1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Welcome to our interactive version of Fertilizer International Issue 464

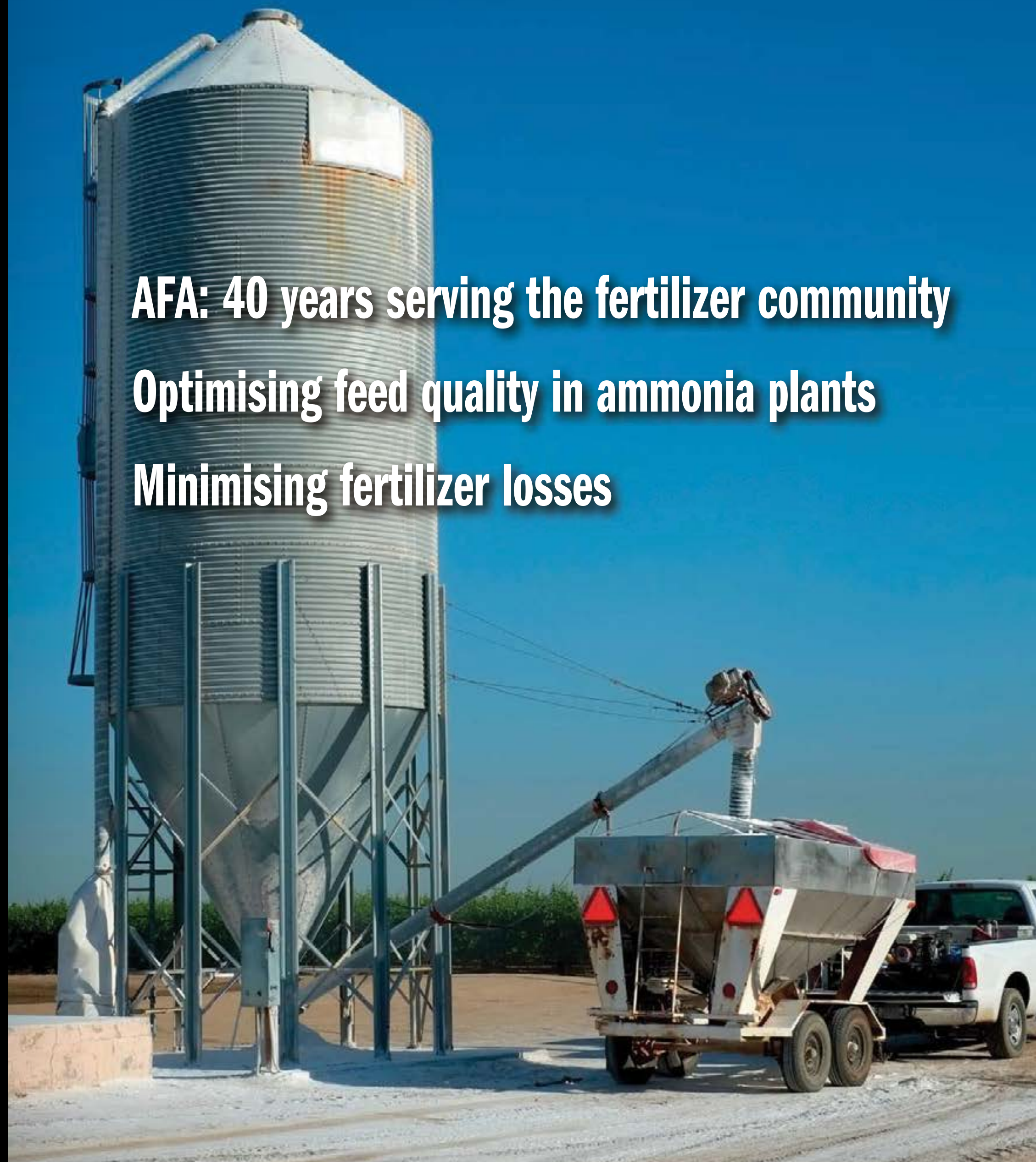
Please use either the buttons on the left or top right of the page to navigate your way around this interactive PDF

Number 464

January | February 2015

INTERNATIONAL Fertilizer

www.fertilizerinternational.com



AFA: 40 years serving the fertilizer community

Optimising feed quality in ammonia plants

Minimising fertilizer losses

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

INTERNATIONAL
Fertilizer

www.fertilizerinternational.com

NUMBER 464 JANUARY | FEBRUARY 2015

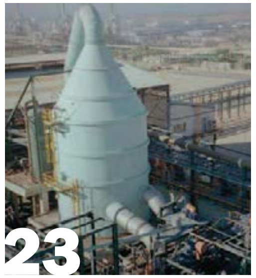
Cover: *Loading fertilizer from a storage tank on a Central California farm. Richard Thornton/Shutterstock.com*

CONTENTS

PHOSPHATES AND POTASH INSIGHT

REGULARS

17 **Minimising fertilizer losses**



23 **Removing phosphoric acid impurities**

Read this issue online at: www.fertilizerinternational.com

Published by: BCInsight

CONTENTS
What's in issue 464

COVER FEATURE 1
AFA: 40 years serving the fertilizer community

COVER FEATURE 2
Optimising feed quality in ammonia plants

COVER FEATURE 3
Minimising fertilizer losses

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Supply holds the key to another volatile year

Few fertilizer suppliers will mourn the passing of 2014 – a year which like its predecessor was marked by lacklustre prices and disappointing margins. At least the leading suppliers are getting used to this scenario: they have been as vigilant as ever in keeping costs under control, by drastic means of plant and mine shutdowns if necessary, and they have scaled back investment outlays. There were even some causes for greater optimism as a measure of stability returned to potash markets, while prices for urea, phosphates and sulphur ended the year on a firmer note.

The bullish tone is forecast to continue into the first quarter of 2015. In the case of urea, this is being spurred by steady demand from the United States for granular product from the Middle East, echoed by firm Brazilian demand too. Netbacks for Middle Eastern producers are expected to remain attractive during this immediate period. Likewise, DAP benchmark forecasts show a stronger price for the first quarter, possibly extending into the following quarter as buyers perceive that the bottom of the market has been reached for now. Far Eastern markets for phosphates have been slow (caused in part by the continuing weakness of the Indian rupee), but new sales have been made in Pakistan. European and US phosphate demand has also strengthened.

After the blood-letting of the second half of 2013, potash markets have remained delicately poised: while prices bottomed out earlier last year, there has been no uplift to the levels that prevailed before the market crash, and demand has remained soft in the key buying countries.

A firm pattern is reported in sulphur markets, buoyed by Chinese offtake, but the prospects are far less certain for the second 2015 quarter and beyond, especially as there is ample availability of product.

These prospects are set against a background of collapsing energy prices. Led by Saudi Arabia, the OPEC cartel has shown little inclination to curtail oil output, which is being held at 30 million barrels/day. OPEC accounts for 40% of global oil production. Not all its members are sanguine about oil falling below $50/barrel for the first time since April 2009, with Venezuela and Nigeria hurting in particular.

The immediate impact of these developments is favourable for fertilizer producers, as they are in a position to benefit from lower feedstock and other energy costs. However, hedging and contract purchase arrangements may mean that the full benefits of lower energy costs seep through only gradually.

Elsewhere in commodities, analysts suggest that the long boom in grain prices may be over. After two years of buoyant production of corn, wheat and soybeans, cereals stocks have been replenished, now being equal to 25% of annual global consumption, the highest ratio in more than a decade. Any sustained weakening in grain prices poses a potential threat to the demand for fertilizers, if farmers choose to reduce their plantings. This is already evident in the oil palm sector, where excess supply and weak market prices have significantly reduced the demand for potash in Malaysia.

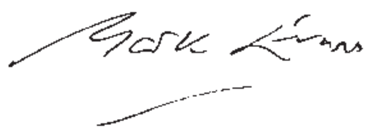
Across the commodities spectrum, while demand has been steady and even growing (including oil), there is ample product available. According to the *Financial Times*, "Supply has been the key narrative in commodity markets, determining the winners and losers in everything from nickel to soybeans. It is the reason that commodities are on course to be the worst-performing major asset class for a third consecutive year." (22 December 2014.) The Bloomberg Commodity Index fell by 14% in 2014 to a five-year low.

Fertilizers and associated raw materials have been caught in the general commodities undertow, and for much the same reasons. Global demand in 2014 is thought to have risen by around 3% to 184 million tonnes nutrient and is forecast by IFA to rise by an additional 2% in 2014/15, to 187.9 million tonnes nutrient. The forecast of such steady growth rates underpinned the financial submissions of many projects promoted by putative new entrants to the fertilizer industry, notably the junior mining companies in the phosphates and potash sectors.

However, the rise in demand is being more than matched by the growth in availability of product – a trend which is expected to continue over the next five years. IFA forecasts that in the medium term, global fertilizer consumption will rise moderately by 1.8%/year to reach 199.4 million tonnes nutrient by 2018. Established suppliers are meanwhile investing in new capacity (which will have the positive effect of securing the rising demand for fertilizers), an overall increase of 18% being forecast over the five-year period. These investments suggest a growing potential surplus in all nutrient sectors and a softening supply/demand balance.

Supply and demand are very closely aligned in fertilizer markets and indeed in commodities markets overall, and any small change or perception of change can now have a disproportionate effect on market sentiment. Similar scenarios of extra capacity coming on stream apply in metals markets. What is clear is that in fertilizers and associated raw materials, rising demand in the medium term will be a less powerful market driver – in contrast with the period during the past decade, when supply lagged behind.

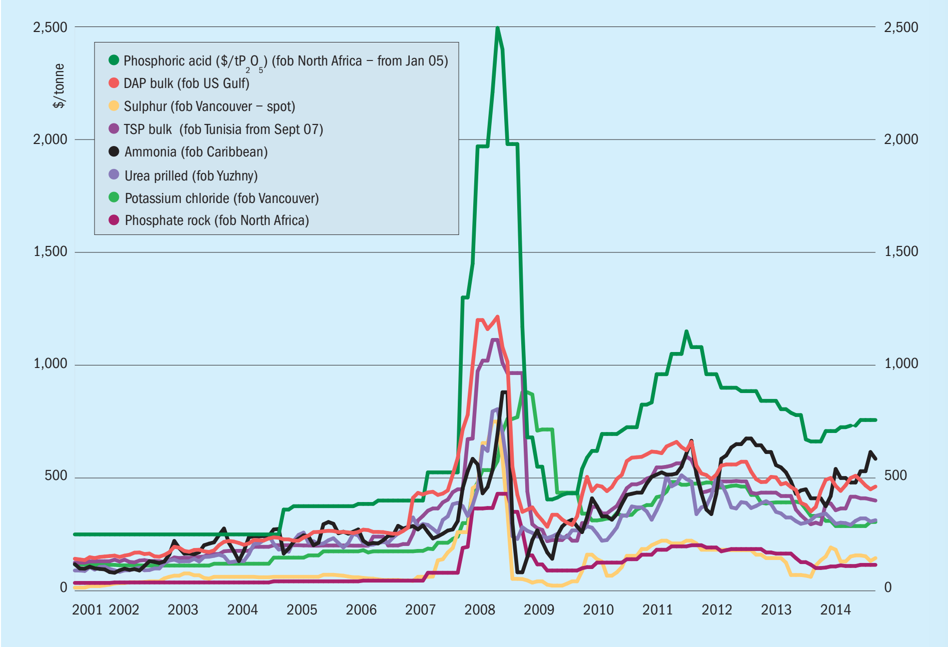
This prognosis poses a challenge for the junior miners and other potential new entrants to the industry, all capital-hungry and having to convince an ever more sceptical financial sector. For all existing industry participants meanwhile, 2015 is expected to be a year of continuing challenges.



FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Historical price trends $/tonne



AMMONIA

- Ammonia prices ended 2014 on a soft note, with lower values recorded in all key markets and some buyers withholding purchases in the hope of securing further discounts.
- In the United States, phosphate producer Mosaic and ammonia supplier Yara agreed January deliveries at $545/t cfr, a cut of $80/t from the December price, which in turn was $30/t down on the November level.
- Black Sea prices have also lost ground, with recent deals reported to be netting back to below $450/t f.o.b. and firm offers indicated at $470/t f.o.b.
- OCP, Morocco is reported to have secured around 30,000 tonnes for January delivery at a price assessed at around $450/t f.o.b., some $80/t below earlier deliveries.
- Middle Eastern ammonia values have likewise tumbled, with last-done business confirmed at around $547/t f.o.b. This represented a drop of at least $50/t on earlier assessments.

UREA

- US prices have edged up in Middle Eastern and North American markets, based on trader optimism for buoyant granular urea demand. Prilled values from the FSU have also been firm, averaging around $320/t f.o.b. at year-end, up $5/t on mid-December values.
- Middle Eastern offers have been in the $335-355/t f.o.b. range, some $5-10/t above earlier sales. Freight rates have also eased, ensuring higher netbacks to the regional producers.
- In Brazil, imported granular urea has been secured at $348/t cfr, up on earlier deals at around $343/t cfr. Trade slowed down in the final weeks of the year but is expected to pick up during January.
- The Chinese Ministry of Finance has set the export tax for urea at Rmb 80/t, equivalent to about $13/t. While higher than the Rmb 40/t applied for the low-season July-October 2014 period, the 2015 rate is down sharply on the high-season peak of Rmb 40/t plus 15% of the net export value and is a flat rate for the full year. Prices for prilled urea have meanwhile remained close to $290/t f.o.b., while recent sales to India have netted back to just below $285/t f.o.b.

PHOSPHATES

- While DAP values have come under pressure in eastern markets, they have been buoyant in the western hemisphere. A recent boost in sales to Brazil enabled prices to rise to $490/t cfr.
- Mosaic concluded new DAP and MAP sales to Brazilian and Mexican buyers out of Tampa for January/February shipment at prices in the $465-472/t f.o.b. range. Relatively tight DAP has narrowed the differential between DAP and MAP price levels to $10-20/s.ton.
- Russian MAP has traded at between $440-447/s.ton in US markets, undercutting Mosaic tonnage at $450/s.ton. Firmer North American prices have aroused interest from potential offshore suppliers, with the latest indications being in the range of $490-495/t CFR for DAP and MAP, and suggestions that higher bids of $500/t could emerge for MAP.

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

- Chinese 2015 export tariffs for DAP have been confirmed at a flat rate of Rmb 100/t throughout the year. TSP and SSP tariffs remain unchanged at 5% for the full year. Chinese DAP exporters are meanwhile reported to be targeting Australian markets, where domestic prices continue to equate to an f.o.b. level of $470-480/t.

SULPHUR

- Prices have revived, as indicated by the latest Tasweeq tender for 35,000 tonnes, awarded at $167/t f.o.b.. ADNOC, UAE, currently has no spare spot tonnage, following the commitment of most of its volumes to OCP, Morocco.
- Talks for Brazilian first-quarter contracts are expected to be settled in the mid-$170s/t cfr. This is in line with recent spot sales and fourth-quarter contracts.
- European sulphur sellers plan to secure higher prices for Q1 contracts, with reports suggesting that they are pushing for price increases of EUR10-15/t.
- Chinese sulphur prices have inched up by around Rmb 60/t ($10/t), with quotes from ports at Rmb 1,310/t f.c.a. General prices at port have been quoted by traders at up to Rmb 1,350/t, while international quotes have increased to $178/t cfr, with some sellers subsequently refusing offers below $180/t cfr.

POTASH

- Global potash market activity has been lacklustre as buyers and suppliers assess the impact of the production outage at Uralkali's Solikamsk-2 2.35 million t/a mine. The company hopes to sustain production at around 10.2 million t/a from its other mines.
- APC, Jordan has agreed terms for 70,000 tonnes of potash to Malaysia, Indonesia and the Philippines at the target price of $350/t cfr. Some analysts believe that the buyers have been able to secure some discounts, as Malaysian prices have been seen as low as $325/t cfr, while product is reported to be readily available.
- The Brazilian market is currently out of season, with import prices remaining stable at $365-375/t cfr after a recent dip from suppliers' price target of $380/t cfr. ■

Market price summary $/tonne – Late-December 2014

Nitrogen	Ammonia	Urea	Ammonium Sulphate	Phosphates	DAP	TSP	Phosphoric Acid
f.o.b. Caribbean	585	n.m.	f.o.b. E. Europe 150-155	f.o.b. US Gulf	460-465	n.m.	n.m.
f.o.b. Yuzhny	535-550	310-316	-	f.o.b. N. Africa	500-512	400	675-840
f.o.b. Middle East	605	310-315**	-	cfr India	473-480	-	765*
Potash	KCl Standard	K_2SO_4	**Sulphuric Acid**		**Sulphur**		
f.o.b. Vancouver	281-330	-	cfr US Gulf	80-85	f.o.b. Vancouver	140-150	
f.o.b. Middle East	271-333	-			f.o.b. Arab Gulf	140-155	
f.o.b. Western Europe	-	€415-440			cfr North Africa	130-135	
f.o.b. FSU	267-333				cfr India	160-170+	

Prices are on a bulk, spot basis, unless otherwise stated. (= contract ** = granular). Phosphoric acid is in terms of $/t P_2O_5 for merchant-grade (54% P_2O_5) product. Sulphur prices are for dry material. (+ Quotes for product ex-Arab Gulf)*

MARKET DRIVERS

- Ammonia production remains erratic at the Sofert complex in Algeria, with the Ammonia I plant reported to be down again but Ammonia II and the urea facility are reported to be operational. Three cargoes of about 15,000 tonnes have been lined for January delivery.
- Greater interest has been shown in Chinese ammonia by South Korean and Taiwanese buyers as Middle Eastern product has proved costly. There is some speculation whether the Chinese authorities will re-impose VAT on fertilizer exports in the second half of 2015.
- **Ammonia outlook:** Continuing soft as ammonia markets remain oversupplied.
- Many states in India report urea shortages, availability to farmers for the Rabi season and a substantial carry-over is expected into Kharif 2015. This in turn suggests that additional tenders for imported urea may be delayed until the budget for the next April 2015-March 2016 financial year is announced.
- While still ample, urea supply from the Middle East is being cut via additional sales to the United States, which could affect supply in Europe. Prospects for improved availability of Egyptian product in January are good, and no sustained shortages are forecast.
- **Urea outlook:** Improving, buoyed by firm US sales.
- Chinese phosphate exporters are weighing up their options in the wake of the announced export tax regime for 2015, and analysts suggest that they have no pressing need to concede lower prices to secure export business. Indian buyers may be disappointed, as they had hoped for additional Chinese availability in the first quarter at competitive prices.
- The weaker rupee has also put pressure on Indian buyers' price ideas for phosphoric acid contracts, with the latest indications some $80/t P_2O_5 below current levels.
- **Phosphates outlook:** US and South American business has kept phosphate prices steady during Q4 and hopes are high for continuing firmness in the New Year.
- Chinese sulphur traders hope to boost prices over the current $180/t cfr level, especially if the 2015 export tariffs help boost phosphate production.
- **Sulphur outlook:** Sulphur prices remain volatile.
- US sanctions against Belarusian fertilizer products are expected to be lifted shortly, which would allow Belarus Potash Co. to begin exports to the country at competitive prices.
- Suppliers to Indian markets are aiming for a 5-7% increase on recent import prices of around $322/t cfr, although others have suggested that they should be content to accept a roll-over in order to secure higher sales volumes.
- **Potash outlook:** Still vulnerable to softer prices. ■

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

40 years serving the fertilizer community

The Arab Fertilizer Association (AFA) was founded in March 1975 and this year celebrates 40 years of success in promoting the sustainable use of fertilizers – essential food for crops in order to help them grow better to provide food, feed and fibre for mankind. From a modest beginning, the AFA forum has grown into a highly-esteemed event, which can be a source of great satisfaction and honour to its members. Their committed efforts have been crowned with resounding success, and the Arab World can be proud of its prominent role in global fertilizer markets. It accounts for 70% of world phosphate rock reserves and around one-third of the world urea market.

Left: Mr. Mohamed A. Zain, AFA Secretary General. Below: A full house at the official opening of the 2014 AFA Annual Forum.

Mohamed A. Zain, AFA Secretary General said, "Convening the 21st AFA Annual Forum coincides with commemorating the 40th anniversary of the establishment of the Arab Fertilizer Association. We would thus like to honourably highlight our achievements since laying down our foundations in 1975, reflected in a clear and developed vision and strategy. AFA seeks the service of its Arab and international member companies, the development of the fertilizer industry and agriculture and the contribution to international endeavours to bridge the food gap and achieve international food security.

"This is being carried out in the light of overwhelming world challenges and changes, namely rising poverty rates and unemployment, declines in rainfall, the spread of drought in a number of countries, shortages in energy resources, as well as the threat of hunger. The number of hungry people is reaching one billion across the world, while the world population will reach nearly 8 billion by 2030. All these factors present major challenges for the fertilizer industry, leading to a rise in demand for food and as a result necessitating the provision of the required amount of fertilizers and related materials. This issue undoubtedly was and will be surmounted by making use of the capacities added to the commercial production in 2012/13 in a number of Arab countries, including Qatar, Egypt and the Kingdom of Saudi Arabia, and by the additional capacities expected by 2020. It is noteworthy that the Arab countries contributed with a quarter of the world's production of phosphate rock and more than half of the rock traded, at nearly 15.4 million tonnes. Arab countries also provided 35% of the urea traded internationally, at around 15 million tonnes, 76% of DAP, amounting to 6.6 million tonnes, 51% of TSP and 6% of potash export volumes.

"While celebrating the 40th anniversary of the establishment of the AFA, we are privileged to welcome you all in such a wonderful resort, located in the centre of Sahl Hasheesh Bay in the Red Sea, to attend the 21st AFA Annual Fertilizer Forum and accompanying exhibition, from 3-5 February 2015. The 2015 Forum will provide you with the opportunity to interact during the three-day function, with the heads of Arab and international fertilizer companies, chairmen of related international organisations, together with executives and general directors from all over the world. The event notably attracts over 600 senior executives concerned with the fertilizer industry from more than 40 Arab and non-Arab countries.

"The Forum will further highlight the latest fertilizer issues through international experts in this field. We look forward to your attendance and participation to celebrate AFA's 40th anniversary in the marvellous location of the Red Sea."

Table 1: Arab countries' fertilizer production and exports 2012-13, million tonnes

Product	Production 2012	Production 2013	Arab region share of world total (%)	Exports 2012	Exports 2013	Arab region share of world total (%)
Ammonia	14.43	15.17	9	3.40	3.35	19
Urea	16.49	17.87	11	13.60	14.94	35
Ammonium nitrate	1.29	1.28	10	0.09	0.08	<1
Phosphate rock	47.05	44.21	23	19.29	15.33	57
Phosphoric acid	6.29	6.50	15	2.34	2.37	56
TSP	1.73	1.93	32	1.62	1.82	52
DAP	6.60	7.88	27	4.98	6.31	76
Potash	1.82	1.75	5	1.48	1.58	6
Sulphur	7.06	7.06	13	6.07	6.72	22

Source: AFA

AFA's global role

The expansion in attendance at the annual conference over time reflects the growing importance of Arab fertilizer producers in the world market. With an abundance of a range of fertilizer raw materials, including natural gas, phosphate rock and potash, the Arab region is already a fertilizer industry hub. It accounts for around one-third of the world's natural gas and 70% of its phosphate rock reserves. As a consequence, its fertilizer industries account for between one-fifth and two-thirds of global exports of nitrogen, phosphates and other fertilizer products.

The Arab region accounts for around 33% of the world urea market, around two-thirds of the phosphate rock and TSP markets, almost 70% of the phosphoric acid market, one-quarter of the DAP market and 13% and 6% respectively of the ammonia and potash markets.

The importance of the Arab region is set to increase in the future, because of the concentration of new projects within its fold and the likelihood of cost pressure on producers in a number of other regions will result in rationalisation of capacity and possible plant closures elsewhere. A series of presentations by leading speakers will cover the following main strands:

- Fertilizer policies
- Investments and enhancing competitiveness in the fertilizer industry
- Outlook for European fertilizer demand and production
- Shale technology and the nitrogen sector
- Impact of gas supply and pricing on the fertilizer sector: future pricing scenarios
- Role of fertilizers in promoting food security in the Arab countries
- Slow-release fertilizers
- Fertilizer scenarios in the major markets
- The changing nature of the fertilizer supply chain
- Energy saving in the fertilizer industry
- Environmental issues.

Meet the AFA team.

The speakers' programme will be supplemented by a display exhibition, providing an ideal platform for manufacturers and suppliers to showcase their products and services to a highly-focused and professional local and international audience.

In order to encourage researchers from AFA members as well as academic centres, the AFA Board has decided to present an award for the best applied research in agriculture. This will help achieve more contacts and co-operation among those who work in the fertilizer industry and at universities and research centres. The Award will be presented to the winning nominee at the opening session of the 2015 AFA International Forum.

Records continue to be broken

Arab fertilizer producers broke fresh records for production and exports during 2013. An abundance of a wide range of raw materials, including natural gas, phosphate rock and potash, has enabled the Arab Region to establish itself as a major hub for the international fertilizer industry. The latest data reveals how Arab producers have consolidated their global leadership in the markets for urea, phosphate

CONTENTS

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

rock, phosphoric acid and TSP, as well as being key players in the ammonia and sulphur sectors. (Table 1)

In 2013, the Arab Region accounted for 27% of world DAP production and 76% of the DAP traded, 23% of phosphate rock production and 57% of the world trade, 56% of the phosphoric acid production market, 35% of world trade in urea, together with 52% and 6% of the TSP and potash markets respectively.

Arab producers represented a 9% share of total world ammonia production and 19% of total trade. Saudi Arabia is the leading Arab supplier, accounting for 26% of regional production, followed by Qatar (23%), Egypt (21%) and Oman (9%). Saudi Arabia was also the leading regional ammonia exporter, with 42% of the total, followed by Algeria (16%), Qatar (16%) and Egypt (12%). In 2013, Arab ammonia producers shipped 3.35 million tonnes, 19% of the world total.

Arab producers represent 11% of total world urea production and have a 35% share of export trade. Qatar is the leading regional producer, representing 25% of total Arab production, followed by Egypt (25%), Saudi Arabia (23%) and Oman (12%). Urea production in these countries is highly export-oriented. Qatar is the world's leading urea exporter, shipping 4.3 million tonnes out of a total production of 4.6 million tonnes in 2013. Its export total represents 29% of total Arab region urea exports.

Arab phosphate rock producers represent a share of 23% in total world production and 57% of world trade. OCP, Morocco is the regional leader, accounting for 58% of total Arab Region production. Egypt (with three companies, accounting for 13%), Jordan (12%), Tunisia (7%) and Saudi Arabia (6%) are other significant producers. OCP is the world's largest phosphate rock exporter, representing 56% of total Arab Region exports. Jordan, Egypt and Tunisia are other significant phosphate rock exporters.

The Arab share of phosphoric acid production represents 15% of the global total and 56% of total exports. OCP, Morocco predominates in this sector, with a 67% share of regional production. Other leading regional producers are Saudi Arabia (13%), Tunisia (12%) and Jordan (7%).

Arab countries predominate in the TSP sector, representing a 32% share in total world production and 52% in world market trade. OCP again enjoys market leadership, supplying 52% of regional TSP output, together with Tunisia (27%) and Lebanon (13%). In DAP markets, Arab countries produce 27% of the world total and supply 76% of total exports. OCP is the leading regional supplier, with 44% of the Arab total output, supplemented by Saudi Arabia (38%), Tunisia (10%) and Jordan (7%). Saudi Arabia has emerged as a world player within just one year of establishing full-scale production, and accounts for 29% of the combined Arab countries' exports.

Arab Potash Co., Jordan is the Arab region's sole potash producer, accounting for 5% of global production and 6% of trade. In the sulphur sector, Arab countries – especially in the Gulf area – enjoy a high global profile, accounting for 13% of world production and 22% of total international trade. The production provided by the Arab Gulf region was led by Saudi Arabia, with a 46% share, while the UAE contributed a further 27% of the regional total, together with Qatar (12%) and Kuwait (12%). Most of the regional output of sulphur was export-oriented.

A continuing investment in new capacity

New capacity continues to be developed throughout the Arab Region, further enhancing its contribution to global fertilizer capacity and share of world market trade. (Table 2)

Table 2: **Arab Region nitrogen fertilizer projects** 2014-2020

Location	Plant	Capacity ('000 t/a)	Comments
Saudi Arabia	SAFCO V	1,250 urea	Q3 2014
UAE	Fertil, Jebel Ali	660 ammonia 1,200 urea	On stream, 2013
Qatar	QAFCO VI	1,200 urea	On stream, 2013
Bahrain	GPIC	660 ammonia 900 urea	Under study
Egypt	MOPCO, Damietta	800 ammonia 1,200 urea	N/A
Egypt	El Delta Fertilizer Co.	396 ammonia 650 urea	2016
Egypt	KIMA, Aswan	396 ammonia 530 urea 220 AN	2017
Egypt	Alexfert, Alexandria	150 ammonium sulphate	On stream, 2013
Algeria	Orascom, Arzew	1,600 ammonia 1,400 urea	Started Q2, 2014
	Bahwan, Arzew	1,600 ammonia 1,400 urea	Under commissioning

Tables 3, 4 and 5 show the phosphate, potash and sulphur projects under way in the Arab region during the same period.

The Arab Region suppliers enjoy unrivalled competitive advantages in the production of high-volume fertilizer products, helped by the lowest feedstock costs in the world. Several of them are now considering developing their product ranges, looking at higher added-value speciality sectors. In one recent development, QAFCO has signed a contract with NIIK of Russia for the design and supply of a high-speed drum granulation unit that will enable the company to produce added-value urea products. Construction of the unit will begin later this year, with the goal of starting production by the end of 2015. This will be a pilot unit to test the feasibility of larger-scale production and will have the capacity to produce 2.4 t/a, enabling QAFCO to develop a range of urea-based products by adding sulphur, ammonium sulphate and other micronutrients. If successful, the granulation unit will also enable QAFCO to use more of the by-product sulphur from gas processing that is currently exported.

QAFCO has also indicated its intention to develop a range of environmentally-friendly fertilizers to meet rising demand in Western Europe. In a further development, QAFCO's marketing arm Muntajat will open ten new offices in Asia and Africa

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Table 3: Arab Region phosphate projects

Location	Plant	Capacity (000 t/a)	Comments
Jordan	JPMC, Shidiya	500 phosphoric acid	On stream March 2014
Saudi Arabia	Ma'aden, Wad Al Shamal	1,500 P_2O_5 DAP/MAP	Q4 2016
Tunisia	Tifert JV with GCT/CPG, India	360 phosphoric acid	On stream June 2013
		450 TSP	Due on stream 2015
Egypt	EFIC	700 SSP	Under study
		500 SSP	Under construction
Morocco	OCP, Jorf Lasfar	1,000 DAP/MAP	2014
		480 phosphoric acid	
		3,000 DAP/MAP	2015
		1,440 phosphoric acid	
		4,000 DAP/MAP	2016
		1,920 phosphoric acid	

Table 4: Arab Region potash and compound NPK projects

Location	Plant	Capacity (000 t/a)	Comments
Tunisia	GCT	400 NPK	Under study
Egypt	NCIC, El Nasr	150 NPK	Started Q4 2013

Table 5: Arab Region sulphur projects

Location	Plant	Capacity (000 t/a)	Comments
UAE	ADNOC	6 projects to reach 6.5 million t/a	2014-16
Kuwait	KPC	2 projects 850/300	Under study

in an effort to broaden the reach of Qatar's chemical and petrochemical products. The new offices in Casablanca, Colombo, Bangkok, Dubai, Mumbai, Guangzhou, Shanghai, Manila, Jakarta and Karachi will supplement the existing QAFCO offices in Australia, Malaysia, Jordan, South Africa and Turkey.

Jordan Phosphate Mines Co. (JPMC), Jordan is also forging stronger links via joint ventures. In September 2014, the company signed an MoU with Chongqing Minmetal and Machinery Import & Export (CQMM) to build a phosphate fertilizer plant at Aqaba, Jordan. Under the terms of the agreement, JPMC will supply between 1.5-2 million t/a of phosphate rock to feed the new plant with a capacity of up to 500,000 t/a P_2O_5 phosphoric acid with associated downstream high added-value products. (Source: *Fertilizer Week*, 19 September 2014.) The partners will undertake a feasibility study to determine the type and volume of final products. CQMM was involved in the construction of the JAFCO plant in Jordan, a smaller speciality plant producing dicalcium phosphate (DCP) and TSP.

Earlier in 2014, JPMC announced its intention to establish $1.55 billion worth of joint Arab and overseas ventures as part of its strategic plan, with the goal of raising the production of phosphate rock by 50% by 2018. In February 2014, JPMC also signed an MoU with Kaltim Fertilizer of Indonesia for the construction of a new 200,000 t/a P_2O_5 phosphoric acid plant which would feed new downstream NPK capacity. This is part of a longer-term plan to build three such phosphoric acid plants in total, in Java (Petro Abadi, now on stream), Sumatra and Borneo. All are fed with Jordanian phosphate rock.

In Tunisia, an expansion of current mines in Sra Ouertane and Tozeur and the reopening of the open-cast mine in Meknassi will increase the country's rock supply and ensure sufficient feedstock for its rising phosphoric acid capacity.

In Egypt, Phosphate Misr Company is investigating the extension of mining activities in the Abu Tartour phosphate deposits. This area is thought to hold phosphate ore reserves in excess of 1 billion tonnes. Future activities may comprise an expansion of current reserves and the establishment of a new phosphate fertilizer complex. The company currently extracts phosphate ore from several open-cast mines in four blocks, which hold 70 million tonnes of mineable reserves.

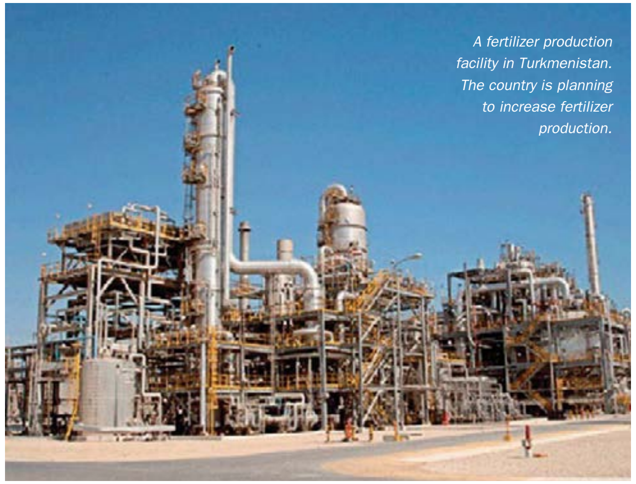
The next five years may be seen as a period of consolidation for the Arab Region's fertilizer industry. In the ammonia sector, while the region has an unassailable competitive advantage in seaborne trade, the availability of seaborne ammonia is expected to fluctuate as new downstream nitrogen capacity absorbs some exportable surplus, notably in Saudi Arabia when the SAFCO-V urea plant comes on stream this year. Only Egypt is forecast to be adding new merchant ammonia capacity over the next five years, with up to 660,000 t/a ammonia capacity.

The Arab Region has invested heavily in export-oriented urea capacity, and around 12 million tonnes of such capacity in the gas-rich Arab Region are forecast to come on stream between 2014 and 2018, equating to around one-quarter of current global trade.

Considerable additions to the Arab Region's phosphate rock capacity are foreseen by 2018. In this way, the strategic vision of the Arab Region fertilizer producers makes them well placed to enjoy global market leadership in both the nitrogen and phosphate sectors. ■

New capacities in the FSU republics

We outline the projects that will bring the Asian republics of the Former Soviet Union into greater prominence.



A fertilizer production facility in Turkmenistan. The country is planning to increase fertilizer production.

PHOTO: CENTRAL ASIA ONLINE

Central Asia is the core region of the Asian continent that stretches from the Caspian Sea in the west to China in the east and from Afghanistan in the south to Russia in the north. Since the break-up of the Soviet Union, the region has comprised five independent republics with a total population of 66.5 million, namely Kazakhstan (population 17.9 million), Krygyzstan (5.8 million), Tajikistan (8.0 million), Turkmenistan (5.2 million) and Uzbekistan (30.2 million).

Landlocked Kazakhstan extends across both sides of the Ural River, ranging between the Caspian Sea to the Altay Mountains and from the plains of Western Siberia. The country's economy has been driven by rising oil output and is the largest in Central Asia, with an estimated GDP of $243.6 billion in 2013. Energy forms the country's leading economic sector, enabling Kazakhstan to play a major role in global energy markets. Kazakhstan has a strategic geographical location to influence oil and gas flows from Central Asia to both western and eastern countries.

Kazakhstan is estimated to have around 30 billion barrels of crude oil reserves, placing it 11th in the world. Foreign investment and improved production efficiencies have enabled Kazakhstan to step up oil production during the past decade and it is planning to increase its oil production to 3.5 million barrels/day, of which 3 million bbl/d would be exported. This would lift Kazakhstan into the ranks of the world's top ten oil producing countries. The main production sites are the Tengiz field (290,000 bbl/d), on north eastern Caspian shores, and the Karachaganak field, located near the Russian border. Future oil production will also come from the Kashagan field, the largest outside the Middle Eastern Gulf, which possesses between 7-13 Gbbl of recoverable reserves. Western companies, including ChevronTexaco and ExxonMobil have invested in these fields, participating in joint ventures with the state-owned KazMunayGas oil company.

Kazakhstan's natural gas reserves total between 3.3-3.7 trillion cubic metres (tcm), of which 2.5 tcm are proven. The country became a net gas exporter in 2003 and has set the goal of producing between 60-80 bcm by 2015. The major natural gas fields are Karachaganak, Tengiz, Kashagan and Amnageldy. Kazakhstan's major gas company is KazMunaiGaS, which had a reported income of around $3 billion in 2013.

Kazakhstan has a comprehensive gas pipeline network, running to 10,138 km in overall length. The major transit pipelines are the Central Asian-Centre system and the Bukhara-Ural pipeline, which transport gas from Turkmenistan and Uzbekistan to Russia. The Gazli-Bishkek pipeline transports gas from Uzbekistan to Kyrgyzstan. There is a plan to build a natural gas pipeline to China.

Tengiz is the sixth largest oilfield in the world, with estimated reserves of 25 billion barrels. The oil has a high sulphur content of up to 17%. The field has been developed by the Tengizchevroil (TCO) joint venture, formed between ChevronTexaco and the Republic of Kazakhstan. The partners are currently expanding oil production to around 830,000 bbl/d by mid-2018. Sulphur output from TCO has been quite variable. Initially, sulphur recovered from the associated gas and liquids was poured to block, and by 2002 an estimated 6 million tonnes had been thus treated. Stocks peaked at 9.2 million tonnes of sulphur by 2005 (by which time sulphur production was about 1.6 million t/a). However, environmental issues regarding fugitive sulphur dust led to TCO being fined around $600 million by the Kazakh authorities, prompting the consortium to seek alternative approaches to sulphur treatment

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Table 1: **Kazakhstan sulphur exports** 2012-2014 '000 tonnes

Month	2012	2013	2014 (Jan-June)
January	270.6	83.3	299.3
February	157.7	281.3	340.7
March	321.3	311.8	301.8
April	99.8	230.8	246.0
May	338.1	474.0	295.6
June	223.9	344.0	315.2
July	160.0	219.0	-
August	427.1	333.2	-
September	282.1	341.8	-
October	315.1	295.2	-
November	276.6	260.8	-
December	308.9	317.5	-
Total	**3,181.2**	**3,492.7**	**1,798.6**

Source: Global Trade Information, via Fertilizer Week

and production, and stocks have been progressively drawn down. (*Central Asian Sulphur*, **Nitrogen+Syngas** No. 353 [July-August 2014].)

The by-product sulphur from Kazakhstan's oil industry has become a useful source of export earnings, and shipments in the first six months of 2014 were a record 1.8 million tonnes. This compares with same-period export totals of 1.73 million tonnes in 2013 and 1.41 million tonnes in 2012. (Table 1)

China is the main destination for Kazakhstan's sulphur exports, while Brazil and Morocco have stepped up their uptake. The United States has begun importing Kazakh sulphur too, bringing in 25,000 tonnes of solid product in July 2014. The phosphate producer Mosaic is keen to reduce its dependence on North American suppliers of molten sulphur and is building a 1 million t/a sulphur smelter at its New Wales complex in Central Florida, thus paving the way for further imports from Kazakhstan and other overseas sources.

An oil project in Kashagan is further expected to boost Kazakhstan's sulphur production and exports. This project is expected to result in the production of up to 1 million t/a sulphur by the second half of 2016. However, the project has been subject to a series of delays. Meanwhile, TCO's sulphur inventory is diminishing, putting into question whether exports from Kazakhstan can be maintained overall in the immediate term.

Fertilizer prospects

The agricultural sector accounts for 5% of Kazakhstan's GDP, and the country is a world-ranking exporter of wheat and cotton. The northern regions specialise in grains and animal husbandry while the southern regions engage in grains, oil-yielding crops, fruits, vegetables and cotton. Wheat predominates in crop production, accounting for 14.1 million ha of total agricultural lands of 93.7 million ha. (*Demand for Fertilizers in Kazakhstan*, Kazphosphate LLC. Paper presented at IFA Fertilizers & Agriculture Conference, Tashkent [April 2012].)

The agricultural sector faces several limiting factors, including logistical difficulties, limited finance and credit availability, and low investment in modern water-conserving technologies. The demand for fertilizers consequently falls short of full potential, despite various subsidy schemes, averaging around 129,000 t/a N, 41,000 t/a P_2O_5 and 10,000 t/a K_2O. An indigenous fertilizer industry has the capacity to produce 100,000 t/a N and 450,000 t/a P_2O_5 and has the potential to be increased further.

Kazakhstan's natural gas resources have been harnessed to set up several Soviet-era ammonia and urea plants in bordering regions of Russia and Uzbekistan, but these have substantial excess capacity. The phosphate sector offers considerably more promise as, in terms of mineral resources, Kazakhstan ranks among the top five countries that account for 90% of the world's phosphate reserves. The government has identified phosphates as a key area in its GDP growth strategies. In particular, the Karatau phosphate basin covers an area of 3,000 km², spread between Kazakhstan, Uzbekistan and Turmenistan, where there are more than 45 deposits with a total estimated reserve of 13.7 billion tonnes of ore. The P_2O_5 content is relatively high, at 21-25%.

Kazphosphate LLC was founded in 1999 and has access to 15 of the identified deposits in the Karatau Basin, covering estimated explored reserves of 4 billion tonnes. Probable reserves exceed 13 billion tonnes. Six of these deposits are being exploited, four as open pits and the other two as underground mines. The mines are located close to Karatau and Zhanatas. The ore is crushed and sorted and undergoes beneficiation at the Chulaktau processing facility at Karatau. Some of the mined phosphate is shipped to Russia, Ukraine, Uzbekistan and Turkmenistan, but most of the processed tonnage is transported to Kazphosphate's downstream plants at Taraz, some 200 km away. The downstream products comprise fertilizers, including MAP, detergents and industrial phosphates.

Taking over mines and processing plants that date from the Soviet period, Kazphosphate has invested heavily in upgrading its facilities, achieving cost savings, improvements in product quality and environmental benefits. In 2011, the company completed an upgrade of its purified phosphoric acid plant, doubling acid production and gaining sales for high-grade acid to EU countries. Overall capacity at the plant was raised to 120,000 t/a phosphoric acid, including 7,000 t/a of purified phosphoric acid. In addition to supplying the domestic market and those of the adjacent FSU republics, Kazphosphate has identified the EU as a target market, particularly for sales of yellow phosphorus. Kazphosphate has also invested $80 million in a new sulphuric acid plant at the fertilizer complex in Taraz, which came on stream in early 2013. In July 2012, Kazphosphate inaugurated a joint-venture feed phosphate and sodium hexametaphosphate facility in the Zhambyl region of southern Kazakhstan, in partnership with the Czech Fosfa company.

A major project is the development of a new beneficiation plant near the mines in Karatau, at an estimated cost of $170 million. The plant will incorporate both suspension and flotation processes to pro-

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

duce around 3.5 million t/a of phosphate rock with a higher P_2O_5 content. Construction of the facility may begin later this year.

Competition from EuroChem

In June 2009, the Russian fertilizer producer EuroChem announced its own project to develop a phosphate rock mining and processing operation and 2 million t/a fertilizer complex in the Zhambyl region, at an estimated cost of $2.5 billion. This project has now come to fruition, and EuroChem began phosphate ore production in mid-2014.

Total production was expected to reach 150,000 tonnes of phosphate ore by the end of 2014, and EuroChem plans to reach a steady production level of up to 650,000 t/a in 2016, following the full commissioning of Phase I of the programme. The company also plans to step up output to 1.5 million t/a once the downstream fertilizer complex has been completed. To date, EuroChem has invested around $75 million in the Karatau project.

EuroChem's plans to develop downstream production in the longer term, although no phosphoric acid capacity is envisaged at this stage. Originally, EuroChem was considering an ammonium nitrate/NPK facility, but more recent plans suggest a possible on-site capacity for DCP and other low-analysis phosphate products. Other options are for DAP/MAP and NPK capacity, for which in-house ammonia capacity would be provided. This phase of the project is expected to cost about $120 million.

The trials of Sunkar Resources

A third company has been seeking to harness Kazakhstan's phosphate resources. Sunkar Resources was incorporated in the UK in 2006 and listed on the AIM market in June 2008, with the stated goal of becoming an integrated phosphate fertilizer producer. It gained 100% ownership of Temir Service LLP, a Kazakh-registered company which holds permits to exploit the Chilisai phosphate deposit in north west Kazakhstan. The Chilisai deposit has a resource base of over 800 million tonnes of ore at 10% P_2O_5.

Sunkar Resources began mining at Chilisai in September 2008, producing 634,000 tonnes of phosphate rock in the six months to 30 June 2009. The initial output was sold as a direct-application fertilizer in Kazakhstan and in small tonnes to Uzbekistan and Russia as additional feed to fertilizer production operations there. Sunkar Resources has been keen to develop the downstream production of MAP and DAP, but has been hindered by several factors. One factor has been the R_2O_3 (iron and aluminium) content of the rock, while the credit crunch and downturn in global phosphate demand led the company to delay its plans to build a plant with the capacity to produce 1.76 million t/a of DAP and a slightly smaller tonnage of MAP. Instead, the company directed its efforts towards achieving high volumes of phosphate concentrate sales and extended the capacity of the beneficiation plant to match the rate of ore extraction.

Sunkar Resources' plans have been thwarted by financial issues, and it was obliged to suspend mining at Chilisai in late 2011 because of a shortage of working capital. This factor also led the company to suspend the bankable feasibility study (BFS) it was preparing on the downstream expansion project. Production at the Sunkar milling units resumed in April 2012 and the company sought investors to help resolve its financial problems. The BFS was duly completed, confirming the project's financial viability. The phosphate resource estimate was also revised, suggesting a 130% increase in total resources at 1.13 billion tonnes at 10.28% P_2O_5, yielding a total of 116 million tonnes of phosphate.

Sunkar has continued to maintain operations in the face of further financial uncertainty, exacerbated by the devaluation of the Kazakh tenge currency in February 2014. However, it has been operating at a loss and has been reliant on loan facilities provided by Sun Avenue Partners Corporation (SAPC) to remain afloat.

Fig 1: Central Asia and the Former Soviet Union

Potash from Kazakhstan?

Kazakhstan hosts potash in the form of sylvite, carnallite-sylvite and polyhalite. The deposits are shallow, at a depth of between 300-700 m. In 2011, the Australian exploration company Fortis Mining was working on two potash deposits in western Kazakhstan, the Chelkar and Zhilyan deposits, which according to Soviet data had an exploration target range of 6.5-6.6 billion tonnes. (*Potash Investing News*, 29 September 2011.) The Chelkar deposit is located in the Terektinsski region, with the potash mineralisation located approximately 300-700 m below the surface. At the Zhilyan deposit, potash mineralisation has been identified over an area 0.5-2 km wide and up to 5 km in length, with mineralisation occurring between 430-700 km below the surface.

In May 2013, as Kazakhstan Potash Corporation (KPC), the company acquired the 100% ownership of Satimola Limited, a closely-held Kazakh potash exploration company which had rights to deposit also in western Kazakhstan. Satimola began a drilling programme in 2008 which uncovered a resource of more than 8.5 million tonnes of potash at a 10% cut-off grade. Satimola was targeting an initial output of 700,000 tonnes of potash, which it hoped to expand to a 6 million t/a operation.

Kazakhstan has worldscale phosphate reserves, which it is now beginning to exploit.

KPC is meanwhile progressing with the development of the Zhilyan potash deposit. SRK Consulting has undertaken a feasibility study, which showed a JORC resource of 119.8 million tonnes of sylvinite at 18.61% K_2O, and 983.7 million tonnes of polyhalite at 7.99% K_2O, giving KPC the option to produce both potassium chloride and potassium sulphate. The feasibility study envisages extracting the resource by underground mining and processing the ore on site, with the final KCl and K_2SO_4 product being transported to market via the existing Kazakhstan rail network.

The study envisages a three-stage ramp-up in production, with initial production of KCl from the sylvinite resource, followed by K_2SO_4 from the polyhalite resource. KPC is seeking to advance from exploration to the production phase and has applied for a building permit with the local authorities to allow construction at the Zhilyan plant site and associated infrastructure to commence.

The Chelkar project covers an area of approximately 779 km², containing horizons of sylvinite and carnallite. Drilling continued throughout the past year to a depth of 1,100 m. KPC is waiting for several batches of final assay results to be received from the laboratory before sending an independent consultant to the site to review the drilling data.

Other reports have suggested that China will invest in a potash joint venture in Kazakhstan, following an agreement signed between China-Agro Holding and the country's ministry of industries and technology in September 2013. An initial estimate for construction was made at $1 billion, which could increase to $3 billion should the projected plant's capacity expand. There have been no subsequent reports of this project's progress, and industry analysts have assumed that the project has been given a lower priority in the aftermath of weakening prices in global potash markets.

Catching up in Kyrgyzstan

Kyrgyzstan is also landlocked, sharing borders with Kazakhstan, China, Tajikistan and Uzbekistan. The country is less well endowed with resources than its neighbours and the agricultural sector is the primary segment in the GDP, accounting for around 30% of the total. Grain production in the lower valley regions and livestock grazing on upland pastures are the main farming activities. Cotton and tobacco have long been the principal crops, but there has been a recent shift towards grains. Much of the agriculture is subsidence. Further expansion of the sector depends on banking reform to increase investment and on market reform the streamline the distribution of inputs.

There is a high dependence on irrigation throughout the country, with 80% of the cultivated area being irrigated. However, crop yields have been limited because of the poor condition of much of the irrigation infrastructure, and these were showing a declining trend in 2009 and 2010. (*Agricultural and Fertilizer Sectors of Kyrgyzstan and Tajikistan*, Ian Gregory, IFDC. Paper presented at IFA Regional Conference, Tashkent [April 2012].) There is a significant difference between the north and south in average farm size, with farms in the south being very small. Large commercial farms predominate in Chui Oblast in the north. Overall, the agricultural sector in Kyrgyzstan has suffered from under-investment.

After rising steadily during the first half of the 2000s, fertilizer consumption peaked at just over 150,000 tonnes of all nutrient products in 2007, only to fall during the following years to between 80-90,000 tonnes, comprising product imported from neighbouring countries by rail and truck. Border issues have occasionally disrupted these supplies, especially when Uzbekistan banned its fertilizer exports in 2011. This led to a shift towards Russian urea imports. In late 2011, the government of Kyrgyzstan imposed a seasonal fertilizer export tax of $300/t in order to prevent the legal and informal re-export of fertilizers during the spring season. The government is promoting the greater use of fertilizers, having stated that based on agronomic needs, the total fertilizer product use should be 340,800 t/a, comprising around 200,000 tonnes of nitrogen, 129,100 tonnes of phosphates and 11,700 tonnes of potash. However, despite a bilateral supply agreement with Uzbekistan, supplies from there have been minimal, penalising all Kyrgyz farmers, especially the small-scale farmers in the south. The stagnation in agricultural production and productivity is reinforced by poor quality seed.

Fertilizer importers and wholesalers are concentrated in the Bishkek area, while retailers are more numerous in the north of the country. The poor profitability of the Kyrgyz farming sector has seen a reduction in the number of fertilizer retailers, and by 2012, it was estimated that only 50 continued to trade. There are opportunities to raise crop yields and productivity, especially for wheat and soybeans, but such improvements require renewed investment in irrigation systems and improved access to affordable finance, as well as reliable supplies of fertilizers.

CONTENTS
What's in issue 464
COVER FEATURE 1
AFA: 40 years serving the fertilizer community
COVER FEATURE 2
Optimising feed quality in ammonia plants
COVER FEATURE 3
Minimising fertilizer losses

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Tajikistan – a turbulent baptism

The smallest of the Central Asian FSU republics, Tajikistan is likewise landlocked and is covered by the mountains of the Pamir range, with more than 50% of the country being over 3,000 m above sea level. The country is bordered by China in the east, Kyrgyzstan and Uzbekistan in the north, Turkmenistan in the west and Afghanistan in the south. Almost immediately after independence, Tajikistan was plunged into a civil war that culminated in the departure of most of the republic's ethnic Russian population by 1999.

Tajikistan was the poorest republic of the Soviet Union and it remains the poorest country in Central Asia today. Agriculture contributes around 20% of GDP, with cotton as the main export. Cotton occupies approximately one-quarter of arable land, but cereals (mainly wheat), potatoes, vegetables, fruits and rice have been increasingly cultivated. Tajikistan has only limited hydrocarbon and mineral deposits.

After independence, agrarian reform was very slow-paced and the old state farms for long continued to predominate. Today, family farms of between 5-50 ha play a larger role, accounting for between 30-50% of arable land and between 50-70% of agricultural output. Large state-owned farms of more than 50 ha account for between 30-40% of arable land, but only 10-20% of output. The Soviet Union developed Tajikistan as a cotton-growing area and considerable quantities of fertilizers were used then, at rates of between 750-1,100 kg/ha. As elsewhere in the FSU, fertilizer use collapsed in the aftermath of the USSR's demise and in the case of Tajikistan remains well below pre-1991 levels.

There has been one indigenous ammonia and urea facility, Tajik Azot, located at Sarband, Khatlon Oblast. The complex commenced operations in 1964, using Russian technology and was revamped in 1972. It was privatised in 2002, becoming part of the Group DF, under the ownership of the Ukrainian tycoon, Dmitry Firtash, with a 75% stake. The government of Tajikistan retained a 25% shareholding. Present capacity comprises 110,000 t/a of ammonia and 180,000 t/a of urea. Urea production post-privatisation peaked at 87,662 tonnes in 2005 but gas shortages led to a fall in output in subsequent years. Tajik Azot imported natural gas feedstock from Uzbekistan, but the flow of gas from this source was subsequently stopped, forcing the plant's closure since 2008. In March 2014, Dmitry Firtash was arrested in Vienna on corruption charges, at the instigation of the US Federal Bureau of Investigation (FBI). In the wake of his arrest, the Tajikistan government seized full control of Tajik Azot. The facility remains closed pending the resolution of the feedstock supply problems.

The shortfall in domestic production was covered by imports, mainly from Russia, Turkmenistan, Kazakhstan and also irregular imports from Uzbekistan. Ammonium nitrate (AN), calcium ammonium nitrate (CAN) and urea are the principal fertilizer imports, with smaller tonnages of MAP/DAP. Informal trade, avoiding import duties, feeds, VAT and other taxes provide further tonnage: the total informal trade is estimated at around 40%.

Meanwhile, as an alternative to importing natural gas, the Tajikistan Ministry of Industry and New Technologies is turning to coal gasification. In September 2014, the ministry is reported to have signed an MoU with China's Xinjiang Zhontal Sinsilu Noriye Invest on the construction of a new 300,000 t/a nitrogen fertilizer plant based on gas produced from coal, together with a 150,000 t/a phosphate fertilizer facilty. No further information is available at this stage of the project.

There remain several limiting factors to any quest to raise fertilizer consumption in Tajikistan. There is no consistent linkage between importers and the wholesale and retail suppliers, and there is also a lack of technical knowledge. Finance for purchases is very limited at all levels, and there are now only about 30 retailers, mainly in southern Tajikistan. Until these issues are resolved, agriculture in Tajikistan will continue to be marked by poor yields and low farm incomes.

The outlook need not be a pessimistic one. Potential strengths and opportunities have been identified, including good land in agricultural areas, continuing land reform, adequate water and irrigation, and growing domestic and export markets for high-value crops (such as apricots and tomatoes). IFDC believes that if fertilizer blending were to be introduced in Tajikistan, it would help to kick-start a transformation of the country's agriculture and farming economics.

Turkmenistan – riches from the desert

Over 80% of Turkmenistan is covered by desert. The climate is mostly arid subtropical desert, with little rainfall. The country is entirely landlocked but has a shore of 1,768 km in length along the Caspian Sea, while the Volga-Don Canal provides shipping access to the Black Sea. The country possesses the world's fourth-largest reserves of natural gas and significant oil reserves. The Galkynysh gas field ranks second to the South Pars field of the Persian Gulf in terms of volumes and has estimated reserves of around 21 million tcm. China is the largest buyer of Turkmenistan gas, connected by two pipelines, running via Uzbekistan and Kazakhstan. Further gas pipelines are being planned, including the Turkmenistan-Afghanistan-Pakistan and India pipeline.

Extensive irrigation systems have enabled Turkmenistan to develop an intensive agriculture, the two largest crops being cotton, mainly for export, and wheat for domestic consumption. Turkmenistan is among the top ten producers of cotton in the world.

Despite the abundant natural gas reserves, Turkmenistan has until now not developed a significant fertilizer industry, and much of its nutrient needs are met by imports, mainly AN from Uzbekistan. Indigenous fertilizer production is centred on an ammonia and urea complex in Mary Oblast, operated by the state-owned chemical company, Turkmenhimiya. The country has however announced its intention to raise fertilizer production threefold and build up an export capability. The Mary facility is being revamped, raising its capacity to around 640,000 t/a urea. In August 2014, a consortium of Mitsubishi Corporation and the Turkish construction company GAP Inşaat announced a project to build a 2,000 t/d ammonia plant and a 3,500 t/d urea plant, to be operated by Turkmenhimiya. The facility will be located in Garabogaz on the Caspian Sea coast and is planned to come on stream in mid-2018. The total cost for the project has been estimated at \$1.3 billion, 85% of which will be financed by a loan from the Japan Bank for International Co-operation.

Mitsubishi will be responsible for the basic and detailed fertilizer plant design, manufacture and procurement of equipment and plant commissioning. Haldor Topsøe has been awarded the contract to design the new ammonia plant, which will feature an SCR (Selective Catalytic Reduction) DeNOx unit to treat the flue gas from the facility, thus reducing NOx emissions. Saipem will supply the technology for the urea plant. It is envisaged that two-thirds of the annual production of 1.56 million t/a urea will go for export, shipped via the

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Caspian Sea. Based on estimated gas costs of around $2/mmBtu, the urea plant is expected to enjoy a competitive advantage, although some industry analysts have suggested that this advantage could be partly negated by high logistical costs in reaching the target markets.

Turkmenistan also has potash resources, which it is seeking to exploit, possibly in conjunction with partners in Belarus. The Garlyk potash deposit in Lebap province will provide the basis for Central Asia's largest mining and processing operation, with a projected output of 1.4 million t/a potash. In 2010, Turkmenhimia and Belgorkhimprom of Belarus signed a contract to build Turkmenistan's first mining and beneficiation complex, with a target date of summer 2016 for the first production. The contract cost was agreed at $1 billion. The Garlyk GOK operation hopes to achieve an output of 4.5 million t/a at full capacity, meeting domestic demand and supplying large tonnages for export. The project fell behind schedule earlier in 2014 after problems with payments for the construction process, but these now appear to have been resolved.

In another fertilizer-related project, a Japanese-Turkish consortium has begun the construction of a new sulphuric acid plant in Turkmenabat, Lebap province, with a capacity of 500,000 t/a. The new plant is scheduled for completion in late 2016 and will supply acid for the production of phosphate fertilizers. It will harness sulphur recovered from gas processing.

Uzbekistan boosts fertilizer competitiveness

Uzbekistan is Central Asia's most populous country, with 30.18 million citizens, half the region's total population. Gold, copper and uranium are major mineral sources of the country's wealth, while Uzbekistan ranks 11th in the world in natural gas production, with an annual output of 60-70 bcm. There are significant untapped reserves of oil and gas. Agriculture contributes 18% to the country's GDP, with cotton formerly a major cash crop, now playing a smaller role in the agricultural economy as wheat, fruit and vegetables become more significant. Virtually all agriculture requires irrigation, but as with other Central Asian republics, there has been a shortfall of investment in the irrigation infrastructure.

Uzbekistan sustains an indigenous fertilizer industry, which comes under the control of JSC Uzkimyosanoat. The company comprises 14 industrial enterprises and 13 regional distribution centres, operating the fertilizer supply chain in Uzbekistan, embracing manufacturing, warehousing and distribution to end-users. Its activities cover other agricultural inputs and chemical products.

An aerial view of Tashkent, capital of Uzbekistan.

The demand for nitrogen fertilizers in Uzbekistan was estimated at 600,000 tonnes N in 2011 and just under 120,000 tonnes P_2O_5. (*Uzbekistan's fertilizer industry*, Hamidila Shermatov. Paper presented at IFA Regional Conference [April 2012].) Domestic fertilizer production totals around 1 million t/a. The costs of production are kept down by subsidised energy prices. The government has identified fertilizer production as a matter of national security and is keen to ensure its long-term viability. It is however not resorting to open-ended subsidies but seeks an eventual convergence between domestic and export prices for energy resources. (*Uzbekistan: increasing competitiveness in producing fertilizers*, **Development Focus** [February 2011].)

One report suggested that Uzkimyosanoat could modernise its fertilizer plants and develop improved marketing and distribution systems, at an estimated cost of $1.5 billion. The application of the latest fertilizer production technology could achieve significant savings, of around 850 mcm/year of natural gas. The gas thus saved could be exported, earning revenues of about $150 million at 2011 prices.

The fertilizer production units within Uzkimyosanoat produced 955,800 tonnes N of nitrogen fertilizers in 2010, 148,800 tonnes P_2O_5 of phosphates and 30,000 tonnes K_2O of potash. Around 600,000 tonnes of the nitrogen fertilizer output were sold on the home market, while the rest was exported. For 2015, this total is expected reach 1.25 million tonnes N, 160,000 tonnes P_2O_5 and 372,000 tonnes K_2O. AN, ammonium sulphate and urea comprise the main nitrogen fertilizers produced in Uzbekistan, while MAP and single superphosphate (SSP) are the main phosphate products. The three principal nitrogen fertilizer producers within the Uzkimyosanoat group are Maxam-Chirchiq, FarghonaAzot and NavoiAzot, while Ammofos, Samarkandqkimyo and Quqon Superphosphate Plant are the main phosphate producers.

Recent investment projects have included the revamping and upgrading of the Maxam-Chirchiq and FarghonaAzot urea plants and the modernisation of the sulphuric acid unit at Ammofos. Another major investment project is the construction of a new NP and NPK production facility in the Navoiy region. The facility will include a 650,000 t/a sulphuric acid plant, a 143,500 t/a phosphate fertilizer unit and the capacity to produce 150,000 t/a of NPKs. Phosphate rock will be supplied from the expansion of the Qizilqum phosphate complex. The project is scheduled for completion later this year. A further phosphate project envisages the production of DAP fertilizers.

Additional new ammonia and urea capacity is being provided by the revamping of the NavoiAzot complex, giving it the capacity to produce 660,000 t/a of ammonia and 1.0 million tonnes of urea. Around 700,000 t/a of the ammonia output will be exported. The project is being undertaken in partnership with IPIC, UAE and Borealis AG, Austria.

Uzbekistan joined the ranks of potash producers in August 2010, when production began at the Dehkanabad Potash Fertilizer Plant. The plant has the capacity to produce 200,000 t/a, doubling to 400,000 t/a in 2013, helped by $110.5 million of funding from China's Eximbank. Capacity is eventually projected to reach 620,000 t/a. The facility harnesses the carnallite deposits in the Kashkadarya region on southern Uzbekistan, bordering with Turkmenistan. The total reserves are estimated at 400.2 million tonnes at 36.8% KCl.

These projects are helping Uzbekistan to harness its indigenous resources and in common with the other Central Asian republics, achieve a higher profile in world fertilizer markets. ■

The role of iron in fertilisation

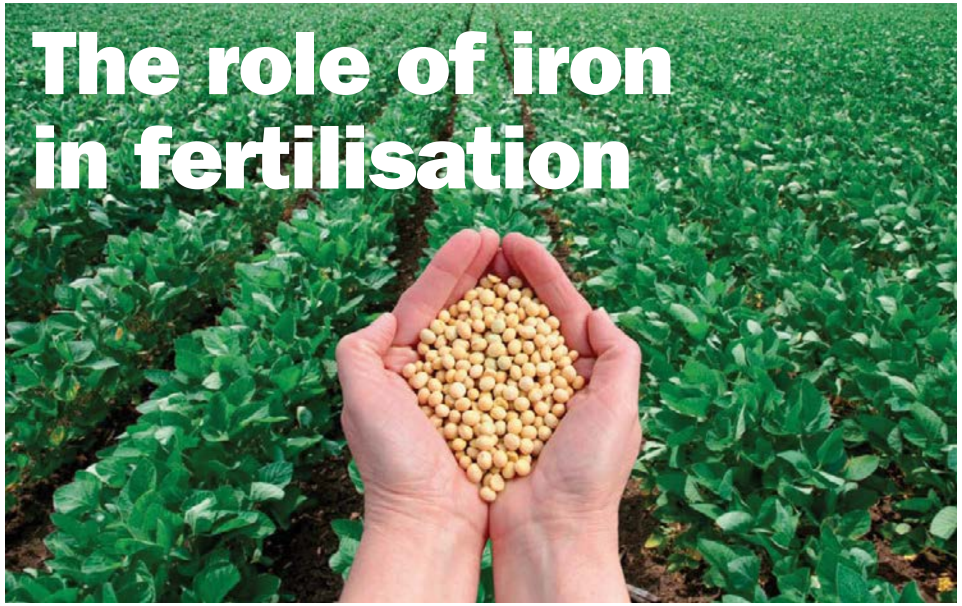


PHOTO: SIMA/SHUTTERSTOCK.COM

Iron is an important nutrient in soybean growth and quality.

Iron is needed to produce chlorophyll and its deficiency leads to plant chlorosis. We examine how Fe deficiency can be remedied.

Iron is necessary for photosynthesis and is present as an enzyme cofactor in plants. Fe deficiency can result in intraveinal chlorosis and necrosis. Iron is not a structural part of chlorophyll but is very much essential for its synthesis. Copper deficiency can be responsible for promoting an iron deficiency. Iron deficiency can occur even when the element is abundant in the soil. The soil's reduction-oxidation status and pH determine their availability. The lowest availability occurs is well-aerated, alkaline soils.

In most cases, plant Fe deficiency is not due to the lack of iron in the soil, but due to soil conditions that reduce its plant availability, such as:

- High soil pH
- Low soil oxygen levels caused by either soil compactions or waterlogging
- Prolonged periods of excessive soil moisture
- High temperatures
- High soil P, Cu, Mn and Zn levels.

Iron exists in the soil solution as either the ferrous (Fe^{2+}) or ferric (Fe^{3+}) cation, the valence form being determined by soil conditions. Fe^{3+} is insoluble in neutral and high pH, making iron unavailable to plants in alkaline and in calcareous soils. In these types of soil, iron readily combines with phosphates, carbonates, calcium, magnesium and hydroxide ions.

Soil moisture and pH are the prime determinants of Fe formation and uptake. As soil pH increases, the concentration of Fe_2 and Fe_3 in soil solution decreases. The critical pH level is 6.0: below 6.0, Fe_2 in soil solution will likely be in sufficient quantity to meet plant demands. Above 6.0, the plant will be increasingly likely to exhibit an Fe deficiency. Not only does pH directly influence iron solubility, but it also indirectly influences the presence of bicarbonates. Bicarbonates may react with Fe, which will create a precipitate, $FeCO_3$. (*Irony in Iron*, Dave Nowakowski, **Turf & Landscape** [July 2012].) This precipitate renders the iron unavailable for plant uptake and as a result, iron deficiency can be more likely found in high pH soils.

The reaction involving bicarbonates may also be observed at lower pHs, especially when irrigation water contains bicarbonates. This phenomenon may be observed when using reclaimed water.

Iron becomes more available as hydrogen ion activity increases, as per the equation:

$$\underset{\text{Unavailable}}{(Fe(OH)_3} + 3H^+ \leftrightarrow \underset{\text{Available}}{Fe_3} + 3H_2O$$

As soil moisture is increased, soil O_2 levels decrease. It is the basic concept that manages the conversion of Fe_2 to Fe_3 in waterlogged soils. As O_2 levels decrease, less oxygen is available to maintain the oxidised Fe_3 form and thus Fe_2 is likely to form. With more Fe_2 being available, additional iron applications may not be required.

Plants use various uptake mechanisms, including the chelation mechanism,

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Table 1: **List of Fe-containing commercial fertilizers**

Source	Formula	Water solubility	% Fe
Ferrous ammonium phosphate	$Fe(NH_4).PO_4.H_2O$	Soluble	29
Ferrous ammonium sulphate	$NH_4SO_4.FeSO_4.6H_2O$	Soluble	14
Iron chelates	NaFe-EDTA	Soluble	5-11
	NaFe-HDPTA	Soluble	5-9
	NaFe-EDDHA	Soluble	6
	NaFe-DTPA	Soluble	10
	Fe-HEDTA	Soluble	5-9
	Fe-EDDHA	Soluble	6
Iron polyflavonoids	Organically-bound Fe		9-10
Ferrous sulphate	$FeSO_4.7H_2O$	Soluble	20
Ferric sulphate	$Fe(SO_4)_3.4H_2O$	Soluble	23
Ferric sucrate	Fe_2O_3 organic complex	Soluble	50
Ferrous oxide	FeO	Limited	77
Ferric oxide	Fe_2O_3	Limited	69

whereby the plant releases siderophore compounds which bind Fe and enhance its solubility. This mechanism also involves bacteria. Another mechanism involves the release of protons (H^+) and reductants by the plant roots, to lower pH levels in the root zone. The result is increased Fe solubility. In this respect, the choice of nitrogen fertilizer is significant. Ammonium N increases proton release by roots, thus lowering pH and facilitating Fe uptake. Nitrate N enhances the release of hydroxide ions that increase pH in the root zone and counteract efficient iron uptake.

Some plants have been designed as "iron sufficient" due to the ability of their roots to acidify the rhizosphere and/or secrete phytosiderophores that complex iron at the root/soil interface and thereby enhance Fe uptake. Rice paddy fields are rich in iron available to the plant because of the reducing conditions in the soil. Rice plants take up much Fe, but the amount transferred to the grain depends on the rice variety. This factor is now taken into account in rice breeding, as Fe deficiency in humans is widespread in South East Asia, where rice forms a major part of the diet.

New roots and root hairs are more active in Fe uptake, and thus it is important to maintain a healthy active root system. Any factor interfering with root development affects Fe uptake.

Iron is an important nutrient in soybean growth and quality. Fe is widely deficient in the US Upper Midwest and takes the form of chlorosis (yellowing) between the leaf veins. The yellowing occurs on new growth because the nutrient is not mobile within the plant. Fe is necessary for nodule formation and function and when deficient can result in reduced N fixation. This occurs because of the soil pH and the high levels of calcium iron molecules become tightly bound to the soil particle and are not released for plant uptake. This deficiency can be difficult to correct because the soil binds any additional Fe: too high an application rate could become toxic to the plant.

Choice of fertilizers

Table 1 lists some of the commercially-available iron fertilizers.

Ferrous sulphate (20% Fe, 18.8% S) is the most commonly used inorganic iron source. It is not as effective as a soil-applied material because it quickly reverts to unavailable forms. However, ferrous sulphate can be used a foliar spray with some success, and one spray application of a 1-1.5% solution may correct mild iron chlorosis. Several applications one or two weeks apart may be needed for more severe chlorosis. (*Plant and Soil Sciences eLibrary*) When applied to soil, $FeSO_4$ may be of limited effectiveness in pH above 7.0 because its iron quickly transforms into Fe^{3+} and precipitates as an iron oxide.

It is better to apply ferrous iron than ferric sources of iron sulphate. In alkaline soils, most iron in granular iron fertilizers is quickly converted to the unavailable form, $Fe(OH)_3$.

Iron chelates are compounds that stabilise metal ions and protect them from oxidation and precipitation. They consist of three components:

- Fe^{3+} ions
- A complex, such as EDTA, DTPA, EDDHA, amino acids, humic-fulvic acids, or citrate
- Sodium (Na^+) or ammonium (NH_4^+) ions.

Different chelates hold Fe ions in different strengths at different pH levels. They also differ in their susceptibility to iron replacement by competitive ions. For example, at concentrations, Ca or Mg ions may replace the chelated metal ion.

Fe-EDDHA chelates (6% Fe) are the most stable iron chelate. Their main use is in soil application (placed with the seed) and they are effective even in high pH soils. They are stable at pH levels as high as 11.0. Product cost has however proved a limiting factor in their more widespread use. Fe-DTPA chelates (10% Fe) are the most commonly used Fe chelate. They can be soil-applied if the soil pH does not exceed 7.5. They are also used as a foliar treatment. While effective, cost factors limit their use on crops. They are not as susceptible to iron replacement by calcium.

Fe-EDTA is stable at pH below 6.0. Above pH of 6.5, nearly 50% of the Fe is unavailable. This chelate is thus ineffective in alkaline soils. It also has a high affinity with Ca, so it is advised not to use it in Ca-rich soils or water.

In soil-less media and hydroponics, pH monitoring of water and media is relatively easier than in oils. When regular testing is performed and pH control is adequate, it is possible to prefer the inexpensive, less stable iron chelates. On the other hand, in alkaline soils, where it is difficult to effectively decrease soil levels, it is advised to use more stable iron chelates, such as Fe-EDDHA.

The highest percentage source, iron oxide (rust) is nearly completely unavailable for plant uptake above pH 6.0. While it is more available below pH 6.0, iron deficiencies rarely occur below this level because the existing iron in the soil is more soluble in acid soils. Iron oxide thus provides very limited plant benefit.

Iron sucrate is produced by blending iron oxide with sugars to form an iron-containing organic complex. Molasses or other inexpensive sugar sources are used. Iron sucrate has limited water solubility. Natural organics can also supply Fe. Iron humate, biosolids and compost are some of the sources that are commonly applied.

Foliar benefits

Fe deficiency is typically manifested by interveinal chlorosis, reduced shoot growth, defoliation during the growing season and ultimately, tree death. Often affecting fruit crops, iron chlorosis has harmful effects on fruit production, reducing the number of fruits per tree, fruit size, total yield and affecting fruit quality parameters, such as colour, firmness or acidity. (*Foliar iron-fertilisation of fruit trees: present knowledge and future perspectives*, V. Fernandez et al, Department of Plant Nutrition, Zaragoza, Spain. [July 2008].)

Strategies to alleviate Fe chlorosis in fruit crops include:

- The use of root stocks tolerant to soil conditions that induce the development of the disorder and with Fe-uptake mechanisms
- Modifying soil characteristics
- Treatment with Fe substances via root, trunk or canopy applications.

Fe fertilisation of roots is regarded as the most reliable and widely-used technique to control iron deficiency. However, foliar Fe fertilisation is often a cheaper and more targeted strategy. Response to Fe sprays has been shown to vary according to many plant-related, environmental and physico-chemical factors. Three distinct processes can be distinguished in the plant's response to foliar Fe treatment:

- The penetration of the foliar-applied Fe through the leaf surface
- The distribution of Fe from the site of application
- The active involvement of exogenous Fe in physiological processes.

Physico-chemical properties

Current research on foliar Fe fertilisation is focusing on investigating the potential interactions between formulation components and seeking a better understanding of the relevance of the physico-chemical properties of spray solutions in order to design optimised Fe-containing formulations.

Ferrous sulphate heptahydrate is a useful Fe source and is commonly used in turf culture as a moss-killing agent. It is also occasionally used as a soil-acidifying agent.

Market gardeners also use the product in mixes as it enhances the green colour in plant leaves.

Haifa Group supplies chelated iron fertilizers under the *Haifa Micro* brand-name. A stable, water-soluble Fe-EDDHA chelate (6% Fe), *Haifa Micro* has been devised for soil and hydroponic applications at a rate of 60 g/l.

The US company Wolf Trax Innovative Nutrients has developed an innovative range of micronutrient products. Wolf Trax Iron DDP has been scientifically designed for better plant availability and earlier uptake, with a guaranteed analysis of 47% Fe. A unique coating technology ensures that Iron DDP is delivered at the right time for optimum plant nutrition.

Yara International markets *Ferrichel Ninety*™ as part of its YaraVita range. This is a formulated soluble powder that combines nitrogen (12% N), phosphorus (13% P_2O_5) and iron (9% Fe). It is recommended for use on fruit and vegetable crops. ■

CONTENTS

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015
BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Iron fertilisation of the oceans

Iron fertilisation of the oceans has been proposed to combat global warming, via the stimulation of a phytoplankton bloom that would enhance biological productivity and benefit the marine food chain. A number of ocean labs, scientists and businesses are exploring iron fertilisation as a means to sequester atmospheric CO_2 in the deep ocean, and several trials have been undertaken during the past 20 years. However, controversy remains over the effectiveness of atmospheric CO_2 sequestration and ecological effects.

An oceanic phytoplankton bloom in the South Atlantic Ocean.

Fertilisation occurs naturally when upwellings bring nutrient-rich water to the surface. This form of fertilisation produces the world's largest marine habitats. Fertilisation can also occur when weather carries wind-blown dust long distances over the ocean, or when iron-rich minerals are carried into the ocean by glaciers, rivers and icebergs.

Iron is a particularly important nutrient for phytoplankton growth and photosynthesis. Areas of the oceans have been identified as "desolate zones", where there has been little plankton growth – a factor that has been attributed to Fe deficiency.

In 1991, the eruption of the Mount Pinatubo volcano in the Philippines is estimated to have deposited around 40,000 tonnes of iron dust into oceans worldwide. This fertilisation event generated an easily observed global decline in CO_2 formation and a parallel pulsed increase in oxygen levels. This phenomenon prompted the hypothesis that increasing phytoplankton photosynthesis through iron fertilisation could sequester major volumes of CO_2 in the sea and thus slow or even reverse global warming.

A series of ocean studies have examined the fertilisation effects of iron since 1995. About 70% of the world's surface is covered in oceans, and the upper part of these where light can penetrate is inhabited by algae. In some oceans, the growth and reproduction of these algae is limited by the amount of iron in the seawater. Fe is a vital micronutrient for phytoplankton growth and photosynthesis.

Small amounts of iron (measured by mass parts per trillion) in desolate marine zones can trigger large phytoplankton blooms: marine trials suggest that 1 kg of fine iron particles may generate over 100,000 kg of plankton biomass. The size of the Fe particles is critical, with particles of 0.5-1 microns or less seeming to be the optimum.

Atmospheric Fe deposition is an important iron source, with particularly large dust sources located in northern and southern Africa, North America, Central Asia and Australia. As noted above, volcanic ash is a major Fe source.

Previous instances of carbon sequestration have triggered major climatic changes in which temperature of the planet has been lowered. Plankton that generate calcium or silicon carbonate skeletons account for the most direct carbon sequestration. When these organisms die, their carbonate skeletons sink quickly and form a major component of carbon-rich deep-sea precipitation known as marine snow. Other components of marine snow include fish fecal pellets and other organic blooms.

Of the carbon-rich biomass generated by plankton blooms, about half is consumed by grazing organisms (zooplankton, krill, small fish, etc.) by between 20-30% sinks below 200 m into the colder water strata. Much of this fixed carbon continues falling but a substantial percentage is redissolved and remineralised. At this depth, the carbon is now suspended in deep currents and effectively isolated from the atmosphere for centuries.

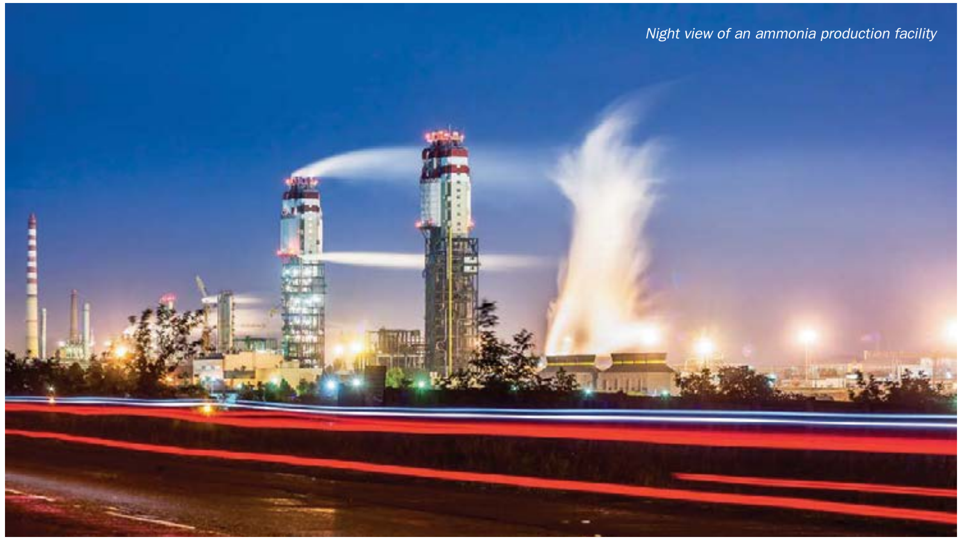
Proposals for more widespread iron enrichment in oceans have prompted major debates, and while ocean iron fertilisation could represent a potent means to arrest global warming, concerns have been raised about possible adverse side-effects. These potential side-effects are not as yet known, but the suggestion has been made that creating phytoplankton blooms in naturally Fe-poor areas of the ocean in effect changes one type of ecosystem into another.

It is argued that Fe fertilisation could sequester too little carbon per bloom, supporting the food chain rather than raining on the ocean floor, therefore requiring too many seeding voyages to be practical. Some ocean trials have reported positive results, with one reporting conversion of 1,000 kg to carbonaceous biomass and a fixation ratio of nearly 300,000 to 1. Recent estimates of the amount of iron need to restore lost plankton and sequester 3 gigatons/year of CO_2 range from approximately 200,000 t/a to over 4 million t/a. The latter scenario involves 16 supertanker loads of iron and a projected cost of around $27 billion.

Critics are concerned that iron fertilisation will create harmful algae blooms, including species that cause red tides and other toxic phenomena: increased phytoplankton populations are not always benign. One study showed that fertilised phytoplankton which are generally non-toxic in the open ocean began producing toxic levels of domoic acid. Even short-lived blooms containing such toxins could have detrimental effects on marine food webs.

The current consensus is that much more research is necessary on the impact, safety and efficacy of ocean Fe fertilisation. ■

Optimising feed quality in ammonia plants



Night view of an ammonia production facility

PHOTO: ANDREY PROKHOROV/SHUTTERSTOCK.COM

Upgrades and revamps can result in substantial savings in ammonia plant operating costs. One key area in which savings can be made is by optimising the quality of the feedstock through enhancements in catalyst technology. We assess recent developments in this field.

A synthesis gas with a 3:1 final H_2:N_2 mole ratio is required for the synthesis of ammonia. This syngas is generated by steam reforming of natural gas under pressure. Sulphur compounds in the feed gas have to be removed before the reforming process. The basic reactions involved in the steam reforming of methane, which is the main constituent of natural gas, are represented by the following reactions:

$$CH_4 + H_2O \rightarrow CO + 3H_2 \text{ and}$$
$$CO + H_2O \rightarrow CO_2 + H_2$$

The required stoichiometric hydrogen-to-nitrogen ratio is achieved by introducing air into the process. This is typically done by splitting the reforming into two stages:

- Primary reforming
- Secondary reforming.

In primary reforming, the natural gas is reformed with steam in furnace tubes packed with catalysts. Natural gas burners in the furnace radiation box supply the intense heat needed for the endothermic reaction. The reformer is controlled to achieve only a partial conversion, leaving approximately 14% methane in the effluent gas (dry basis) at temperatures of approximately 750 to 800°C.

The effluent gas is then introduced into a secondary reformer, a refractory-lined vessel filled with catalyst, in which it is mixed with a controlled amount of air introduced through a burner. This raises the temperature of the gas sufficiently to complete as far as possible the reforming of the residual methane without any further addition of heat. It also introduces the nitrogen needed for the ammonia synthesis. The gas usually leaves the secondary reformer at a temperature of approximately 850 to 1,000°C, depending on the process technology.

Syngas purification is the second key step in the ammonia production process.

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

The syngas from the secondary reformer contains CO and CO_2, which must be removed before the syngas is sent to the ammonia synthesis section. Reformed gas is typically purified with high and low temperature shift of CO to CO_2. CO_2 removal by solvent absorption or methanation. There are several alternative routes for the purification of syngas, which includes pressure-swing adsorption and cryogenic methods.

The residual CO_2 content typically ranges between 50 and 3,000 ppmv. In chemical absorption, the solvents mostly used are aqueous amine solutions (MEA and aMEA) or hot potassium carbonate solutions. In physical absorption, typical solvents are glycol dimethylethers (Selexol), propylene carbonates and others. The heat requirements in a modern ammonia plant range between 30 and 60 MJ/mol CO_2.

With the methanation method, after CO_2 removal there may still be small amounts of CO and CO_2 which could poison the ammonia synthesis catalyst and which need to be removed. In this process, CO and CO_2 are transformed into methane in a reactor filled with a nickel-containing catalyst. The reactions are:

$$CO + 3H_2 \rightarrow CH_4 + H_2O.\ \Delta H = -206\ kJ/mol$$

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O.\ \Delta H = -165\ kJ/mol$$

The water produced needs to be removed before entering the converter. This is done by cooling and condensation downstream of the methanator.

It is imperative to remove impurities like sulphur and chlorine efficiently from the hydrocarbon feed in order to prevent the poisoning of catalysts in the downstream steam reformer. Sulphur is encountered as a combination of H_2S and organo-sulphur species, including sulphides. Chlorine, if present, can be encountered as hydrogen chloride or as organo-chlorides. In addition, any olefins should be removed as these can present problems with carbon formation in the steam reforming section.

The feedstock purification section includes a number of steps and is usually achieved by employing a combination of catalysts and absorbents:

- Hydrogenation
- Absorption
- Final purification.

Hydrogenation converts organic compounds into hydrogen sulphide and hydrogen chloride, as the organic compounds are not easily absorbed on downstream absorbents. The hydrogenation process is also applicable for feedstock containing olefins and di-olefins. The process begins with a catalytic hydrogenolysis step to convert organo-S and organo-Cl into H_2S and HCl respectively. Dedicated downstream absorbents remove the H_2S and HCl produced.

Hydrogenolysis is the cleavage of C-S (or C-Cl) bonds by the action of hydrodesulphurisation (HDS). It is carried out over a cobalt-molybdenum (CoMo) or nickel-molybdenum (NiMo) catalyst. The hydrogenous reaction of organic sulphur compounds is exothermic, but the exotherm is typically negligible due to the normally observed relatively low sulphur levels in the feedstocks used for ammonia plants.

After hydrogenation, the feed contains hydrogen sulphide and hydrogen chlorine, which are absorbed on a zinc oxide and chlorine guard respectively. The concentration of these components at the outlet of the absorber is practically nil. The sulphur is removed to very low concentrations.

In the final purification stage, large variations in the sulphur content of the feed, low operating temperatures and high CO_2 or water content may require a final purification step to remove any remaining hydrogen sulphide as well as organic sulphur in the bottom of the zinc oxide reactor.

Typical purity requirements for syngas are:

- Total sulphur exit the feed purification section: <0.01 ppm by volume
- CO_2: 2 ppm to 3% by volume, depending on type of synthesis.

Fig 1: **Effect of catalyst on activation energy**

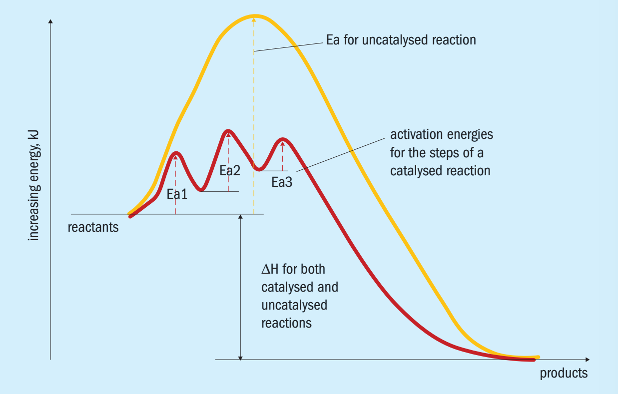
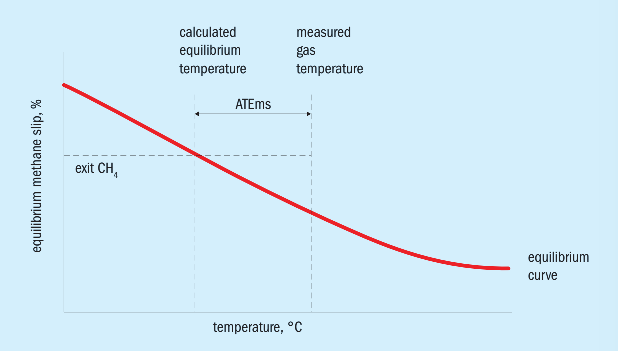


Fig 2: **Graphical description of ATE for a primary reformer**



The sulphur compounds should be discharged in a stream as concentrated as possible in order to improve the economics of subsequent treatment. The CO_2 must be sufficiently clean to allow it to be discharged directly into the atmosphere or used as a product.

The CO_2 separated from the gas can be a mixture with nitrogen when it is vented to the atmosphere. If the CO_2 is used as a feedstock for another process (such as in a urea synthesis), the CO_2 has to be partially or completely recovered as a highly-concentrated, pure and dry product stream. The allowable residual H_2S content typically varies in a range of 5-25 ppmv. In all, the following functions have to be fulfilled by the gas purification system:

- Trace contaminant removal
- Deep desulphurisation
- Drying
- Bulk CO_2 removal
- Acid gas enrichment.

The key role of the catalyst

Within a syngas flow-sheet, the catalyst plays a key role in feedstock purification. A catalyst is defined as "a substance that increases the rate of chemical reaction without itself undergoing any permanent chemical change." Catalysts used in ammonia production do not remain infinitely active and change over time. This deactivation is not due to the catalysed reaction that takes place but can occur because of:

- Physical changes over time on line at normal operating conditions
- Trace contaminants in the process gas (poisons) that result in unwanted chemical reactions taking place
- Deactivation and/or damage due to excursions outside the normal operating parameters.

Thermodynamics dictate that for a given set of conditions (temperature, pressure, reactant concentration), the position of the chemical equilibrium is fixed. If reactants are mixed together at a given temperature and pressure, and the reaction is able to proceed freely, the reaction proceeds to equilibrium and stops. In the absence of a catalyst, however, many reactions do not proceed because the reactants have insufficient energy to overcome the reaction activation energy and proceed towards equilibrium. The addition of a catalyst in the same conditions provides an alternative reaction pathway which has a lower activation energy such that the reaction now proceeds towards equilibrium (Fig. 1).

Catalyst performance in the syngas plant can be assessed via the approach-to-equilibrium (ATE) concept. ATE is defined as the difference between the gas temperature at the exit of the catalyst bed and the equilibrium temperature for the measured exit gas composition (Fig. 2). (*The chemistry within your catalysts*, P.V. Broadhurst, F.E. Lynch and N. MacLeod, **Nitrogen+Syngas** No. 310 [May-June 2011].)

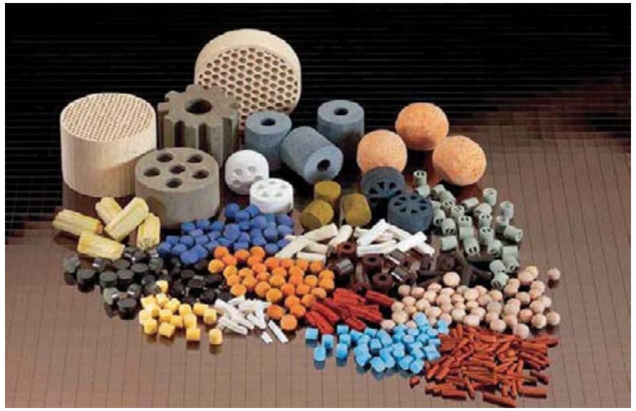
Although active and selective, many catalysts used in modern ammonia plants are susceptible to trace poisons that are present in the hydrocarbon feedstock. Effective purification is essential to maximise catalyst life, and a service life of over ten years is attainable.

Most syngas plants operate split-bed catalyst systems, with combinations of dedicated HDS (hydrodesulphurisation) catalysts and zinc oxide-based H_2S absorbents that reduce sulphur levels in the feed to around 10-50 ppbv. This provides an adequate level of protection for downstream catalysts in many applications. In

CONTENTS
What's in issue 464
COVER FEATURE 1
AFA: 40 years serving the fertilizer community
COVER FEATURE 2
Optimising feed quality in ammonia plants
COVER FEATURE 3
Minimising fertilizer losses

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com



Above: Haldor Topsøe continues to upgrade its ammonia catalyst range.

cases where the flow-sheet contains a particularly sensitive catalyst (such as a pre-reformer) further protection is usually required.

HDS catalysts are most active when the CoMo or NiMo phases are sulphided. In most syngas plants, the catalyst is installed in the oxide form and the catalyst reaches an adequate degree of sulphidation by reaction with the S compounds in the feed gas. Discharged samples generally contain from 1-4 wt% S, depending on the level of sulphur in the feed. Full conversion of the CoMo or NiMo in a typical syngas plant would require approaching 7 wt% S.

If chlorides are present, the next step in the purification process is HCl removal. This is typically carried out using an alkali-promoted alumina-based absorbent which operates the same temperature and pressure as the upstream HDS catalyst. Following chloride removal, H_2S is removed by reaction with a zinc oxide (ZnO)-based absorbent. This step is usually carried out at the same temperature and pressure as the upstream HDS catalyst:

$$ZnO + H_2S \leftrightarrow ZnS + H_2O$$

The reaction between ZnO and H_2S generates H_2O. As a result, high levels of water (or CO_2) in the feed can affect the equilibrium position of the reaction, resulting in increased levels of H_2S slip.

Most syngas plants operate split bed systems with combinations of dedicated HDS catalysts and ZnO-based H_2S absorbers.

Copper-based products, such as the *Puraspec$_{jm}$ 2084* and the *ST-101* developed by Johnson Matthey Catalysts and Haldor Topsøe respectively, are used for sulphur polishing or "ultra-purification" duty to lower the sulphur level below 10 ppbv. This is sufficient to provide adequate life for the most sensitive of downstream catalysts. The ultra-purification product is usually utilised as a relatively thin layer installed at the bottom of the H_2S removal bed and operates at a high GHSV (gas hourly space velocity). Copper-based ultra-purification products capture any H_2S/CPS/organo-S slip from the upstream beds via a surface adsorption (chemisorption) mechanism on metallic copper sites. The reaction is limited to the copper surface only, which limits the capacity in ultra-purification duties typically to 1-2 wt% S. Copper-based ultra-purification products also provide added protection for feeds containing high CO_2/water levels. The Cu-S species produced are much less readily hydrolysed to H_2S than is the case with ZnS.

Leading catalyst suppliers

Johnson Matthey offers both the *Puraspec$_{jm}$* and *Katalco$_{jm}$* range of purification absorbents and catalysts that provide optimised systems for meeting individual plant purification requirements. In addition to removing H_2S, down to ultra-purification ppb (parts per billion) levels, these catalysts and absorbents remove mercury impurities down to ppbv levels.

The *Katalco 59-3* catalyst range has been designed for use in the HCl removal phase, using sodium aluminate phases to react with the HCl. The sodium chloride formed by the reaction is locked into the structure of the absorbent, ensuing removal to very low levels (<5 ppbv).

Katalco 33-1 has been developed for combined systems that optimise HDS activity in conjunction with high saturation S capacity and a narrow H_2S absorption front. Typical operating temperatures are in the 300-400°C range. Offering benefits over a traditional two-stage S removal process, the *Katalco 33-1* range provides enhanced protection against COS slip. This is because the H_2S formed by reaction over the HDS function of the catalyst is immediately captured by the H_2S absorption function of the product. This prevents subsequent reaction of the H_2S with CO_2 so that COS is not generated. *Katalco 33-1* can additionally provide ultrapurification by extending the contact time in the bed.

Clariant Catalysts (formerly the Catalyst Division of Südchemie) has developed the *HDMax* and *ActiSorb®* series of catalysts and absorbents for use in the purification of nearly all hydrocarbon feedstocks, removing sulphur, chlorides and other impurities that can poison downstream catalyst systems and foul or corrode equipment. *ActiSorb S2* and *S6* catalysts are effective for removing sulphur in hydrogen operations and are typically installed in beds following *HDMax* catalysts. The *ActiSorb S2* is a zinc oxide material with a very high surface area that enables high pick-up of S-containing species (that is, greater than 32wt% pick-up). For deep desulphurisation, *ActiSorb S6* is a copper-zinc-based product that is typically applied to protect a pre-reforming catalyst from premature sulphur poisoning. *ActiSorb S12* is used to remove hydrogen chloride.

The Clariant *HDMax* series of catalysts also converts most S-containing species, being typically used with a downstream zinc oxide-based sulphur trap and are resistant to heavy hydrocarbons. The *HDMax200* series are cobalt-molybdenum (CoMo) catalysts, while the *HDMax 300* series are nickel-molybdenum (NiMo) catalysts, which have the advantage of remaining in the sulphided state more easily than the cobalt-molybdenum (CoMo) option.

Haldor Topsøe provides ammonia producers with tailor-made solutions from its portfolio of purification catalysts to remove sulphur and chlorine compounds from hydrocarbon feedstocks. Topsøe undertakes considerable R&D to enhance the performance of its catalyst range. In the hydrotreating area, the company has developed high-performance catalysts, including the *TK-250* (CoMo type) and *TK-261* (NiMo type). *TK-250* is a ring-shaped hydrogenation catalyst that efficiently converts organic sulphur and olefins. A benefit of the ring-shape is the added protection against increasing pressure drop caused by dust or other contaminants present in the feed. *TK-261* is the latest hydrogenation catalyst developed by Haldor Topsøe for syngas applications and is manufactured using an improved carrier material and a new metal dispersion technique, resulting in superior hydrogenation activity.

The Topsøe chlorine guard *HTG-1* offers high Cl-absorption capacity at a wide range of temperatures in the next process stage, absorption. The zinc oxide-based *HTZ* series provides very efficient sulphur removal for all applications. The *HTZ-3* and *HTZ-5* are high-purity (>99%) ZnO absorbents with high-capacity suitable for high and low sulphur concentrations respectively. In addition, the *HTZ-31* and *HTZ-51* product ranges also feature hydrogenation activity, thereby providing protection in case the absorbents are exposed to unexpected leakage of organic sulphur.

For the final purification step, Topsøe has developed the *ST-101* sulphur guard catalyst, where a high copper surface area removes any remaining H_2S as well as organic S in the bottom of the zinc oxide reactor.

The cryogenic alternative

An alternative syngas purification route is the cryogenic method. The cryogenic purification section typically comprises a cooling column and a reflow unit, or else a purifier. The latter in turn consists of two feed effluent heat exchangers, a gas expander (such as a turbine), a rectifier column and a reflux column. The process involves auto-refrigeration and expansion of the raw syngas in the gas expander, which provides the net refrigeration of the cryogenic section, keeping the whole cryogenic process in heat balance.

KBR has harnessed cryogenic technology with the development of the *Purifier™* ammonia process. The process simultaneously removes impurities and adjusts the hydrogen-to-nitrogen ratio to 3:1. The system removes methane, argon and excess nitrogen from the synthesis gas and allows use of air instead of oxygen in the reforming section of the ammonia plant, eliminating the need for an air separation unit. This process combines the following proprietary technologies to yield a reliable, robust and low-energy plant:

- Mild reforming with excess air
- KBR purifier
- Magnetite ammonia synthesis in a horizontal converter.

The *Purifier™* process system is a simple design consisting of three pieces of equipment: a feed/effluent exchanger, a column with a built-in condenser, and an expander. All items and the connecting piping are welded and enclosed in a perlite-insulated cold box. The equipment includes:

- A plate-fin exchanger design, constructed of aluminium
- A cryogenic column, designed to operate in temperatures ranging between 170°C and -200°C
- A shell-and-tube design integral condenser
- A compact low-speed expander, typically coupled to a generator to recover power. A 2,000 t/d ammonia plant requires an expander with a capacity of about 200 kW.

By providing a clean, dry make-up gas to the synthesis loop and a simple and precise H_2/N_2 ratio control, KBR's *Purifier* technology offers benefits to the entire ammonia production process, in particular via is lower energy consumption and reduced capital costs. The clean, dry make-up gas reduces the load on the synthesis loop compressor and refrigeration systems, thereby providing operational cost savings. The mild reforming temperatures that are used as methane slip helps to reduce fuel consumption and increases tube life, while the higher loop conversion is achieved with low inerts.

Purifier plants operate at some of the lowest proven energy consumption levels, with one recent installation achieving an energy consumption of 6.5 Gcal/t. Operating costs are reduced because no purge gas recovery unit is needed: purge gas rejected from the synloop is passed through the *Purifier* unit. The very clean make-up gas provided by the *Purifier* process lowers synthesis pressure, catalyst volume and purge rate, enabling smaller synloop equipment to be installed.

The *Purifier* process offers excellent stability and flexibility of operation, as the reforming section does not need to be tightly controlled to produce a precise H_2/N_2 ratio. Ammonia production can be maintained, even in the event of catalyst deactivation upstream. The low reforming temperatures result in lower stresses and longer life for the reformer tubes.

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015
BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Minimising fertilizer losses in transportation, handling and storage

Technological developments that ensure the integrity of the fertilizer granule between manufacture and application.

Careful storage and handling are essential to guarantee the nutrient content, quality and optimal performance of the fertilizer.

PHOTO: YARA

Fertilizers are manufactured to very high quality standards but are at risk of degradation and other hazards throughout the manufacturing, handling, storage and distribution chain. This in turn may affect the evenness, cost and effectiveness of the fertilizer application. Organisations such as Fertilizers Europe, Fertilizer Australia and CSIRO have established codes of practice that seek to eliminate as far as possible these hazards.

The nutrient content, its chemical form and other factors need to be taken into account to ensure optimal performance. However, inappropriate storage and handling can lead to a deterioration in physical quality and performance as a nutrient input.

The physical quality of fertilizers depends on:

- The physical properties of the products from production
- Storage facilities and the climatic storage conditions
- Stresses in the handling chain.

A product's physical properties are determined by its chemical composition and how it is produced. The most important product properties for handling, storage and spreading are:

- Hygroscopicity
- Caking
- Particle shape and size distribution
- Particle strength and mechanical resistance
- Segregation
- Tendency to generate dust and fines
- Bulk density
- Compatibility (chemical and physical).

Fertilizers are supplied in a variety of physical forms, including solids, liquids and as a compressed gas in the case of anhydrous ammonia. Solid products can be supplied as powders, crystals, prills or granules. (*Handling and Using Fertilizers*, CSIRO.) The most suitable physical form for a fertilizer is normally determined by its chemical characteristics, end-use and application method. Thus, products that are very low in solubility should be supplied in a very finely ground form to ensure rapid dissolution and plant availability. Solid products should be free-flowing and free of aggregated particles (lumps) caused by caking. Particle size should also be consistent to ensure an even application pattern. In addition to caking, excessive moisture uptake, dustiness and segregation of particles are the main physical problems that can arise.

Particle size affects the granulation and process performance during manufacture, blending, storage, handling and application properties, and ultimately agronomic response. Reducing particle size increases the total surface area of a material: the greater the surface area, the greater the reactivity of the particle. Fine powders, dusty fertilizers and small crystals are susceptible to caking because their larger surface area results in greater moisture uptake and reaction with adjacent particles.

Table 1: Critical Relative Humidity (CRH) of leading fertilizer products

Product	CRH at 30°C
Urea	70-75
Ammonium nitrate	55-60
Ammonium sulphate	75-85
DAP	65-75
MAP	70-75
TSP	75-85
SSP	80-85
Potassium chloride	70-80
Potassium sulphate	75-80

Source: CSIRO

The mechanical strength of a granule or prill determines its ability to withstand the degradation that can occur in handling and storage. The crushing strength is important when determining the fertilizer storage properties, while abrasion will generate fine particles and dust during handling. The transfer of augers is a common cause of product degradation through abrasion. Granular materials generally have a greater impact resistance than prilled materials.

Hygroscopicity is an important characteristic of solid fertilizers because of its effect on the physical quality of a product, which in turn affects storage and handling properties. It is defined as the moisture absorption properties of the fertilizer under specified conditions of temperatures and humidity. The greater the hygroscopicity of the fertilizer, the greater the likelihood of problems in the course of storage and handling. The hygroscopic properties of a fertilizer can be quantified and qualified by measuring the Critical Relative Humidity (CRH) and its moisture absorption-penetration characteristics. Table 1 shows the CRH of the most widely-used fertilizer products. CRH normally decreases with the increase in temperature.

Caking is caused by the formation of contact points between the fertilizer particles. A major cause is the formation of salt or crystal bridges between the particles at the contact points. These develop during storage as a result of continuing internal chemical reactions, dissolution and recrystallisation processes and/or thermal effects.

Dust emissions are an environmental hazard and are subject to regulation by law. Dust and fines normally arise during handling from:

- Water absorption
- Poor surface structure and particle strength
- Low mechanical resistance
- Mechanical stresses in the handling chain
- Wear and tear from handling equipment.

Coating systems suppress dust formation. CSIRO advocates a containment approach when handling and using fertilizers. Fertilizers should be kept dry and free from contamination, and any moisture changes should be controlled.

Technology to the rescue

Coating agents are used to improved the quality of the fertilizer and ensure its robustness in the course of handling, storage and transportation. Several specialist companies have developed efficient coatings for the various grades, ensuring that:

- Water absorption is substantially reduced when exposed to humid air
- Any tendency to caking is reduced
- Dust formation is substantially reduced.

In addition, a pigmented coating is often used to give a certain colour to the product. Most fertilizers are surface-coated to obtain these effects, but the product must nevertheless be handled properly to maintain the functionality of the coating applied.

Yara International, for example, has developed a unique coating for its CAN that reduces the rate of water absorption. Yara Technology Centre has developed a range of efficient coatings for many fertilizer grades, in close co-operation with its business partner, Novochem Fertilizer Additives.

A very wide range of specially-formulated anti-caking agents have also been developed to tackle the issue of caking. Fertilizers tend to aggregate during transport and storage and this factor has been a major concern to fertilizer manufacturers. Considerable research has been devoted to solving the problem.

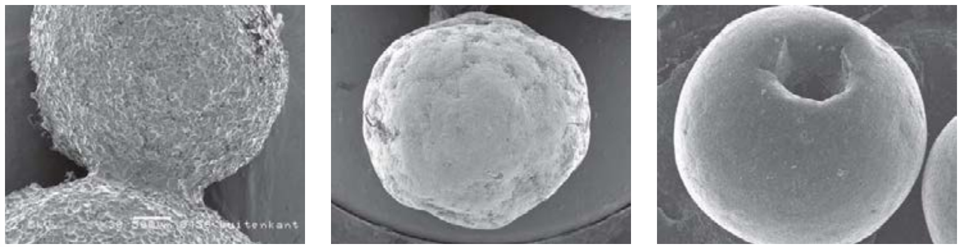
In order to prevent caking, fertilizers are treated with various agents that normally include a surface active compound and a fine inert powder. The surface active compound controls crystal formation, preventing the formation of strong bridges, while the powder reduces the surface contact area.

There are two principal types of anti-caking agents: manufactured or man-made, and natural anti-caking agents. Some anti-caking agents are water-soluble; others are soluble in alcohols or other organic solvents.

With the prevention of dust formation, the amount of dust released from fertilizer products depends on several physical properties, including particle strength and shape, handling methods and the coating system applied. Yara has developed coating systems that reduce dust release by up to 90% in the bulk handling chain.

The principal types of coating materials include:

- Particulates
- Coating oils
- Thermoplastic mixtures
- Water-soluble liquids
- Polymer systems.



PHOTOS: NOVOCHEM FERTILIZER ADDITIVES

Above left: To be avoided: crystal bridge formation of a urea granule. Above centre and above right: Urea granules and prills after coating.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Particulates (sometimes called parting agents) include clay and talc. They are good for ensuring flowability and preventing caking, but can result in dust formation and must be applied in large amounts. Coating oils can be derived from fuel oil, asphaltic oils, refined oils, natural oils and fats. They are effective dust control agents but are less effective in combating caking. Thermoplastic mixtures mainly comprise wax, waxy surfactants, sulphur, resins and polymers and are effective agents for dust control and anti-caking, but can involve higher costs. Water-soluble liquids, such as glycerine, molasses, surfactant solutions and polymer solutions, are suitable for special applications where solubility is needed. Polymer systems include polymerised film formed via reaction with the surface or cross-linking on top of the surface of the fertilizer. This involves a costly process but results in a high-performance product. (*Aspects of Coating Technology for Granular Fertilizers.* V. Granquist, Nufarm Specialty Products, Inc. Paper presented at FIRT 2004.)

Some indication of the effectiveness of dust control additives was shown in gravimetric tests undertaken by IFDC on granular sulphur. Untreated granular sulphur emitted an average 740 mg dust/kg. Treatment with a light oil additive reduced dust emissions to 150 mg/kg, while viscous oil proved even more effective, with dust emissions being further reduced to 83 mg/kg.

The IFDC tests also showed how coating products curtailed caking tendency. Uncoated ammonium sulphate showed a crushing strength of 15.2. After treatment with at a dosage of 2 kg/t, crushing strength fell to 0.1 and the product was free-flowing.

Coating with speciality chemicals can be undertaken at various stages of the fertilizer production and distribution process. Coating drums with the spray inside the drum can be installed as part of the granulation process, while in blending installations the coating can be sprayed or injected during blending. Spraying can also be undertaken at the drop point in a conveying system, using some type of enclosure. An important aspect inside the coating drum is to determine the correct spraying angle of the nozzles towards the fertilizer. In addition, the type of nozzle (flat spray or hollow cone) is another important parameter for a correct dosage of the coating oil.

To optimise coating application efficiency, it is recommended that the surface area exposed should be maximised, while minimising void space. It is also recommended matching the rate of coating application to the rate of surface area exposure. The selection of the most appropriate coating agent will depend on the viscosity/temperature curve and spreadability during application.

The cost of coating per tonne of fertilizer is assessed at around $0.50-1.00/t at the low end of the range, for basic dust control agents, while applying mid-range products to cover both dust control and anti-caking is assessed at between $1-3/t. At the high end of the coating range, with special compositions fully soluble in salt solutions for controlled-release or food-grade products, the coating cost is assessed at between $3-10/t.

The prevention of thermocycling is another imperative, especially with ammonium nitrate. AN occurs in different stable crystalline forms, changing from one to another and accompanied by volume changes. The transition at 32°C results in density changes and can cause the product to break down into fines if the product is heated or cooled while passing this temperature. AN 33.5 and some other products high in ammonium nitrate contain stabilisers that minimise thermocycling. However, during long periods of storage, these products may still degrade if the conditions for thermocycling are favourable.

Condensation should also be prevented. The air can release approximately 0-15 g of water/m³ per night in a hot and humid climate, equivalent to approximately 90 l/day in a small warehouse of 1,000 tonnes. It is important to lead water outside in any storage facility. In new projects, roof insulation is used to reduce temperature variation.

Specialist suppliers

For more than 20 years, **Novochem Fertilizer Additives** offers a range of customised additives, including anti-caking agents, moisture-repellent agents, dedusting agents, granulation additives and corrosion inhibitors. Marketed under the *NovoFlow* brand-name, Novochem coating agents are available for each type of production process, including prilling, blending, granulation and crystallisation, and for the widest range of fertilizers. The application of *NovoFlow* is adjusted to the specific fertilizer properties, production process, storage conditions and climate conditions. Coating concentrates are also available for liquid concentrated fertilizers and as *NovoFlake* for solid concentrated products. These products are diluted with a suitable oil on-site.

Novochem markets a corrosion inhibitor for liquid fertilizers. These can be very corrosive, making the addition of an effective corrosion inhibitor crucial. The addition of the corrosion inhibitor ensures that metal surfaces and welds can be maintained in excellent condition during the whole process from the production facility to the end-user. Novochem's corrosion inhibitors are marketed under the *NovoCor* and *Cor-Blok* brand-names.

NovoDust can be applied on a wide range of fertilizers to guarantee the safe handling of products sensitive to dust. *NovoTec* has been developed as a granulation additive for ammonium nitrate and CAN fertilizers. The Novochem range of additives also includes *NovoTint* colouring agents, which also offer strong dust binding properties, and *NovoFoam,* which controls foam formation in phosphoric acid production processes. The *NovoFloc* range comprises flocculants designed to optimise industrial processes by improving the filtration rate of phosphoric acid-gypsum slurry, resulting in lower P_2O_5 losses. These flocculants can also act as a clarifying agent to separate solid particles from acids more readily.

Clariant Mining Solutions offers a range of high-performance, tailor-made products that increase the value of the final product and improve internal handling. The range covers anti-caking, anti-dust and anti-moisture reagents for AN, CAN, NPKs, DAP/MAP and KCl. Products are also available for explosive-grade AN. Clariant's range includes products that provide corrosion protection for liquid fertilizers and defoamers for use in phosphoric acid production.

Clariant's water-based coatings form effective anti-caking agents and are fully water-soluble. They are not sensitive to pH or electrolytes and are stable at drying temperatures of up to 200°C. The coatings preserve the integrity of the manufactured fertilizer throughout the shipping, storage and handling processes. While typical coatings cannot correct inherent problems in granule integrity and stability, Clariant's quality coatings can help compensate for irregular surface shape, excessive porosity, softening over time, high moisture content and poor or variable coating dosing.

Clariant's *Flotigam V4900T* range provides anti-caking and water-repellent properties for AN and nitrate-based NPKs. It offers an anti-caking efficiency in excess of 80% and initial water-repellent qualities of greater than 50%.

The Spanish company **Chemipol S.A.** offers a range of additives that enhance fertilizer integrity and performance. The *Chemisil*® range of soluble anti-caking agents is based on sulfonated derivatives that integrate different formulations of additives to prevent fertilizer caking during the manufacture and storage stages. Due to their dispersing effects, *Chemisil* additives prevent the agglomeration of fertilizer in bags at the bottom layers of pallets by the effect of the weight above them.

The *Chemisil AG* range of anti-caking agents is based on silica dioxide and has been developed for the production of powdered fertilizers. Its application avoids agglomeration during the manufacturing process due to its highly absorbent qualities.

Neelam Aqua & Speciality Chemical of India was established by Dr. Suresh Singh in 1980. The company began by manufacturing organo-phosphates for cooling water treatment in the fertilizer industry, later evolving into a supplier of fertilizer treatment speciality products. The Neelam Aqua range includes anti-caking agents for granular NPKs and DAP/MAP fertilizers, marketed under the *Neelcoat* brand-name. Other *Neelcoat* products treat AN and CAN. Neelam Aqua also offers the *Urecoat* and *Urefix* range for treating urea.

Fertibon Products provides innovative speciality performance chemicals, including agents for anticaking and colouring, urea melt additives, granulating aids and defoamers. Fertibon's anti-caking agents incorporate active ingredients based on surface activity and ionic activity relating to crystal growth modification and/or suppression during storage. They also incorporate various promoters, migrating aids, lubricants, softeners and carriers solids and liquids, as well as coupling agents that enable the organic chemicals to interact effectively with the hydrophilic fertilizer salt surfaces.

Fertibon anti-caking agents are non-rubber reactive when compared with the commonly-used oil carriers, which can cause distress to product conveyor belt systems.

ArrMaz is a global leader in supplying to the fertilizer markets and provides unique solutions that improve product quality and environmental conditions. Since 1967, ArrMaz has been a dependable and innovative source for fertilizer process chemicals and coatings. ArrMaz remains dedicated to delivering world-class technical services and adapting to changing customer needs.

The experts at ArrMaz assist in the optimisation of industrial processes by specifically tailoring products to customer applications and needs, serving as a quick-response supplier and ensuring customer satisfaction. Their solutions and engineering team help increase throughput, improve product handling characteristics, reduce product caking and more.

ArrMaz specialises in custom-formulated products that optimise performance with the inclusion of dust control agents, anti-caking agents, defoamers, flocculants, filter aids, granulation aids and colouring agents. They are strategically located to serve customers across the globe, with facilities in the United States, Brazil, China, France, Morocco and Saudi Arabia.

ArrMaz works closely with customers who manage fertilizer warehouses, which can experience high levels of dust or fertilizer caking. ArrMaz has developed the *Dustrol*® range of dust control solutions that improve product quality and safety, making the fertilizer easier to handle and minimising the amount of dust the fertilizer generates. *Dustrol* coatings are designed to suppress dust when applied to granular fertilizer products, forming a thin coating across the fertilizer surface. This coating provides a barrier that ensures that less dust is generated and can even absorb dust after it is generated.

The ArrMaz *Galoryl*® range of anti-caking formulations improves product handling in high moisture environments. While many coatings are solids which require heating before application, *Galoryl* products do not require heated application systems. The treated fertilizer needs only to be maintained near room temperature. ArrMaz has in turn custom-designed a range of coating feed systems.

Hubei Forbon Technology Co. provides integrated and turnkey solutions in the supply of fertilizer additives and technical support services. Forbon can customise all types of anti-caking agents for every fertilizer type and has particular experience in NPK compounds. The company also markets fertilizer coatings and additives, including colouring for DAP and NPKs.

Kao Global Chemicals specialises in the supply of tailor-made anti-caking and granulation agents under the *SK Fert* brand-name for AN, CAN, DAP and NPK solid fertilizers, and *Uresoft 120* in liquid form for urea. Kao offers a range of environmentally-friendly agrichemical agents based on research that ranges from the basics to applications development and covering the entire work process from raw materials to product manufacturing.

Nukote Coating Systems International (NCSI) has manufacturing facilities in the United States, China and Saudi Arabia, supplying a wide range of polymer coating and liner products. NCSI's range of proprietary products includes *Pure Polyureas, Modified Polyureas, Poylurethanes* and *Metal Polymers*. Each NCSI production centre includes testing laboratories and commercial offices providing product and application support in the regions where they are allocated.

NCSI polyurea products were selected and specified by Mitsubishi Heavy Industries (MHI) to supply the protective coating system for the Sofert urea plant in Algeria. Nukote *XT* was applied in various locations in the project, which included primary containment of process basins, secondary containment of the chemical storage facilities and the waste water process tanks.

Continuing innovation

The leading suppliers of chemical reagents maintain large R&D departments, and their research is supplemented by that of several academic institutions. For example, the University of Florida has developed a unique dry-transfer coating composed of fluoropolymer and amorphous carbon that will control dangerous emissions and minimise caking when applied to fertilizers. While many commercially-available reagents applied on granular fertilizers manage to curb dust emissions, they are only effective for a limited period and the liquids must be reapplied frequently at an estimated cost that can range from $0.50 to more than $10/t.

The dry coating developed by researchers at the University of Florida is made from amorphous carbon and polytetrafluorethylene and works in a single application. It has been shown to be effective in reducing airborne dust caused by granule-to-granule interactions by up to 25%. The coating is applied through mechanical interactions between granules during normal handling operations and as such does not require specialised application systems. Because the external coating does not penetrate

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015
BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

The Laycote™ automated coating system can be easily integrated with a bulk blending installation.

A Layco automatic coating facility as supplied to Wolf Trax Innovative Nutrients.

PHOTOS: LAYCO

the granules, it will not interfere with the fertilizer's functionality. The new coating offers the following advantages:

- It will not seep into the fertilizer granules in the way some liquid coatings can.
- It requires just one application, saving time and money.
- Coating coverage increases with mechanical input, maximising efficiency.
- It offers a versatile design, providing opportunities for a range of alternative uses outside the agricultural fertilizer sector, such as mineral, steel and paper production.

The University of Florida is now seeking companies interested in commercialising the newly-developed coating, which it believes could capture a major share of the global fertilizer market.

Automated coating systems

A number of companies have developed automated fertilizer coating systems as an integral part of the fertilizer manufacturing process. GEA Barr-Rosin offers systems tailored to customers' needs, paying particular attention to energy-savings through recuperation and/or equipment integration. The range of technologies includes de-dusting equipment and conditioning/polishing/coating drums. Coating and conditioning drums can be typically incorporated as part of the fertilizer granulation process, while the GEA Barr-Rosin ring dryer can incorporate additional feed conditioning by introducing dry material to the feed point.

The US manufacturer Feeco International has developed a coating drum, in which premade pellets are fed into one end of the rotating drum and the coating material is sprayed on to a bed of pellets. As the drum rotates, the pellets pick up the coating and the rolling action helps to agglomerate the coating on the surface of the pellets.

For bulk blending companies, Layco has developed the *Laycote*™ automated coating system that accurately delivers conditioning powders and liquids on to dry fertilizer blends. The Layco Pro Automation technology system provides positive feedback monitoring to accurately meter the fertilizer input and impregnate liquid and powder additives as per the required rates. In developing the system, Layco has taken note that fertilizer suppliers are moving increasingly towards a value-added balanced fertilisation approach that incorporates innovative additives, such as urease inhibitors, micronised micronutrient powders and phosphate enhancement additives. These products therefore need to be applied accurately to either a single fertilizer or to the entire blend. The *Laycote* system accurately applies both liquids and powders for each required process via a unique metering and mixing chamber which provides accurate results as the Layco PLC computer monitors the flow of the product as well as the flow of the liquid or powder during the coating process.

The Dutch company EMT has recently introduced a portable fertilizer coating unit which enables small quantities of liquid additives to be incorporated into a blend during a continuous weight-controlled bulk handling process. The machines produced by EMT are constructed of stainless steel and designed to handle an aggressive fertilizer environment.

The long-established A.J. Sackett & Sons Company offers an extensive range of fertilizer blending and bagging systems that can incorporate integrated coating systems. The Sackett High Intensity Mixer (HIM) is engineered for highly accurate and efficient mixing and coating of materials. It is particularly suited for bulk blending units that incorporate micronutrients (granular, powder or liquid) and liquid additives, such as polymers, de-dusting agents, NBPT, etc. The process of coating and blending fertilizer with the Sackett High Intensity Mixer is the same used by manufacturers in the pharmaceutical and food industry. Batch blending or coating using static weights assures 99.9% accuracy, which is well beyond what can be achieved with a continuous weighing system. Blending and coating times can be as little as 30 seconds per batch of material while maintaining near-perfect blending and coverage. A notable feature is that the system can be customised for timing of different materials. For example, high-viscosity liquids such as liquid micronutrients may need a longer mix time to be applied correctly. The important thing is to have the flexibility to change the mixing time, based on the physical and chemical properties of the new liquid products now being launched. This can only be achieved with a batch coating system.

There are many new liquid products entering the market that need to be added to dry blends. As there is a minimum amount of liquid that can be applied to a dry blend without causing caking, new liquid additives will need to be in higher concentrations/lesser volumes, thus making the need for higher-efficiency batch mixers like the HIM even more important. Sackett also offers a continuous coating system, but this design is not a fit for all applications, The company works hard to offer experience and expertise to its customers. ■

January-February 2015

phosphates & potash INSIGHT

CONTENTS

What's in issue 464

COVER FEATURE 1

AFA: 40 years serving the fertilizer community

COVER FEATURE 2

Optimising feed quality in ammonia plants

COVER FEATURE 3

Minimising fertilizer losses

FERTILIZER INTERNATIONAL

ISSUE 464

JANUARY-FEBRUARY 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England

Tel: +44 (0)20 7793 2567

Fax: +44 (0)20 7793 2577

Web: www.bcinsight.com
www.bcinsightsearch.com

Ukraine's hopes for self-sufficiency

Although Ukraine is best known as a world-ranking producer and exporter of ammonia and urea, the country also has a significant potash resource. **Eugene Gerden** outlines the latest plans to revive Ukrainian potash production.

UkrLandFarming, one of Ukraine's largest agricultural holdings and owned by Ukrainian billionaire Oleg Bakhmatyuk, plans to invest up to $1 billion to establish a potash mine and processing facility near Stebnyk, in the Lviv area of western Ukraine. The property is currently in the hands of Polimineral, a subsidiary of UkrLandFarming. Total potash reserves are estimated at 1.1 billion tonnes.

According to the plans of Oleg Bakhmatyuk, production capacity of the new facility will initially be 600,000 t/a of potash fertilizers, rising to 1 million t/a during the subsequent years.

The Stebnyk potash field was previously exploited by a mine that was closed in 2003. According to the Ukrainian Ministry of Energy, the development of the Stebnyk potash resource fulfils an acute need for the country, as it will help ensure Ukraine's self-sufficiency in potash fertilizer markets, reducing its reliance on imports from Russia and Belarus. The Ministry wishes to accelerate the development of the Stebnyk resource, despite the relatively low potassium content.

At present, the potassium content is estimated at 8% K_2O, which is significantly less than the content of Russian-supplied potash fertilizers, based on sylvinite resources of around 30% K_2O, while potash supplied by Belaruskali can have a K_2O content as high as 60%.

According to Ivan Fabyak, chief engineer of Polimineral, the development of the Stebnyk potash mine will involve significant costs for the investor, the majority of which will involve the ore beneficiation and enrichment processes. In the initial phase of the project, production will be around just 100,000 t/a of kainite. The second stage will seek to raise production up to 300,000 t/a of compound fertilizers.

Fig 1: Development of underground industrial salt mining in western Ukraine

Ivan Fabyak said that a significant share of the investment funds will be allocated to the acquisition of technology to enrich the potassium ore. By 2017/18, production is targeted to reach about 600,000 t/a of complex fertilizers.

UkrLandFarming plans to allocate part of the funding for the project from its own reserves, while the rest of the funding is expected to be raised from Western financial institutions in the form of loans. Other foreign investors may also get the opportunity to take a stake in the project.

According to analysts at the Ministry of Energy, the successful implementation of the project would make UkrLandFarming the largest NPK fertilizer producer in Ukraine, able to meet most of the country's demand for compound fertilizers. Annual demand for these products is currently estimated at around 1 million t/a, while the demand for potash averages some 125,000 t/a, met entirely by imports. Currently, Belarus is the main supplier.

Oleg Bakhmatyuk believes that the Ukrainian market for potash fertilizers offers good prospects for further growth in the years ahead, with the potential for consumption to more than double to 270,000 tonnes. At the same time, in the case of other market segments, consumption of nitrogen fertilizers is forecast to increase from the current 950,000 t/a to around 2 million t/a by 2017, while the demand for phosphate fertilizers could rise from 225,000 t/a to 460,000 t/a in the same period. In addition to the domestic market, Bakhmatyuk has not ruled out the possibility of starting exports of potash fertilizers to the EU market, in volumes of between 400-500,000 t/a.

UkrLandFarming is also considering the possibility of producing complex fertilizers. Until now, the lack of indigenous phosphate and potassium raw materials has made the production of complex fertilizers uneconomic in Ukraine. As a result, many local complex fertilizer production facilities, which were mainly built during the Soviet era, have remained idle. Meanwhile, the cost of importing fertilizers has increased significantly, following the deval-

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

uation of the Ukrainian national currency, the hryvna.

According to data published by the Ukrainian Ministry of Energy, prices for compound fertilizers have recently reached a historic high. For example, prices for the best-selling 15-15-15 and 16-16-16 NPK grades reached UAH 6,550/t ($438.85/t) in October 2014, while DAP was selling at UAH 8,100/t ($542.70/t) and MAP at UAH 8,500/t ($569.50/t). At the same time, prices for potassium chloride (KCl) were averaging UAH 5,600-5,700/t ($375.20-381.90/t).

According to Dmitry Gordeychuck, head of the Ukrainian fertilizer industry analysis company Infoindustriya, the Stebnyk project can be considered as very promising, but its implementation will involve considerable costs for the investor. He also added that the establishment of a new production facility will help weaken the current duopoly of the Sumyhimprom and Dnipro fertilizer plants in supplying the Ukrainian market for compound fertilizers. At the same time, Polimineral is poised to become the sole producer of potash in Ukraine, as the Kalush potash plant which previously served the market suspended its operations in 2001.

Oleg Bakhmatyuk acquired the Polmineral enterprise from the Ukrainian government in 2013 for the relatively low price of UAH 100 million ($12 million). Among the other bidders for the company were Agrotrade LP, which specialises in supplying nitrogen fertilizers from Russia, and Group DF, owned by another Ukrainian billionaire, Dmitry Firtash.

Meanwhile, analysts at the Ministry of Energy have already welcomed Bakhmatyuk's plans. According to them, successful implementation of the project will provide an impetus for the development of the entire fertilizer industry in Ukraine. Group DF forecasts that, despite the country's current economic crisis, production and consumption of fertilizers will increase during the next few years, being driven by the increase in the area of arable land, as well as the rise in fertilizer applications per hectare.

Dmitry Firtash, head of Group DF commented: "Over the next five years, the area of cultivated land in Ukraine is expected to rise by 7 million ha, from the present 18.7 million ha to 25.4 million ha by 2017. We can also assume that the volume of fertilizer application per ha will increase by 35-40%." ■

Reviving Ukraine's potash mines

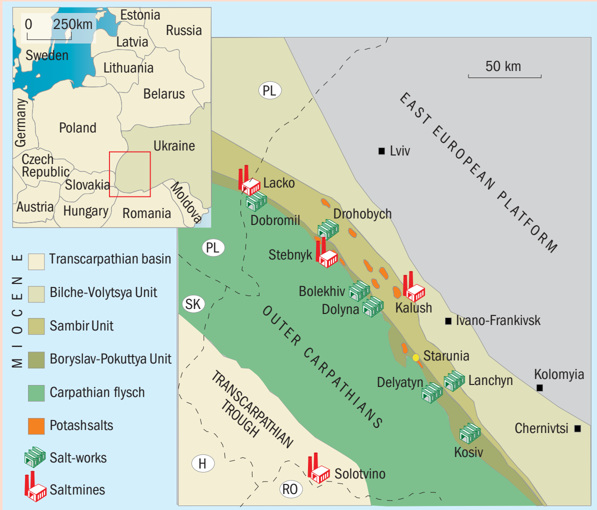


Fig. 2: *Distribution of potash and rock salt deposits (red areas, salt mines marked) in background of regional geological structure of western Ukraine*

The discovery of large potassium-magnesium salt deposits in Kalush (1854) and Stebnyk (1901) in the Carpathian region of Poland and Ukraine led to the development of underground mines to extract the salts. The potash salt concentrations occur within the Miocene sedimentary complexes in a belt of around 235 km in length and up to 20 km wide. The thickness of the exploited potash seams range from 4 m up to 150 m, mainly comprising sylvite with additional deposits of carnallite, kainite and langbeinite. (*Salt geology and mining traditions: Kalush and Stebnyk mines*, K. Bukowski and G. Czapowski, Akademia Gorniczo-Hutnicza, Krakow.)

The Kalush potash salt deposit ranges between 50-170 m in thickness. Mining began in the 1870s, at a time when the region belonged to the Austro-Hungarian Empire. By the 1980s, the Kalush mine operated on a room-and-pillar system, comprising chambers that were 10 m wide, with separating pillars of around 7.7 m in width. The chamber height depended on the thickness of the exploited seam and varied from 12 m to 30 m. An additional open-pit mining operation was undertaken at Domrowo, south west of Kalush. Mining eventually ceased at the two sites because of water inflows and the gradual depletion of the ore reserves.

The Stebnyk potash salt deposit form part of the Miocene Vorotyshcha mineralisation and occur at depths of between 80-650 m, commonly at 100-360 m. The potash-bearing beds are 10-125 m thick and are overlain by a rock salt deposit 60 m thick. Commercial exploitation began with the processing of the langbeinite ore ($K_2SO_4.2MgSO_4$) into magnesium oxide (MgO), potassium sulphate (K_2SO_4) and sulphur.

Mining and processing finished in 2003. In 1983, there was a serious ecological accident when over 5 million m³ of industrial brines flowed into the Dniester River. ■

A boom in demand prompts Latin American projects

Above: SQM, Chile extracts potash from brines in the Atacama Desert.

PHOTO: SQM

The demand for potash in Latin America is being spurred as new lands are brought into cultivation, notably for soybeans in Brazil and Argentina. The region produces potassium chloride, potassium sulphate and secondary potassium nitrate, with indigenous supply currently limited to Brazil and Chile. We assess the medium-term prospects for demand and new capacity.

The demand for potash has surged in Latin America, reflecting the rapid increase in crop production, expansion of cropping areas with unfavourable soils and large nutrient exports with cereal and oilseed shipments. The share of soybean and sugarcane (including for the downstream production of biofuels) explains the high proportion of the K nutrient in overall N:P:K application ratios. The recent average growth in potash consumption of between 4-5%/year is expected to be sustained in the medium term.

Soybean, which has a particularly high requirement for the K nutrient, has enjoyed a boom in production, buoyed by firm market prices. Larger planted areas have further boosted soybean production. In 2013/14, soybean output is estimated to have increased by 10% in Argentina and 7% in Brazil and is forecast to rise by a further 4% in Brazil in 2014/15. (*Medium-Term Outlook for World Agriculture and Fertilizer Demand*, Patrick Heffer, IFA [May 2014].)

IFA forecasts that over the medium term to 2018/19, South America will remain the region witnessing the largest agricultural growth rates, with production gains led by both increases in yields and the expansion of planted areas. In Brazil, production is seen as rising by 10-11% between 2014 and 2018 for soybean, maize, cotton and sugarcane. Substantial growth is also projected in Argentina, with output of maize and wheat expected to increase by 15% and soybean by 10%. Agricultural production in both countries is heavily export-oriented, especially to China.

These forecasts are expected to translate into an increase in overall fertilizer demand of 5.5% year-on-year throughout the Latin American region – a growth that would be led by strong demand for K.

For the Latin American region overall (including the Caribbean), IFA forecasts that demand will increase from 20.58 million tonnes nutrient in 2013 to 24.40 million tonnes nutrient by 2018. During this period, the regional demand for potash is expected to rise from 6.37 million tonnes K_2O to 7.56 million tonnes K_2O – an increase of 18.7% over the five-year period.

The Latin American region produces potassium chloride, potassium sulphate and secondary potassium nitrate. At present, production is limited to Brazil and Chile. In Brazil, the only operating mine

CONTENTS

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

is located in Taquari-Vassouras in Sergipe State and has a capacity of around 625,000 t/a KCl. Reserves in the Vale-operated mine would allow mining operation until 2018 or so. The entire output from the mine is sold in the Brazilian domestic market and meets only a partial share of domestic demand. The shortfall in potash supply must be met by imports, which account for an estimated 90% of all potash sold in Brazil. The principal overseas potash suppliers are Canada, Russia, Belarus and the Middle East.

A major issue arising from the high volumes of potash imports is the reliability of supply, arising from chronic delays at the ports and exacerbated by poor local transport infrastructure. During the peak importing season, ships can wait up to 60 days awaiting discharge, incurring demurrage charges of $1/t/day.

In an effort to secure domestic supply as the Taquari-Vassouras resource becomes depleted, Vale is promoting the Carnalita Project solution mine, adjacent to the Taquari-Vassouras underground mine, and is hoping to start production from around 2018. Vale had previously promoted the Rio Colorado potash project in Mendoza province, in the Nuevo Cuyo region of Argentina. The cost of bringing the mine on stream was estimated at $5.9 billion. The resource comprised 519 million tonnes of recoverable KCl, including an indicated reserve of 124 million tonnes KCl. Vale had hoped to establish a production capacity of 2.1 million t/a KCl by 2016, with Phase 2 of the project expected to follow in 2017, when KCl production could be raised to 3.5 million t/a, and to 4.3 million t/a by 2023. After a series of setbacks, including disputes with the local regulatory authorities, and a deteriorating macroeconomic environment, Vale announced in March 2013 that it was shelving the Argentinean project.

The Carnalita Project will part help make up for the shortfall in planned production in the wake of Rio Colorado postponement. The first phase of the Carnalita project is expected to take two years to build. The potash will be mined by injecting water thousands of feet into the earth to dissolve the potassium. The water-potassium solution will then be pumped up to the surface, where the potash will be extracted from the water and dried into a usable form of fertilizer. Vale hopes to achieve an initial production of 1.2 million t/a, enough to supply 15% of Brazil's needs. The mine could be doubled in capacity within two years of opening the first phase.

The project has not advanced as smoothly as Vale would have wished. In early 2014, Vale threatened to sell the project if it was unable to reach agreement with two rival local authorities which were deadlocked in a dispute over the location of the planned processing facility that would enable them to reap the expected tax benefits.

As one of the world's largest mining companies, Vale has invested in production overseas, and the company is looking to develop an additional potash project in Saskatchewan, Canada. The project is for a potash solution mine near the hamlet of Kronau, approximately 30 km from Regina. The Vale potash discovery spans around 51,840 ha and is part of the Prairie Evaporite Formation, which extends to a depth of between 1,600-1,750 m underground. Vale plans to produce between 3-4 million t/a over a mine life of more than 40 years. Brazil would be the target market for most of this output.

The company is currently holding discussions with potential partners and in August 2014, it awarded the contract for engineering services to WorleyParsons. The final feasibility report is in preparation and later this year, Vale will complete the financial investment evaluation. If the report is favourable, Vale will begin construction and drilling activities in 2016, with the goal of beginning production at the processing plant in 2020.

New players wait in the wings

The Cerrado Verde project is one of several being promoted by junior mining companies keen to develop Brazil's indigenous potash resources. Following discoveries in the late 2000s in the northern and eastern parts of the country, it has been suggested that Brazil may now hold the world's third-largest potash deposits, second only to Canada and Russia in the size of reserves. Large deposits were found in the Amazon region and in Bahia and Espirito Santo states of eastern Brazil. The Amazonian deposit in northern Brazil stretches about 400 km from Nova Olinda in Amazonas state, south of Manaus, north east into Para state, and contains an estimated 1 billion tonnes of potash. The potash salts are thought to hold 30-40% potassium, with a potassium content of similar quality to the potash found in Canada. The deposit in Bahia and Espirito Santo runs along some 400 km of the coastline north east of Rio de Janeiro and into the Reconcovo region near Salvador.

The Cerrado Verde project is located in western Minas Gerais state in Brazil's Cerrado agricultural region and is wholly owned by Toronto-registered **Verde Potash**. The project spans more than 118,600 ha and has an NI 43-101 indicated resource of 1.47 billion tonnes at an average grade of 9.22% K_2O. The inferred resource is estimated at 1.85 billion tonnes with an average grade of 8.6% K_2O, at a 7.5% cut-off.

In August 2013, Verde Potash announced a change of strategy for the development of the Cerrado Verde project. The revised strategy is intended to mitigate risk by reducing the front-end capital expenditure through developing the mine site in two phases. In Phase 1, Verde intends to build a 1,000 t/d plant for the production of *ThermoPotash*, a controlled-release, non-chloride multinutrient fertilizer. In Phase 2, the company will focus on large-scale potash production.

In March 2014, Verde published a prefeasiblity study on *ThermoPotash*, which evaluated the technical and financial aspects of a plant to produce the product, running a pyro stage of a KCl production route. The same plant will be used to process KCl. At current estimates of the K_2O content of *ThermoPotash*, the initial start-up

Fig 1: **Location of the Cerrado Verde project in Minas Gerais state, Brazil.**

of Verde's plant would equate to production of 40,000 t/a of KCl.

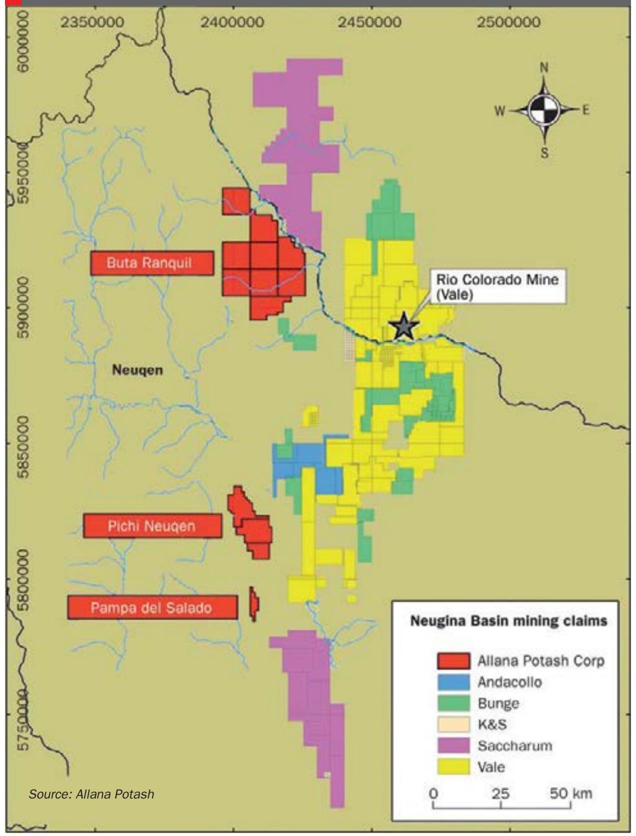
In late 2013, a Brazilian authority, IBD Certifications, approved the use of *ThermoPotash* on organic crops, potentially opening a niche for Verde Potash to supply the Brazilian market. Conventional KCl is not certified for use on organic crops and its use is thus not an option for farmers. *ThermoPotash* may prove popular with growers of speciality coffee varieties. A further boost to the project came in February 2014, when Verde Potash secured government funding via its Inova Agro programme for agriculture-related projects. The programme will provide finance in the form of debt capital at subsidised interest rates, equity investment and non-reimbursable grants.

Brazil Potash Corporation is also registered in Canada and is promoting the Potassio do Brasil project near Autazes, 100 km from Manaus, in Amazonas state. The mining project has total potassium reserves of about 500 million tonnes at a depth of around 720 m, of which at some 125 million tonnes comprise at least 25% KCl. The Brazil Potash project is expected to cost between $2-3.5 billion to bring on stream, with the ability to produce between 2-4 million t/a of potash over a mine life of at least 25 years. The company is currently undertaking a feasibility study and is pursuing the permitting process. Once approvals and financing are in place, construction of the underground mine and associated processing facilities will take 3-4 years to complete. Production is not expected to begin before 2018/19.

Lara Exploration is promoting a potash project in Sergipe, comprising two separate licence blocks with a total area of 21,483 ha and covering strike extensions of the known potash deposits in Vale's Taquari-Vassouras mine. The licence blocks are also contiguous with the Capela and Panqeca targets held by Rio Verde Minerals Ltd. The project is at a very early stage of development and no production is likely until the longer term.

Pacific Potash is also promoting a project in Amazonas and began drilling the site in October 2013. Results from the first drill hole, announced in June 2014, returned no commercially significant potash. The Canadian-registered company may cancel the project or else have its Brazilian tenements revoked following reports that tax payments due had not been received by the Brazilian authorities.

Fig 2: **The Allana Resources property in Argentina is adjacent to the shelved Vale project.**



Source: Allana Potash

Argentina in limbo

Vale's unhappy experience in trying to harness Argentina's potash resources is described above and marks the latest chapter in a long-running saga. A deposit containing 300 million tonnes of deep resources in an area of 300 m², located some 260 km from an existing rail line and 650-850 km from the nearest port was discovered in the 1980s. Two potash zones were identified, one of which is 2.2-2.5 m thick and analyses at 28-32% K_2O, the other being 10-20 m thick at an average grade of 20-27% K_2O. The first plan for a solution mining plant to produce 250,000 t/a KCl was mooted in 1992.

Major mining companies began to show an interest in these deposits. In 2005, the global mining company Rio Tinto announced that it had bought the entire shareholding of Potasio Rio Colorado S.A., the company formed to develop potash production facilities in Mendoza and Neuquén provinces. Rio Tinto's plan was to produce 2.4 million t/a of potash using solution mining technology, with the option of stepping capacity up to 4.3 million t/a in the longer term. This was Rio Tinto's first venture into potash and fertilizer markets, but after the company fended off a hostile take-over bid from BHP Billiton and in the wake of the first signs of the global market downturn, it chose to dispose of various non-core assets, striking a deal with Vale for the potash property in January 2009.

Vale (under its earlier guise as CVRD)

CONTENTS
What's in issue 464
COVER FEATURE 1
AFA: 40 years serving the fertilizer community
COVER FEATURE 2
Optimising feed quality in ammonia plants
COVER FEATURE 3
Minimising fertilizer losses

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

had already shown an interest in Argentina's potash resources, having won a tender held by the provincial government of Neuquén in November 2004 to evaluate and explore the potash mineral reserves in a 1,454 km² section of the Neuquén basin. Production of up to 1 million t/a was envisaged, with a targeted start-up date of 2010/11.

In February 2001, Admiralty Resources of Australia acquired the Rincon Salar tenements in Salta province, north west Argentina, near the border with Chile. The deposits cover an area in excess of 200 km² and are rich in lithium and potash brine, supplemented by magnesium and boron. The ponded evaporation deposit is estimated to contain 2.48 million tonnes of KCl and 1.45 million tonnes of potassium sulphate. Admiralty Resources set up a subsidiary, **Rincon Lithium Ltd.** (RLL), to operate a pilot plant for the production of 8 t/m lithium carbonate and 10 t/m of potash. RLL was also granted an additional 4,500 ha of exploration tenements north of its established production area.

The buoyant global market for lithium has enabled RLL to concentrate in that sector. Admiralty Resources sold the company to the Sentient Group in 2008 and is today run by ADY Resources, a part of Sentient's Enirgi Group. Capacity currently comprises 1,200 t/a lithium carbonate. The company has not to date developed any potash extraction capacity from the Salar de Rincon brines.

In 2008, **Allana Resources** acquired Latin American Potash Corporation, which held a 154,000 ha potash property in Neuquén province. A portion of the land package is directly adjacent to Vale's former Rio Colorado project. The company's current focus is on its potash property in the Danakhil region of Ethiopia, leaving the Argentinean project on hold meanwhile.

Meanwhile, all is not lost for Vale in Argentina since it suspended work in the Rio Colorado project in March 2013. Reports last year suggested that Marubeni Corporation is interested in picking up the reins on the $6 billion project. The Japanese company is reported to have sought to enrol Chinese investors as partners in a revived Rio Colorado project. Another option for Marubeni would be to partner Vale on restarting the project. However, Vale has indicated that after spending $2.5 billion and completing over 40% of the project, continuing inflation and exchange rate controls make the climate for investment unattractive in Argentina, especially as the cost of the project has almost doubled to $11 billion from earlier estimates. Weak world market prices for potash have been a further deterrent to potential investors.

> **"Brazil is the major market for SQM."**

Chilean opportunities

SQM in Chile operates potassium and nitrate capacity at Salar de Atacama, based on caliche ore and salar brines. Over the past five years, SQM has invested heavily in the expansion of the potassium-based products at Salar de Atacama and has raised effective production capacity to 2.3 million t/a KCl. SQM's potash capacity is close to 2.5 million t/a, comprising KCl and K_2SO_4. The company is the world's largest producer of potassium nitrate, accounting for a 48% market share. SQM completed a new 300,000 t/a potassium nitrate facility in Coyo Sur in 2012 but is not currently planning any additions to capacity in the medium term.

Brazil is a major market for Chile's potash exports, taking a record 498,000 tonnes in the period between January and October 2014, out of a total of 1.15 million tonnes shipped.

SQM exploitation of the mineral resources of the Atacama Desert has enabled it to build up a global presence in five principal business areas, covering plant nutrition, iodine, lithium, industrial chemicals, as well as potash. It enjoys global leadership in the production of potassium nitrate, holding a 48% world market share, and is the world's lowest-cost producer of lithium. The current lithium carbonate plant capacity stands at 48,000 t/a.

The company has also forged links with overseas partners, having formed a joint venture in India with Coromandel International to operate a 15,000 t/a NPK plant. A second joint venture in Asia is with Qingdao Plant Protection Star Technology Co. Ltd., Shandong province. The partners formed SQM Star to produce, distribute and commercialise water-soluble NPK fertilizers in China. Also in China, SQM has teamed with Migao Corporation to set up a 50:50 joint venture partnership, developing a 40,000 t/a potassium nitrate facility in Sichuan province. Other partnerships are with Groupe Roullier in Europe.

PotashCorp (Potash Corporation of Saskatchewan) holds a minority 32% stake in SQM. Industry analysts have suggested that the Canadian major may be interested in acquiring a majority shareholding in due course.

In 2012, the Canadian-registered junior mining company **Inspiration Mining Corporation (ISM)** acquired about 20% of Potash Dragon, which holds the rights to various potash properties in northern Chile in the Atacama Desert's Salar de Llamara. The Llamara potash project is close to the Pacific Coast of Chile and has high solar evaporation rates, making it a suitable location for low-cost mining and the recovery of soluble minerals, including potassium.

ISM gained control of the project in 2012 via the purchase of a 20% shareholding in Potash Dragon Inc. The latter company holds various properties and applications, covering an area of 4,122 ha in Region I, some 160 km south east of the town in Iquique, adjacent to SQM's operations. Potash Dragon has been conducting various surveys of the tenements and is due to submit an NI 43-101 report.

Cautious assessments

While the government of Brazil has embraced a strategy of achieving a much higher level of self-sufficiency in fertilizer inputs, this goal remains a distant prospect in the case of potash. The projects to develop new potash capacity currently mooted in the country and elsewhere in Latin America will not come on stream in the medium term, and several of them remain mired in an uncertain climate for investment. The financial institutions are currently extremely wary of providing capital to commodity projects, and their caution appears justified while global potash prices remain weak. As several leading industry analysts have noted, there is at present a global oversupply in potash, and worldwide supply/demand balances are expected to worsen in the immediate term. Junior mining companies throughout the world face a tough fight to secure investment capital against these prognoses. As a result, Latin America and Brazil specifically are set to remain reliant on the leading international suppliers for their own potassium requirements for the foreseeable future. ■

Removing impurities from phosphoric acid

The wet process for phosphoric acid production yields an acid that contains several organic as well as mineral impurities. The technologies for removing these impurities are assessed.

The IMACID facility at Jorf Lasfar. Morocco. OCP uses a process developed by Prayon to remove impurities from phosphoric acid.

As the average P_2O_5 content of phosphate rock has diminished in many producing regions, downstream producers have faced ever-increasing problems with the minor element content of the phosphoric acid. These elements mainly comprise iron, magnesium and aluminium. Removal of magnesium has received the most attention but the reduction and/or elimination of any of the three main impurity elements would greatly benefit the phosphate industry by enabling it to produce on-grade DAP without having to utilise other additives, such as supplementary urea. Other metallic impurities include sodium, as sodium fluorosilicate – a by-product of the production of phosphoric acid – chromium and fluorine.

Iron (Fe) and aluminium (Al) are found usually in the form of oxides and silicates in phosphates and impact on the performance of the industrial processing and manufacture of phosphate fertilizers. Al is often associated with Fe. The detrimental effect of these impurities occurs in various stages of the phosphoric acid manufacturing process. These impurities R_2O_3 (Al_2O_3 and Fe_2O_3) behave almost in the same way in the acid by increasing its density and viscosity by passage of 75-90% in the acid. (*Various Methods Used for the Treatment of Wet Phosphoric Acid*, H. Omri and N.H. Batis, University of Carthage, Tunisia [July 2013].)

Magnesium (Mg) is widely considered as the element most harmful in the manufacture of phosphoric acid and its derivatives. Rising Mg levels in the acid results in higher viscosity and brings down the P_2O_5 content. Merchant-grade phosphoric acid is often stipulated with a maximum limit of 1-1.2% MgO content.

Fluoride (F) in the form of fluoroapatite contains approximately 4 wt% F. During its digestion by phosphoric acid, the F is released as hydrogen fluoride, which reacts with the silica present to form fluorosilicic acid. Some of the fluorosilicic acid precipitates with sodium or potassium ions as Na_2SiF_6, K_2SiF_6 or $NaKSiF_6$. The remaining fluorosilicic acid partly decomposes in SiF_4 and HF. The residual F in solution is distributed between the phosphoric acid and the by-product during precipitation. In the by-product, it is present as AlF_5^{2+}, which can substitute for SO_4^{2-}. The presence of F in phosphoric acid makes it more corrosive and thus unsuitable for fertilizer applications. F discharge must be carefully managed.

The problem of high levels of metallic impurities in the phosphate rock used in the production of phosphoric acid has for long been acute in the Florida phosphate industry, where the total impurity content of the rock being used has steadily increased. The problem if not addressed leads to scale formation in all piping and equipment.

The Florida Institute of Phosphate Research (FIPR) – today known as the Florida Industrial & Phosphate Research Institute – has undertaken much research on the removal of unwanted materials in phosphoric acid. In particular, FIPR has examined the use of magnetism to effect the separation of unwanted materials from the acid.

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England

Tel: +44 (0)20 7793 2567

Fax: +44 (0)20 7793 2577

Web: www.bcinsight.com
www.bcinsightsearch.com

Wet-process phosphoric acid (WPA) with dissolved impurities is produced by the interaction of phosphate rock with sulphuric acid, and the insoluble precipitate $CaSO_4.2H_2O$ is removed by filtration. The impurities in WPA form precipitates during processing and storage. Iron precipitates readily at P_2O_5 concentrates of about 35% and ferric iron and aluminium are often the major sludge-forming impurities in WPA shipping grades. (*Removal of Unwanted Metals and Materials in Phosphoric Acid by Means of Magnetic Separation*, FIPR [October 1997].)

FIPR identified several processing techniques for the purification of WPA:

- Physical methods, such as crystallisation and solvent extraction
- Electrochemical methods
- Chemical methods
- Magnetic methods.

FIPR's research identified magnetic separation as being particularly useful, as it could limit scale formation in the WPA plant, as well as limiting undesired metals in the acid. The basis of the FIPR tests using magnetic separation is that molecules and materials can be divided into two electronic categories: those with unpaired electrons and those with spin-paired electrons. Those in the first category are attracted to regions of a magnetic field (the magnetic susceptibility is positive) and the substance or material experiences an apparent change in weight per gram of substance. Members of the second group are repelled from a magnetic field (susceptibility is negative) and the substance experiences a negative change on apparent mass in high-field magnetic regions.

The materials in the WPA production process typically fall either into the category of paramagnetism or diamagnetism. In the case of paramagnetism, substance is drawn into a magnetic field, or appears to be heavier in a magnetic field than it really is, which is typical for iron. With diamagnetism, substance is repelled by a magnetic field and appears to be lighter than it actually is, which is typical for aluminium, magnesium, calcium ions and their compounds.

An early industrial application of high-gradient magnetic separation (HGMS) involved the removal of coloured impurities from kaolin clay and has been used by the paper industry to enhance brightness. Other HGMS applications include water purification by the addition of a flocculating agent to precipitate dissolved or suspended paramagnetic species and removing paramagnetic particulate material.

Table 1: Iron treatment decision table

Iron (ppm)	Hardness (grains/cal)				
	0-5	5-10	10-20	20-40	>40
0.3	B*	A	A	A	A
0.3-1.0	C	B	A	A	A
1.0-2.0	C	C	B	B	A
2.0-3.0	C	C	C	C	B
>3.0	C	C	C	C	C

A: no iron treatment suggested*
B: iron treatment optional
C: iron treatment needed

FIPR undertook a series of experiments using magnetic treatment to remove iron impurities. Several parameters were used, namely a static test, pump method and hydrocyclone method. The general trend was that more iron was absorbed in the presence of a magnetic field that in its absence, and it was concluded that the magnetic field (4 x 1,200 gauss) has some positive effects for Fe removal from scale sized smaller than 18 mesh. The removed Fe goes into solution and overflow suspension.

While magnetic field was found to remove paramagnetic impurities from WPA by different types of apparatus in the FIPR research programme, the P_2O_5 content was not changed. The percentage of Fe removal from acid varied with the treatment method, in which the fluid transportation and magnetic field were different. The highest efficiency of Fe separation achieved was 15.1%, while chromium separation up to a maximum 32.9% was also achieved.

The FIPR tests showed that the successful application of magnetism to the prevention of scale and impurity removal in this phase of the WPA production process depended on the composition of the water. Calcium carbonate with a magnetic susceptibility of -0.381 cgs units can be controlled and deposits removed, as can deposits of $CaSO_4$ (-36.4) or sodium fluorosilicate. Paramagnetic species, such as the hydrous oxides of Fe and Mn, were found to be troublesome and may need to be removed. An empirical Fe treatment table has been developed (Table 1): as a general guide, a maximum 1 ppm of iron and/or manganese can be tolerated for each 200 ppm of total dissolved solids (TDS).

Scaling can add to the cost and danger of processing. Operating costs increase due to the costs of make-up water and the costs of replacing control chemicals (corrosion inhibitors, dispersants, pH control chemicals). For example, a thin scale (0.61 mm) of $CaSO_4$ on boiler tubes results in a 183°C temperature drop across the scale, as well as higher skin temperatures and loss of energy efficiency, and could contribute to metallurgical problems with tubes.

Tests undertaken in the mid-1990s of magnetic fields on a cooling tower system yielding savings that yielded a payback of 3.3 years. Diamagnetism can be usefully applied to remove hydrocarbon deposits, for example in petroleum refineries when crude oil is passed through pipes.

Magnetic treatment of scale

In the production of phosphoric acid, scale is a nuisance material that must be cleaned out of pipes. Diamagnetism can be used to enhance the solubility of sodium fluorosilicate scale from a phosphoric acid plant. The problem of trying to prevent scale formation is more challenging for sodium fluorosilicate scale than for certain carbonate scale because of the magnitude of the magnetic susceptibilities. The stronger the magnetic field, the greater the scale solubility in the phosphoric acid. Higher temperatures also result in higher solubility. The presence of a magnetic field also enhances the solubility of sodium fluorosilicate.

The FIPR process does not eliminate scale, but it can mitigate against the inconvenience of formation in pipes, with magnetic treatment shifting scale formation to an open area where it can be filtered off more conveniently and more economically.

After magnetic treatment, Fe was enriched in the smaller particles of scale and was removed from the larger particles. Fe distribution with the particle size showed that the magnetic field shifted the Fe concentration to smaller particles. The scale solubility change and Fe removal followed the same trend with the magnetic treatment, suggesting that the iron species tends to coexist with smaller-scale particles and is located at an interstitial position in the Na_2SiF_6 lattice. When Na_2SiF_6 scale is dissolved, the Fe species in the scale does into suspension. Under magnetic field treatment, more small particles were observed because of higher entropy and the less stable lattice, and these particles are easily dissolved in solution because of their higher specific surface area.

Iron removal from phosphoric acid

WPA contains unwanted paramagnetic impurities. The removal of these unwanted metal ions reduces post-precipitation in the acid. The solubilisation or precipitation of ferric iron can be controlled at various P_2O_5 concentrations. Above 60% P_2O_5, the pyrophosphate content controls the solubility of the ferric iron. Although the iron is relatively soluble at 60% P_2O_5 (~3% Fe_2O_3), the presence of other impurities oxides (Al_2O_3, MgO, etc.) reduces the free water to a low concentration, where the composition is more like the pure system at 67-70% P_2O_5. Since ferric iron does not form strong soluble complexes with the impurity components such as F or SO_3, the ferric iron complex with orthophosphate reaches saturation at about 1.0% Fe_2O_3 and precipitates. At higher impurity concentrations, the free water content approaches zero and as pyrophosphate ions form, iron is again complexed to very soluble complexes, up to 7% Fe_2O_3.

Below 60% P_2O_5, alkali metals (K, NH_4 and Na) control the precipitation. When the alkali-metal content is above 0.01%, iron alkali-metal phosphates precipitate until the iron is reduced to 0.2% Fe_2O_3. When the alkali-metals content is below 0.01%, the highly-soluble acid ferric phosphates will remain in solution until the iron content reaches about 7-9% Fe_2O_3.

The major iron forms in 28% acid at 25°C are $FeH_3(PO_4)_2.4H_2O$ and $Fe_3H_9(PO_4)_6.H_2O$. If the temperature is increased to 75°C, only $FePO_4.2H_2O$ is observed in 28.5% acid suspension. As with the temperature effect, FIPR researchers may change the iron composition in the Fe_2O_3-Al_2O_3-P_2O_5-H_2O and affect the solubility of iron compounds and thus affect the sludge precipitation. The magnetic field could break Fe- and Al-F complexes and precipitate freed Fe and Al. Ferric iron precipitates readily at P_2O_5 concentrations above 35% and is identified as the major sludge-forming impurity in merchant-grade WPA.

Central Florida phosphoric acid at 28% P_2O_5 typically contains 0.75-0.83% Fe in solution and ~5% solid with a high Fe content (5.4-9.3%). In 54% phosphoric acid, Fe in solution is reduced and solid content is as high as 10% of acid. Most of the Fe went to the solid and this solid contained high Fe (10.64%). Alkali-metals reduce the iron in acid solution.

The FIPR tests using a magnetic field to remove the sludge-forming impurities of Fe and Cr from phosphoric acid helped the fast precipitation of these impurities and the removal of solid, as well as solvated paramagnetic species from the acid. The solid can be separated by a hydrocyclone, and a magnetic field was found to improve the efficiency of this solid-liquid separation. In the presence of the magnetic field, more Fe was transferred to the underflow by the hydrocyclone. To get better separation, magnets should be placed alternatively so that paramagnetic species move through the pole when the fluid moves along the magnet place.

In summary, FIPR found that the magnetic attraction method works for paramagnetic material removal from wet-process phosphoric acid (WPA). The system is easily designed and the magnetic field can be applied at any position of the apparatus. Under optimum conditions, more than 15% Fe separation could be achieved.

Fe removal using chelating reagents

FIPR has also studied the use of chelating reagents for the removal of Fe from WPA. The study involved bench-testing four different chelating agents, which were added at three stages of the WPA production process:

- Filter acid (25-27% P_2O_5)
- Partially-concentrated acid (42-45% P_2O_5)
- Concentrated acid (52-56% P_2O_5).

Among the reagents used was IR3 (aminotri methylene phosphoric acid). Different reagent dosages were applied, achieving up to 63% Fe_2O_3 removal efficiency using filter acid at room temperature. (*Decreasing Iron Content in Wet-Process Phosphoric Acid*, FIPR [February 2001].) FIPR also developed a regeneration scheme to recover the precipitating reagent for reuse. The results revealed that up to 69% of the reagent could be regenerated and recycled. Up to 60% Fe_2O_3 removal efficiency could be achieved while using a regenerated precipitating reagent. The reagent can be used and regenerated up to four times without losing its efficiency.

The chelating reaction using IR3 can be represented as:

$$C_3H_{12}O_9NP_3 + Fe^{+3} \rightarrow C_3H_9O_9NP_3Fe + 3H^+$$

(Iron phosphonate, one chelated ferric ion) or

$$C_3H_{12}O_9NP_3 + 2Fe^{+3} \rightarrow C_3H_9O_9NP_3Fe_2 + 6H^+$$

(Iron phosphonate, two chelated ferric ions).

The ferric phosphonate chelate can stay soluble in acid or precipitate out, depending on such factors as phosphoric acid strength, reagent concentration and temperature. The precipitated iron phosphonate chelate dissolves as pH and is raised to pH 5.0, then a precipitate is formed as the pH is raised to 8.0 using ammonium hydroxide. This reacts with free phosphoric acid to form diammonium phosphate (DAP) and three molecules of Fe-IR3 complexes react together for form one containing Fe_3-IR3 complex (insoluble) and two molecules of IR3 complexes in ammonium form (ammonium phosphonate complex). IR3 in ammonium form is fully soluble and precipitates with Fe at low pH. This process can thus lead to partial regeneration of IR3.

Other chelating reagents containing different phosphonate groups were also tested (IR5, IR5-7H and IR5-3H). Fe removal efficiency was found to be lower, however.

In an attempt to recover P_2O_5 from 52% acid post-precipitated sludge, IR3 reagent was found to help in recovering over 92% of the P_2O_5 as compared to only 70% recovered without the addition of IR3. The recovered acid contained 25% P_2O_5 and very low iron content (0.055% Fe_2O_3).

FIPR did note however that the use of these chelating agents to decrease the Fe content in dilute acids may not be economical, as the minimum required amount is about 15.0 kg/t of acid. On the other hand, the addition of a smaller quantity (2.5 kg/t of acid) may be beneficial in preventing sludge formation during evapora-

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

tion, preventing sludge formation during clarification and increasing P_2O_5 recovery by at least 2%. This may lead to a net economic gain since the IR3 consumption may not exceed 5 kg/t P_2O_5.

Other technologies

High operating costs are a potential limiting factor with other purification technologies. These processes include liquid-liquid extraction, chemical precipitation, ion flotation, adsorption on activated carbon and ion exchange resins. Liquid-liquid extraction technology is well established for purifying phosphoric acid, using solvent extraction (SX) techniques. The crude phosphoric acid is contacted with an organic solvent of limited water miscibility, with the solvent displaying a greater preference for phosphoric acid than it does for the acid-contained impurities, enabling it to effect a selective separation. Among the solvents that have been tested on phosphoric acid are trialkylphosphate and trialkylphosphine oxide. OCP, Morocco uses a process developed by Prayon, using tributylphosphate as the extracting solvent.

Adsorption technology has also been trialled, using activated carbons for phosphoric acid purification. Activated carbons are frequently used for the removal of organic matter, for example in the Tunisian phosphate industry. The method is based on the modification of activated carbon DSS (dodycyle sulphonate sodium) for ion exchange. Sodium DDCS (diethyl-dithiocarbonate) has also been trialled, proving effective in removing nickel and vanadium, especially in low-concentration acid.

The removal of impurities by flotation involves the addition of a surfactant collector of metal to the solution, such as sodium diethyl-dithio-phosphate. The process is easy to use and is less expensive. However, it has proven to be of limited effectiveness when applied to phosphoric acid, achieving low elimination yields. One study addressed the issue by reducing trivalent iron in the acid in the divalent state, before introducing the purifying collector in the acid.

A mixture comprising a dithiophosphoric ester diorganyl and an adsorbent such as activated carbon can be used. This method is easy to implement and requires very low amounts of dithiophoshoric ester. It is less effective at low or slightly elevated temperatures. To remedy this drawback, it has been proposed to operate at two different temperatures, firstly at above 50°C to remove the heavy metals content by extraction. This however incurs higher energy costs. The filtration of the metals content must be conducted at a low temperature, resulting in lower yields. GCT, the Tunisian phosphate producer, has trialled ionic flotation in a pilot plant.

Precipitation technology involves significant investment and maintenance costs. Efforts have been made to improve the physical conditions, kinetics and thermodynamics of the process. Cadmium and other heavy metals can also be precipitated by ions of hydroxides, carbonates or sulphides. Sulphides are the less soluble, but in an acid medium, their solubility can remain high.

Ion exchange resins are effective in removing Mg. Generally the resin used is polystyrenic and macroporous. The ion exchange is realised according to the following reaction:

$$2H^+_r + Mg^{2+}_s \rightarrow 2H^+_s + Mg^{2+}_r$$

(S and R indicate the ions in solution or fixed to the resin.)

The regeneration of the resin is effected by the introduction of protons with higher activity than those of a strong acid. The following reaction then occurs:

$$2H^+_s + Mg^{2+}_r \rightarrow 2H^+_r + Mg^{2+}_s$$

Mg removal takes place in two stages, the first stage involving the acid in an ion exchange monitoring regeneration of the resin using sulphuric acid. The second stage consists of treating the sulphuric acid in order to regenerate and recycle it.

There are a number of drawbacks when using these techniques, including:

- The high cost of organic solvents and resins
- Difficulties in recovering the solvents from the raffinate and the purified acid
- The risk of environmental pollution when using certain solvent products
- Complicated process
- High operating costs
- Yield of purified WPA is relatively low.

Messrs. Omri and Batis have proposed more effective and economical methods to purify WPA, including the valorisation of the clays. These adsorbents have the dual advantage of low cost (being abundantly available) and a good capacity for impurity capture, due to their specific surface.

Phosphoric acid produced in Tunisia is purified in two stages, upstream and downstream. In the first stage, the acid treatment is carried out using a locally-available siliceous earth. During the WPA manufacturing process, the most critical stage is in the separation of dihydrate calcium sulphate from the acid. This separation depends on the shape and size of the gypsum crystals obtained by the reaction of the phosphate rock with sulphuric acid and the process conditions that govern the crystal properties. When the crystals are small, heterogeneous and poorly trained, they retain excess phosphoric acid. This acid is difficult to separate during the phosphoric slurry filtration phase. However, the size and shape of the phosphogypsum crystals can be modified by the addition of traces of certain chemical reagents, thus improving filterability and production capacity at the WPA plant. Among the reagent additives that can be used are polyethylene oxide, alkylated sulphonates and polyacrylamides.

In the case of Tunisian phosphate rock, the SiO_2/F ratio of >0.526 corresponds to the stoichiometric value of the reaction of the F in the fluorosilica ion SiF_6^{2-}. Adding a silica product in the phosphoric acid reactor is necessary in order to prevent the recycling of part of the fluorine. A high level of F ions in the slurry deteriorates the morphological characteristics of the phosphogypsum crystals, becoming thinner and longer and making then difficult to filter and wash.

Test results in Tunisia have shown that the use of this siliceous earth during the production of phosphoric acid allows a defluorination exceeding 50%, while losses of soluble and insoluble P_2O_5 are cut by more than 30% and the median diameter of the phosphogypsum crystals increases by 25%. The resulting higher chemical yield from the addition of the siliceous earth to the WPA production process has led to increased phosphoric acid production of around 17,000 t/a.

In the second, downstream processing stage, natural adsorbents (siliceous earth and bentonite) are used to remove Cd, F, carbon and organic chlorides. The use of bentonite allows a good fixation of these impurities, averaging around 60% for Cd, 90% for F and chloride and 80% for organic carbon. The fixing of anionic pollutants such as fluorides and chlorides on clays stems from the presence of alumina and silica in the adsorbent's structure. A large proportion is retained on alumina, which has an isoelectric charge of around 8.3. ■

People & projects

PROJECTS

Cronus chooses Illinois

Cronus Chemicals LLC has chosen Illinois as the site for its proposed $1.4 billion nitrogen complex. Harnessing shale gas as feedstock, the complex will produce ammonia and downstream urea, UAN and DEF (diesel exhaust fluid) at a site at Tuscola, 60 miles south of Chicago. Construction is planned to begin in the first half of 2015 and is expected to take just under three years to complete. Cronus settled on the Tuscola site after looking at alternative locations in Iowa and several other US states. As a sweetener, the State of Illinois will provide tax exemptions worth $52 million, although Cronus will only reap the benefits once the plant begins production. However, while the tax relief package helped sway Cronus' final decision on location, the company also emphasised that Tuscola was better placed than the alternative sites for access to natural gas pipelines and close proximity to a rail link.

Cronus Chemicals was set up by four executives with long experience in the fertilizer industry. **Erzin Atac** is a native of Switzerland and served as CEO of the Transammonia Fertilizer division between 1997 and 2007, latterly based in Tampa, Florida. In 2008, he formed a marketing company, Acta Fertilizers, which he managed until 2012 before helping to start Project Cronus. **Seref Surmen** is a Turkish citizen and has followed a career in project development. **Fred Gill** has over 40 years of experience in the nitrogen sector, latterly as President and CEO of Saskferco until its sale to Yara International and his retirement in 2009. **John Kinnamon** has over 34 years of experience in project management and is the founder of several businesses involving the reformation of coal and natural gas, while **Robert L. Willoughby** is an experienced financial executive.

Simplot ammonia plant under construction

JR Simplot Co. has begun construction of a long-planned ammonia plant adjacent to its phosphate fertilizer complex at Rock Springs, Wyoming. The new plant will produce 600 s.tons/d of ammonia, more than the company needs for its present ammoniated phosphate production. The new plant will supply Simplot's phosphate fertilizer plants at both Rock Springs and Pocatello, Idaho and will have the capacity to meet the needs arising from any future expansion in phosphate production at Rock Springs. The new ammonia plant is scheduled for completion in late 2016.

Linde Engineering North America is providing the technology and primary engineering, procurement and construction for the project and is the company's third ammonia project in the last two years.

KBR wins Algerian contract

KBR has announced the award of the contract to provide licensing and basic engineering design services for the revamp of the Fertial SpA ammonia plants at Annaba and Arzew in Algeria. The contracts provide for KBR to supply Fertial with the technology to raise production capacity at the plants while also reducing energy consumption and enhancing the plants' reliability.

Turkmenistan plans ammonia/urea complex

The government of Turkmenistan will build a new fertilizer complex in the city of Garabogaz, on the Caspian Sea coast. The plant will have a capacity of 2,000 t/d ammonia and 3,500 t/d urea and will be the country's largest fertilizer plant when it opens in June 2018. Feedstock will come from the country's natural gas reserves. Haldor Topsøe will design the new ammonia plant, in collaboration with Mitsubishi Heavy Industries Ltd. Other project partners are Mitsubishi Corporation and the Turkish construction company, GAP Inşaat. Haldor Topsøe will undertake the engineering design of the ammonia plant, with a special emphasis on minimising the environmental impact of production by featuring a selective catalytic reduction DeNOx unit to treat the flue gas.

Brazilian updates

Petrobras has indicated that its new 1.19 million t/a granular urea at Três Lagoas will commence production in July/August 2015.

WorleyParsons has been awarded an engineering services contract for Vale's Kronau potash project in Saskatchewan, Canada. Vale began exploring potash deposits in Saskatchewan since 2009, as part of Vale's strategy to become one of the biggest global producers of potash fertilizers. WorleyParsons has been involved in the Kronau project since late 2010, and this award will enable the engineering company to continue to support Vale with the critical definition phase of the project, scheduled to be concluded at the end of 2015. The Kronau project comprises a potash solution mine and is Vale's first potash project in Canada. Depending on the outcome of the definitive feasibility study, a final decision will be taken whether or not to proceed with the project. If the prognosis is favourable, Vale will begin construction and drilling activities in 2016, with the first potash processing to follow in 2020. Production of between 3-4 million t/a KCl is envisaged, over an expected mine life of 40 years.

Jordan and Indonesia build Gresik JV

In conjunction with PT Petrokimia Gresik, Jordan Phosphates Mines Company (JPMC) has developed a 200,000 t/a phosphoric acid plant in Gresik, Indonesia. The plant cost $220 million and was inaugurated on 21 October. Each partner has a 50% stake in the PT Petro Jordan Abadi joint venture that was formed to operate the plant. The plant will use phosphate rock shipped from Jordan and its entire production will be bought by PT Petrokimia Gresik, replacing imported phosphoric acid. Indonesia currently imports around 2.5 million t/a of phosphate rock and phosphoric acid, mainly from Morocco.

JPMC has meanwhile signed an agreement with PT Pupuk Sriwijaya to establish a similar 200,000 t/a phosphoric acid plant in Aceh, Indonesia.

QAFCO and NIIK sign granulation contract

On 22 October 2014, representatives of Qatar Fertilizer Co. (QAFCO) and the Russian engineering and urea technology company NIIK (R&D Institute of Urea) signed a contract for the provision of a pilot plant that will trial NIIK's high-speed drum granulation process. CEO **Khalifa A. Al Sowaidi** signed on behalf of QAFCO, while **Igo Esin**, President and CEO signed on behalf of NIIK. The ceremony was also attended by **Ivan De Witte** and **Hamed Al Marwani**, respectively QAFCO Chief Operations Officer and Chief Administration Officer, and **Natalia Kargaeva**, NIIK's Head of International Affairs.

The pilot granulation plant is due to start production at the end of 2015. The installation will include a high-speed drum and have a capacity of 2.4 t/d, enabling QAFCO to develop various urea-based products by adding sulphur, ammonium sulphate and a range of micronutrients. QAFCO is seeking to extend its product portfolio, adding higher-added value products. Subject to the success of the pilot

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Khalifa A. Al Sowaidi, QAFCO CEO and Igor Esin, President and CEO of NIIK, sign the contract for the design and supply of a high-speed drum granulation unit. Also present at the ceremony were Natalia Kargaeva of NIIK, Hamed Al Marwani and Ivan De Witte of QAFCO.

plant, QAFCO plans to develop commercial-scale speciality fertilizer operations at a later date, using sulphur currently exported from Qatar. The future product range could include urea with added sulphur and urea ammonium sulphate.

Muntajat, QAFCO's marketing arm, plans to extend the parent company's reach in Asia and Africa, having opened ten new offices there. These offices are located in Bangkok, Casablanca, Colombo, Dubai, Guangzhou, Jakarta, Karachi, Manila, Mumbai and Shanghai. The Casablanca office will serve Morocco, Algeria, Mauritania and Tunisia; Colombo will serve Sri Lanka and the Maldives; Mumbai will target markets in India, Nepal and Bhutan; and Karachi will serve Pakistan and Afghanistan.

Canpotex green light for BC terminal

Canpotex Limited has signed a lease agreement with the Prince Rupert Port Authority, British Columbia for the development of new potash export terminal, with the capacity to handle up to 11.5 million t/a of potash. The planned site is at Ridley Island. Canpotex has already invested around $50 million into the project and it has now signed all the necessary commercial and environmental agreements to proceed with the development. Confirmation is awaited of the final investment decision, which is expected to involve a total investment of approximately C$775 million.

The development of the Prince Rupert terminal would provide Canpotex with a third export outlet, adding to the existing terminals at Portland, Oregon, USA and the jointly-owned Neptune Terminals operation in North Vancouver. Canpotex has meanwhile announced plans to upgrade the Portland terminal, at an expected cost of $140 million, as a result of expectations of increased export tonnages as its member companies bring major new capacity on stream.

BPC's Brazilian foothold

Belarus Potash Company (BPC) has taken a major advance in its desire to seek extra market share in Brazil by signing a contract with Rocha Terminais Portuarios e Logistica, enabling it to lease customs warehouses in the Brazilian port of Paranagua and offer improved storage and handling facilities. The deal will enable BPC to supply its Brazilian customers more speedily. Paranagua handles around 40% of all fertilizer imports into Brazil. Fertilizer warehouse space is in fairly short supply, and is estimated to total around 400,000 tonnes. BPC recently shipped 25,000 tonnes of KCl for discharge in the Rocha terminal.

BPC's Russian rival Uralkali concluded a similar deal with Equiplan Partipacoes in February 2014, taking a 25% stake in the company, which is the majority shareholder in the Ponta do Felix terminal in Antonina. The deal gives Uralkali between 80-90,000 tonnes of dedicated storage space.

BPC meanwhile announced that construction has commenced at its Petrykov mine. Levelling operations at the processing site are under way, together with the building of a reservoir. The mine shafts will be sunk using freezing technology and the first phase of the facility is due to be commissioned in December 2019, while the design capacity of 1.5 million t/a KCl is expected to be reached in 2021. With an expected reserve base of around 2.2 billion tonnes, the mine will have an estimated working life of approximately 90 years.

K+S water protection project

K+S Kali is investing €400 million ($508 million) on improved wastewater disposal at its Werra potash plant in Germany. The work will be undertaken in four stages, beginning later this year, and will involve the provision of a kainite crystallisation flotation facility that will reduce the amount of wastewater produced by 1.5 million m³/year. A long-distance pipeline will also be provided to carry the wastewater away from the Werra River, for disposal elsewhere. The goal over the long term will be to reduce or eliminate the process of releasing salty water into underground rock formations or indirectly into rivers. K+S expects to continue mining operations at Werra until around 2060 and by 2075, the local rivers should return to normality.

Cleveland Potash gets polyhalite go-ahead

Cleveland Potash Ltd. has been given planning approval for the construction of a new polyhalite processing plant at its Boulby mine in the North York Moors National Park. The facility will comprise a crushing and screening plant, augmenting Cleveland Potash's overall capacity by 12,000 t/a. The company is currently investing £38 million ($64 million) to expand its mining and production capacity of polysulphate at the Boulby site from 130,000 t/a to 600,000 t/a.

Arianne Phosphates resource boost

The Canadian junior mining company Arianne Phosphates reports a 13% increase in the mineral resources located at the Paul zone of its Lac à Paul project in the Saguenay-Lac-Saint-Jean region of Quebec. The measured and indicated resource estimate for the overall project has now been revised to 668 million tonnes at 7.01% P_2O_5 with a 4.0% P_2O_5 cut-off grade. Arianne Phosphates has also discovered a new inferred resource in the Paul zone of 38 million tonnes at 6.13% P_2O_5 at the same cut-off grade. The Paul zone is the main zone in the Lac à Paul project, which itself has proven and probable reserves of 472 million tonnes of ore at 6.90% P_2O_5 with a cut-off grade of 3.5%, sufficient to support a mine life of around 26 years. (Fig. 1)

Fig 1: **Arianne Phosphates' Lac à Paul Project**

Yara plans Porsgrunn expansion

Yara International has announced plans to expand capacities of its NPK and calcium nitrate facilities at the Porsgrunn complex in Norway. Additional production of 50,000 t/a NPKs and 200,000 t/a calcium nitrate is foreseen. An additional nitric acid plant will also be provided. The planned investment and debottlenecking process will also result in increased NPK production at Glomfjord and the Uusikaupunki site in Finland, by up to 150,000 t/a. The work is expected to be completed in 2017. Yara currently has the capacity to produce 2 million t/a of NPKs at Porsgrunn, 500,000 t/a at Glomfjord and 1 million t/a at Uusikaupunki.

African Potash reports Lac Dinga drilling progress

African Potash Limited seeks to develop the Lac Dinga project in the Republic of Congo (ROC), having acquired an indirect 70% interest in La Société des Potasses et des Mines S.A. in February 2013. The company reports that it has intersected a strong potash mineralisation at its second exploration drill hole, finding a 112-m thick salt sequence that includes 48 m multiple potash seams, similar to the results of its first exploration drilling, announced in September 2014. The similarities point to extensive potash horizons at shallow depth. African Potash CEO **Edward Marlow** said, "This is an initial indicator for the wider resource potential of Lac Dinga and we can now move forward with confidence and plan further exploration activities in order to continue to prove-up the tangible value of the project." He notes that the outlook for the exploitation of commercial potash in the Lac Dinga region is "highly positive".

Yara Dallol completes DFS

Yara Dallol, a subsidiary of Yara International, has completed the definitive feasibility study of the Dallol potash exploration project in the Danakil region Ethiopia. Drilling began on the property in Afar in 2010 and was mainly completed by 2012. The cost of the project to produce a planned initial output 600,000 t/a of potash via a solution mine is estimated at $1 billion. Once the project is approved, production would begin within 2-3 years and capacity could be raised subsequently to between 1-1.5 million t/a over a 30-year mine life. Other potash mining companies are evaluating projects in the area, including Allana Potash, in conjunction with ICL, Israel, while South Boulder Mines seeks to exploit a resource in neighbouring Eritrea.

Potash Ridge signs acid MoU

Canadian-registered Potash Ridge Corporation has entered into a non-binding Memorandum of Understanding for a potential offtake and marketing arrangement with a third-party supplier of sulphuric acid from its Blawn Mountain potassium sulphate project in Utah, USA. Under the terms of the arrangement, Potash Ridge will grant either exclusive marketing rights or offtake for the entire output of its sulphuric acid production, according to the terms and conditions agreed by both parties. Potash Ridge plans to develop a potassium sulphate facility at the Blawn Mountain site that would produce around 645,000 t/a K_2SO_4. The Blawn Mountain deposit has proven and probable mineral reserves of 426 million t/a of potassium sulphate.

APPOINTMENTS

IFA promotes African fertilizer access programme

The International Fertilizer Industry Association (IFA) has joined forces with the African Fertilizer and Agribusiness Partnership (AFAP) and six other agricultural development partner organisations to promote easier access to fertilizers and other inputs for African farmers. The campaign was launched at the African Green Revolution Forum in September. The campaign calls for six key actions to help the African continent to reduce the agricultural yield gap compared with other regions in the world, namely:

- Facilitate local fertilizer production and imports.
- Provide better access to credit, finance and insurance.
- Invest infrastructure which connects farmers to input and output markets.
- Develop mobile technologies.
- Train more extension workers to work with farmers.
- Disseminate best practices based on the integration of both organic and mineral nutrients and balanced fertilisation.

Charlotte Hebebrand, Director General of IFA said, "Fertilizer use in Africa remains startlingly low compared to other regions,

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Dr. Abdulrahman Jawahery.

with average use at around 10 kg/ha, a tenth of the global average. As the voice of the global fertilizer industry, IFA will continue to dedicate time and resources to raising awareness on fertilizers' role in reducing the yield gap and driving African agricultural development."

GPIC head appointed as AFA chairman

Dr. Abdulrahman Jawahery, president of Gulf Petrochemical Industries Co. (GPIC) has been appointed Chairman of the Board of Directors of the Arab Fertilizer Association (AFA). He took up his new role on 1 January. Prior to chairing the AFA, Dr. Jawahery served on the AFA board. He also serves as a member of the Gulf Petrochemicals and Chemicals Association (GPCA) and is head of the Responsible Care Committee. He additionally plays a leading role in the International Fertilizer Industry Association (IFA), where he is currently Vice Chairman and an executive member.

President Lukashenko appoints new potash chief

President Alexander Lukashenko of Belarus has appointed **Ivan Golovaty** as CEO of the state-owned Belaruskali potash producer. He was previously technical director at the organisation and succeeds **Valery Kirienko**, who presided over Belaruskali during the dissolution of its marketing partnership with Uralkali of Russia. The break-up of this partnership proved very bitter, and prompted a collapse in international potash market prices and falling margins for all the leading producers. The turmoil also led to the ousting of **Vladislav Baumgertner** as CEO of Uralkali and his replacement by **Dmitry Osipov**. The changes in top-level personnel are not expected to result in any thawing of relations between Belaruskali and Uralkali, however, and both companies have indicated their intention to continue to market their potash independently. The fall in prices ended the hiatus in international demand, and the leading suppliers have been able to report improved volumes and higher prices. Between January and September 2014, Belaruskali reported a 62% surge in year-on-year potash volumes, with exports totalling 7.3 million tonnes. The company was expecting to report record full-year volumes for 2014.

OCI Nitrogen succession

Gert Jan de Geus has been appointed as CEO of OCI Nitrogen, with effect from 1 October 2014, in succession to **Renso Zweirs**. Gert Jan de Geus was appointed as OCI Nitrogen's chief operating officer in 2010 and was responsible for the fertilizer, ammonia and melamine production operation in Geleen, Netherlands and Rotterdam. He was previously director of operations at DSM Agro, prior to its acquisition by OCI NV (previously Orascom). Renso Zweirs was appointed CEO in 2010 at the time of the OCI acquisition. He takes up a new appointment as chief operating officer of the OCI Nitrogen parent company, OCI Fertilizers & Chemicals Group.

EuroChem outlines planned reorganisation

JSC EuroChem Mineral & Chemical Co. recently outlined further details of its planned corporate reorganisation, which includes plans to re-domicile its headquarters in Zug, Switzerland. The change in structure has been prompted by the growing internationalisation of the group's activities, potential merger and acquisition activity and other capital markets considerations. For this purpose, the group has established EuroChem Group AG, a new holding company, based in Zug.

Transammonia restructures

International trading company Transammonia has combined its Ammonia Division and Fertilizers & Commodities Division into a single unit. The new Commodities Division is headed by **Christian Wendel**, latterly CEO of the Fertilizers & Commodities Division. He is based at Transammonia's offices in Singapore and Zurich. The management for ammonia trading is based in Tampa, USA, while international ammonia trading will be undertaken in Paris. The Tampa ammonia group is headed by **Jeff Minnis**, while **Christophe Savi** is in charge of the Paris international ammonia trading group. Transammonia Group CEO **Henk van Dalfsen** is overseeing the merger of the ammonia and fertilizer business operations from the New York head office. "The merger will allow us to increase synergies, use our global infrastructure to provide a larger portfolio of products and present ourselves to customers and suppliers as a company with different products but co-ordinated activity," he said. "We believe all of Transammonia's operations will be strengthened by the move." During 2013, Transammonia shipped 2.8 million tonnes of ammonia and 25 million tonnes of fertilizers and commodities.

Transammonia has meanwhile held talks with the Russian chemical company JSC KuibyshevAzot over a possible joint venture to produce nitrogen fertilizers in Togliatti. The two companies are reported to have outlined a timetable for preparing the documents for the JV. During the past two years, JSC KuibyshevAzot has formed several JVs with fertilizer and chemical companies, including one with Linde Group of Germany for ammonia production.

BioConsortia boosts R&D team

The microbial crop solutions company BioConsortia Inc. has expanded its R&D team, based in Davis, California. **Dr. Graham Hymus, Dr. Thomas Williams** and **Dr. Elsebeth Kolmos** bring considerable expertise and have begun utilising BioConsortia's proprietary plant microbe selection process. BioConsortia's R&D platform seeks to identify teams of microbes that improve plant traits and increase crop yields. The process is underpinned by a synergy between the scientific disciplines of microbiology, ecology, genetics, plant science and plant breeding.

Graham Hymus leads BioConsortia's plant physiology efforts, while Thomas Williams is responsible for expanding and enlarging BioConsortia's microbial culture collection. Elsebeth Kolmos has been recruited to fill the position of plant geneticist. Senior Vice President of R&D **Dr. Susan Turner** has welcomed the new members of her team. "We have been extremely successful in our hiring process. Graham, Tom and Elsebeth are each skilled and experienced scientists, and nicely complement each other in their work here at BioConsortia. I am excited and honoured to be working with such an impressive group of scientists." The BioConsortia R&D team now totals 26 and is continuing to grow, with the goal of accelerating the development of new biological products that will increase fertilizer use efficiency, improve plant growth and resistance to abiotic stresses.

Change at the helm of GSFC

Following his appointment by the state government of Gujarat, India as Principal Secretary Industries and Mines, **Atanu Chakraborty** has stepped down as chairman and managing director of Gujarat State Fertilizer Company (GSFC). His successor is **S.K. Nanda**.

Sulphuric Group Inc. formed in Canada

Les Lang and **John MacDonald** have joined forces to set up the Sulphuric Group Inc., based in Calgary, Canada. The two founders bring over 50 years of collective experience in the sulphur industry and in association with other internationally-recognised independent experts will provide a range of consultancy services. These services will cover the fields of sulphur recovery units, forming and handling technologies, remelting and block pouring technologies, planning and cost optimisation of faculty operations and sulphur shiploading and discharge audits.

In charge at Jansen

BHP Billiton has appointed one of its top managers to oversee the development of the group's Jansen potash project in Saskatchewan, Canada. **Phil Montgomery** is the head of group project management, and his arrival in Saskatchewan to manage the Jansen operations has been interpreted by industry analysts as a clear statement of BHP Billiton's intent to complete the project. While BHP Billiton has been unwavering in declaring its commitment to potash as a strategic arm of the group's business, progress has slowed down while BHP reassesses the medium-term prospects for potash demand and supply. The group has already committed around $3.8 billion to fulfilling the project, but it reduced spending for 2014 by one quarter in April and dropped an exclusivity agreement. CEO **Andrew MacKenzie** has stated that BHP Billiton is not in a hurry to bring the project on stream while potash markets appear to be oversupplied. He confirmed that construction of the mine shaft at Jansen is proceeding at a reduced pace and once complete, BHP Billiton will decide the pace of further investment. Production of 10 million t/a potash has been envisaged but is unlikely to begin before 2020.

Uralkali CFO change

After 12 years of service with the company, **Viktor Belyakov** has resigned as chief financial officer with Uralchem. As an interim measure, **Anton Vishanenko** is undertaking the role, pending the appointment of a permanent CFO. CEO **Dmitry Osipov** paid tribute to the contribution made by Viktor Belyakov. "He helped steer the business through key milestones, including Uralkali's IPO in 2007, the transformative merger with Silvinit in 2011 and subsequent integration. He also capably led the company as acting CEO during September-December 2013.

Calendar 2015

FEBRUARY

3-5
TFI Fertilizer Marketing & Business Meeting, SAN DIEGO, California, USA. Contact: Linda McAbee Tel: +1 202 515 2707
Email: lmcabee@tfi.org
Web: www.tfi.org/conferences-events

3-5
21st AFA Annual Fertilizer Forum & Exhibition, Arab Fertilizer Association, HURGHADA, Egypt. Contact: AFA Conference Section
Tel: +20 2 2417 2347
Email: info@afa.com.eg Web: www.afa.com

23-26
Nitrogen+Syngas 2015, CRU Events, ISTANBUL, Turkey. Tel: +44 20 7903 2444
Email: conferences@crugroup.com
Web: www.crugroup.com

MARCH

5-6
2nd European Sustainable Phosphorus Conference, European Sustainable Phosphorus Platform (ESPP), BERLIN, Germany. Contact: ESPP
Email: info@phosphorusplatform.eu
Web: www.phosphorusplatform.eu

23-25
Phosphates 2015, CRU Events, TAMPA, Florida, USA. Contact: CRU Events
Tel: +44 20 7903 2444
Email: conferences@crugroup.com
Web: www.crugroup.com

23-26
IFA Global Safety Summit, VANCOUVER, Canada. Contact: IFA Conference Service
Tel: +33 1 53 93 05 25
Email: conference@fertilizer.org
Web: www.fertilizer.org

29-3
April *Beneficiation of Phosphates VII*, Engineering Conferences International, MELBOURNE, Australia. Contact: ECI.
Tel: +1 212 514 6760
Email: info@engconfintl.org
Web: www.engconf.org

APRIL

20-22
TSI Sulphur World Symposium 2015, The Sulphur Institute, BARCELONA, Spain. Contact: Joshua Maak Tel: +1 202 296 2318
Email: JMaak@sulphurinstitute.org
Web: www.sulphurinstitute.org

MAY

18-20
SYMPHOS 2015, 3rd International Symposium on Innovation and Technology in the Phosphate Industry, MARRAKESH, Morocco. Contact: SYMPHOS Technical Committee. Tel: +212 5 23 34 51 22 Email: symposiumocp@ocpgroup.ma
Web: www.symphos.com

25-27
83rd IFA Annual Conference, ISTANBUL, Turkey. Contact: IFA Conference Service
Tel: +33 1 53 93 05 25
Email: conference@fertilizer.org
Web: www.fertilizer.org

JUNE

5-6
***Clearwater 2015*, 39th Annual International Phosphate Fertilizer and Sulphuric Acid Technical Conference**, AIChE Central Florida, CLEARWATER, Florida, USA.
Email: chair@aiche-cf.org
Web: www.aiche-cf.org

For further information on these and other events see www.bcinsight.com

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Editor: MARK EVANS
mark.evans@bcinsight.com

Publishing Director: TINA FIRMAN
tina.firman@bcinsight.com

Subscription rates:
GBP 300; USD 550; EUR 450

Subscription claims:
Claims for non receipt of issue must be made within 3 months of the issue publication date.

Subscriptions Manager / enquiries:
MARIETTA BESCHORNER
Tel +44 (0)20 7793 2569
Fax +44 (0)20 7793 2577
Email: marietta.beschorner@bcinsight.com
Cheques payable to BCInsight Ltd

Advertising enquiries:
TINA FIRMAN
tina.firman@bcinsight.com
Tel: +44 (0)20 7793 2567

Agents:
Japan: (also subscription enquiries)
KOICHI OGAWA
O.T.O. Research Corporation
Takeuchi Building
1-34-12 Takadanobaba
Shinjuku-Ku, Tokyo 169, Japan
Tel: +81 3 3208 7821
Fax: +81 3 3200 2889

Previous articles from *Fertilizer International* and *PK Insight* from 1997 to the present are available digitally in PDF format. To make a purchase, or for a list of available articles, please see: www.bcinsight.com

ISSN: 0015-0304

Design and production:
JOHN CREEK, DANI HART

Mixed Sources FSC

Printed in England by:
Buxton Press Ltd
Palace Road, Buxton, Derbyshire, SK17 6AE

BCInsight

Published by: BCInsight Ltd
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Advertisers' index

Advertiser	Page	Contact	Fax / Email
Arab Potash Company Ltd	9	Ms. Tania Abadi	962 6 5200080
Casale	5/21	Ms Rosella Gazzaniga	41 91 960 7291
CFI holding Private Limited	7	Ms Kristell Le Louam	332 99 54 07 73
European Machine Trading	31	Mr Gustaaf Zeeman	31 224 591 454
FLSmidth Ventomatic	13	Ms Nicoletta Cattaneo	39 035 528 027
Kingenta Ecological Eng. Co Ltd	IFC	Mr Ashley Kuang	0086-539-6219688
Köppern GmbH & Co. KG	29	Mr Stefan Bremer	s.bremer@koeppern.de
Ludman Industries	25	Mr James Lenahan	jlenahan@ludman.net
Neelam Aqua & Speciality Chem (P) Ltd	OBC	Mr Mithlesh Kumar Mathur	91 141-2460081
Phosphates 2015 Conference	17	Ms Kay Rowlands	Kay.rowlands@crugroup.com
Prayon Technologies s.a.	38	Mr Marc Collin	mcollin@prayon.be
TSI Sulphur World Symposium 2015	55		events@sulphurinstitute.org

Next issue: March/April 2015

Distribution at:
Phosphates 2015, Tampa, Florida, USA
TFI Sulphur World Symposium, Barcelona, Spain

- Global phosphate supply and demand
- The USA as a centre of phosphate excellence
- Potash ore processing
- Fertilizers for paddy farming
- Feedstock availability
- Advances in urea plant design

Full details of features can be found in the 2015 Media Prospectus, download a copy at www.bcinsight.com

Closing date for advertisement space booking is 2 March 2015
For further information and to book advertisement space contact:
Tina Firman, Publishing Director: tina.firman@bcinsight.com
Tel: +44 (0)20 7793 2567 Fax: +44 (0)20 7793 2577

CONTENTS
What's in issue 464

COVER FEATURE 1
AFA: 40 years serving the fertilizer community

COVER FEATURE 2
Optimising feed quality in ammonia plants

COVER FEATURE 3
Minimising fertilizer losses

BCInsight
Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com

Don't forget the next issue of Fertilizer International March/April 2015

FERTILIZER INTERNATIONAL
ISSUE 464
JANUARY-FEBRUARY 2015

BCInsight

Southbank House, Black Prince Road
London SE1 7SJ, England
Tel: +44 (0)20 7793 2567
Fax: +44 (0)20 7793 2577
Web: www.bcinsight.com
www.bcinsightsearch.com