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SUSTAINABLE OPTIMIZATION OF FLOCCULATION PROCESSES FOR ENHANCED SOLID–LIQUID SEPARATION IN MINING: INFLUENCE OF OPERATIONAL AND PHYSICOCHEMICAL PARAMETERS

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Abstract: This research focuses on optimizing solid-liquid separation at the Yaramoko-Bagassi gold mine (Burkina Faso), operated by Soleil Resources for US$135 million. The plant processes 1,400 t/d of ore (reserves > 1 Mt at 6.6 g/t) for an annual production of 100,000 to 120,000 ounces of gold. The study aims to stabilize sludge settling in the thickener, which is disrupted by the alternating mixing of oxidized ore and fresh rock. Four anionic flocculants supplied by Nowata BF were tested using Jar-Test on two 15% solids blends: Blend 1 (66.67% oxides / 33.33% fresh rock) and Blend 2 (50% oxides / 50% fresh rock). Sedimentation performance measured after 45 seconds reveals the following: On Blend 1 (highly oxidized): The new flocculant DP 9629 - 2024 consistently outperforms the others. Its sedimentation rate reaches 71.42% at 15 g/t, 80.00% at 20 g/t, and peaks at 91.42% at 25 g/t. In comparison, the original product (Plant - DP 9629 - 2020) shows sedimentation rates of 57.14%, 74.28%, and 88.57%, respectively. Flomin AN 913 achieves the lowest results (from 40.00% to 74.28%). Regarding Blend 2 (mixed): At a dose of 15 g/t, the kinetics reverse in favor of Flomin TFA 934 SH (X1), which becomes the most efficient, surpassing DP 9629-2024. In conclusion, the mineralogy dictates the separation efficiency. The document validates the existence of an optimal dosage (the supernatant clarity level improving significantly at 25 g/t for Blend 1) and confirms the overall structural superiority of DP 9629-2024 over highly oxidized ores.

Keywords: Flocculation; Polymers; Solid-liquid separation; Jar testing; Mining industry

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INTRODUCTION

In Burkina Faso, a mine's profitability no longer depends solely on its or content, but also on its water management capacity. This is a major technical constraint. In the processing plant, everything hinges on the thickener: this critical piece of equipment recovers clear water for reinjection into the circuit and reduces the volume of sludge to be stored. To accelerate this settling process, the plant uses chemical flocculants (Zaman et al., 2020). In theory, this works, but the operational reality at the Yaramoko mine (Bagassi) is more complex. The plant's feedstock changes frequently, alternating between oxidized ore and fresh rock. The immediate consequence is that standard dosages are no longer very effective, and the solid-liquid separation becomes unstable (Fernando Concha, 2014). Which flocculation strategy (product type and dosage) allows for maintaining stable performance despite the ore changes? We tested four commercially available anionic flocculants (DP 9629-2024, DP 9629-2020, Flomin TFA 934 SH, and Flomin AN 913) on oxidized and mixed blends of rocks. The goal was to define, for each geological scenario, the product vs. dosage combination that offers the best compromise between sedimentation rate and supernatant clarity.

EXPERIMENTAL

Site Description: The Yaramoko mining project is a high-grade gold deposit located in the Houndé greenstone belt in western Burkina Faso (Weedon et al., 2022), more precisely in the commune of Bagassi, Balés province (Figure 1), about 200 kilometers southwest of Ouagadougou and the mine is owned by the Canadian company Roxgold Inc.

Figure 1. Location of Yaramoko Mine adapted from (Weedon et al., 2022)

Pulp Samples: Direct sampling at the plant was conducted where pulp samples were collected sterilely from the hydrocyclone overflow to create the two study blends:

Blend 1: Pulp predominantly composed of oxides (≈ 66.67% oxides / 33.33% fresh rock).

Blend 2: Pulp with a balance of oxides/fresh rocks (≈ 50% oxides / 50% fresh rocks).

To explore greater mineralogical variability, ore samples (oxides and fresh rock) were collected on the ROM Pad. After oven drying at 105°C to constant weight, the samples were crushed and then ground in a laboratory ball mill to achieve a target particle size of P80 ≈ 90 µm, representative of the liberation mesh (Andriese, 2015; Little, 2016). Pulps were then reconstituted with process water to achieve the desired concentration.

Tested Flocculants: Total 4 anionic polyacrylamide flocculants supplied by NOWATA (NOWATA Burkina Faso, 2026) were selected for this comparative study: DP 9629 -2024, DP 9629 -2020, FLOMIN TFA 934 SH and FLOMIN AN 913 SH.

Preparation of Flocculant Solutions: A 0.1% (1 g/L) stock solution of each flocculant is prepared by slowly dissolving the powder in process water under gentle magnetic stirring to avoid degradation of the polymer chains. The solution is allowed to mature for 24 hours to ensure complete hydration. The stock solution is diluted to 0.01% (0.1 g/L) to facilitate dispersion and titration. The characteristics of the solutions are shown in table 1.

Table 1. Flocculation Parameters

Characteristics	Amount
Flocculant Mass in g	0.100
Volume of Water Added in ml	200.0

Flocculant Concentration in %	0.05
Volume of Flocculant Solution Used for 15 g/t in ml	2.25
Volume of Flocculant Solution Used for 20 g/t in ml	3.0
Volume of Flocculant Solution Used for 25 g/t in ml	3.75
Flocculant Mass in Solution for 15 g/t in g	0.001125
Flocculant Mass in Solution for 20 g/t in g	0.0015
Flocculant Mass in Solution for 25 g/t in g	0.001875

Test Procedure: The experimental procedure began by introducing a 500 ml volume of pulp into a 1000 ml graduated cylinder. Subsequently, the diluted flocculant was added at the desired dosage, expressed either in grams per tonne or as millilitres of the diluted solution; the dosages tested were 15, 20, and 25 g/t for Blend 1, while Blend 2 was initially evaluated at 15 and 20 g/t only. To ensure accuracy, the precise volume of flocculant stock solution required to achieve each target dosage was calculated and measured using a graduated syringe. Finally, to guarantee reliability, the jar-test for each sample was performed in three replicates, and the average value was reported as the final result.

RESULTS AND DISCUSSION

The flocculation rate was determined by observing the volume of clear supernatant obtained after decantation in the test tubes and the flocculation rate and efficiency represented in table 2 and Table 3, respectively for Blend 1 and Blend 2 (Li et al., 2013; Saritha et al., 2017). The flocculation rate (F%) was calculated using the following formula (Ian et al., 2011):

F(%) = Vf / Vt × 100, where:

Vf = volume of clear supernatant after flocculation (ml)

Vt = total volume of pulp initially used (ml)

Performance on Blend 1 (66.7% Oxides): Blend 1, characterized by its high proportion of oxides, constitutes a particularly interesting case study for evaluating the effectiveness of flocculants under demanding conditions. Due to their fineness and generally negative surface charge, the oxide particles exhibit marked colloidal stability, necessitating the use of high-performance flocculants (El Ouadrhiri et al., 2025).

Flocculation kinetics and dosage optimization: Examination of the kinetics confirms an overall positive correlation between dosage and settling velocity, validating the inter-particle bridging model (Kitching, 2023; Wu et al., 2026). However, dose sensitivity reveals marked disparities depending on the reagent. Examination of Figure 2 highlights the efficiency of DP 9629-2024. Its performance curve climbs linearly up to 25 g/t without any change. This lack of saturation shows that the reagent retains a margin for handling oxide charge peaks, where others encounter difficulties.

Table 2: Flocculation Test on Blend 1

Applied Dosages	DP 9629 – 2020	DP 9629 – 2024	FLOMIN AN 913 SH	FLOMIN TFA 934 SH
15 g/t	57.14%	71.42%	40.00%	42.85%
20 g/t	74.28%	80.00%	45.71%	65.71%
25 g/t	88.57%	91.42%	74.28%	85.71%

Table 3: Flocculation Test on Blend 2

Floculants	15 seconds (%)	30 seconds (%)	45 seconds (%)	60 seconds (%)
DP 9629 – 2020 (PLANT)	82.85	94.28	97.14	98.57
DP 9629 – 2024	85.71	97.14	99.42	100
FLOMIN AN 913 SH (AN 913)	57.14	85.71	91.42	94.28
FLOMIN TFA 934 SH (X1)	87.14	97.14	99.71	100

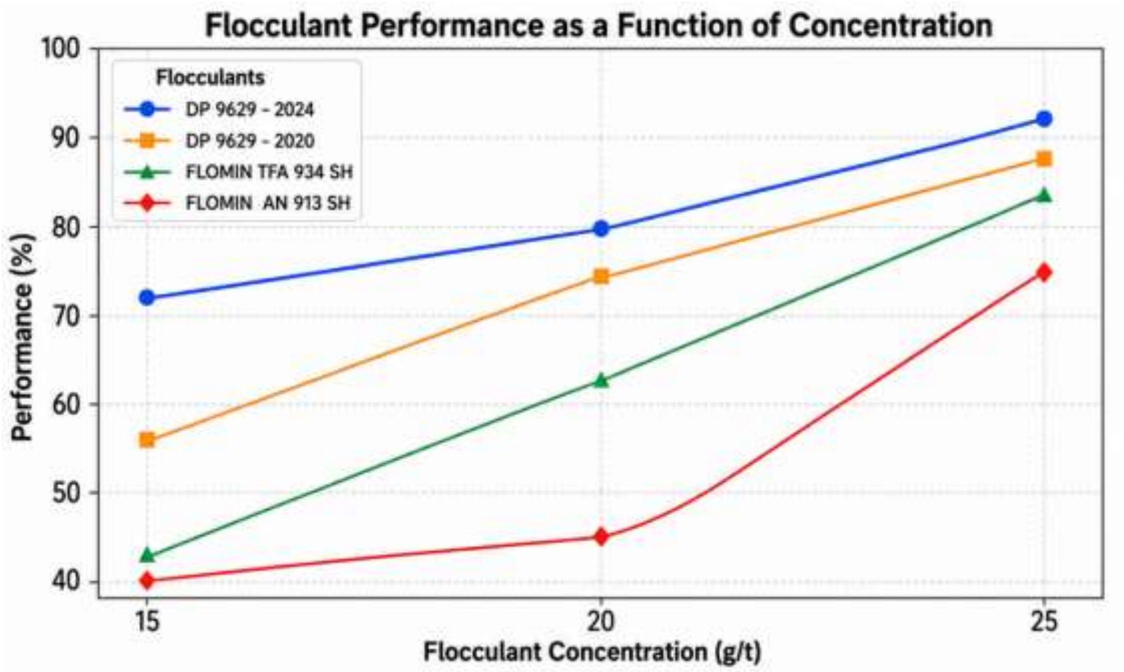

Figure 2. Flocculant performance as a function of dosage

FLOMIN AN 913 dynamics are hampered by an initial inertia, meaning that a high concentration is required to trigger the reaction. This "activation delay" is the chemical signature of a short-chain polymer, which struggles to bridge particles until the reagent density is sufficient (D'hooge et al., 2015).

CONCLUSION

Our work confirms that mineralogy dictates flocculant performance. While DP 9629-2024 performs well on complex oxidized matrices, FLOMIN TFA 934 SH has proven its effectiveness on fresh rock (Blend 2). This duality invalidates the idea of a universal dosage or product, favoring a targeted approach. DP 9629 should be used as a safety reagent for oxidized campaigns. Conversely, as soon as the feed switches to fresh rock, an immediate transition to FLOMIN TFA 934 SH is recommended. At only 15 g/t, this product becomes a profitability lever without risk to water quality. However, laboratory tests cannot perfectly simulate the turbulence of a 20-meter diameter industrial thickener.

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