

Gold Recovery with Purolite® A100/2412 ion exchange resin

Hydrometallurgy

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PUROLITE[®]
ION EXCHANGE RESINS

Recovery of aurocyanide using Purolite® A100/2412 resin

Introduction

This introduction covers the application of Purolite ion exchange resins for gold recovery from cyanide solution.

There are different industrial methods of gold mining. We can roughly divide them in two main groups:

1. Gravimetric separation of nugget gold (gold sand);
2. 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 metals' exceptional density. 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 **Purolite® A100/2412**, 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:

1. Ore excavation, crushing and milling.
2. Leaching of gold from the milled ore.
3. Sorption of gold from the PLS.
4. Desorption of gold from the loaded sorbent.
5. Production of metallic gold from concentrated desorbate (Doré alloy or the like).

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.

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. Purolite's special gold selective resin, **Purolite® A100/2412**, has a higher selectivity for the aurocyanide complex than for the other metal-cyanides present.

Table 1. Typical composition of gold pregnant solution after cyanidation of ore (mg/liter):

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.

There are two general types of gold ores:

- Oxide ores; the contained gold is readily available for gold leaching.
- Sulfide ores; contain gold particles that are occluded by sulfide minerals resistant to cyanide leaching.

The most economical method of leaching is dependent on the concentration of gold in the ore (the grade) and the mineralogy of the ore and can typically be:

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

Photo 1 (right). Stockpiling of classified ore on a specially prepared pad for further leaching

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



Photo 2 (left). Sprinkling system on the top of the ore heap (white mass on the surface is snow).

The heaps are sprinkled with lixiviant through a top distribution system.

Photo 3 (right). 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 tonnes of ore. Typically, a heap is leached for one year while a new one is prepared to replace it.





Photo 4. (left) The gold bearing cyanide solution on the top of an ion exchange column

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

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



Photo 5. (left) 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 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).

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/liter.

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 tonne of processed ore.

The acidic thiourea eluate obtained has a gold concentration of 0.3 – 1.5 g/liter 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.

Ion exchange resins versus activated carbon

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 States (FSU).

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).

Which sorbent is better?

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	comparable	comparable
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

Some gold ores contain high amount 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 for the processing of “preg-robbing” ores due to a higher affinity for aurocyanide than that of the carbonaceous matter in the ore.

Purolite® A100/2412 is a unique resin with optimally balanced weak and strong base anion exchange groups providing 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.

Standard strong base anion exchange resins have less selectivity and, consequently, less gold capacity when complex PLS’s are processed.

Purolite® A100/2412 has extracted over 1200 metric tones of gold worldwide since 1994!

General Properties of Purolite® A100/2412 resin

Basic features	
Application	Gold recovery from PLS after cyanidation of gold ores
Polymer Structure	Macroporous polystyrene cross-linked with divinylbenzene
Appearance	Spherical Beads
Functional Group	Strong and Weak Bases
Ionic form as shipped	Chloride Form

Typical Physical and Chemical Properties	
Total Anion Exchange Capacity (min.) (Cl ⁻ form)	3.80 eq/l
Particle Size Range	800 - 1200 µm
<700 µm (max.)	1%
Moisture Retention (Cl ⁻ form)	46 - 56 %
Specific Gravity	1.04 - 1.06 g/ml
Temperature Limit (Cl ⁻ form)	100 °C (212 °F)
pH Limits (stability)	None

Americas

Purolite
150 Monument Road
Bala Cynwyd, PA 19004 USA
Telephone +1 610 668 9090
Telephone +1 800 343 1500
Fax +1 610 668 8139
Email info@puroliteusa.com

Europe

Purolite International Ltd
Llantrisant Business Park
Llantrisant
Wales
CF72 8LF
UK
Telephone +44 81 572 7726
Fax +44 81 577 1436
Email sales@purolite.com

Asia Pacific

Purolite (China) Co Ltd
Room 707, C Section
Huanglong Century Plaza
No. 3 Hangda Road
Hangzhou, Zhejiang
China.310007
Telephone +86 571 87632229
Fax +86 571 87631385
Email info@purolitechina.com

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