

Digital chemistry

From the first digital platform for reagent optimisation to investment in rail transport for sulphuric acid logistics, Paul Moore reviews trends in the mining chemicals industry

Digitalisation is coming to all aspects of the mining industry and mining chemicals are no exception. **Solvay** recently announced the successful launch of SolvExtract™, a first-of-its-kind app-based digital platform for mining operations, with Chile's Codelco, the world's largest copper producer. Solvay says SolvExtract™ connects chemistry and operational insight, "bringing Solvay's technical expertise in mining chemistry to customers at an unprecedented speed and frequency. It enables them to make more informed decisions faster, thus reducing process variability, boosting productivity and improving their bottom line."

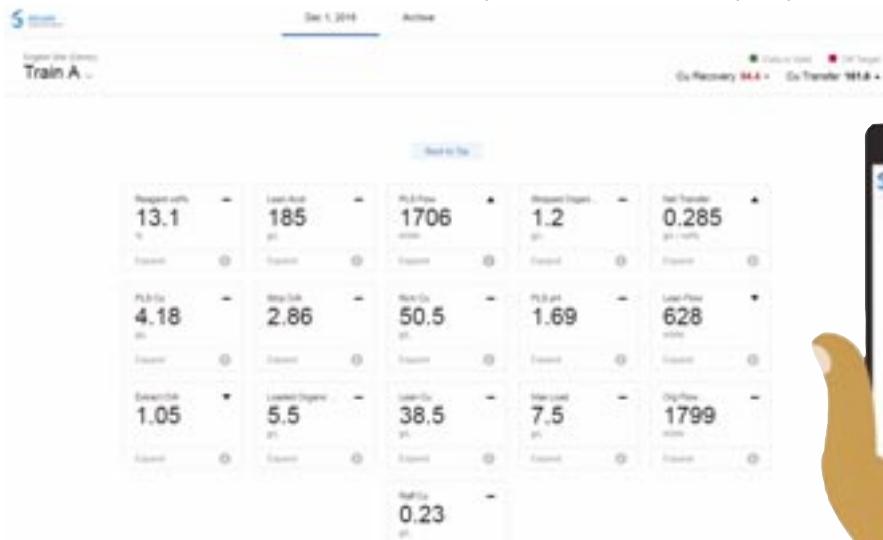
SolvExtract™ is just the first of Solvay's new digital solutions for mining operations, it says, and the only digital platform today dedicated to reagent optimisation. The platform enables data flows between a mining operation and Solvay's proprietary MINCHEM® solvent extraction (SX) modelling software. Using this software, Solvay personnel are able to monitor key variables of the SX plant, such as copper recovery and copper transfer, comparing actual values and trends to model predictions, to identify and analyse deviations. Leveraging a dashboard, custom alerts and expert analysis, Solvay quickly notifies plant operators when issues arise and offers recommendations through the platform. Via SolvExtract™, plant personnel can

Orica's LeachIT™ - a process simulation software consultation with a customer

engage in dialogue with Solvay to support continuous improvement and enhance the quality of future suggestions.

"SolvExtract™ has helped the Gabriela Mistral plant validate operational performance and will support us in identifying opportunities for continuous improvement," shared Rodrigo Benavides Oswald, Codelco innovation director. "Through SolvExtract™, Solvay has proven to be a partner to the plant by providing deeper, more frequent insight, which has positively influenced our daily decision making."

"As available ore grades decline, mines are looking for ways to maximise the amount of copper extracted from each ton of ore," explained Chuck Price, Executive Vice President



Intuitive visual KPIs and trends

Solvay's SolvExtract™ is a first-of-its-kind app-based digital platform for mining operations. It monitors key variables of the copper SX plant, such as copper recovery and copper transfer, comparing actual values and trends to model predictions, to identify and analyse deviations

of Solvay's Mining Solutions business.

"SolvExtract™ utilises a new generation of data-gathering and analytics capabilities – along with Solvay's reagents, applications expertise and customer feedback – to help SX plants reach their true potential."

In detail, the SolvExtract™ tool receives data routinely measured from the SX plant including flow rates, organic extractant concentrations, PLS and electrolyte compositions. Data inputs are customer specific and are able to accommodate the range of Cu SX circuits found in industry (parallel streams, bleeds, blends, etc). The SolvExtract™ tool first performs calculations to confirm the validity of the data to make sure it is suitable for analysis. The theoretical plant performance is then simulated using MINCHEM®. When performance is below the plant's operating targets, the actual performance is compared to the MINCHEM model to identify the source of the problem – either process conditions are such that metallurgically it is not realistic to meet the recovery target; or something is interfering with the plant's ability to meet the recovery that is possible under the given process conditions.

If current process conditions are insufficient to achieve the plant targets, multiple variables are analysed to determine what specific recommendations could be made to return the plant to the target. Practical constraints of the specific customer's plant design are considered. Some potential recommendations to correct low Cu recovery or low Cu transfer may include but are not limited to:

- Increasing the organic flow rate
- Increasing the lean electrolyte flow rate
- Increasing the lean electrolyte acid
- Increasing the extractant concentration

Recommendations are issued to help the customer achieve their Cu recovery and production targets. Using the strip electrolyte acid as an example, MINCHEM® defines how the % recovery and net transfer changes as a function of the sulphuric acid concentration. In one example, the % recovery could be increased from 94% to the customer's target of 95% by increasing the sulphuric acid concentration from 182 g/l to 200 g/l.

Intelligent gold processing

Maximising gold recovery relies on constant adjustment of variables throughout the process, often without the necessary tools to quantify and react in a timely manner. The inability to respond to this variability undoubtedly has a cost to the industry, but how much? Top-down information from published recoveries, combined with Orica's intelligence database estimated the scale of global gold losses to be in the order of \$16-20 billion at a gold price of \$1200/oz. Based on observed experience at the time, Orica further

estimated the scale of 'avoidable losses' – defined as solution losses plus gold leachable in a 24-hour bottle roll on process plant tailings – to be in the range of \$2-5 billion globally.

In a concerted effort to use big data to define best-practice gold processing, Orica's Cyanide Customer Solutions team leveraged detailed operational data across 50 sites in the development of an intelligent system, LeachIT™ that is capable of validating industry estimates, determining the drivers behind gold losses and delivering insights to accelerate the capture of these losses.

Since 2014, LeachIT™ has been enabling customers to maximise economic recovery through identifying shortcomings at site and confidently predicting the recovery impacts of process changes and variability. The intelligent software also allows metallurgists to see how their process will respond to changes without time-consuming and expensive experiments.

Aimed at enabling best practice leaching, LeachIT™ simulates changes to the process and presents the impact on tails grade. Adjustments could be made based on feed, tank, or tail measurements. Alternatively, they may include changes to the physical plant such as simulating a tank going offline for maintenance. The software harnesses this information not only to calculate but also visualise gold recovery and cyanide consumption. Rapid scenario modelling of commonly observed process changes is brought to life through an easy to use digital interface, giving Orica's customers and site teams a clearer understanding of the benefits that any proposed changes will bring to their operations.

Orica Cyanide Customer Solutions Lead, Peter Leckie said: "We aim to take our customers' operations data and combine it with our expansive global Cyanide process data gathered over time, and then interpret that data into insights, delivered visually so that our customers can make more rapid and confident decisions. "The LeachIT™ simulation software simply provides a tool to empower the people who know your process best."

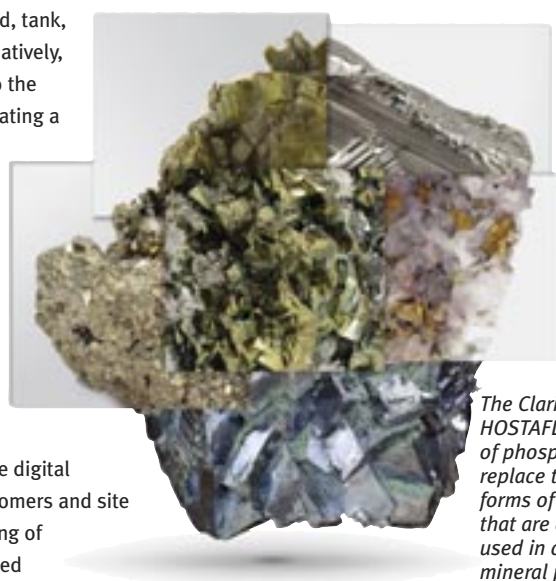
The simulation software can be harnessed to provide insights for a one-off exercise or installed onsite to allow discovery of insights on an ongoing basis. This way, customers can continually turn everyday information and data into actionable insights that improves their bottom line.

Improving efficiency & safety: replacing xanthates in copper mining

Copper remains one of the most valuable industrial metals due to its high electrical and thermal conductivity. In parallel with other sectors, the mining industry has been focussed on the challenges of improving operational efficiency while increasing sustainability and safety performance.

Xanthates are used in the flotation process within the copper and gold mining industry as collectors for recovery of metal sulphides. The most popular are sodium ethyl xanthate (SEX), sodium isopropyl xanthate (SIPX), sodium isobutyl xanthate (SIBX) and potassium amyl xanthate (PAX).

Sodium xanthates have a hydrocarbon chain and a polar group. In the flotation process, the polar group molecules attach to the ore particles, with the non-polar hydrocarbon part sticking out, forming a hydrophobic film. With the addition of air and a flotation frothing agent, air bubbles are created, the hydrophobic film attaches to the bubbles and is carried to the surface. The float



can then be collected and dried. At this point, most of the

The Clariant HOSTAFLOT family of phosphates can replace the many forms of xanthates that are currently used in copper mineral processing

xanthate is attached to the concentrate, however small amounts may be contained within the process water and tailings waste material.

Because of the hazardous nature of xanthate and difficulties associated with storage, handling, and disposal, mining companies have sought a cost-effective alternative for years. Clariant told IM it has been working on replacement technology for the use of xanthate. Its answer is HOSTAFLOT®, part of the company's high-performing, highly sustainable EcoTain® range of products.

The HOSTAFLOT family of phosphates can replace the many forms of xanthates that are currently used in mineral processing. The numerous benefits of this application include environmental performance, cost reduction, and safety. On the environmental front, it is available

in liquid form, unlike xanthates that are supplied as pellets or powder, reducing the need for product handling to create a solution. An additional benefit is that there is no extraneous packaging in contrast to xanthates whose boxes or cartons are difficult to dispose. As HOSTAFLOT is non-flammable, there are no special storage requirements, unlike xanthates that are highly flammable and need special treatment.

It has similar recovery levels at the same dosage as SIPX with a 12-15% better cost performance and further savings from preparation because of its liquid state. With the production of xanthates limited to the countries of China and South Africa, security of supply concerns linked to long distance logistics are alleviated. Lastly, HOSTAFLOT can replace xanthates as both a primary and secondary collector, improving metallurgy recovery during both processes.

The product has already proven its worth in two extensive trials that Clariant has conducted in South America. At a Brazilian copper ore mining operation, the company mines bornite and chalcocite as prominent copper-bearing minerals with chalcopyrite occurring in lower percentages.

The Clariant application development team created and tested several chemistries from the HOSTAFLOT collector series, using the customer's ore as feed material. After laboratory trials showed satisfactory results, Clariant supplied four tonnes of HOSTAFLOT for the plant trials. This achieved a 40% reduction of total collector consumption with frother consumption decreased by 25%. With copper and gold metallurgical recoveries equivalent to that of the xanthate collector, it is now the reagent of choice to replace potassium amyl xanthate.

In Chile, two further companies trialed the product, one using it as a primary collector, the other as a secondary collector. Clariant's application experts developed and conducted in-house lab experiments to produce a liquid collector that exhibited the same mineral collection performance as SIPX. HOSTAFLOT produced the same copper and molybdenum recovery levels, as well as identical copper concentrate grade, to those cultivated by a xanthate collector. By switching to HOSTAFLOT, these companies are projected to save hundreds of thousands of dollars annually based on their annual collector consumption.

Currently, the product is available in Brazil and Chile and is being introduced in Australia, Sub Saharan Africa, Europe and Peru. "HOSTAFLOT® is not an off the shelf product," says Wagner Silva, MsC, Head of Technology - Mining Solutions. "For these two diverse projects, we delivered a customized solution to meet the individual requirements of the mine and



the ore they produced. As a company, we have the experience and capabilities to provide a sustainable solution that is achieved through close collaboration with our customers."

Frother innovations

Frothers and the froth phase have been neglected in the past, but have a significant impact on metallurgical performance and optimising the frother scheme in a flotation operation is critical to enable value creation. Solvay told *IM* that it has a novel, advanced way to adjust the froth formulation in real time based on the ore being treated and the plant characteristics.

These capabilities are linked to Solvay's emerging focus on digital solutions. "Solvay is uniquely positioned to improve plant performance through its holistic offering: custom-tailored reagent schemes, applications expertise and enabling digital technologies based on connected chemistry."

Solvay says it is taking a "back to basics" approach to frother innovation. "Leveraging decades of experience in frother development, Solvay's back to basics approach enables our technical experts to combine basic frother building block chemistries (eg alcohol and glycol-based frothers) into custom-tailored reagent schemes that address operation-specific needs."

Solvay's latest innovation in frother optimisation involves on-site blending, novel dosing units and remote monitoring called "the cube". Specifically, Solvay's new dosing equipment allows for more precise blending and control of frother building block chemicals and "real-time" adjustments based on plant results. As a result, plants benefit from improved operational stability and metallurgical performance. This holistic approach is a

Solvay's recently launched frother dosing equipment that enables customers to fine tune Solvay's tailored formulations to achieve desired plant performance

departure from the conventional use of one-size-fits-all commodity frothers, which can be ineffective in treating today's complex ore feeds.

"By evaluating frothers in the laboratory, operators gain insight as to expected performance. However, lab testing frothers cannot capture the complexity of the full flotation circuit, making it critically important to run trials to accurately predict plant performance," said Paulo Martins - Frother Business Development Manager.

"In our experience, it's best to run a short, initial laboratory evaluation and move on to a controlled plant trial as soon as possible. Adjusting or fine tuning the frother formulation can be done in real time with the support of plant data, as well as plant staff. The ultimate goal is to find a frother solution that is robust in responding to the dynamic needs of the plant as quickly as possible," continued Martins.

Several prototype dosing units have been tested globally, and the results have been positive, leading to commercialisations of new frother formulations under the OREPREP® and AEROFROTH® brands. "We've improved our customers' experience by creating value with our reagents, testing capabilities and technical service. Customers have benefitted from improved productivity because, with our support, they've been able to make operational changes more quickly and track performance using formulations tailored for their operation," said Eammon Guitard, Mineral Processing Marketing Manager. "Solvay is continuing to explore ways to further improve our customers' performance with the use of connected chemistry," he added.

Axis House grows with new Turkey site

South Africa-based **Axis House**, a leading reagent technology management company offering mining chemicals, flotation and mineral processing solutions since 2001, has become a major supplier and distributor of chemicals to the mining industry. As a result of extensive years of experience in the DRC and Zambia, Axis has announced the addition of a satellite office in Turkey that will service Northern Africa, Middle Eastern, European and Central African clients.

Axis House Managing Director Justine Stubbs says: “We have spent years consistently pushing the boundaries of innovation for our diverse clients, and this satellite office is just the first step for Axis House in our scope for expansion into the main copper-producing regions globally as well as gold and platinum.” With a product offering, including both mining chemicals and mining consumables, the company believes that its expert team is always ahead of the curve. “We inherently believe that operational excellence can only be achieved through continuous and progressive innovation, and we are celebrating this progression with our new office in Turkey,” concludes Stubbs.

The Axis House range of products includes mining chemicals for flotation – including proprietary flotation technology, primary and secondary collectors, the Hydrofroth™ range of frothers, and sulphidising agents – as well as depressants, thickeners, hydrometallurgical reagents and laboratory chemicals.

ArrMaz phosphate solutions in Brazil

To meet the needs of Brazil’s sophisticated phosphate processing operations, **ArrMaz** has been engineering superior solutions to maximise Brazil phosphate grade and recovery for selective phosphate flotation while depressing iron and other contaminants. “ArrMaz brings unique ability and chemistry to adapt formulae as the ore changes or as impurities increase. As Brazilian miners extract phosphate deposits from higher quality mines and max out these resources, they will have to turn to processing lower quality ores to meet phosphate demand. Unfortunately, these deposits are likely to contain more undesirable levels of impurities such as barite, dolomite and/or silica than current mineral flotation processes can handle. Removing barytes, dolomite and silica impurities is challenging but necessary to achieve the phosphate grade needed to convert the phosphate ore into phosphate quality fertiliser, while still being able to selectively float phosphate and substantially depress iron.”

While Brazil’s current, technologically advanced reverse flotation processes already float barytes away from phosphate, the demands



of future, lower grade deposits will require more sophisticated collectors that can manage widely varying ore and processing conditions. Brazilian phosphate rock producers will be challenged to make grade – as too much silica and dolomite will make it difficult to convert the phosphate rock into phosphate quality fertiliser. “But ArrMaz is here to help them meet this challenge. We work with Brazilian miners/mineral processors to customize a collector system and flowsheet design specifically for their ore and process, with the goal of simplifying the process by combining flotation steps so that multiple impurities can be floated away in one step, enabling maximisation of phosphate grade and recovery. The lower the rock impurities, the better the fertiliser processing and value.”

A new way for lithium recovery: SX

Lithium demand has increased exponentially in recent years driven by the revolution of electromobility and clean energy. Today more than 50% of lithium production is obtained from brines. The current process of production of lithium from brines is highly inefficient and requires the evaporation of millions of cubic metres of water from salars (salt flats) typically located in arid and environmentally protected areas.

The extraction of lithium from brines via SX, could revolutionise the industry, making for an efficient and environmentally sustainable production, allowing to increase production (as needed by the market today) without environmental impact, and enabling the development of new projects, not currently feasible economically with the traditional technology.

The current extraction process of lithium is based on successive stages of precipitation and

An ArrMaz technical service representative examining Brazilian phosphate flotation cell for optimum froth collection and selectivity characteristics

evaporation, through which the brine is being concentrated and partially purified. Today it is increasingly complex to continue operating under this concept or to replicate it in new projects, for a number of reasons:

- The process is dependent on geography and climatic conditions (evaporation)
- Around 50% of the lithium extracted from the salar is lost in the precipitation processes (physical drag)
- The process requires the construction of gigantic evaporation ponds, which occupy immense surface areas (not always available)
- It also involves the evaporation of huge volumes of water from arid and environmentally protected areas
- The residence time in the ponds ranges from 12 to 18 months

Because of these shortcomings, the market today is looking for new technologies for the extraction of lithium. Solvay has developed **CYANEX®936P**, a solvent extraction reagent to selectively extract Li from brines, eliminating the need for evaporation and allowing a more efficient (recovery >85%) and sustainable process. In addition this process will allow producing different lithium salts as final product, unlike the conventional process which produces only allows to obtain Li_2CO_3 .

CYANEX®936P is an organo-phosphorus reagent that acts through a chelating mechanism by exchanging metal ions (Li^+) for protons (H^+). The reagent allows a selective extraction from brines rich in Cl, SO_4 , Na, B and K, where lithium is one of the least abundant elements.

“It is important to bear in mind that the reagent is not selective with respect to divalent elements such as Mg^{2+} and Ca^{2+} , which must be removed from the brine prior to the SX process. There are different technologies available to remove divalent ions: ion exchange, membranes, precipitation, or even SX (using DEHPA or CYANEX®272 reagents is technically feasible); the various options should be evaluated according to the characteristics of the brine to be treated.”

The reagent requires neutralisation of the protons generated as part of the extraction equation. For this, base is added directly to the feed brine. The base achieves the objective of neutralizing the protons generated, and also precipitates the traces of Mg and Ca that could remain in the solution. The stoichiometric ratio requires a base dosage of 1 mole of OH per mole of Li present in the brine.

The CYANEX® 936P reagent has a high lithium extraction capacity, reaching a recovery close to 100% from an average brine. The high loading capacity, along with the fast extraction and retraction kinetics (cf. Figure 4) make it possible to obtain high purity lithium in a simple SX circuit with a limited number of theoretical stages.

The reagent was developed in collaboration with the engineering firm **Tenova Advanced Technologies (TAT)**. The TAT process provides the conditions that allow the optimum operation of the CYANEX®936P reagent, ie the neutralisation and removal of the divalent ions from the feed brine. The TAT process consists of two main steps, the LIP™ step for the removal of the divalent ions and the LiSX™ step which is the lithium solvent extraction itself. Those are followed by an optional third step called LiEL™, which is an electrolysis process to produce LiOH of high purity.

It is also possible to apply the lithium SX as part of the conventional production process in order to optimise the Li_2CO_3 precipitation process. This allows the recovery of the lithium remaining in the carbonation effluents (known as “mother liquor”), thus generating significant savings in reagents and energy. Solvay says that solvent extraction of lithium has clear advantages over the conventional process:

- It is independent of climate and geography
- In the case of the TAT process, the overall recovery of lithium is between 85 and 90%, and considering only the SX stage, a 99% recovery rate can be achieved
- It does not require large areas for evaporation
- The processing time is reduced to hours, not months (positively affecting time-to-market and working capital)
- The evaporation of millions of cubic meters of water is no longer needed to concentrate the brine. It is possible to return the raffinate of

Chinese mining chemicals trading group Kemcore recently received the first batch of sulphuric acid tankers as it steps up efforts to increase its rail capacity to supply sulphuric acid to its mining clients in Zambia and the DRC



the SX plant to the salar, after treatment to eliminate the possible entrainments of the organic phase

- CYANEX® 936P is flexible and compatible with different SX technologies: pulsed columns, mixer-settlers, etc.

CYANEX®936P is an innovative formulation that can radically change lithium production technology. It can also be used within the traditional process, optimizing the costs and performance of the operation.

Copperbelt logistics

One aspect of the mining chemicals industry that is often overlooked or taken for granted is bulk transportation. Chinese mining chemicals trading group **Kemcore**, recently received the first batch of sulphuric acid tankers as it steps up efforts to increase its rail capacity, to supply sulphuric acid to its mining clients in Zambia and the DRC.

Kemcore, a Hong Kong-based company, with offices in South Africa and Zambia in December 2018 announced that its newly leased sulphuric acid rail tank wagons had passed the inspection at the Germiston wagon depot of Transnet Engineering. The newly acquired sulphuric acid rail tank wagons will join Kemcore's existing 90 acid wagons, which already include 30 TFR XPJ tanker wagons and 60 ISO tank wagons. “The wagons were all converted by the same production line, in the same batch and with the same material and quality standards, from XPJ-10 fuel tankers to sulphuric acid tankers designated RLSJ-1. As such, they are all of the same specification and quality, and in similar condition” read the inspection report.

The conversion scope consisted of installation of a ‘slosh plate’ to reduce longitudinal movement of the liquid load inside the tank, installation of new T long neck bottom discharge

valves, and installation of an air brake system (the wagons are now equipped with dual vacuum and air brakes). The work also included refurbishment of running gear components, namely Saskop couplers and draw gear, brake gear components and Spoorbarber bogies. “Kemcore's ability and capacity to rail sulphuric acid from South Africa is a first for the region and positions the company as one of the only companies to do so in the Copperbelt region. Kemcore is now able to rail 8,000 tonnes per month of sulphuric acid to off-take partners in the region,” Kemcore said in a statement.

Sulphuric acid, used in the leaching of copper has been in short supply since 2017. The region is heavily dependent on supply from Zambian-based copper smelters and sulphur burning. The 2019 outlook for supply was looking very tight as it was becoming expensive for local smelters to acquire concentrates. This was also being exacerbated by the introduction of a sales tax by the Zambia government. Moreover, there were more than 100,000 t per annum of demand from new operations expected to commence in 2019.

Kemcore stated: “The price of imported sulphuric acid from South Africa via road truck tankers is prohibitively very expensive at above \$600/t. It may become uneconomical as the price of copper and cobalt go down. Cobalt prices have dropped more than 25% since a peak in April [2018] amid growing concerns that too much supply has been brought online in response to surging prices. Last week Glencore warned that some buyers in China reneged on contracts after seeing prices plunge, forcing the company to renegotiate the commercial terms of the deals. Miners will be forced to seek cheaper alternative sources of acid. The railing of acid brings the cost down by at least 10% which can lead to millions of dollars in savings.” 