CASE STUDY:

ResinTech SIR-500 In Copper Sulfate Electrolyte Purification

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Challenge

A copper mining company in Chile located at 2,850 m above sea level (9,350 ft asl) has a copper electrorefining capacity of 289K MTon (637M lb) per year. The Copper electrorefining process is an electrochemical process where the raw copper is placed as the anode, and it is dissolved in a sulfuric acid solution at 20% w/w, and a stainless steel plate is placed as the cathode. Electricity is applied to the created cell to move the now dissolved copper ion to the cathode. In principle, the dissolved copper will be deposited on the cathode. This deposited copper should be of an extra pure quality (> 99.999%). In reality, the copper anode has many impurities from the mining process, including the composition of the copper itself. Some of these impurities produce short circuits that generate a low-quality cathode and interrupt the electrorefining process in the cells. Bismuth (Bi^{+3}) and Antimony (Sb^{+3}) are the main impurities that interfere with this process. A process is required to purify the $CuSO_4$ electrolyte solution to reduce the concentration of Bi^{+3} and Sb^{+3} under 0.05 g/l concentration to prevent the short circuits created by those elements, thereby increasing the deposited copper purity on the cathode and improving the whole purification process. To reduce the concentration of Bi^{+3} and Sb^{+3}, ResinTech's Technical Department recommended using their selective resin SIR-500.

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ResinTech SIR-500 is a polystyrene macroporous chelating weak acidic cation resin functionalized with aminophosphonic acid chelating groups. Its selectivity in normal acidic conditions (pH > 3.0 < 7.0) is as follows,

$$Pb^{+2}>Cu^{+2}>Zn^{+2}>Mg^{+2}>Ca^{+2}>Ni^{+2}>>Na^{+}$$

On the other hand, in normal alkaline conditions (pH > 7.5 < 10.5), its selectivity changes to,

$$Cd^{+2}>Mg^{+2}>Ca^{+2}>Sr^{+2}>Al^{+3}>Ba^{+2}>>Na^{+}$$

However, in extreme acidity conditions (pH ≤ 2), the SIR-500's selectivity enhances as follows,

$$Sb^{+3}, Sn^{+4}, In^{+3}, Bi^{+3}, Sb^{+5}, Fe^{+3}, Ge^{+4}, Zr^{+4}, Ti^{+4}> Mo^{+6}, V^{+5}> Cu^{+2}, Al^{+3}, Ga^{+3}> Pb^{+2},$$

$$Sn^{+2}, Cd^{+2}, Fe^{+2}> Be^{+2}, Mn^{+2}> Co^{+2}>Ni^{+2}, Zn^{+2}> Ca^{+2}, Mg^{+2}>> Na^{+}$$

Because of its unique enhanced selectivity under extreme acidity conditions and its very high complexing capacity for Sb, Bi (8.7 g/l and 1.68 g/l, respectively), ResinTech's SIR-500 was selected as the best available $CuSO^4$ purifying media for reducing Sb^{+3} and Bi^{+3} concentrations with low removal of Cu^{+2}.

2. THE $CuSO_4$ ELECTROLYTE COMPOSITION

The $CuSO_4$ electrolyte's composition is for batches, and the quality and composition of those batches vary according to the anode's copper composition. Therefore, we are using an average composition as follows:

Circuit (Cell) 20 # 9546579 $CuSO_4$ Electrolyte

Substance	Concentration in g/l
H_2SO_4	200
Cu^{+2}	41
Sb^{+3}	0.3
Bi^{+3}	0.05
Fe^{+3}	0.1
pH	≤ 2.0

Table #1 $CuSO_4$ electrolyte composition

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The estimated operational cycle based on the electrolyte composition is six hours at a 50 m^3/h (220 gpm) per column for two columns working in parallel for a total of 2,400 m^3 (634K gallons) per day, and one column in standby/regeneration. Each column contains 5,000 liters (176.55 ft^3) of SIR-500.

Electrolytic cells inspection and cathode extraction(Reference image).

3. THE INSTALLED $CuSO^4$ ELECTROLYTE PURIFICATION SYSTEM.

As mentioned before, the installed system has three columns that work at 50 m^3/h for an estimated cycle of six hours. Two columns work in parallel, and the third column is in regeneration/standby. In the near future, the $CuSO_4$ electrolyte purification system will have three additional columns to increase the purification capacity up to 4,800 m^3 per day.

The purified electrolyte is stored in a tank to pump into the electrolytic cells, with both cathodes and anodes submersed in the purified electrolyte kept at 60ºC, with continuous electric current through the cells.

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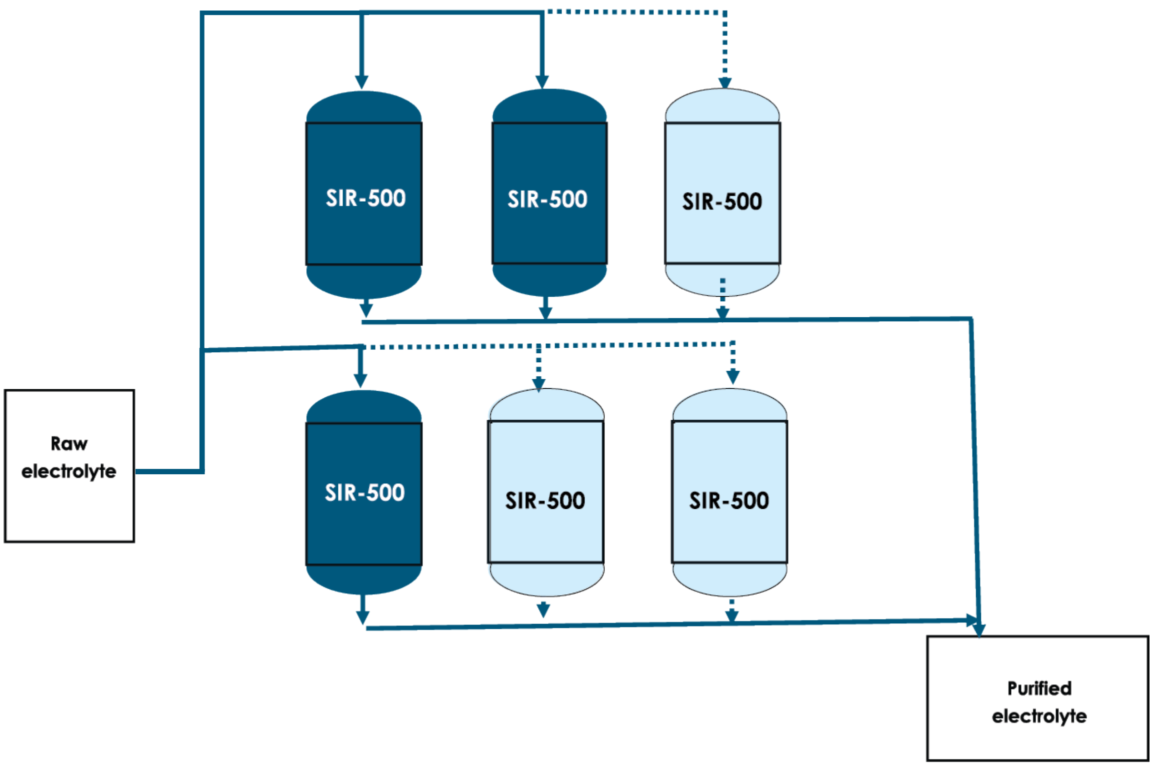
Schematic Design of the Ion Exchange Purification System (IX Plant)



The darker color vessels are the existing and operating equipment; the light-colored vessels are for future operation.

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4. INDUSTRIAL TEST RESULTS

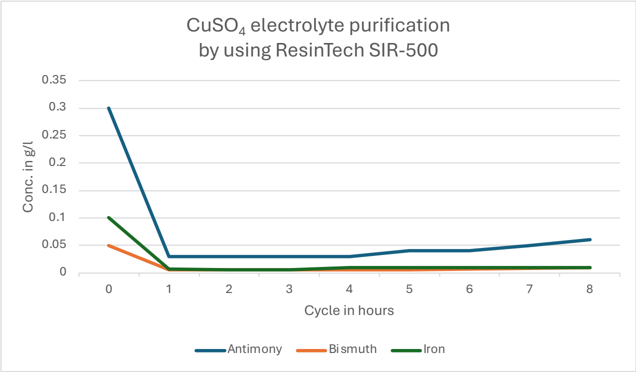
The industrial test was conducted with the average $CuSO_4$ electrolyte described in Table #1.

The calculated operational cycle was estimated for six continuous hours at 50 m3/h (220 gpm) flow rate per column for 100 m3/h (440 gpm), and one column in standby/regeneration.

The industrial test's operational cycle was extended to eight hours for 30 consecutive days with the following results.

Substance	Initial Conc. in g/l	1st hour conc. In g/l	4th hour conc. g/l	8th hour conc. g/l
H_2SO_4	200	200	200	200
Cu^{+2}	41	36.4	36.4	36.7
Sb^{+3}	0.3	0.03	0.03	0.06
Bi^{+3}	0.1	0.005	0.008	0.01
Fe^{+3}	0.1	0.007	0.009	0.01
pH	<1.0	<1.0	<1.0	<1.0

Table 2. Industrial test results for the first 30 operational cycles



Graph #1. $CuSO^4$ purification curve with ResinTech SIR-500

5. REGENERATION

The SIR-500 is intended for regeneration with hydrochloric acid at 20%, followed by neutralization with sodium hydroxide at 20%, and final conversion back to H^+ form using once again HCl @ 20%. This regeneration procedure ensures the proper activation and selectivity of SIR-500.

The acid regenerant eluate has the following characteristics,

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Parameter	Initial Concentration	Final Concentration
HCl	200 g/l	200 g/l
Cu	< 0.05 mg/l	3 g/l
Fe	< 0.01 mg/l	1 g/l
Sb	< 1 mg/l	9 g/l
Bi	< 1 mg/l	2 g/l
Temp.	40º C	40° C
pH	< 0.1	< 0.1
Viscosity	0.75 cPs	0.75 cPs

Table 3. HCl Characteristics before and after regeneration

The copper mining company has a recovery plant for HCl, allowing it to maximize the process efficiency by cutting the cost of the primary reagent used in the SIR-500 regeneration and reducing its environmental footprint in the Atacama desert region.

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