Agents of reagents

Ailbhe Goodbody looks at the range of chemicals available for mineral-processing applications and the factors that influence their use

Mining chemicals are part of a complex market and are used for many applications. There are specialised chemicals for flotation, thickening and metal extraction, along with more general chemicals used for anti-scaling, dust control, filter aids, agglomeration aids, and bulk acids and cyanide.

Extractants and diluents are both used in leach operations. The role of the diluents, usually a hydrocarbon-based solvent, is to increase the concentration of metal for recovery, maximising the efficiency of the process.

Flotation agents are used to separate minerals from gangue. The flotation process is used to concentrate a wide range of materials including sulphides, oxides and carbonates of a range of metals including copper, lead, zinc, gold and molybdenum along with industrial minerals such as phosphates and fluorspar and coal. The approach and the group of chemicals used depend on the material being recovered and on the different types of ore.

Froth flotation is widely used, and the process relies on the differences in the hydrophobic character of the mineral surfaces. Most minerals do not easily float in froth flotation, as they are hydrophilic, so the use of chemical reagents known as collectors is required to make them float. Some gangue minerals have hydrophobic surfaces, however, and will readily float and contaminate the mineral concentrate; to counter this, depressants are used to adsorb on the surface of the gangue and stop them from floating. The use of depressants results in higher recovery rates and grades.

The xanthate family are the most widely-used collector compounds, and apply to about three-quarters of global mining applications. Xanthate and other standard collectors only float sulphides, rather than oxide mineral species, so if a mine has a mixed ore containing sulphides and oxides, the oxides would be lost to the tailings dam if another type of collector was not included as well.

There are also ‘speciality’ collectors such as thionocarbamates, dithiophosphates and monothiophosphates or other formulations of these chemicals. Dithiophosphates are more selective than xanthates, and do not require on-site mixing; thiocarbamates are also selective and are normally used for copper sulphide minerals. It is conventional in non-sulphide flotation systems to use naturally-derived substances such as starches and gums as depressants. These include guar gums, used to depress talc minerals, along with synthetic depressants such as carboxymethyl cellulose (CMC) and sodium silicate.

SELECTING CHEMICALS

The choice of chemicals for processing a specific sulphide deposit is influenced by various factors. Mineralogy plays the biggest part, and determines which approach will be used. In general, copper sulphides will be processed via flotation and use flotation collectors, depressants and frothers; while copper oxides will pass through a hydrometallurgical process, employing leaching chemicals and solvent extractants. However, subtle differences in mineralogy or water chemistry can have a significant impact on product selection and performance; a flotation collector that works in one plant may not work at all in another, even though both are floating copper-sulphide minerals. For this reason,
“There are cost variations between the different types of mining chemicals, and even between products within the same chemical family”

Cost considerations

Cost is an important consideration for mine operators when choosing chemicals. “Even 1% increase in recovery can increase revenue at mines by about US$10 million,” says Mr Velgaard at Cheminova.

The type and quality of the deposit, the ultimate market and the producers’ philosophy about the conservation of the resource are the largest cost considerations. Mine operators usually choose chemicals on a cost-versus-benefit basis that weights dosage and performance (recovery and/or grade) against cost. There are times when budgetary concerns cause mine operators to disregard such a value proposition to simply minimise the amount they spend on chemicals. However, the ‘total cost in use’ needs to be the guiding principle.

“Low-cost reagents, that require a high dosage and yield lower than optimal mineral recoveries, cost more overall than specialised reagents that increase overall plant profitability,” says Paul Gould, global head of marketing and applications, mining solutions at Clariant. “Focusing on the reduction of a single operating budget might not provide the highest return for the shareholders.”

Xanthates are inexpensive compared to other reagents, which may be two or three times the cost, but the benefits in recoveries and grade can far outweigh the initial price. “One goal is to utilise a collector that is stable through detrimental orebody changes, especially higher iron pyrite or clays.” Colin Cumberbatch, marketing director at SNF FloMin adds.

There are cost variations between the different types of mining chemicals, and even between products within the same chemical family. This is due to the chemical composition of the product and the process involved in the manufacturing.

“Scale inhibitors comprise a wide range of different chemistries, some much more expensive than others,” comments Steve Paulson, lead marketing manager – Americas at Nalco. “Likewise, in sulphide flotation, xanthate is substantially lower in cost than other collector chemistries such as thionocarbamates; this is mainly a function of raw materials and the manufacturing process used for each. Ultimately, the specific product selection boils down to meeting operating objectives and performance requirements.”

Variations in cost can also be due to the fundamentals of supply and demand just as much as production and supply costs, according to manufacturer ArrMaz. Competition from some Chinese suppliers has also influenced prices.
Customers.

Recycling chemical containers from disposal issues and even picking up and optimisation, assisting customers with formulations, re-circulating mining oils in place of hydrocarbons in product improve customer operations.

Develop products that minimise the product. Most companies strive to classification and composition of the procedures which are dependent on the product.

Deliver a free-flowing operator-friendly vacuumed-stripped before packaging to ensure a dry product. Our xanthates are sealed liners within boxes and drums to extremely flammable.

Examples of this include using natural oils in place of hydrocarbons in product formulations, re-circulating mining reagents, water recycling and use optimisation, assisting customers with disposal issues and even picking up and recycling chemical containers from customers.

Manufacturers

Many companies provide mining chemicals, though none provides all chemicals for all applications. Some offer a broad spectrum globally, but most have chosen to focus on a specific area such as flotation chemicals or extractants. The companies detailed below cover a wide range of those involved in the market.

Other important global and regional manufacturers not detailed here include Chevron Phillips, Orica, Cytec, Nasaco, CT Prospec, Akzo Nobel, Sasol, TallBennett, Mathiesen, Senmin, Dow Chemical and Chemorama.

BASF Mining Chemicals

BASF operates globally and offers a range of mineral processing reagents. The acquisition of the mining chemicals businesses CIBA in 2008 and Cognis in 2010 have helped it to expand in the sector. The company says its strengths lie in solid-liquid separation and solvent extraction, but also has reagents that support other mineral-processing applications such as flotation, grinding and agglomeration.

The company recognises that the mining industry faces challenges and issues relating to the use of water and the impact of exploration, mineral extraction and residue management on the environment. To address this, BASF has developed the Rheomax DR (Density & Rheology) range of advanced flocculants and LIX high-performing solvent extractants.

Additionally, its Rheomax ETD (Enhanced Tailings Deposit) is a new approach to tailings management that uses technology to change the structure and drainage properties of mineral-processing residues. The method allows customers to capture and re-circulate process water faster, and is beneficial to land management.

Martin Neale, global marketing industry and strategy manager at BASF, tells MM: “BASF’s mining reagents are either re-circulated and used again, or consumed during the normal course of the mining process. BASF continually develops products that are more dose-efficient, less hazardous to handle and more sustainable towards the environment.”

Clariant Mining Solutions

Clariant manufactures a complete range of specialised collectors and frothers for the flotation of sulphide and non-sulphide ores. It also manufactures depressants to prevent the adsorption of collectors onto the mineral surface, or prevent attachment of air bubbles to a mineral surface. The company has withdrawn from providing xanthates.

Paul Gould, global head of marketing and applications, mining solutions at Clariant, tells MM: “At Clariant we just do ‘mining’, without the distraction of supporting other businesses.” The company is also constantly engaged in researching ways to improve recovery and grade and releases products after careful testing.

As mining is a global business with mineral processing plants located in some of the most remote parts of the planet, Clariant has resources in the major mining regions. The company’s goal is to provide customers with the best local logistical and service support possible. Its local infrastructure includes manufacturing, testing laboratories and service personnel. Mr Gould adds: “The familiar ‘family values’ of mining reagents remain as important to our customers as they have ever been. These are performance, value, service and security of supply.”

Cheminova

Cheminova, founded in 1938 in Copenhagen, is still based there. Now a global company, it serves customers in Europe, South America and North America.

Cheminova makes high-quality dithiophosphate sulphide mineral flotation collectors. Its product line is augmented with a number of other specific sulphide collector chemistries to ensure that a sulphide mineral flotation technician has the reagent tools needed to capture the flotation opportunities and resolve issues that are presented. On a segment basis, Cheminova’s primary sales are to copper, lead-zinc and gold-silver mines, but it has collector sales in other sulphide mineral applications too. Its dithiophosphates are marketed globally under the brand name Danalfoam.

Thomas Velgaard, global portfolio manager at Cheminova, says that the company is keen to minimise its environmental impact. “For manufacturing of dithiophosphates, Cheminova is...”

“Mining chemicals are safe to use as long as they are transported, stored and applied properly.”

With resources in the major mining regions, Clariant’s goal is to provide customers with the best local logistical and service support...
focused on treatment of chemical waste from our production. Furthermore, in our corporate social responsibility policies, we have focus on minimising the environmental impact of our products.”

Ashland

Ashland Hercules Water Technologies, a commercial unit of Ashland Inc, supplies specialty chemical products and technologies to the mining and mineral-processing industries. Historically, Ashland has been known for its water-treatment products, but has recently expanded its offering with major emphasis on products to increase mineral recovery and process throughput. These lines include flotation reagents, viscosity and rheology modifiers and filtration aids.

Ashland’s Zalta viscosity and filtration aids allow mineral processing plants to increase production rates and maximise water recovery, and to recycle with existing equipment. Ashland has also increased its R&D and product development efforts regarding mineral-processing aids to develop and introduce products that provide improved performance while reducing environmental impact and potential health impacts on workers. For example, Ashland’s Zalta DS dust-control product line is formulated to provide options, based on renewable raw materials, to assist mining operations in controlling fugitive dust emissions. This helps to reduce the overall environmental, health and safety impact of the entire mining operation. It also aims to improve water recycle rates, water-use optimisation and the ability to cost-effectively treat mine effluents to meet increasingly stringent discharge water-quality guidelines.

ArrMaz

ArrMaz provides flotation reagents for phosphate ore, potash ore and other industrial minerals. It has developed a range of products that are mine/ deposit-specific and are effective over a broad range of flotation conditions and ore types.

The company custom-manufactures anionic flotation reagents and cationic flotation reagents for the flotation of phosphate ore and sand, respectively. It also makes flocculants for various conditions, and frothers that improve recovery rates and increase selectivity during flotation.

The company says there are no significant environmental issues associated with its products. In the past, it produced an imidazole collector for calcium carbonate, and environmental concern arose about one of its chemical constituents, called aminoethanolamine. ArrMaz developed an alternative collector for this application several years ago, which eliminated the constituent of concern.

ArrMaz’s main markets for its chemicals are the US, Saudi Arabia, China, Brazil, Morocco, Turkey and Canada.

SNF FloMin

SNF FloMin, a subsidiary of the SNF group of companies, makes and distributes reagents for the minerals-processing industry. Its head office is in the US but it has production sites in the US, Chile, Europe, South Africa, Peru, Australia, Canada, China and Brazil.

Among the products the company makes are xanthates, dithiophosphates, thionocarbonates, dithiocarbamates, xanthogen formates, xanthogen esters, frothers and depressants.

As each orebody responds differently to the various reagents and blends, SNF FloMin has fully-staffed metallurgical labs around the world to help the customer achieve desired results for recovery and grade improvements.

Although SNF FloMin is one of the few global suppliers actually producing xanthates, the company is also implementing and modifying other promoters such as thionocarbamates and dithiophosphates. Colin Cumberbatch, marketing director at SNF FloMin, says: “There are some new discoveries such as modified thionocarbamates used in combination with chemicals from other industries. One product is SNF FloMin C 7810 which is an oily collector that selectively floats copper but not undesired iron pyrites.”

Other products from SNF FloMin include the new thionocarbamates FloMin C 4140 – C 4146 series, which offer higher recoveries and selectivity over the standard IPETC. The ammonium diethiophosphate blend FloMin C 5460 has produced higher gold recoveries for some large customers.

CP Kelco

CP Kelco specialises in base-metal and platinum-group-metal froth flotation, where it offers products and application technology for depression.

Hydophobic gangue mineral depressants are marketed under its Finnfix brand, as selective depressants that prevent unwanted gangue minerals from floating. The company says Finnfix products facilitate cost-effective recovery of valuable minerals and improvement of the concentration grade, resulting in reduced smelting operation energy costs.

In addition to the depressive function, Finnfix can provide an effective dispersant function for gangue slime, to stop it from coating valuable components and preventing their flotation. Finnfix products are classified as non-toxic and inherently biodegradable, as they are manufactured from renewable raw materials.

Nalco

Nalco makes a wide range of products designed to increase production, improve efficiency and quality and maximise water recovery and reuse. Its products include flotation reagents, flocculants and coagulants for solid-liquid separation, mine and wastewater treatment and tailings management. Nalco has a strong

Copper bubbles in a flotation tank at the BHP Billiton Olympic Dam mine and processing facilities, Australia

Photo: BHP Billiton via Bloomberg News
The flotation circuit at Montana Resources’ mining operations, in Butte, Montana
Photo: Bloomberg News