

**OF ION-EXCHANGE RESINS FOR GOLD AND SILVER SORPTION AND
EVALUATION OF THEIR PERFORMANCE****Nurmurod Xujakulov**

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Abstract: The gradual depletion of high-grade mineral resources and the steady increase in demand for precious metals have led to growing interest in efficient recovery technologies. Sorption processes play a significant role in the extraction of gold and silver from cyanide solutions due to their operational efficiency and technological simplicity. This study presents a comparative investigation of ion-exchange resins and activated carbon used for precious metal recovery. Laboratory experiments were performed under controlled cyanidation conditions to assess sorption efficiency and kinetic behavior. The obtained results show that activated carbon provides higher recovery rates, particularly for silver, while ion-exchange resins demonstrate limited efficiency under identical conditions. These findings emphasize the importance of sorbent selection and process optimization for improving precious metal extraction.

Keywords: gold recovery, silver recovery, sorption process, ion-exchange resins, activated carbon, cyanide leaching.

1. Introduction

Gold and silver are strategically important metals widely used in electronics, chemical industries, and financial systems. In recent years, the exhaustion of easily processable ores and the rising costs associated with primary raw materials have intensified the need for alternative recovery approaches.

Cyanide leaching remains the dominant method for dissolving gold and silver; however, traditional recovery techniques, such as zinc cementation, are often accompanied by technological complexity and metal losses. As a result, sorption-based methods have gained increasing attention in modern hydrometallurgy.

Activated carbon has long been recognized as an effective sorbent due to its extensive surface area and developed pore system. Ion-exchange resins, in contrast, enable selective metal

recovery through functional group interactions. Despite their industrial application, a clear comparison of these sorbents under uniform experimental conditions is still required. The purpose of this study is to evaluate the performance of selected ion-exchange resins relative to activated carbon during gold and silver sorption from cyanide solutions.

2. Materials and Methods

Experimental investigations were carried out at laboratory scale to study the sorption behavior of gold and silver from alkaline cyanide solutions. Sodium cyanide solutions with a concentration of **3000 mg/L** were prepared to simulate industrial leaching conditions. The pH level was maintained within the range of **10.5–11.0** in order to stabilize cyanide complexes and prevent reagent degradation.

The solid-to-liquid ratio was fixed at **1:2.5**, while the amount of sorbent added corresponded to **10%** of the pulp mass. Each experiment was conducted for **16 hours** under continuous mechanical agitation to ensure effective interaction between the solution and the sorbent.

Fresh activated carbon and three ion-exchange resins (D301G, Jacobi, and HIGE) were used as sorption materials. Prior to testing, the sorbents were conditioned and washed to eliminate surface impurities. During the experiments, liquid samples were periodically withdrawn, filtered, and analyzed for gold and silver content using atomic absorption spectrometry. Throughout the process, pH and cyanide concentration were carefully monitored and adjusted when necessary.

3. Results

The experimental data demonstrated a strong dependence of sorption efficiency on the type of sorbent employed. Activated carbon showed the highest recovery rates, with silver extraction exceeding **70%**, while gold recovery remained consistently high.

Table 1.

Results of the experiment on determining the optimal sorbent for silver extraction during the sorption process

Product name	Initial composition of elements		Content in solid waste		Content in the liquid phase		Separation		The sorbent used is 10% of the pulp volume;
	Au, g/t	Ag, g/t	Au, g/t	Ag, g/t	Au, mg/l	Ag, mg/l	Au, %	Ag, %	
Providing chemical sorption	33.50	31,22	5.12	12.5	0.03	0.13	84.5	59	New coal
			5.36	13.2	0.2	1.66	82.7	45.5	D301G resin
			5.27	12.9	0.27	2.78	82.5	38.2	Jacobi resin
			5.16	13.4	0.23	2.17	83.1	41.1	HIGE resin

In comparison, ion-exchange resins exhibited lower extraction efficiency under the same experimental conditions. Among the tested resins, D301G showed relatively improved performance; however, it remained less effective than activated carbon. A noticeable proportion of gold and silver remained dissolved in the solution phase when resins were applied.

Table 2.

The name of the sorbent	Gold concentration in the liquid phase of the plant, mg/l							
	2 hours	4 hours	6 hours	8 hours	10 hours	12 hours	14 hours	16 hours
Without sorbent	4.05	5.18	6.84	8.31	9.45	10.64	11.29	11.81
New coal	0.61	0.21	0.18	0.14	0.11	0.08	0.06	0.03
D301G resin	0.56	0.46	0.38	0.42	0.35	0.28	0.26	0.22
Jacobi resin	0.45	0.49	0.44	0.38	0.35	0.29	0.31	0.28
HIGE resin	0.51	0.44	0.35	0.37	0.31	0.27	0.26	0.24
	Silver concentration in the liquid phase of the pulp, mg/l							
Without sorbent	4.12	4.69	5.23	5.81	6.38	7.17	7.54	7.8
New coal	0.56	0.31	0.25	0.22	0.18	0.16	0.14	0.12
D301G resin	3.45	3.15	2.5	2.16	2.35	1.93	1.84	1.71
Jacobi resin	4.15	3.91	3.5	2.91	3.15	3.06	2.84	2.78
HIGE resin	3.76	3.3	2.95	3.12	2.84	2.76	2.31	2.2

Results of the experiment on determining the optimal sorbent for silver extraction during biocake sorption

Implementation of a two-stage sorption scheme led to an increase in overall silver recovery to approximately **73%**, with nearly **59%** of the metal extracted during the first stage. Sorption kinetics analysis revealed rapid metal uptake during the initial period, followed by a gradual stabilization as equilibrium was approached.

4. Discussion

The superior efficiency of activated carbon can be explained by its high specific surface area and interconnected pore network, which facilitate fast diffusion and effective adsorption of metal–cyanide complexes. These structural features result in improved kinetic performance and higher sorption capacity.

Ion-exchange resins operate through selective exchange mechanisms that may restrict their efficiency in strongly alkaline cyanide environments. Limited diffusion of metal complexes into the resin matrix and competition with other ionic species reduce the overall recovery efficiency.

The results indicate that the exclusive use of ion-exchange resins is insufficient to achieve high silver recovery. To enhance extraction efficiency, additional physico-chemical pretreatment methods—such as oxidative treatment or thermal activation—should be considered to improve metal liberation prior to sorption.

5. Conclusion

The present study confirms that activated carbon outperforms ion-exchange resins in the recovery of gold and silver from cyanide solutions, particularly in terms of silver extraction efficiency. The findings highlight the importance of optimizing sorbent properties and operational parameters. Future research should focus on integrated approaches combining pretreatment and sorption techniques to improve precious metal recovery from complex raw materials.

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