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## The Use of Cyanides in Gold Refineries and the Generation of Wastewater

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**Annotation:** *The relevance of this article is due to the waste of cyanide in wastewater, its high cost and the need to dispose of it before disposal. Sodium cyanide is currently common for precious metals in ores and concentrates and is the only effective solvent in practice. The use of this reagent in the processing of ores containing gold and silver is explained by its ability to form soluble cyanide complexes with gold and silver. At the same time, non-precious metals form complexes with zinc, copper and iron. Thiocyanates are formed when cyanide solutions react with sulfide minerals. All this leads to an increase in cyanide consumption in the selective smelting of precious metals and the formation of wastewater containing highly toxic compounds.*

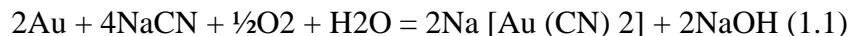
**Keywords:** *Cyanides, floto concentrates, sulfides, thiosulfates, non-ferrous metal ions.*

Cyanides are formed and used in various industrial processes, such as galvanic plating, coke extraction, organic synthesis, leaching of rare metals from ores and flotation concentrates with cyanide, and so on. Today, many gold miners extract gold from flotation concentrates by flotation enrichment by cyanide leaching of the metal. In addition, the wastewater and circulating water of enterprises are multi-component, containing other toxic compounds in the same column with cyanide - non-ferrous metal ions, flotation reagents, sulfides, thiosulfates, etc. scheme, the composition of the substance being processed, and so on. Typically, such facilities use closed, water-use cycles with special waste storage facilities.

Hydrometallurgical methods are mainly used in gold production worldwide. Gold refineries are formed as a result of the separation of cyanide-containing wastewater from minerals containing gold and its compounds in the form of pure and semi-finished products from gold and related precious metals. The most widely used solution for the conversion of gold is sodium cyanide. Sodium cyanide is currently widely used for precious metals in ores and concentrates and is the only cost-effective solvent in practice. The use of this reagent in the processing of ores containing gold and silver is explained by its ability to form soluble cyanide complexes with gold and silver. At the same time, non-precious metals form complexes with zinc, copper and iron. Thiocyanates are formed when cyanide solutions react with sulfide minerals. All this leads to an increase in cyanide consumption in the selective smelting of precious metals and the formation of wastewater containing highly toxic compounds.

One of the most expensive things in cyanide processing of gold-bearing ores is the cost of sodium cyanide consumed. Depending on the cost of processing 1 ton of ore or concentrate, the cost of cyanide ranges from 20% to 40%. At the beginning of 2019, the price of 1 ton of sodium cyanide was 10,950,000 soums, now the average price of 1 ton of cyanide produced in South Korea is 28,870,000 soums. Therefore, it is very important to regulate and restore the causes of sodium cyanide consumption during cyanidation of ores and concentrates.

The theoretical consumption of cyanide is very low for the direct dissolution of gold. Based on the stoichiometry of the gold leaching reaction, we calculate the cyanide consumption per gram of gold:



$$2 \cdot 197.2 - 4 \cdot 49$$

$$1 \text{ g} - X,$$

where X is the one that interacts with gold.

amount of cyanide (g),

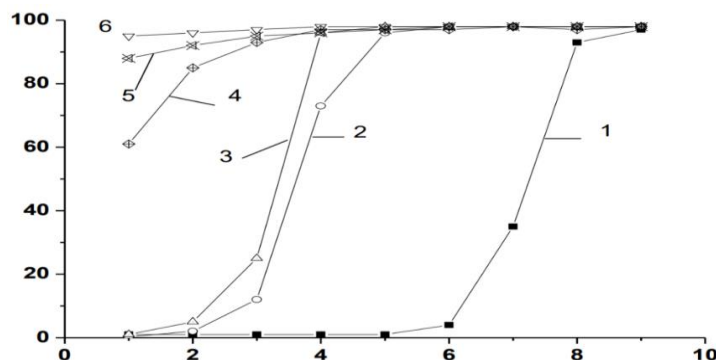
$$X = 4 \cdot 49 / 2 \cdot 197.2 = 0.49 \text{ g}.$$

Calculations show that according to the stoichiometry of the reaction, 0.49 grams of sodium cyanide is used for 1 gram of gold. However, the practical consumption of sodium cyanide is theoretically several hundred times higher. It is known from the practice of factories that use the cyanidation process that the actual consumption of cyanide for 1 gram of gold in the ore during the processing of gold-bearing ores is from 100 grams to 160 grams (i.e., theoretically 200-326 times more). and in the processing of concentrates from 140 grams to 180 grams (theoretically 280-360 times more). It turns out that a large part of cyanide is wasted.

Because of the importance of these issues, it is necessary to analyze in detail the causes of irreversible loss of sodium cyanide and identify ways to minimize them.

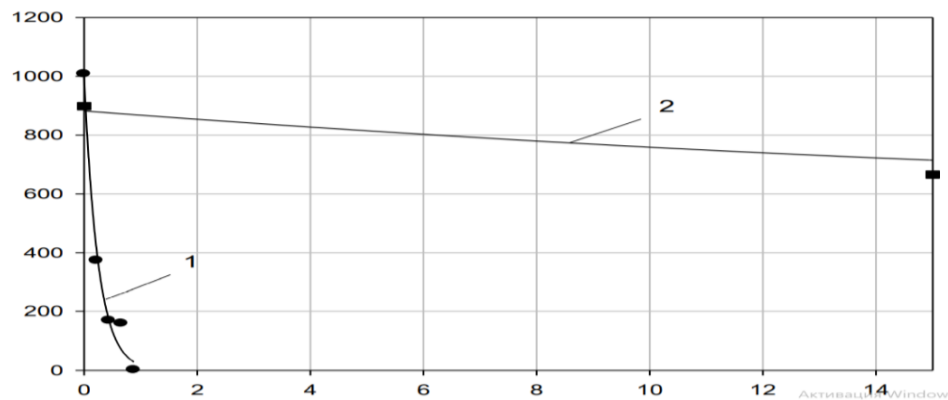
Loss of sodium cyanide during ore cyanide processing is mainly due to harmful compounds that are always present in the ore in the form of various minerals. The effects of these compounds are complex and varied, but they can be divided into three groups:

1. Substances that absorb oxygen from the liquid phase of the pulp and working cyanide solutions.
2. Minerals that bind alkaline cyanide and convert it into complex cyanide compounds of iron and iron compounds.
3. Minerals that break down sodium cyanide.



**Figure 1.** The effect of pH on the stability of metal complexes of cyanides in aqueous solutions: 1-Zn (CN) 42-; 2-Ni (CN) 42-; 3-Cu (CN) 32-; 4-Fe (CN) 62-; 5-Au (CN) 2-; 6-Co (CN) 42-.

Binding of free cyanides in HCN at a decrease in pH from 10.4 to 3.7-2.4 in solutions, a significant decrease in the concentration of  $\text{SCN}^-$  and  $\text{S}_2\text{O}_3^{2-}$ , as well as the formation of a reddish-brown precipitate (1.9) is observed on the reaction. According to the results obtained, the AVR-process in the leaching phase is first carried out in accordance with the reaction equations (1.11), (1.12) and (1.13) with  $[\text{Zn}(\text{CN})_4]^{2-}$  and  $[\text{Cu}(\text{CN})_4]^{3-}$  well-soluble complex ions and the formation of red-brown hexacyanoferrates of  $\text{Cu}_2[\text{Fe}(\text{CN})_6]$  and  $\text{Zn}_2[\text{Fe}(\text{CN})_6]$ .



**Figure 2.** Diagram of the kinetic state of cyanide loss during airborne driving of HCN in MBA (1) and bubble column (2)

Intensive mass transfer of alkaline samples in MQA during 4-fold processing results in almost complete loss of HCN in solution. The alkaline reserve formed by the excess of  $\text{H}^+$  ions in sample 2 leads to the complete loss of copper cyanide complexes and the acceleration of the process (1.14), as a result of intensive mass transfer in the centrifugal field with  $\text{Cu}(\text{I})$  to  $\text{Cu}(\text{II})$  with atmospheric oxygen. ) to oxidation. Reaction (1.14) is particularly important because it allows the return of additional sodium cyanide to production and the reduction of oxidizing material consumption in the final stage of cyanidation treatment process solutions. Experimental data show that the average volume conversion rate of the initial compounds is higher than that of ordinary bubble columns due to the immediately regenerating "liquid-gas" phase contact surfaces developed in the MQA vicious  $\text{pH} < 3$  chamber under intensive mass transfer conditions. 40-60 times higher (Fig. 3), and in one minute there is a complete disappearance of HCN and insoluble compounds in solution. Copper, iron and spirit loss efficiency was 99.5, 92.4 and 98.2%, respectively. However, almost 100% of the cyanide hydrogen is lost in the alkaline solution.

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