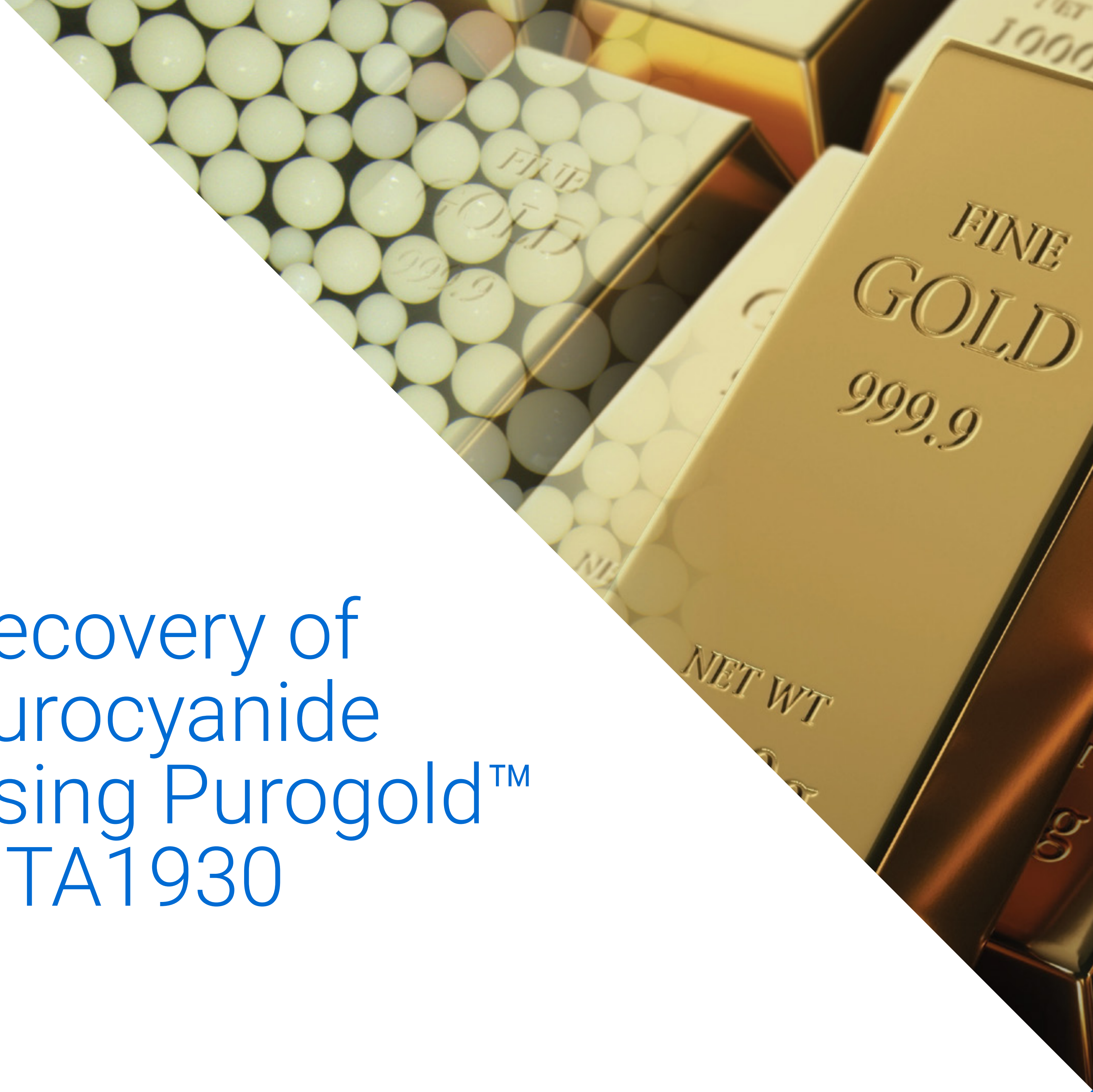

Recovery of Aurocyanide Using Purogold™ MTA1930

This Engineering Bulletin provides information and engineering data for using Purogold MTA1930 for gold recovery from cyanide solution. A general overview of gold processing and extraction from ore is also provided.

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Introduction

Purogold MTA1930 is a macroporous polystyrene crosslinked with divinylbenzene anion exchange resin, primarily designed for effective recovery of aurocyanide complexes obtained from alkaline cyanide processing of gold ores. Due to properly tailored strong base functionality, the resin has superior selectivity for gold against the base metals existing in pregnant solution. The resin is supplied in bead form with a specially graded particle size required by resin-in-pulp gold recovery circuits. This grade is also suitable for use in fixed and fluidized beds for processing of filtered or heap leach solutions. This document provides information and engineering data for using Purogold MTA1930 for the recovery of gold from cyanide solution.

Gold Processing and Extraction

There are different industrial methods of gold mining. They can be roughly divided into two main groups:

- Gravimetric separation of nugget gold (gold sand)
- Hydrometallurgical processing of gold ores

In both cases, the gold ore is usually crushed and milled before further processing. In the first case, metallic gold is separated from a mineral body due to the exceptional density of the metal. In the second, gold — included as very fine particles in the mineral body — is leached by special reagents and then recovered from this pregnant leach solution (PLS) by various chemical methods. Ion exchange resins, such as Purogold MTA1930, can be used for gold recovery from the PLS, providing advantages over activated carbon.

The physical and chemical process of gold extraction from ore typically consists of the following stages:

- Ore excavation, crushing and milling
- Leaching of gold from the milled ore
- Sorption of gold from the PLS
- Desorption of gold from the loaded sorbent
- Production of metallic gold from concentrated desorbate (Doré alloy or similar)

When gold is included in the minerals as fine metal particles, milling of the ore allows the lixiviant components to reach the gold particles and dissolve them.

There are two general types of gold ores:

- Sulfide ores — gold particles are trapped by the ore and cannot be penetrated by leachate solution, either physically or chemically; these are also called refractory ores
- Oxide ores

Removing gold from sulfide ore requires high temperature heating and high pressure to oxidize the minerals entrapping the gold before leaching can occur.

The most economical method of leaching oxide ore is dependent on the concentration of gold in the ore (the grade) and the mineralogy of the ore. Methods of leaching typically include:

- Heap leaching
- Leaching of milled ore in different vessels or autoclaves with agitation
- Leaching of gold with simultaneous sorption on the resin in the same vessel

For heap leaching, the milled and classified ore is stockpiled in heaps on specially lined pads.

Sprinkling system on the top of the ore heap. The heaps are sprinkled with lixiviant through a top distribution system.

Collector pond for the pregnant gold solution between the operating heap and dam.

The solution percolates through the ore heap and is collected in the pregnant liquor ponds from where it is pumped to the sorption plant. The volume of an operating heap can vary from several hundred thousand to 1.5 million tons of ore. Typically, a heap is leached for one year while a new one is prepared to replace it.

The gold bearing cyanide solution on the top of an ion exchange column.

Design of gold sorption circuits can be based on different techniques:

- Filtrated “clean” solutions may be processed in packed bed columns
- Turbid solutions and light pulps (up to 10% suspended solids) can be treated in fluidized bed columns
- Sorption directly from a dense pulp (slurry) with up to 50% solids, in vessels equipped with agitation systems

Fluidized bed ion exchange columns

Solutions for the first two options above are produced by heap leaching operations or vat leaching followed by solids decantation.

Sorption from dense pulps is an economically efficient method because it allows the elimination of a costly liquid-solids separation stage.

For oxidized ores, both leaching and sorption processes can run simultaneously in the pulp; such a method is called “resin-in-leach” (RIL). In other cases, such as during processing of more difficult sulfide ores, the ore is leached in separate vessels or autoclaves under increased pressure and temperature. The process of sorption from the resulting pulp is called “resin-in-pulp” (RIP).

Usually, sorption from pulps is arranged in a counter-current cascade of several vessels. The resin is separated from the pulp by simple mechanical filters, and transfer of the resin from stage to stage is achieved by airlifting.

Desorption of gold is carried out in separate columns. Cyanide solution, sulfuric acid and weak thiourea sulfate solution can be used for removal of impurities from the resin, while gold is stripped by a more concentrated solution of thiourea in sulfuric acid. After gold desorption, the resin must be converted back to its working form by alkali treatment.

As the resin is being cycled through the process stages, it experiences hard mechanical impacts generating resin fines. The resin losses from these fines can reach 12 to 60 mL per ton of processed ore.

The acidic thiourea eluate obtained has a gold concentration of 0.3–1.5 g/L and is ready for deposition of gold by electrolysis. The gold deposit is smelted to Doré alloy, which is an alloy of gold (typically 70–90%) with silver and some base metal admixtures. The Doré alloy is processed further to 99.99% purity.

Resin with a large bead diameter is required in RIL and RIP operations to ensure ease of separation of the resin from the pulp. These resins must also have high mechanical strength to withstand the harsh pulp environment.

Gold Selective Ion Exchange Resins

The most common method for gold leaching is based on the application of sodium cyanide at a pH 10 to 11.5 in the presence of an oxidizing agent — usually oxygen from air — but other oxidizing agents may be used. This process is referred to as cyanidation. Cyanide anions form a very strong anionic complex (aurocyanide) with oxidized gold.

Silver behaves very similar to gold in this process. The ore usually contains many other components, such as base non-ferrous metals (copper, nickel, cobalt, zinc) and iron, which also form strong anionic complexes with cyanide. These complexes compete with gold for the ion exchange sites on the resin.

A typical gold PLS is listed in Table 1. Ecolab's special gold selective resin, Purogold MTA1930, has a higher selectivity for the aurocyanide complex than for the other metal-cyanides present. The amount of gold loading onto the resin that can be achieved is dependent on the feed solution/pulp composition, but is typically 1–12 g/L.

TABLE 1 Typical composition of gold pregnant solution after ore cyanidation (mg/L)

Au	Ag	Cu	Ni	Co	Zn	Fe	pH
0.5–15	1.6–95	9–93	3–70	0.4–5	1.3–4	0.9–21	10–12

The concentration of each individual metal in the pregnant solution depends on the ore type and mineralogy and therefore varies from ore body to ore body.

Ion Exchange Resins Versus Activated Carbon

Coconut-based activated carbon has been used for the recovery of gold from cyanide solutions for many years. Processes using this technology are called, “carbon-in-leach” (CIL) and “carbon-in-pulp” (CIP).

There are approximately thirty operating plants around the world using ion exchange resin for the recovery of gold in the cyanidation of ores. These are located in China, Malaysia, Australia and the Former Soviet Union (FSU). Purogold MTA1930 has extracted over 1,200 metric tons of gold worldwide since 1994.

Preg-Robbing Ores

Some gold ores contain high amounts of natural carbonaceous matter (often called “preg-robbing” ores) and this organic matter readily adsorbs dissolved gold, significantly reducing the achievable metal recovery. Synthetic ion exchange resin has proven to be much more efficient than activated carbon for the processing of preg-robbing ores due to a higher affinity for aurocyanide than that of the carbonaceous matter in the ore.

Choosing a Sorbent Material

Ion exchange resin and activated carbon are compared in Table 2. The best sorbent (carbon or resin) will depend on the specific conditions in each mine.

TABLE 2 **Benchmarking of activated carbon and ion exchange resin for gold recovery**

Parameter	Ion Exchange Resin	Activated Carbon
Purchasing Cost of the Sorbent	More	Less
Operational Losses of the Sorbent	Less	More
Gold Operating Capacity	More	Less
Gold Selectivity	Less	More
Desorption and Regeneration Costs	Less	More
Resistance to Industrial Organics Fouling	High	Very Poor
Tolerance to Hardness Scaling	High	Poor
Resistance to Blockage of the Sorbent Pores by Fine Clays	High	Poor

Purogold MTA1930

Developed by Ecolab, this unique resin features optimally balanced weak and strong base anion exchange groups and provides the best selectivity for gold. It was first used in 1992 at the Aldanzoloto gold mine in the former Soviet States. The Aldanzoloto mine uses a cyanide RIP process.

Purogold MTA1930 is superior to standard strong base anion exchange resins for the recovery of gold from cyanide solution as standard resins have less selectivity and, consequently, less gold capacity when complex PLSs are processed.

TABLE 3 Typical physical and chemical properties of Purogold MTA1930 resin

Characteristics	Description/Value
Polymer Structure	Macroporous Polystyrene Crosslinked with Divinylbenzene
Appearance	Spherical Beads
Functional Group	Mixed Tertiary Amine and Quaternary Ammonium
Ionic Form	Cl^- form
Dry Weight Capacity (min.)	3.8 eq/kg (Cl^- form)
Moisture Retention	46–56 % (Cl^- form)
Particle Size Range	800–1300 um
Reversible Swelling, $Cl^- \rightarrow OH^-$ (max.)	22%
Specific Gravity	1.06
Shipping Weight (approx.)	645–665 g/L (40.3–41.6 lb/ft^3)
Temperature Limit	100 °C (212.0 °F) (Cl^- form)
Temperature Limit	60 °C (140.0 °F) (FB form)

Ecolab is a global developer, manufacturer, and supplier of Purolite™ Resins including ion exchange, catalyst adsorbent and advanced polymers that make the world cleaner and healthier.

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