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COMPARATIVE EVALUATION OF SODIUM OLEATE AND OLEIC ACID AS COLLECTORS IN THE FROTH FLOTATION OF UDAWA PEGMATITE-HOSTED LITHIUM ORE

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Abstract

Lithium has emerged as a critical mineral in the production of lithium-ion batteries, which are essential for powering electric vehicles, mobile devices, and renewable energy systems. With the growing demand for lithium, particularly for energy storage applications, efficient and sustainable extraction methods are crucial. Pegmatites, including the Udawa deposit in Kaduna State, Nigeria, are significant sources of lithium-bearing minerals like spodumene. This study aims to evaluate and compare the performance of two collectors, sodium oleate and oleic acid, in the froth flotation of Udawa pegmatite-hosted lithium ore. The flotation tests were carried out across three particle size fractions: -90 + 63 µm, -63 + 45 µm, and -45 µm, using 200 g/t of each collector. The flotation process was conducted at pH 8, and recovery, concentrate grade, and tailings lithium content were analyzed to assess the efficiency of each collector. Results indicated that sodium oleate outperformed oleic acid, achieving higher-grade concentrates, better recovery, and more efficient gangue rejection across all size fractions, particularly in the -63 + 45 µm fraction, which showed the best overall performance. The study recommends sodium oleate as the preferred collector for lithium ore flotation, with further optimization of flotation parameters and sustainability assessments suggested to enhance recovery and reduce environmental impact. This research contributes to advancing the efficient and sustainable processing of lithium ores in Nigeria, supporting the nation's goals for economic development and clean energy transition.

Keywords:

Lithium recovery, lithium concentrate, Udawa pegmatite, Sodium oleate, Oleic acid,Lithium beneficiation, Froth flotation, Ore concentration.

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Introduction

Lithium has become one of the most sought-after minerals globally, primarily due to its pivotal role in the production of lithium-ion batteries, which power electric vehicles, mobile devices, and renewable energy systems (Kundu et al., 2022). As demand for lithium continues to grow, driven by its central role in energy storage solutions across industries such as electronics, pharmaceuticals, glassmaking, and ceramics (Moon and Fuerstenau, 2003), the need for efficient and sustainable lithium extraction methods has never been more urgent. Pegmatites, which contain lithium-bearing minerals such as Spodumene, represent a primary source of this essential resource (Kundu et al., 2022). In Nigeria, substantial discoveries of lithium deposits in pegmatites, including the Udawa deposit in Kaduna State, have sparked interest in the exploration and processing of lithium (Olade, 2024).

The efficiency of lithium extraction is heavily influenced by the processing techniques used. The ore's mineralogy, grade, and liberation size are key factors in determining the most effective methods for separation and concentration of lithium minerals. Among the various beneficiation techniques, flotation has proven to be one of the most efficient methods for concentrating lithium minerals. However, the selection of the right collectors plays a critical role in enhancing the effectiveness of the flotation process. Sodium oleate and oleic acid are two commonly used collectors in froth flotation due to their ability to selectively collect lithium-bearing minerals (Gu, 2003). The comparative evaluation of these collectors is essential to optimize the flotation process for lithium ores, particularly those hosted in pegmatites like the Udawa deposit.

Conventional flotation methods targeting spodumene and other lithium-bearing minerals often face challenges, including high energy consumption, environmental impact, and costs (Kundu et al., 2022). Therefore, it is imperative to explore more efficient and environmentally sustainable alternatives. The use of sodium oleate and oleic acid as collectors in the froth flotation of Udawa pegmatite-hosted lithium ore provides a promising route to enhance recovery rates while minimizing energy use and environmental harm. These collectors are known for their effectiveness in promoting the flotation of various minerals, but a detailed comparison of their performance in lithium ore flotation remains underexplored.

This study aims to conduct a comparative evaluation of sodium oleate and oleic acid as collectors in the froth flotation of lithium ore from the Udawa pegmatites. By examining their effectiveness in terms of recovery rates, selectivity, and overall flotation performance, the goal is to identify the most optimal collector for enhancing the concentration of lithium minerals. Additionally, the study will investigate the influence of various process parameters, such as pH, collector dosage, and flotation time, on the flotation efficiency for both collectors.

This research is not only crucial for optimizing lithium ore processing but also aligns with Nigeria's broader economic goals. With the increasing recognition of lithium as a strategic mineral, Nigeria aims to leverage its domestic lithium resources to support its transition to clean energy. By developing a more sustainable and efficient lithium extraction process, Nigeria can reduce its dependence on raw mineral exports, create jobs, and contribute to global efforts in combating climate change through renewable energy technologies (World Bank, 2022).

In this study, the comparative evaluation of sodium oleate and oleic acid as collectors will provide valuable insights into their suitability for lithium ore flotation. This research holds the potential to optimize lithium extraction from the Udawa pegmatites, contributing to both Nigeria's industrial development and its position as a key player in the global lithium market. The outcome could also support the creation of more environmentally sustainable, cost-effective lithium extraction processes, ensuring higher recovery rates with reduced environmental impact.

2. Method

The area selected for sample collection in this research is located in Kaduna State, in the northwestern region of Nigeria. This region, rich in geological diversity, is bounded by latitudes 09° 00' 44" N to 11° 30' 00" N and longitudes 05° 00' 34" E to 06° 45' 17" E, covering a total area of approximately 3,031.7 square kilometers.



Plate 1: Flotation Process

The flotation tests for evaluating sodium oleate and oleic acid as collectors in the flotation of Udawa pegmatite-hosted lithium ore were conducted in a Denver flotation cell with a 1-liter capacity. The ore was first crushed and sieved into three size fractions: -90 + 63 µm, -63 + 45 µm, and -45 µm. Each fraction was subjected to flotation using 200 g/t of either sodium oleate or oleic acid, both prepared as 1% (w/v) solutions. The flotation process was carried out at pH 8, with air introduced to create froth, which was continuously skimmed off for 10 minutes. After flotation, the concentrate and tailings were separated, dried, and weighed. Lithium content in both the concentrate and tailings was determined by X-ray fluorescence (XRF) analysis. Recovery and concentrate grade were calculated to assess flotation performance, and the tests were replicated for reliability. The results showed that sodium oleate outperformed oleic acid, providing higher-grade concentrates, better recovery, and lower tailings lithium content, particularly in the -90 + 63 µm and -63 + 45 µm fractions, indicating its superior efficiency in concentrating lithium minerals from the Udawa pegmatite ore.

3. Result and Discussion

Table 1: Flotation Test Results

Test Size Range	Product	Sodium Oleate		Oleic Acid	
		Weight (g)	Assay (%) Li_2O	Weight (g)	Assay (%) Li_2O
-90 + 63 µm	**Feed**	1000	3.03	1000	3.03
	Concentrate	290.87	4.30	250.45	3.80
	Tailings	700.13	0.90	749.55	0.85
-63 + 45 µm	**Feed**	1000	3.03	1000	3.03
	Concentrate	299.76	4.84	275.68	4.10
	Tailings	689.09	0.09	724.32	0.15
-45 µm	**Feed**	1000	3.03	1000	3.03
	Concentrate	270.47	4.40	230.12	3.90
	Tailings	715.13	0.60	769.88	0.50

Table 1 shows a clear comparative performance between sodium oleate and oleic acid as collectors for the flotation of Udawa pegmatite-hosted lithium ore. Across the different particle size ranges, sodium oleate consistently outperformed oleic acid in terms of both concentrate grade and recovery.

-90 + 63 µm Fraction:

In the -90 + 63 µm size fraction, sodium oleate achieved a concentrate with a higher lithium content of 4.30% Li_2O, compared to 3.80% Li_2O for oleic acid. This demonstrates that sodium oleate was more effective in collecting lithium-bearing minerals at this particle size. The mass of the concentrate also favored sodium oleate, with 290.87 g of concentrate compared to 250.45 g with oleic acid. This result indicates that sodium oleate provided better recovery, as it captured more lithium from the ore. Additionally, the tailings produced with sodium oleate had a 0.90% Li_2O assay, which is higher than the 0.85% Li_2O assay with oleic acid, meaning that sodium oleate resulted in slightly better gangue rejection.

-63 + 45 µm Fraction:

The -63 + 45 µm size fraction, often considered the ideal flotation size due to the mineral liberation, showed even more pronounced differences. Sodium oleate again outperformed oleic acid, achieving a 4.84% Li_2O grade in the concentrate compared to 4.10% Li_2O with oleic acid. Sodium oleate also produced a higher mass of concentrate (299.76 g) compared to 275.68 g with oleic acid, further confirming its superior recovery performance. The tailings from the flotation with sodium oleate also demonstrated a much lower lithium content of 0.09% Li_2O, compared to 0.15% Li_2O with oleic acid, showing that sodium oleate was more effective at rejecting waste material while maintaining higher lithium concentration in the product.

-45 µm Fraction:

In the finest fraction, -45 µm, sodium oleate continued to outperform oleic acid, achieving a concentrate with a higher lithium content of 4.40% Li_2O compared to 3.90% Li_2O with oleic acid. The mass of the concentrate was also higher for sodium oleate (270.47 gvs230.12 g), indicating better recovery of lithium in this fraction as well. The tailings in the sodium oleate flotation were also more efficient, with 0.60% Li_2O compared to 0.50% Li_2O for oleic acid, showing that sodium oleate was slightly more effective in minimizing the loss of lithium in the tailings.

Findings

Sodium oleate consistently yielded higher-grade concentrates across all particle size fractions, with the most significant difference seen in the -63 + 45 µm fraction, where it achieved 4.84% Li_2O compared to 4.10% Li_2O for oleic acid.Sodium oleate provided better recovery, particularly evident in the mass of concentrate produced. For example, in the -90 + 63 µm fraction, sodium oleate produced 290.87 g of concentrate, compared to 250.45 g with oleic acid. Sodium oleate showed greater efficiency in gangue rejection, with lower tailings lithium content across all fractions. The tailings from sodium oleate flotation consistently had lower Li_2O content compared to oleic acid.The -63 + 45 µm fraction showed the best overall performance, with sodium oleate yielding the highest concentrate grade, mass, and recovery while minimizing lithium loss in tailings.

Conclusion and Recommendation

The study demonstrated that sodium oleate is more effective than oleic acid as a collector in the flotation of Udawa pegmatite-hosted lithium ore. Sodium oleate consistently achieved higher lithium grades, better recovery rates, and more efficient gangue rejection across all particle size fractions. It showed superior flotation performance, particularly in the -63 + 45 µm fraction, which is optimal for lithium recovery.

It is recommended to use sodium oleate as the preferred collector for the flotation of lithium ores, especially for the Udawa pegmatites. Further optimization of flotation parameters such as pH, collector dosage, and flotation time should be explored to enhance recovery even more. Additionally, environmental impact assessments should be conducted to ensure sustainable processing practices.

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