CLARIANT NEW GENERATION COLLECTORS FOR FLOTATION OF LITHIUM ORES

By

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ABSTRACT

Global demand for lithium has increased significantly in recent years due to a dramatic increase in the use of rechargeable lithium-ion batteries in a multitude of applications, including electric vehicles, electric power storage and electronic devices. Hard rock mining of pegmatites has emerged as a major source of lithium to meet this growing demand. The key minerals include spodumene, lepidolite and petalite, and they are often beneficiated via complex flowsheets using multiple techniques including dense media separation, magnetic separation, and froth flotation.

In the flow sheets for processing lithium ores, flotation is often used for processing fine particle size feed, for complex ore deposits, and where high-grade concentrates are required. Clariant Mining Solutions is focused on helping the mining industry deliver the minerals needed to enable the decarbonization megatrend in a sustainable way, and to this effect, Clariant has been working to develop a range of new collectors for more efficient flotation of spodumene and other challenging lithium ores. This paper presents some of the most recent developments.

Fatty acids are often used for lithium flotation; however, the grade and recovery achieved with these collectors is often below the desired level. Also, high dosages of fatty acids are often required, and residual fatty acids in the concentrates can impart a fatty odour to the lithium concentrate which is undesired during further processing into lithium carbonate or hydroxide. Fatty acid collectors can also cause formation of calcium soaps which give rise to filtration problems and the need for acid washing.

Clariant is using two strategies to develop improved lithium collectors. The first is to formulate collectors containing fatty acids but minimizing the negative effects of fatty acids, and the second strategy is to completely replace the fatty acids with alternative chemicals.

Modified fatty acid formulations can improve the metallurgical performance and significantly lower dosages, thereby minimizing the issues associated with residual fatty odour and soap formation while achieving lithium recoveries greater than those achieved with conventional fatty acid collectors at an improved grade.

Furthermore, Clariant's novel collectors that are free of fatty acids have been found to produce superior grade concentrates and improved recovery at less than half the dosage of fatty acid collectors. These collectors completely eliminate the residual fatty odour and have also shown improvements in the filtration efficiency of the final concentrate.

Keywords: Lithium, Flotation, Beneficiation, Fatty Odour

INTRODUCTION

Lithium is an important element in the world economy, with applications as diverse as glass and ceramics, lubricating greases and polymer synthesis[1]. Recently, the development of rechargeable lithium-ion batteries, coupled with the global trend towards electrification of the transportation fleet, has led to a dramatic increase in the demand for lithium[2]. In addition to the production of lithium from brines, the production of lithium from hard rock ores is increasing, and flotation has proved to be an effective means for the beneficiation of many pegmatitic lithium ores[3].

Fatty acids are often used for lithium flotation[4]; however, the grade and recovery achieved with these collectors is often below the desired level[5]. Also, high dosages of fatty acids are often required, and residual fatty acids in the concentrates can impart a fatty odour to the lithium concentrate which is undesired during further processing into lithium carbonate or hydroxide. Fatty acid collectors can also cause formation of calcium soaps which give rise to filtration problems and the need for acid washing.

Clariant is using two strategies to develop improved lithium collectors. The first is to formulate collectors containing fatty acids but minimizing the negative effects of fatty acids, and the second strategy is to completely replace the fatty acids with alternative chemicals.

In previous work, Clariant's collectors containing fatty acids but formulated to minimize the negative effects of fatty acids were described[6]. In those tests, spodumene rougher flotation tests were performed to compare a standard fatty acid to FLOTINOR™ 10339 (Figure 1 and Figure 2). The results showed that FLOTINOR™ 10339 was able to achieve the same grade at half the dose of the standard fatty acid (Figure 1). For example, with fatty acid dosed at 2000 g/ton, the grade achieved was 3.9% lithium oxide, and FLOTINOR™ 10339, was able to achieve the same grade at only 1000 g/ton.

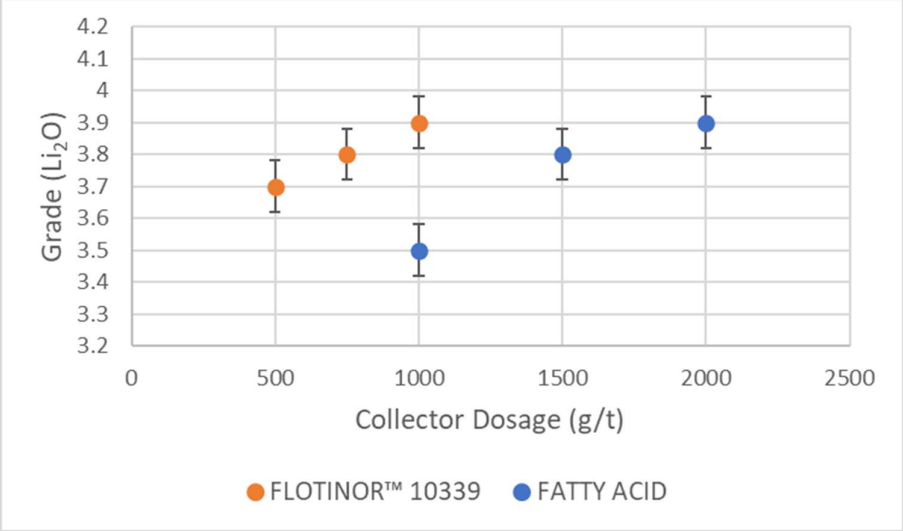

Figure 1: Grade vs Collector Dosage for Rougher Flotation Tests

The lithium rougher recovery results also showed that FLOTINOR™ 10339 was also able to achieve a higher recovery than a standard fatty acid at half the dosage (Figure 2). For example, at a 1500 g/ton fatty acid dosage, the lithium recovery was 90%, and FLOTINOR™ 10339, delivered a recovery of 92% at just 750 g/ton.

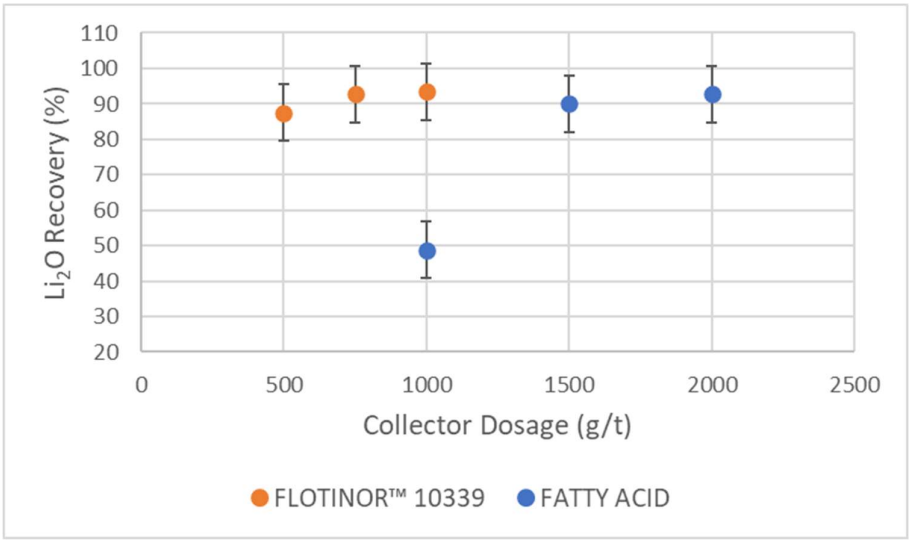

Figure 2: Recovery vs Collector Dosage for Rougher Flotation

In *the previous work*[6]*, both spodumene rougher and cleaner tests were also performed to compare a standard fatty acid with FLOTINOR™ 10381 (Figure 3 and Figure 4). Although there was some variability in the results, FLOTINOR™ 10381 could achieve a grade of approximately 6%, which is higher than the fatty 5.5% that was achieved with a standard fatty acid (Figure 3). This showed that FLOTINOR™ 10381 was more selective against gangue minerals than the standard fatty acid.*

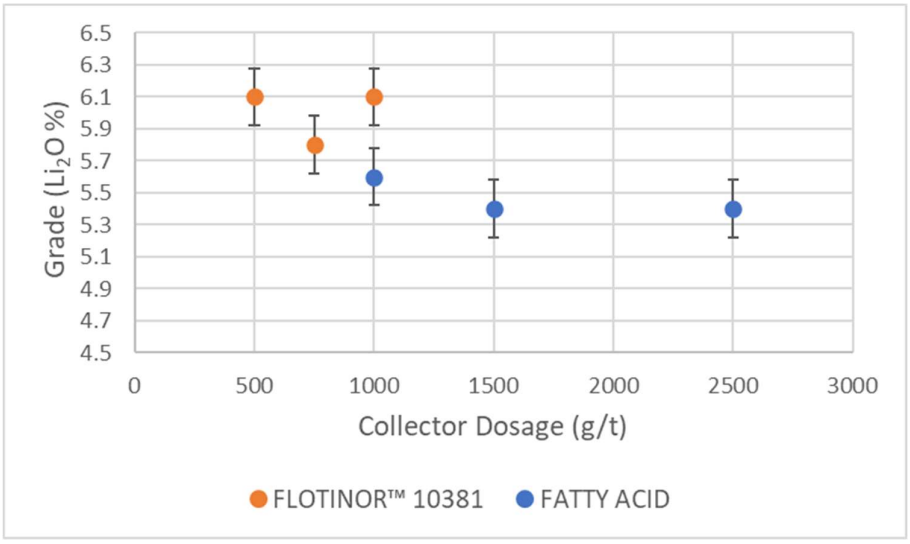

Figure 3: Grade vs Collector Dosage for Rougher and Cleaner Test

FLOTINOR™ 10381 also yielded a higher recovery than the standard fatty acid at all dosage points (Figure 4). As shown in Figure 4, FLOTINOR 10381 was dosed at 500, 750 and 100 g/ton, and the standard fatty acid was dosed at 1000, 1500, and 2500 g/ton, knowing that it would require higher dosages. At the only common dosage, 1000 g/ton, FLOTINOR™ 10381 delivered a dramatically higher recovery of 84.3% versus 65.3%. Increasing the dosage of the standard fatty acid to 2500 g/ton did increase the recovery to 78.6%, but FLOTINOR™ 10381 was able to achieve that same recovery (78.7%) at 500 g/ton, one fifth of the dosage of the standard fatty acid. Such a significant decrease in chemical consumption has multiple benefits, including reduced traffic and emissions from deliveries, requiring less packaging or smaller bulk tanks, and reducing the amount of collector that can plug filter screens.

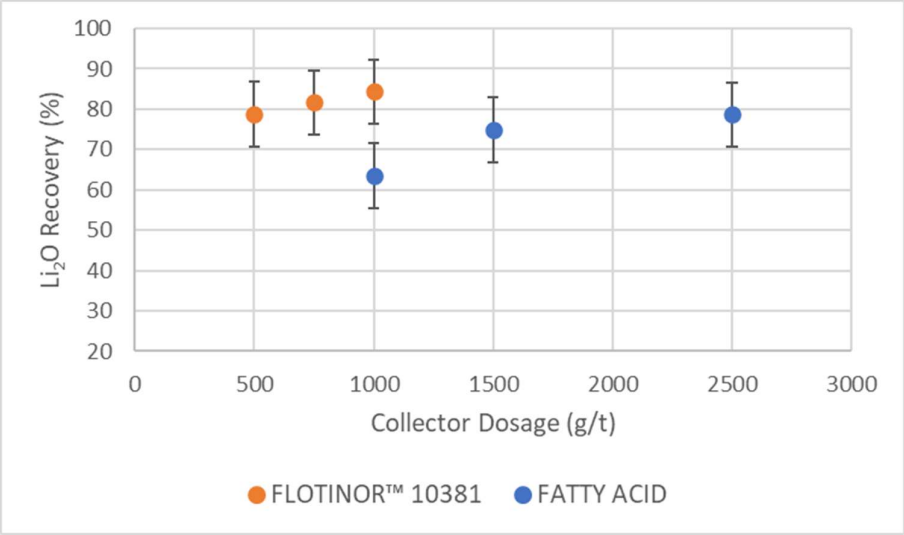

Figure 4: Recovery vs Collector Dosage for Rougher and Cleaner Test

RESULTS AND DISCUSSION

Spodumene Rougher Flotation

Spodumene rougher flotation tests were performed on a lithium ore containing spodumene to compare a standard fatty acid to Clariant's novel FLOTINOR™ 19010 spodumene collector that does not contain fatty acids. This collector is part of a range of novel collectors that are being evaluated to improve metallurgical performance as well reduce consumption of collector significantly compared to fatty acid collectors. These collectors not only achieve required metallurgical performance but also completely eliminate fatty odour in the lithium concentrate, which is undesired during further processing into lithium carbonate or hydroxide.

Spodumene rougher flotation tests were performed to compare a standard fatty acid to FLOTINOR™ 19010 (Figure 5 and Figure 6). The results show that FLOTINOR™ 19010 is able to achieve a similar grade at half the dose of the standard fatty acid (Figure 5). For example, at 1500 grams per tonne of fatty acid, the grade achieved is 4.35% lithium oxide, and FLOTINOR™ 19010, is able to achieve the same grade at only 800 g/ton. At all the dosages evaluated the novel collector could achieve similar grades at almost half dosage. Such a significant decrease in chemical consumption has multiple benefits, including reduced traffic and emissions from deliveries, requiring less packaging or smaller bulk tanks.

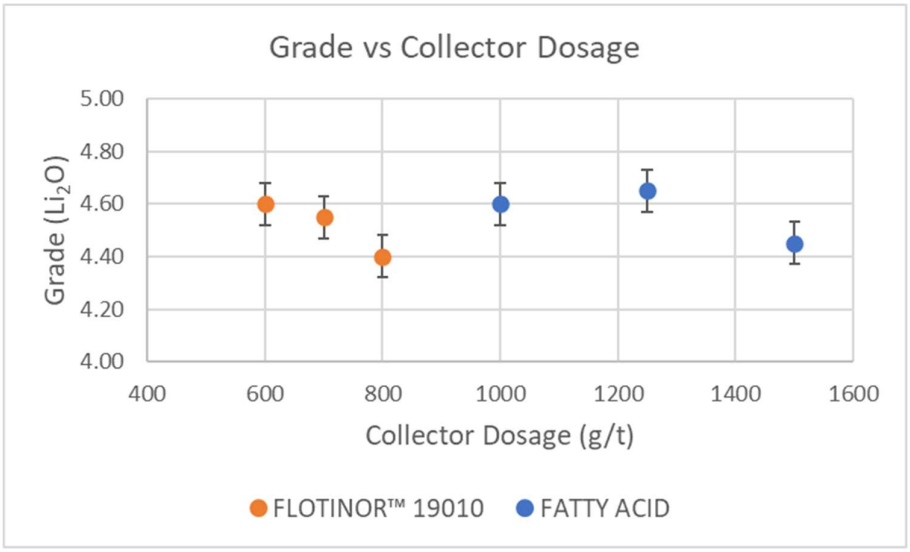

Figure 5: Grade vs Collector Dosage for Rougher Flotation Tests with Clariant's novel FLOTINOR™ 19010

The lithium rougher recovery results further shows that FLOTINOR™ 19010 is also able to achieve a higher recovery than a standard fatty acid at half the dosage (Figure 6). For example, at a dosage of 1500 g/ton of fatty acid, the lithium recovery is 62%, and FLOTINOR™ 10339, delivers a recovery of 66% at just 800 g/ton.

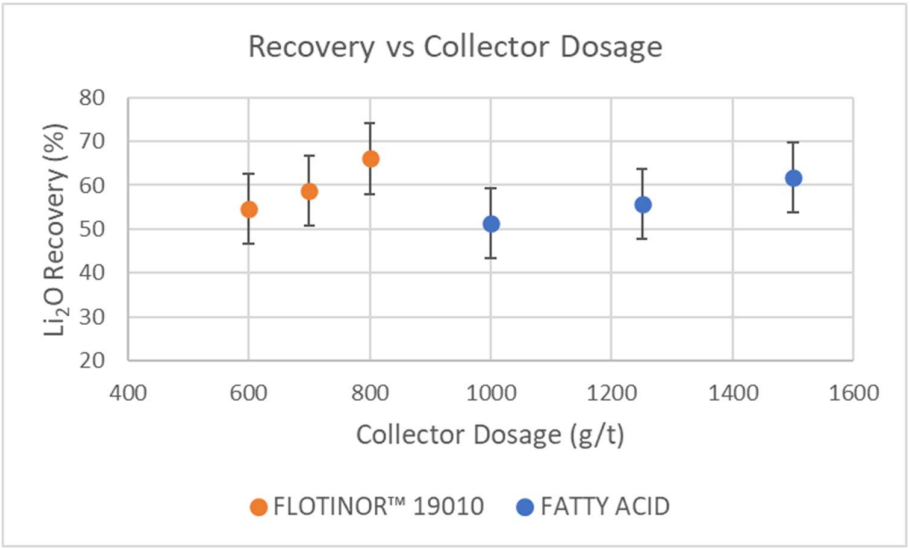

Figure 6: Recovery vs Collector Dosage for Rougher Flotation Tests with Clariant's novel FLOTINOR™ 19010

Clariant's novel FLOTINOR™ 19010 collector not only improved metallurgical performance and almost half of the standard fatty acid dosages, but also produces a lithium concentrate that is free of fatty odour, which is more desirable in further processing into lithium carbonate or hydroxide. Furthermore, FLOTINOR™ 19010 also eliminates the formation of calcium soaps which give rise to filtration problems and the need for acid washing.

METHODS

The flotation tests were conducted using the standard conditions in use at the mines where the ores were sourced. Most notably, long conditioning times were used in order to achieve effective attachment of the collectors on the spodumene surfaces.

Rougher Test

The ore was crushed to -3.35 mm and split into 1.3 kg lots. For each flotation test the sample was ground to a P80 of 150 µm and deslimed in a 600 x 140mm cylindrical column. After mixing in the column and allowing the slurry to settle for a predetermined time, the top 525 mm of slimes pulp was decanted off. The remaining coarse settled pulp was transferred to a 2 L Agitair cell. The pulp was conditioned for 10 minutes at 1000 rpm with the required amount of collector and 1.2 ml of 8% soda ash solution. Three rougher cons were collected at 30 seconds, 1-minute and 1-minute intervals. Lithium assays were performed at an external laboratory by peroxide fusion using ICP-AES.

Rougher and Cleaner Test

The ore was crushed to -3.35 mm and split into 1.3 kg lots. For each flotation test the sample was ground to a P80 of 150 µm and deslimed in a 600 x 140mm cylindrical column. After mixing in the column and allowing the slurry to settle for a pre-determined time, the top 525 mm of slimes pulp was decanted off. The remaining coarse settled pulp was transferred to a 2 L Agitair cell. The pulp was conditioned for 10 minutes at 1000 rpm with the required amount of collector and 1.2 ml of 8% soda ash solution.

The rougher flotation was conducted for 3 minutes, followed by a 3 minute cleaner flotation. Lithium assays were performed at an external laboratory by peroxide fusion using ICP-AES.

CONCLUSIONS

Several FLOTINOR™ collectors for lithium ores have been developed that deliver an equal or better grade and recovery of lithium compared to standard fatty acids at almost half the dose. In addition to the improved metallurgical performance, the lower dose of FLOTINOR™ collector could reduce or eliminate the need for downstream acid washing processes that are often required when using fatty acids and may improve filtration performance. The novel Clariant FLOTINOR™ 19010, part a new range of collectors that do not include fatty acids in the composition, not only improves metallurgical performance but also eliminates fatty odour from the lithium concentrate.

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