This was also the moment when the potash market's reliance on a limited number of major players proved to be a strength, as it allowed countries such as Russia and Belarus to cut through red tape and ensure their big-name MOP producers kept trading with relative ease.

That left the industry with just one key hurdle to overcome – the slow degradation

of potash prices at points across the globe. It was decisive action by the Belarus Potash Company (BPC) that nipped this concern in the bud at the end of April last year.

In a surprise announcement, BPC revealed it had settled a long-term contract to supply a consortium of Chinese buyers with standard-grade MOP fertilizer in the second half of 2020 at a price point of \$220/t cfr (*Fertilizer International* 496, p8).

This agreement – a \$70/t reduction on the previous benchmark of \$290/t cfr for 2018-2019 – caught many players off guard. One Southeast Asian distributor even described the decrease as "amazing" and "beyond predictions". It is certainly true that the predicted potential decrease of \$30-50/t for this key bellwether deal, the cut which was thought to have been on the table, in the end proved too conservative.

BPC called the contract "a vital step" and said at the time: "The price of the new China contract builds a firm foundation for the stabilisation, recovery and further incremental development of the global potash market."

Such sentiments were not universally shared, though. The deal left Russian rival Uralkali particularly unimpressed:

"The price agreed is not appropriate either for the length of that particular contract, or for the industry as a whole.

"Potash producers incur high investment costs to maintain existing production capacities and develop new deposits. This activity is necessary to meet the growing global demand for fertilizers."

Above: Mosaic's Esterhazy K3 mine, Saskatchewan, Canada.

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Then, just two weeks after this benchmark deal with China, the global MOP market watched with interest as the Indian settlement arrived. This six-month potash supply contract to the subcontinent was finalised at \$230/t cfr – a \$50/t slide on the last Indian deal and \$10/t above China's benchmark deal. This second potash agreement further cemented "the basement of the market", as the Latin American sales chief of one MOP major put it.

Steady improvement

Two main schools of thought emerged as the third-quarter of 2020 dawned.

The optimists viewed the China and India settlements as a useful jumping-off point for trade and a secure bottom to the market in a time of uncertainty. But others were more pessimistic, viewing the latest agreements as an unwelcome decline that undercut the future stability of the potash industry at a critical time, given the future uncertainty.

This division of opinion, between the optimists and the pessimists, was even reflected geographically by a growing divergence in potash pricing east and west of Suez (Figures 1 and 2)

In Southeast Asia, for example, many palm oil plantations – notably in Malaysia – continued to delay potash applications under the pressure of fluctuating crude palm oil (CPO) futures and returns. This reluctance to buy, combined with the price decline in China's long-term agreement, saw bids for both standard- and granular-grade potash drop abruptly, leaving producers with little room for manoeuvre in talks with buyers.

Brazilian demand, in contrast, became increasingly healthy throughout 2020, even though the threat of coronavirus-related disruption continued to loom large. Brazil's reliance on truck transport, in particular, presented additional risks. This could have left the market paralysed if drivers had opted to remain at home to protect the health of their families.

In the event, MOP majors managed to sell June and July 2020 cargoes to Brazil at \$230/t cfr. Sellers then pushed-up prices by a further \$10/t during August, September and into October. By November last year, granular MOP was landing in Brazil at around \$250/t cfr and above.

Although this rising price trajectory was impressive, with sales into the Latin Ameri-

Table 1: Nutrien: Third-quarter 2020 potash segment sales and earnings (EBITDA), \$ million

| Net sales | Third-quarter 2020 | Third-quarter 2019 | Change (%) |
|---------------|--------------------|--------------------|------------|
| North America | 252 | 330 | -24 |
| Offshore | 339 | 379 | -11 |
| Earnings | 328 | 430 | -24 |

Source: Company filings

Table 2: Canpotex: percentage international sales, by market

| Region | Third-quarter 2020 | Third-quarter 2019 | Change (%) |
|---------------------|--------------------|--------------------|------------|
| Latin America | 36 | 44 | -18 |
| Other Asian markets | 20 | 21 | -5 |
| China | 23 | 16 | 44 |
| India | 14 | 12 | 17 |
| Other markets | 7 | 7 | 0 |

Source: Canpotex

can powerhouse closing-out 2020 in the \$250s-260s/t cfr, prices still have some way to go before reaching the highs seen for Brazilian granular MOP in 2019.

Financial woes

It was not just potash pricing that bore the brunt of the global pandemic during 2020. The finances of some of the industry's major players also suffered, as third-quarter company results revealed.

In early November, for example, Germany's K+S announced it was expecting a one-off, non-cash loss in the third-quarter of 2020 of around two billion euros (\$2.4 billion), with weaker global pricing for MOP and MOP-related fertilizer products partly responsible.

In the third-quarter, K+S also completed the sale of its North and South American salt business to US-based Stone Canyon Industries Holdings. This early October transaction, which netted \$3.2 billion, was the result of a strategic decision by K+S to refocus on its core business – the production and sales of commodity and speciality fertilizers – as part of a new approach unveiled in March 2020.

K+S also used third-quarter results as an opportunity to revise its potash price assumptions. Although the company is still forecasting a rise in MOP prices in the short- and medium-term, long-term price

trends were corrected downwards, and are now lower than previously expected.

Potash segment earnings (EBITDA) at Canadian fertilizer giant Nutrien also took a knock in the third-quarter of last year, declining by 24 percent year-on-year to \$328 million (Table 1).

The company – one of the world's largest MOP producers – also placed the blame for lower earnings on weaker MOP pricing, as well as coronavirus-related disruption in the first nine months of the year. These negative factors were partially offset, however, by stronger sales and lower production costs in the second- and third-quarters.

Despite Covid-19 disruption, Nutrien's third-quarter North American sales volumes declined only one percent year-on-year, while offshore sales increased by some 24 percent. Indeed, third-quarter sales were Nutrien's second highest quarterly sales ever, while sales for the year-to-date were the highest on record for the first nine months of the year.

These strong sales figures reflected the buoyant performance of Canpotex, the international MOP trading arm of Nutrien and Mosaic. Canpotex directed some sales away from Latin American markets towards India and China during the third-quarter of 2020, compared to the previous year (Table 2).

At Israel's ICL, MOP fertilizer segment profits in the third-quarter of 2020 also

Mergers and acquisitions

Amid the backdrop of the pandemic and falling prices, 2020 witnessed a number of market-moving corporate restructuring and trading announcements.

In the UK, the £405 million (\$518m) takeover of prospective polyhalite fertilizer producer Sirius Minerals by global mining major Anglo American was approved by shareholders in a landmark vote held in London – far away from its headquarters and under-construction Woodsmith mine site in North Yorkshire.

The UK-listed company first revealed in last January that it was in advanced discussions with Anglo about an all-cash offer for its entire share capital at 5.50 pence per share. Anglo subsequently went ahead with this buy-out, paying cash for Sirius Minerals based on a revised valuation of £405 million.

Since then, Anglo has pushed forward construction operations at Woodsmith mine to bring its new acquisition online. While originally sticking to the established project schedule for 2020 and 2021, Anglo has signalled its intention to "update the development timeline, optimise mine design and ensure appropriate integration with its own operating standards and practices".

In Russia, major nitrogen fertilizer producer Uralchem officially acquired a 75 percent share capital in MOP producer Uralkali in early December. This provides Uralchem with a con-

trolling interest in the major potash producer, which is based in Russia's Perm region, east of Moscow.

The move is unsurprising given that Uralchem and Uralkali had already been integrating their businesses for some time. Indeed, the formal announcement of a controlling interest is viewed as a necessary internal restructuring of the business, as it will now allow the pair to jointly supply customers with combined 'package offers' – a sensible move given that Uralkali's MOP product offering naturally complements Uralchem's ability to supply nitrogen and phosphate-based fertilizers. Shortly after announcing the share purchase, Uralchem unveiled joint plans to supply Sudan with its own products in 2021 alongside potash from Uralkali.

In the Middle East, major Israeli MOP producer ICL announced it was purchasing Brazilian speciality fertilizer firm Fertiláqua for \$120 million (*Fertilizer International* 499, p10). The investment is designed to significantly expand ICL's on-ground presence in Brazil, a key importer of MOP and other fertilizers. Fertiláqua serves 500-plus customers across 24 Brazilian states and markets more than 100 different products. ICL expects to close the purchase early in 2021, subject to customary conditions. ■

Table 3: ICL's third-quarter results for its MOP segment: 2020 vs 2019, \$ million

| | Third-quarter 2020 | Third-quarter 2019 | Change (%) |
|---------------------------------|--------------------|--------------------|------------|
| MOP sales to external customers | 224 | 280 | -20 |
| MOP sales to internal customers | 20 | 26 | -23 |
| MOP segment profits | 28 | 83 | -66 |

Source: Company filings

decreased by two-thirds year-on-year, similarly affected by the market factors that hit both Nutrien and K+S (Table 3). ICL went further, however, by directly naming the lower-priced contract settlements with key buyers in China and India – negotiated by BPC – as being partially responsible for the decline in its sector profits.

Looking ahead

At time of writing (early December), no real news has emerged about the progress of the key benchmark annual contracts – those of India and China – which will ultimately define future price trends for much of the global MOP market.

The limited discussions that have been heard, however, suggest an increase is likely for both regions – a development that is more than warranted in the view of some sources. "We foresee an increase of around

\$40/t at least," a source at one European MOP major told ICIS, referring to both the China and India long-term contracts.

What we also know is that India, once again, is likely to be first to the table. That's because Indian buyers have chosen to exercise the option for extra tonnages under their outgoing six-month contract agreement. MOP arrivals at Indian ports under this \$230/t deal are dwindling rapidly currently, with port inventories also in decline.

One key question that remains is: will Indian buyers once again opt to secure a six-month contract, or will they attempt to move back to a full-year agreement as MOP offers look set to increase?

In China, meanwhile, Beijing's focus on ensuring food security during the Covid-19 crisis has tightened MOP availability. Traders there are obligated to supply the national Chinese reserve before

shifting tonnes for themselves. Local pricing is also increasing, supported by expectations of higher import contract pricing in 2021. Similar to India, import shipments to China are also slowing and port inventories declining, two further factors that are underpinning firmer domestic MOP values.

From a wider perspective, the global MOP market is set to enter 2021 with levels of supply and demand broadly similar to last year – albeit with pricing well below that seen at the end of 2019.

In our view, it is likely that MOP offers will tick upwards over time, spurred by firmer contract prices in India in China. Nonetheless, this improvement is a relative one. The potash price highs seen in years past will remain a distant memory until coronavirus vaccines are rolled-out globally, allowing the world to turn right-side-up again. ■

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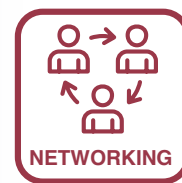
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