

# Chemical optimisation and sustainability in flotation

The depletion of mineral resources associated with the cost and limited availability of water and energy is putting pressure on the industry to optimise its processes, especially concentration by flotation, **Ricardo Capanema\*** reports

To achieve an optimised and sustainable process, mining companies have three major factors to work with: the mechanical, operational and chemical aspects of flotation. Typically the optimisation of mechanical and operational factors is subjected to significant capital investments; however the chemicals can frequently have greater leverage in optimising the process with little or none investment.

Cytec has developed a novel holistic approach to optimise the flotation process, called FLOTATION MATRIX 100™ (FM-100), which encompass all the synergistic effects of the chemicals used in the process: collector, frother and modifiers; while incorporating all the factors to make optimisation practical and economical.

The process comprises of four critical phases schematically represented in Figure 1 below. Although these four phases proceed in a logical sequence, they are indeed highly iterative. The discovery/definition phase provides all the necessary information for reagent selection and sets the objectives, goals and success criteria. The reagent selection phase, then, begins with

preliminary screening of available reagents using the knowledge base and expertise of the reagent developer to arrive at a subset of reagents that meet the requirements established in the discovery/definition phase. The selected reagents can then be screened in the laboratory by an iterative process. Historically, the preliminary screening phase has been rather simplistic, as it involved merely selecting representative candidates from several different families, and essentially ignoring other important reagents in the circuit and operational variables. Thus, if the objective is to screen collectors for a given separation, the candidate products might be a set of representative collectors from several families, keeping all other reagents and conditions constant. The assumption in this one-reagent-at-a-time approach is that reagents perform independently of one another and independent of the operating conditions

This holistic approach for reagent selection is based on the consideration of more than just the chemistry of one reagent in isolation or more than just one type of reagent for a given mineralogy. In fact, all the chemical and operational factors are considered simultaneously.

Below are some case studies of how the application of FLOTATION MATRIX 100 and the use of new chemistries over traditional ones can significantly improve metallurgical performance.

## Collector

The xanthate collectors are a traditional chemistry used in sulphide flotation. However, their combustible properties and release of CS<sub>2</sub> during application presents a significant safety hazard. Recognising this problem, Cytec set forth to develop more sustainable options while keeping or enhancing the metallurgical benefits. The novel solutions are liquid products that can be dosed directly in the process, substantially improving handling and level of exposure of personnel to product, stock safety management, residual generation and simplifying the plant operation.

One successful example is the replacement of Amyl Potassium Xanthate (PAX) by a new Cytec reagent suite in a large epithermal gold operation in the Americas.

Based on the FM-100 approach and using AERO® MAXGOLD™ 900 (AERO MX-900) Promoter as part of the chemical system, Cytec improved performance and delivered significant benefits in the process when compared to the standard PAX reagent. The trial was conducted using a combination of 40 g/t of AERO MX-

**Table 1 – Operational data**

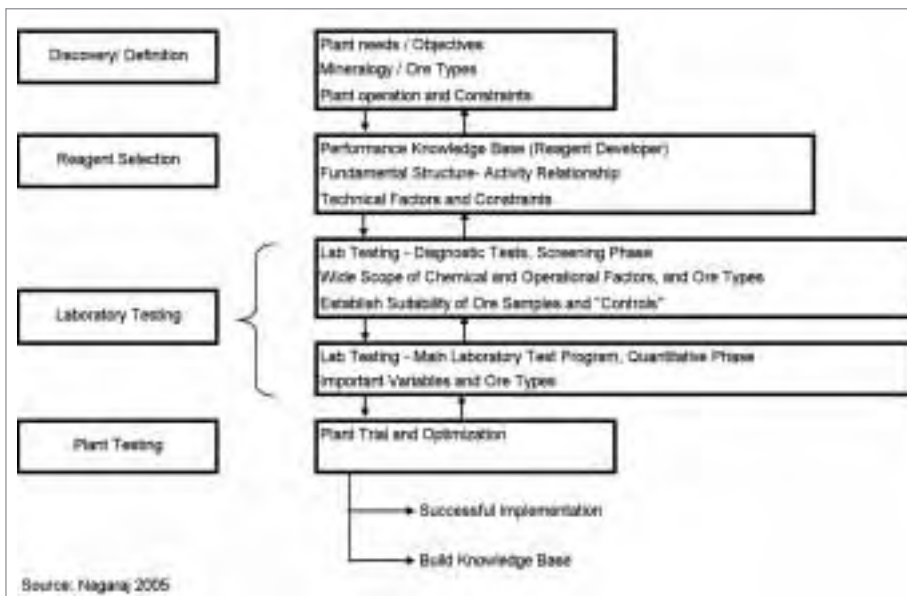
Parameter	Value
Particle size (P80)	150 micron
Standard collector dosage	50 g/t PAX
Flotation pH	natural 7.5-8.5

6000 series collector along with 10 g/t of AERO MX-900 Promoter as a full replacement of PAX in the industrial flotation circuit.

The plant operates in a standard gold circuit comprised of a SAG and ball mill in closed circuit, a gravity concentration circuit, a flotation circuit that receives tails from the gravity concentration and a cyanide leach circuit.

During the trial period, the mean for the flotation tails was 0.19 g/t Au. Comparing this with the PAX historical data, a decrease in the gold tails from an average of 0.25 to 0.19 g/t can be clearly seen when using the new chemical system of MAXGOLD combined with AERO MX-6000 series (Figure 2). This improvement is estimated to generate an additional \$1 million in revenue. It was also observed during the trial that more gold is reporting to the gravity circuit than when PAX

Figure 1. Rational process for reagent selection and optimisation (arrows indicate that the overall process is highly iterative)



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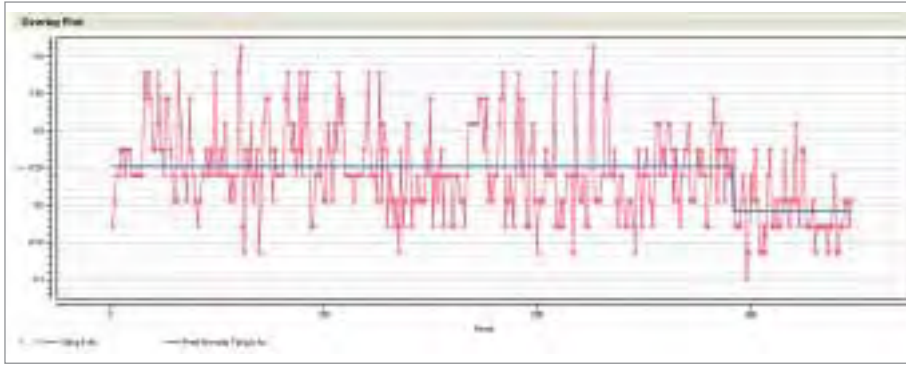


Figure 2: Historical and trial data

## Frother

The OREPREG® F-603 frother is a new formulation designed per Cytec's FM-100 process to improve the safety, environmental and handling aspects over MIBC while enhancing metallurgical recovery for copper and molybdenum.

**Mineral: southwest US copper/molybdenum ore**

### Operational parameters:

Feed Grade: Cu: 0.35%  
Mo: 0.037%  
Tonnage: 115,000 t/d  
Flotation pH: 11.6  
Grind: 35% +65 Tyler mesh

### Reagent Scheme:

Collector: Thionocarbamate and Aromatic fuel oil  
Frother: Blend of 85% MIBC/15% OREPREG X-133 Frother @ 25 g/t  
Frother tested: OREPREG F-603 @ 25 g/t

is used. It was theorised that PAX has been activating auriferous pyrite in the gravity circuit, so that the gold reports to flotation rather than being collected on the tables and that new collector suite enables a smoother operation.

AEROPHINE® 3418A Promoter has also demonstrated benefits in replacing xanthates by providing significant metallurgical improvements and other benefits like significantly lower dosage and optimisation of circuit performance, due to its unusually rapid flotation kinetics and stable grade-recovery relationships.

scale, ten-day, plant trial. The standard mill promoter and frother were sodium amyl xanthate and MIBC, respectively.

Figure 3 shows that copper recovery was increased by 8% and reagent dosage was reduced by 50%. Frother consumption was unchanged. AEROPHINE 3418A Promoter also induced minor improvements in zinc grades and recoveries. Zinc recovery in the copper concentrate and copper recovery in the zinc concentrate were essentially the same for both collectors. The improvements experimented in copper metallurgy alone, more than justified the change to this Promoter.

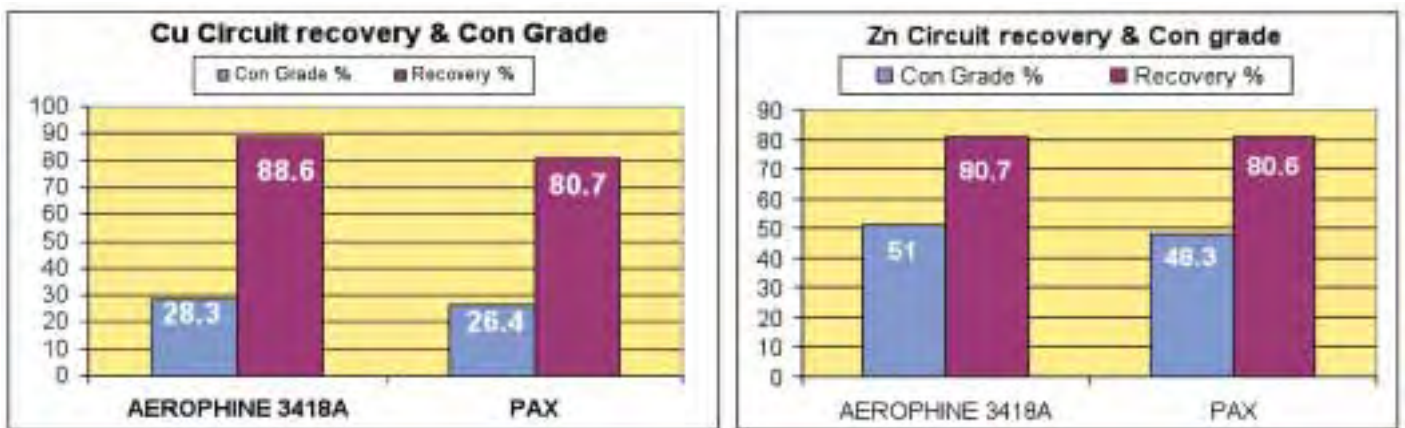


Figure 3 - Concentrate grade and recovery results

Ore from a chalcopryite-sphalerite deposit was being milled at a rate of approximately 10,000 t/d. The concentrator used a conventional flowsheet of copper flotation followed by copper sulphate activation and zinc flotation. After successful laboratory tests, AEROPHINE 3418A was introduced for a full-

In both examples, on top of the metallurgical benefits described, the operations increased sustainability by:

- 1) Reducing the exposure of the employees – Both MAXGOLD and AEROPHINE 3418A are used 'as is', therefore there is not exposure in preparation
- 2) Both MAXGOLD and AEROPHINE have a greener profile when compared to xanthate.

One grinding and flotation test section was compared to the remaining standard seven sections on its side for a period of four months. During the four-month trial, 214 test comparisons were made from 255 test shifts and compared to 237 standard comparisons that were made during a six-month pre and during trial period from 365 standard shifts.

**Table 2 – Operational data**

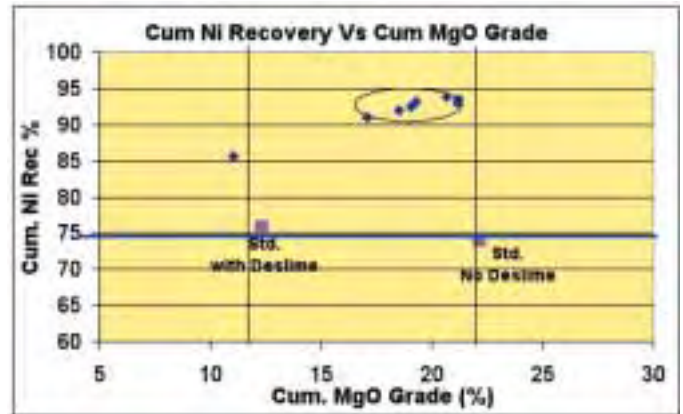
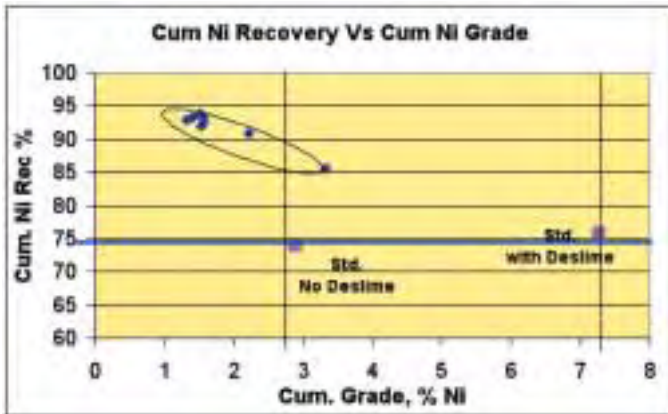
	AEROPHINE 3418A Promoter	Sodium Amyl Xanthate
Heads, % Cu	0.97	0.84
% Zn	1.21	1.59
<b>Reagent Consumption g/t</b>		
Cu Rougher Float	17	24
Zn Rougher Float	0*	10

**Table No. 3 - Rougher Flotation Recovery Results**

	%Cu recovery	% Mo recovery
Standard	84.1	78.1
OREPREP F-603	85.8	79.3

The trialed frother OREPREG F-603 improved the test section results by an average of 1.72% in copper recovery and an average of 1.23% in moly recovery.

# BETTER METAL RECOVERY



Statistical analysis (t-test for samples with unequal variances) shows that this difference is significant at the 95% confidence level; proving the metallurgical enhancement in the process when using OREPREP F-603 as a replacement of the standard MIBC blend.

## Modifier

The industry has reached a point in which the 'good' mineral reserves were depleted and the more challenging ores cannot be treated with standard technologies and processes. Therefore, new technologies need to be developed to convert these resources into profitable reserves.

In mining reagents, collectors and frothers are considered major players to achieve successful flotation; however, modifiers are the unsung reagents that help optimise a plant's processes. Unfortunately, modifiers are often avoided because, although they can help to amplify gains, they can equally hinder gains when not properly understood and dosed without statistical analysis, as is also the case with collectors and frothers.

Cytec has been working to better understand the interactions and effects of modifiers.

Current efforts are converting untreatable resources into profitable reserves as slimes are controlled with new modifiers. Cytec has been working on a nickel ore that has demonstrated untreatable slime characteristics.

In Figure 4, are demonstrations of the test results showing the marked improvement when using a Cytec chemical system of frother, collector, and modifier when compared to the standard reagent suite: xanthates and MIBC.

The metallurgical benefits are a significant increase in both nickel and sulphur recoveries from 75% to higher than 90%, while keeping the MgO content in the concentrate in specification. Other than that, the new chemical system composed of collector, frother and modifier; allows the elimination of the desliming circuit and the possibility of processing at higher solids what enables significant savings in energy and costs. **IM**

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