UPDATE ON GLYCAT™ LEACHING OF GOLD ORES AND CONCENTRATES

Presenter and Corresponding Author
Dr Glen O'Malley,
R & D Manager (Commercial Technologies)
gomalley@mpsinnovation.com.au

Talk Outline

- Background
- Chemistry
- Leaching Testwork
- Continuous Piloting and Demonstration
- Questions

Draslovka: Leader in CN-Based Chemistry

- Global leader in CN-based chemicals
- World's largest producer of sodium cyanide
- Private holding company based in the Czech Republic, owned by a leading family with office based in Prague
- Operations in Czech Republic, United States, Australia, South Africa & India
- Over 100 years of experience in hydrogen cyanide (HCN) production and chemistry
- Over US$1Bn in assets. T/O >US$500m pa
- Owners of Mining and Process Solutions (MPS) and the Glycine Leaching Technology developed by Curtin University

What is Glycine?

- Glycine is an amino acid which is non-toxic chemical, classified as non-dangerous good that is fully bio-degradable
- It is used as a food additive for both humans and animals and has sugar-like appearance
- It generally is cheaper than cyanide and readily available from at least 20 different manufacturers
- Is unique in its ability to selectively leach both base and precious metals leaving iron, mercury, or arsenic in residue
- It is not chemically consumed so as a primary reagent it is recoverable and recyclable – providing a major advantage in costs
- Works synergistically with a range of lixiviants

Cyanidation Chemistry

Gold

$$Au^{+} + 2\,(CN)^{-} \rightarrow Au(CN)_2^{-} \quad logK = 39.3$$

$$Au + 2\,CN^{-} + 0.25\,O_2 + 0.5\,H_2O \rightarrow Au(CN)_2^{-} + OH^{-}$$

Copper

$$Cu + 2\,CN^{-} + 0.5\,O_2 + H_2O \rightarrow Cu(CN)_2 + 2\,OH^{-}$$

$$Cu(CN)_2 + CN^{-} + OH^{-} + 0.25\,O_2 \rightarrow Cu(CN)_2^{-} + OCN^{-} + 0.5\,H_2O$$

$$Cu(CN)_2^{-} + CN^{-} \rightarrow Cu(CN)_3^{2-}$$

Overall for Copper

$$Cu + 4\,CN^{-} + 0.75\,O_2 + 0.5\,H_2O \rightarrow Cu(CN)_3^{2-} + OCN^{-} + OH^{-}$$

Overall for Gold and Copper

$$Au + Cu + 6\,CN^{-} + O_2 + H_2O \rightarrow Au(CN)_2^{-} + Cu(CN)_3^{2-} + OCN^{-} + 2\,OH^{-}$$

Cyanidation Chemistry

- How operator deal with high cyanide consuming ore that contain copper they adopt technologies like ReCYN or SART i.e., accept what cyanide is needed (high) and recover back what they can to recycle
- SART works by making the copper (I) cyanide (WAD) unstable and precipitate as a copper sulphide by acidifying down to at least pH of 4

$$2\ Cu(CN)_3^{2-} + S^{2-} + 3\ H_2SO_4 \rightarrow Cu_2S + \ 6\ HCN + \ 3\ SO_4^{2-}$$

- How much cyanide gets recovered depends on the cyanide speciation where recoveries between 25-70% are typical
- Unfortunately, any iron cyanide is not recovered with SART as you need to drop the pH to below 1 to make that happen
- Also any cyanate or thiocyanate is not recovered or is reusable cyanide

GlyCat™ Chemistry

Gold

$$Au^{+} + NH_3CH_2COO^{-} + CN^{-} \rightarrow Au(NH_2CH_2COO)(\mathrm{CN})^{-} \quad logK{\sim}36.0$$

$$Au + NH_2CH_2COO^{-} + \ CN^{-} + 0.25\ O_2 \ + \ 0.5\ H_2O \rightarrow Au(CN)\big(NH_2CH_2COO\big)^{-} + \ OH^{-}$$

Copper

$$Cu + 2\ CN^{-} + NH_2CH_2COO^{-} + 0.5\ O_2 + \ H_2O \rightarrow Cu(CN)_2(NH_2CH_2COO)^{-} + \ 2\ OH^{-}$$

$$Cu(CN)_2(NH_2CH_2COO)^{-} + NH_2CH_2COO^{-} \rightarrow \ Cu(NH_2CH_2COO)_2 + 2\ CN^{-}$$

$$Cu(CN)_2(NH_2CH_2COO)^{-} + OH^{-} \rightarrow \ Cu(CN)(NH_2CH_2COO)^{-} + CN^{-}$$

$$Cu(CN)(NH_2CH_2COO)^{-} + NH_2CH_2COO^{-} + 0.25\ O_2 + 0.5\ H_2O \rightarrow \ Cu(NH_2CH_2COO)_2 + CN^{-} + OH^{-}$$

Overall for Copper

$$Cu + 2\ NH_2CH_2COO^{-} + 0.5\ O_2 \ + \ H_2O \rightarrow Cu(NH_2CH_2COO)_2 + \ 2\ OH^{-}$$

Overall for Gold and Copper

$$Au + Cu + 3\ NH_2CH_2COO^{-} + CN^{-} + 0.75\ O_2 \ + \ 1.5\ H_2O \rightarrow Au(CN)(NH_2CH_2COO)^{-} + Cu\big(NH_2CH_2COO\big)_2 + \ 3\ OH^{-}$$

GlyCat™ Chemistry

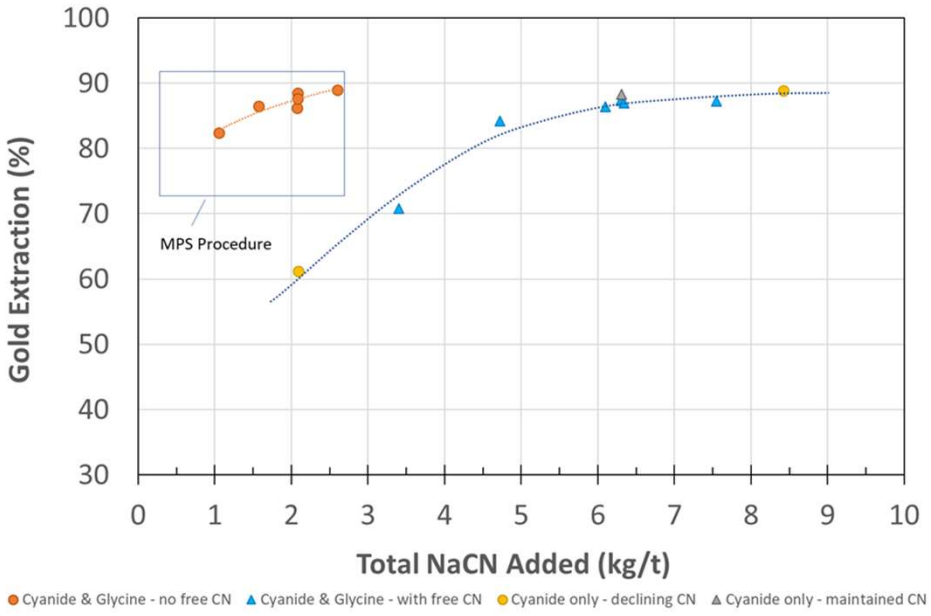
- Works by starving the available cyanide which forces the utilisation of WAD and even SAD metal complexes to give up their cyanide for precious metal leaching
- Can achieve 50-95% reduction in cyanide needed to extract the same or greater amount of precious metals compared to cyanidation
- Kinetics tend to be equivalent or faster than cyanidation
- Copper is converted to copper (II) in solution
- Final PLS is very low in cyanate and thiocyanate compared to cyanide
- Much easier to recover the copper or any other base metals in solution through precipitation, IX or SX
- Can use existing processes like activated carbon or Merrill Crowe to recover the precious metals

Discovered for Process Control

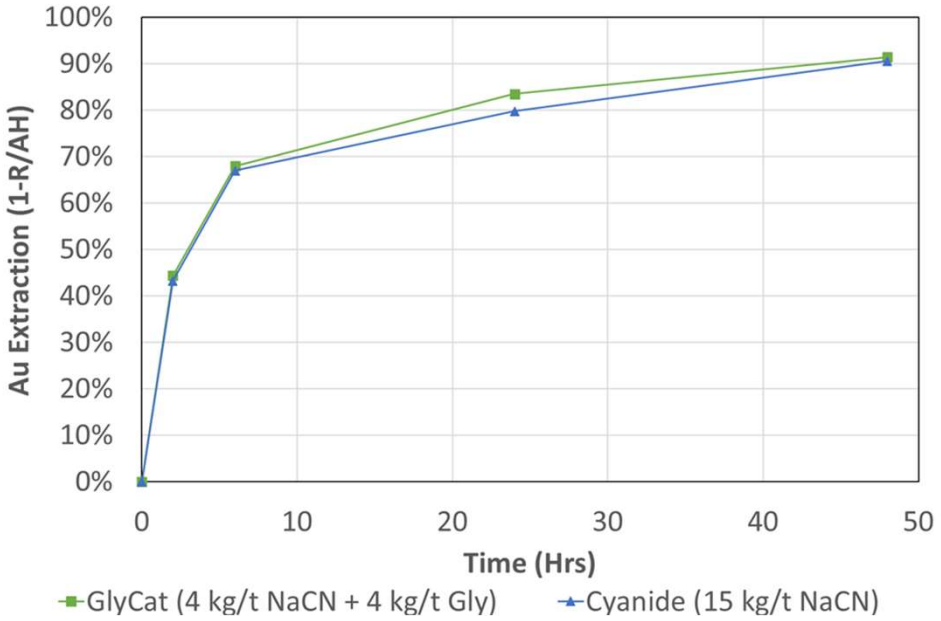
- Need to add optimal cyanide (too little or too much give poor results)
- Need to add optimal oxygen (too little or too much gives poor results)
- Glycine needs a minimum, but excess only increases copper extraction
- If you recover your solution, you will recycle glycine
- Glycine main losses (<5%) occur through adsorption and water loss in the residue
- Glycine oxidation (<1%) can occur, but we have determined to be minimal under operating conditions

Concentrate Leaching Examples

Example 1 19.5 g/t Au, 0.28% Cu



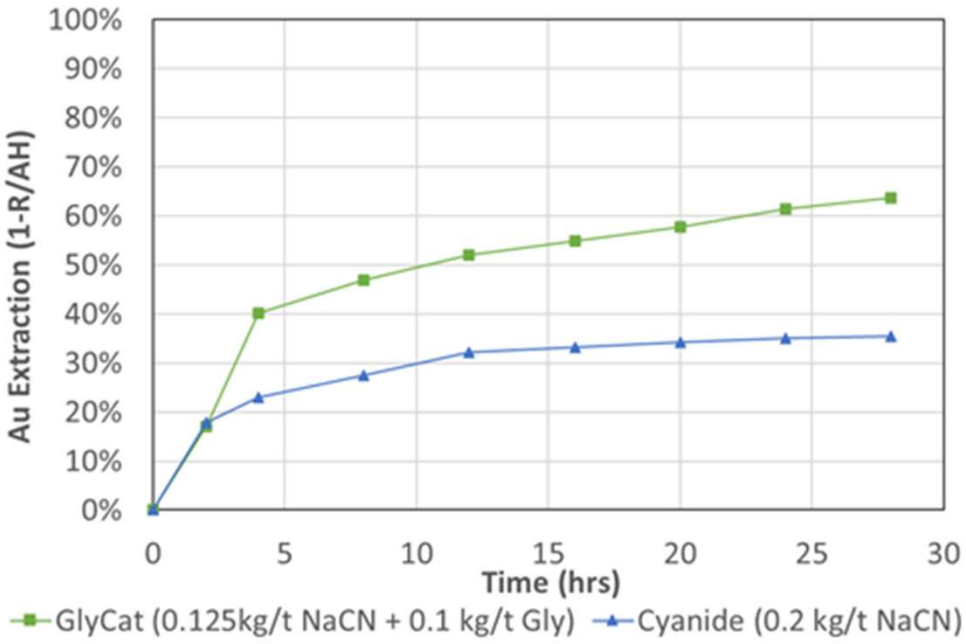
Example 2 35.9 g/t Au, 0.36% Cu



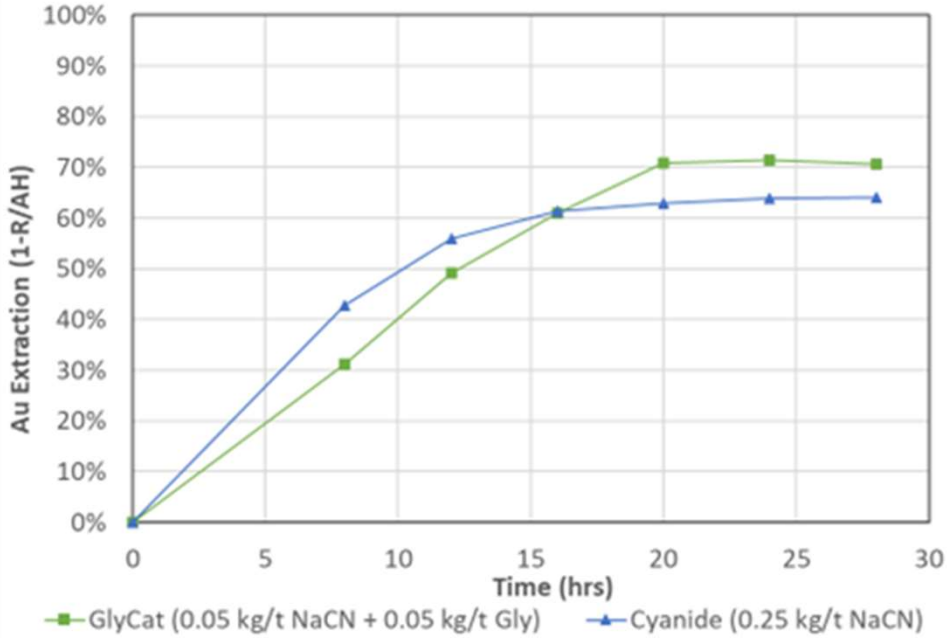
BRTs, 40% Solids, pH 10.5 and room temperature

Flotation Tails Leaching Examples

Example 1 0.24 g/t Au, 0.08% Cu



Example 2 0.2 g/t Au, 0.1% Cu



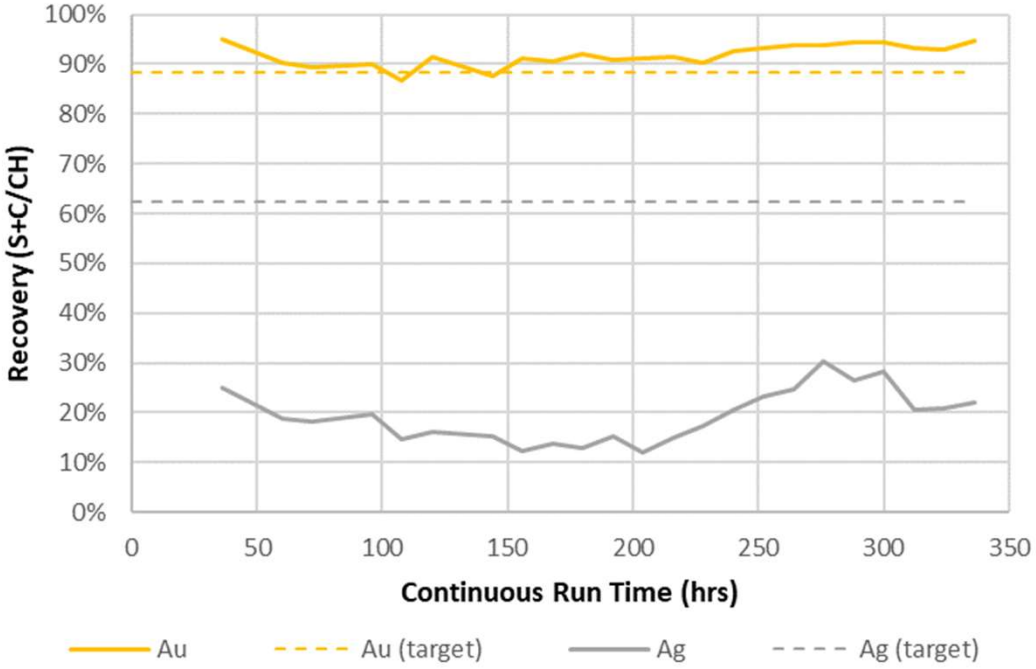
BRTs, 50% Solids, pH 10 and room temperature

Pilot Plant

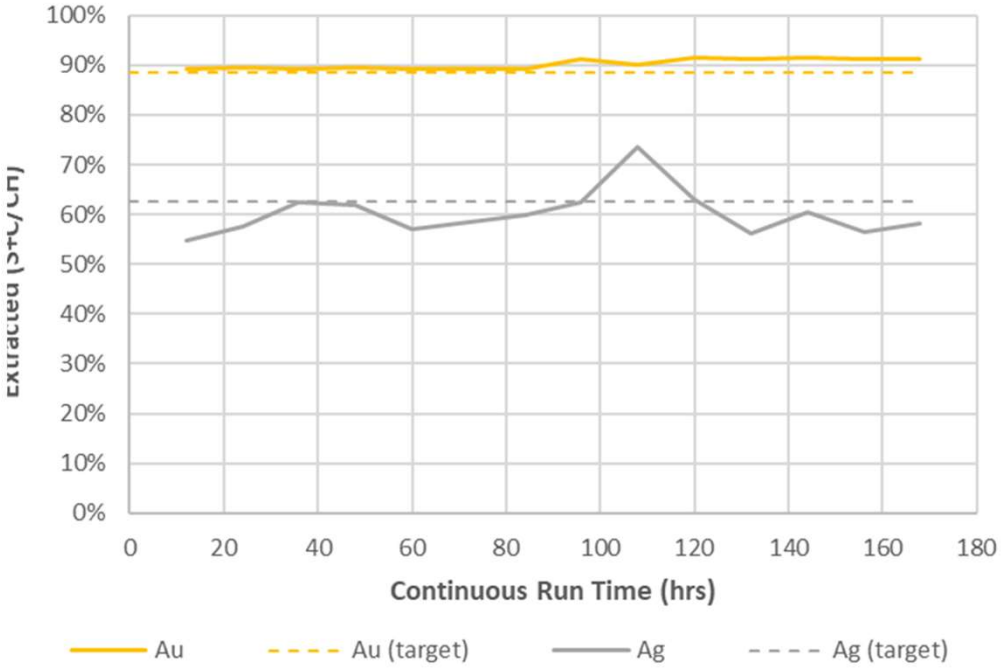

Six leach tanks
6 x 50L Leach Tanks with Air Spargers and Reagent Addition fed by Peristaltic Pump
Leach feed tank
Six Adsorption tanks
Adsorption feed tank
Feed material (Feed tank)
Reagent tank
Gravity-flowed through the tank to Leach Tails Tank
Adsorption tails tank

Pilot Results for Concentrate

Carbon in Pulp (CIP)



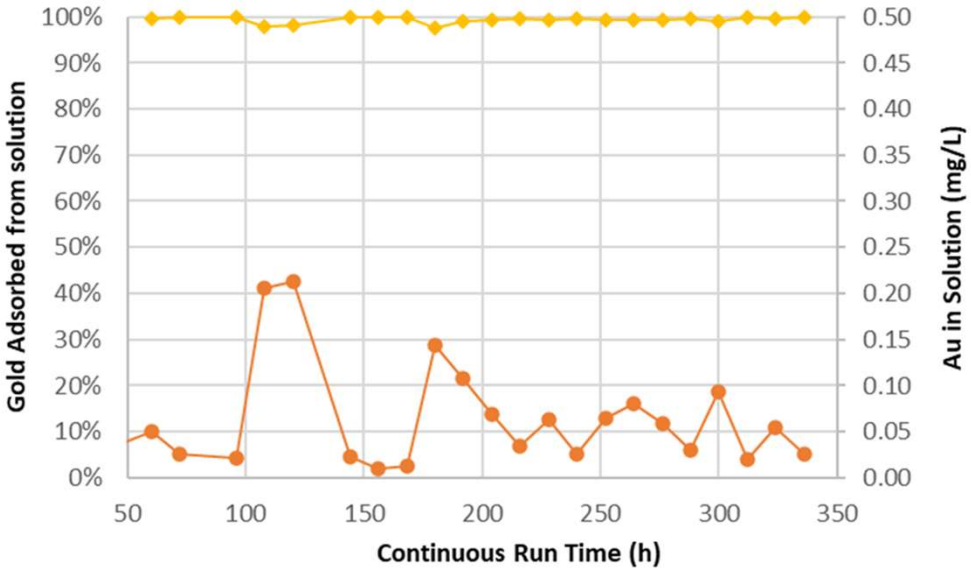
Carbon in Leach (CIL)



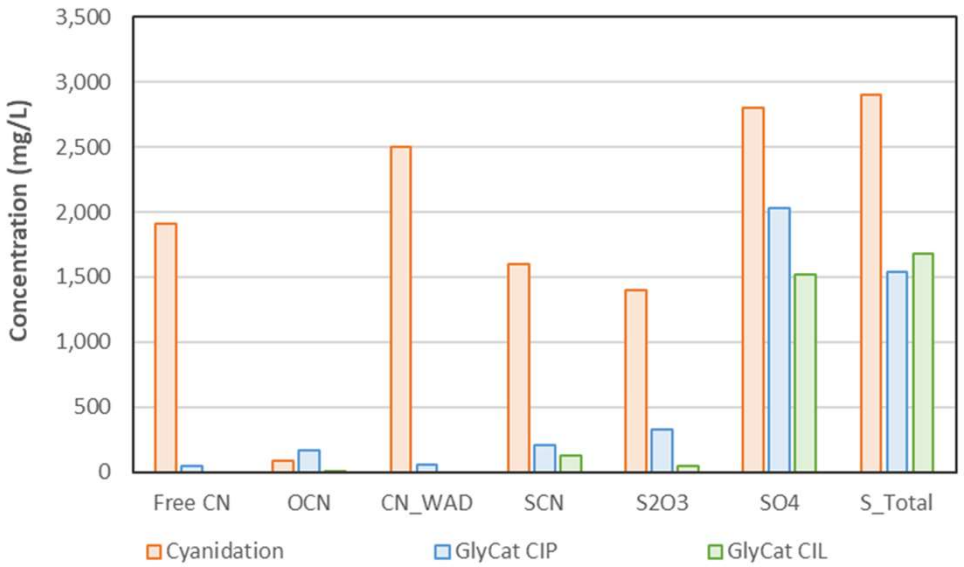
40% Solids, pH 10.5, room temperature, 43 hrs leach

Pilot Results for Concentrate

Carbon in Pulp (CIP)



Cyanide and Sulphur Speciation



12.5 g/L carbon, 28 hrs adsorption, 1,000 g/t Au (CIP), 2000 g/t Au (CIL)

Demonstration Projects

- Draslovka is committed to conducting 10 demonstration with the Glycine Leaching Technology in 2023
- Currently have commitment for 7 demonstrations

Overall Comparison

Item	Cyanidation	GlyCat™
% Solids	40-60%	40-60%
pH	8.9-12	8-12.5
Residence time (hrs)	24-48	24-48
Free cyanide maintained	>0.01% or 100 ppm	<10 ppm
DO (mg/L)	>8	4-5
HCN generation	5-20%	<1%
Gangue Dissolution	Cu, Zn, Ni, Co, Fe, Hg, As	Cu, Zn, Ni, Co
WAD Cyanide (mg/L)	20-100	<10
Residual Free Cyanide (mg/L)	20-200	<1

Conclusions

- GlyCat™ is a uniquely new process being a dual lixiviant and dual oxidant when in the presence of copper
- GlyCat™ can effectively leach the same or greater precious metals from ores, concentrates or tailings at reduced cyanide addition
- This equates to reduce operating cost along with less detox if any is needed at all
- Glycine only complexes metals and is relatively stable so can be recycled
- Metal can be recovered from solution using existing methods

Questions?