Enhancing Wet Bauxite Processing Through Innovative Handling Aid Solutions

Aurélien Bonneau[1], Clément Coquery[2], Oguzhan Yildrim[3] and Andre Azevedo[4]
1. Mining R&D Manager
2. Product Innovation R&D Project Manager
3. Dry Processing Application Specialist - Mining
SNF, Andrézieux-Bouthéon, France
4. Global Technical Alumina Director
SNF Holding Company, Riceboro, USA
Corresponding author: abonneau@snf.com
https://doi.org/10.71659/icsoba2025-bx009

Abstract

Handling and transporting wet bauxite presents significant operational and safety challenges. In industrial settings, moisture-related issues such as material adhesion, flow obstruction, and equipment clogging lead to increased maintenance and reduced plant efficiency. Moreover, during maritime transport, wet bauxite poses a serious risk of cargo liquefaction – recognized by the International Maritime Organization (IMO) as one of the three most problematic bulk materials – potentially endangering boat stability.

This study evaluates a novel range of SNF patented handling aids named FLOMIN™ BHA, developed to improve the flowability of wet bauxite while maintaining the integrity of the Bayer process. Laboratory-scale tests using Boké (Guinea) bauxite assessed flow performance and slurry rheology under simulated Bayer grinding conditions. At dosages of 300–1000 g/t, FLOMIN™ BHA significantly improved discharge rates and reduced agglomeration compared to conventional superabsorbent polymers (SAPs).

A key innovation of FLOMIN™ BHA lies in its controlled degradation during caustic grinding, generating dispersive by-products that reduce slurry viscosity. This dual functionality enhances bauxite handling and grinding efficiency while avoiding the gel formation typically associated with SAPs. Additionally, by reducing free moisture content, the product may contribute to safer maritime shipping. Ongoing evaluations are examining the impact of FLOMIN™ BHA on critical Bayer process parameters, with a particular focus on solid–liquid separation efficiency.

Keywords: Wet bauxite, Handling aid, Acrylate polymers.

1. Introduction

Handling wet bauxite before processing presents several challenges, particularly in transport, storage, and material flow. High moisture content causes agglomeration, leading to blockages in hoppers, silos, and conveyors, requiring frequent manual intervention [1–3]. During transport, wet bauxite tends to stick to vessels, trucks, conveyors and hoppers surfaces, reducing unloading efficiency and increasing maintenance needs. In cold conditions, moisture can freeze, further complicating handling. In storage, excessive moisture can cause bridging and arching in silos, disrupting material discharge. Additionally, inconsistent moisture levels affect dosing and homogenization, leading to unstable material flow in processing units.

To facilitate the handling of ore, several solutions have been considered. Mechanical flow aids such as air blowing, aeration, and vibration methods are commonly used to counteract consolidation forces, disperse loose agglomerates, and break formed bridges. However, these techniques are often ineffective when the strength of the solids exceeds that generated by these methods [4]. Additionally, they require large energy sources and present constraints such as inaccessibility, physical damage, design changes, and safety risks [5]. Flow additives, such as lubricants, anti-caking agents, and flow regulators, have also been used to improve production efficiency and product quality [6–10].

A more practical solution to improve the flow properties of ores is the use of superabsorbent polymers (SAPs). SAPs are cross-linked polymer networks composed of water-soluble base elements, characterized by a low cross-linking density, which gives them a high liquid absorption capacity (up to 1000 times their own weight) [11]. They physically trap water through imbibition mechanisms such as diffusion and capillary forces within their macroporous structure. SAPs have been already applied in the dewatering of coal, clays, activated sludge, and metal plating sludge, achieving better results than centrifugal treatments [12–17].

Industrial-scale trials in the Bayer process with the commercial SAPs have shown these products are not degraded during processing. Instead, gel-like agglomerates accumulate in the red mud settler, are entrained in the overflow stream, and subsequently obstruct the safety filtration systems.

Handling iron ore and coal often poses challenges due to their cohesive and adhesive nature, exacerbated by moisture. Some studies have explored the use of SAPs to improve the flowability of these materials [4, 18–20]. Notably, Dzinomwa et al. pioneered the use of SAPs for dewatering coal fines, showing significant moisture reduction and improved production trials [4].

2. Materials and Methods

2.1 Materials

2.1.1 Chemical

The reagents evaluated in this study, including both commercial references and SNF-developed products, are polymers derived from neutralized acrylic acid. These materials are supplied in powder form and are synthesized via a gel polymerization process, a method well established and widely recognized in the field of polymer chemistry.

Table 1. Handling aid reagents.

Product	Comments
Market Product 1	Conventional SAP from the market
Market Product 2	Conventional SAP from the market
FLOMIN™ SAP 7500 CF	Specific SAP designed by SNF as handling aid and dry mineral processing aid
FLOMIN™ BHA 5478-2	Newly developed reagent designed for Bayer Process
FLOMIN™ BHA 5478-4	Newly developed reagent designed for Bayer Process

2.1.2 Bauxite

Bauxite was sampled from Boké (Guinea) with a residual moisture content of approximately 10 wt%. It was then screened through a 10 mm sieve to remove large aggregates that could affect test reproducibility.

2.1.3 Equipment

Grinding Unit
The grinding equipment used is a laboratory ball mill from the manufacturer "Ceramic Instruments", model SD1-1000, equipped with a rotating unit (Figure 1a). A high temperature fired, totally non-porous porcelain jar with dimensions of 132 mm in diameter and 83 mm in height, and a Mohs hardness of 9, is used (Figure 1b). The jar contains seven non-porous ceramic balls of 18.5 mm in diameter and three non-porous ceramic balls of 25 mm in diameter, all with a Mohs hardness of 9 (Figure 1c).

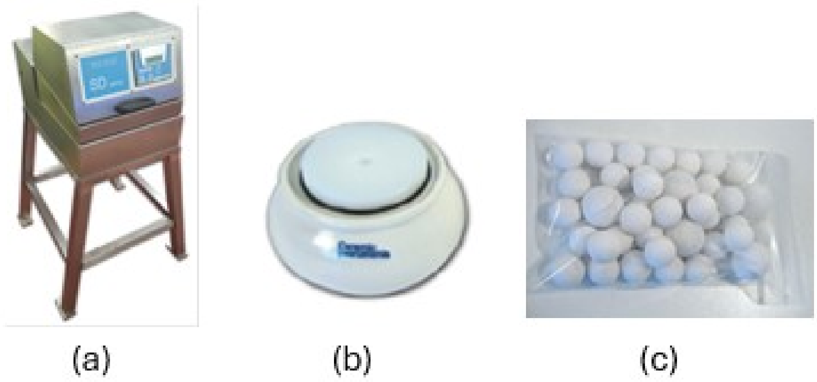

Figure 1. (a) SD1-1000, (b) ceramic grinding ball mill and (c) non-porous ceramic balls.

Brookfield LVT Viscometer
Viscosity was measured using a Brookfield LVT viscometer (Figure 2) at room temperature, employing spindle No. 3 (B-LV-3 (063) at a rotational speed of 30 rpm.

Figure 2. Brookfield LVT Viscometer with spindle unit.

2.2 Methods

2.2.1 Preparation of the Additive-Treated Bauxite

A 200 g sample of bauxite was placed in a 400 mL beaker, and the bauxite handling aid, in powder form, was added. The mixture was thoroughly stirred for 5 rotations and allowed to rest for 1 hour to ensure proper integration of the additive with the bauxite.

2.2.2 Bauxite Handling Aid – Test Protocol

The flowability of wet bauxites treated with various Ore handling aids at various dosage was studied by measuring the discharge of 200 g of treated material through a funnel (Ø = 3,5 cm - see Figure 3) after 20 hours at -20 °C. The opening size chosen considering the particle size distribution of bauxite considering the biggest particle can pass through the hole, which allow no flowability interruption This size enables clear differentiation of discharge rates, facilitating comparison of ore handling aids. The method is based on an internal test protocol previously established for iron ore, ensuring relevance and reproducibility.

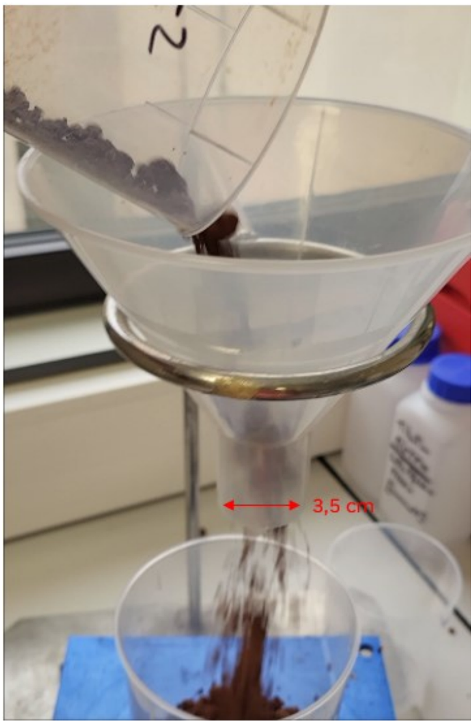

Figure 3. Bauxite handling test – setup.

Flowability performance is evaluated through visual assessment, and aggregate size is also quantified. This product selection method has proven effective, particularly for iron ores. However, more quantitative approaches are currently under investigation, such as measuring residual free water content to more precisely assess product performance.

2.2.3 Grinding Conditioning – Test Protocol

Following the Bauxite handling tests, the additive-treated bauxite is introduced into a ball mill, followed by the addition of a synthetic spent liquor at 70 °C, with the composition outlined below, to achieve a 65 wt% solids slurry (Table 2).

Table 2. Synthetic spent liquor composition.

Bauxite Solid	1300	g/L
Caustic Soda	220	g/L (as Na_2CO_3)
Alumina	90	g/L (as Al_2O_3)
Sodium Carbonate	25	g/L (as Na_2CO_3)

The grinding process is carried out for 5, 15, or 30 minutes, depending on the desired outcome. At the end of the grinding stage, the slurry is sieved through a 300 µm mesh to remove large aggregates, which are returned to the mill. The viscosity of the resulting slurry is then measured using a LVT Brookfield Viscometer at 30 rpm and compared to a blank (non-additive ground bauxite slurry).

3. Results

3.1 Bauxite Handling Aid – Test Result

Bauxite handling tests were conducted at 1000 grams of chemical per tonne of wet Boké bauxite using a commercially available product, claimed to be efficient as a handling aid, and the SNF standard product, FLOMIN™ SAP 7500 CF. A dosage of 1000 g/t corresponds to the maximum recommended amount of bauxite handling aid to be used for highly wet bauxites (> 20wt% moisture). Under standard conditions, a dosage between 200 and 500 g/t is preferred. However, in this study, the maximum dosage was selected to represent a worst-case scenario. These were compared to the newly developed product, FLOMIN™ BHA (Bauxite Handling Aid), as described earlier, and to a blank. The results obtained are presented in Figure 4.

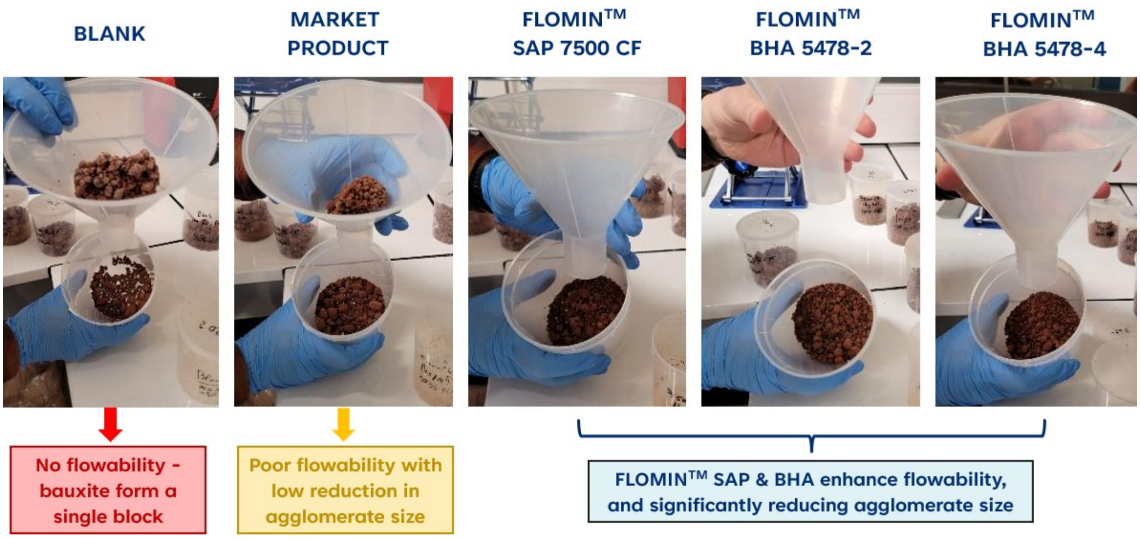

Figure 4. Bauxite handling aid results at 1000 grams per tonne of Boké bauxite.

It can be observed that the FLOMIN™ bauxite handling product range provides good performance at 1000 g/t of Boké bauxite in terms of flowability and aggregate size. In fact, even the product not specifically developed for the Bayer process outperforms the market product.

3.2 Grinding Conditioning – Test Results

3.2.1 Grinding Time Impact

To assess the test conditions, grinding was conducted at different time intervals to achieve an acceptable proportion of fine particles (below 300 µm) and to evaluate the impact on slurry viscosity, both with and without additives at 1000 g/t (Table 3).

The results show that increasing the grinding time leads to higher slurry viscosities, both with and without additives. At a given grinding time, the presence of an additive influences the slurry viscosity differently: the FLOMIN™ SAP 7500 CF has a negative impact, and the presence of gel is noticeable in the filtration residue.

At the same time, FLOMIN™ BHA 5478-2 improves the rheological behaviour. This beneficial effect is most pronounced after 15 minutes of grinding.
Based on these tests, it was decided to fix the grinding time to only 5 minutes for the advancement of this study since the number of fine particles matched the industrial standard.

Table 3. Boké bauxite slurry Brookfield viscosity as a function of the grinding time.

	5 minutes	**15 minutes**	**30 minutes**
Blank	2100 cP	6200 cP	10200 cP
FLOMIN™ SAP 7500 CF	6000 cP	9800 cP	12500 cP
FLOMIN™ BHA 5478-2	2000 cP	4200 cP	10000 cP

3.2.2 Product Selection

To identify the BHA lead candidate, various samples were tested at 1000 g/t using the test conditions as described above.

Table 4. Boké bauxite slurry Brookfield viscosity as a function of handling aid (1000 g/t).

	LVT Brookfield Viscosity
Blank	2100 cP
FLOMIN™ SAP 7500 CF	6000 cP
Market Product	3800 cP
FLOMIN™ BHA 5478-2	2000 cP
FLOMIN™ BHA 5478-4	2200 cP

Test conclusions are almost the same as the one carried out in the previous section meaning that the current handling aid chemical impacted the slurry viscosities negatively, whereas the newly BHA product developed by SNF does not impact the slurry viscosity.

3.2.3 Dosage Impact

The lead candidate: FLOMIN™ BHA 5478-2 was tested at various dosage: 0, 500, 1000, and 1500 g/t to check the impact of the dosage on grinding performance (Table 5).

Table 5. Boké bauxite slurry Brookfield viscosity with FLOMIN™ BHA 5478-2 at various dosages.

	0 g/t (blank)	**500 g/t**	**1000 g/t**	**1500 g/t**
FLOMIN™ BHA 5478-2	2100 cP	2500 cP	2200 cP	1800 cP

Increasing the dosage of FLOMIN™ BHA 5478-2 results in a slight decrease in the viscosity of the bauxite slurry, indicating a moderate dispersing effect of the degradation products of FLOMIN™ BHA 5478-2. Although the observed effect is limited, it remains consistent, suggesting that by-products can help improve slurry rheology. This behaviour may be of interest in processes where viscosity control is critical for operational efficiency.

3.2.4 Dosage Testing Under Varying Moisture Conditions

During laboratory tests with different dosages of the BHA product, the moisture content of the bauxite remained constant. As a result, no significant performance differences were observed between the tested dosages. This is expected, as the wet bauxite under these stable humidity conditions already provided favourable conditions for apparent drying with 300 g/t of BHA.
However, field trials conducted in Indonesia, using West Kalimantan Bauxite at an average moisture content of 15 %, demonstrated that increased bauxite moisture content requires a corresponding increase in dosage for effective performance.

Specifically:

- At 15 wt% moisture content, a dosage of 300 g/t of FLOMIN™ BHA BSA 5478-2 was sufficient.

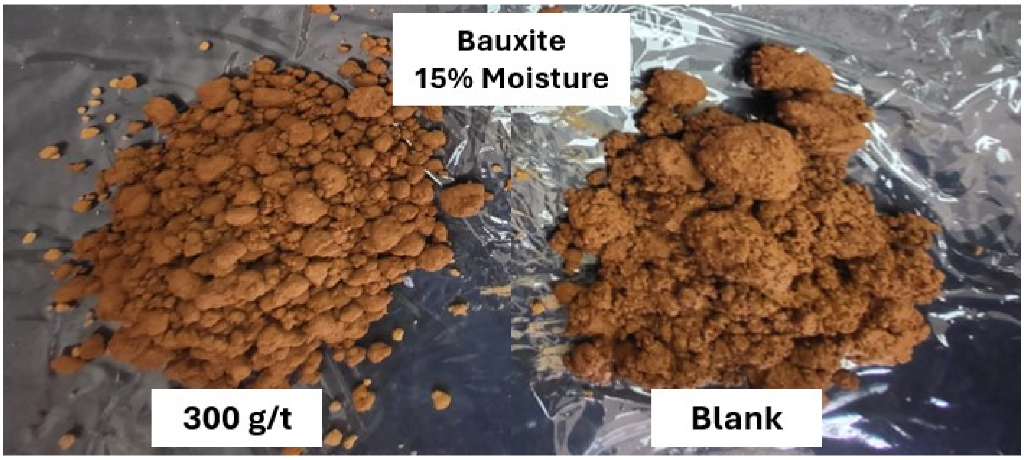

Figure 5. Appearance of bauxite from Indonesia at 15 wt% Moisture (left) with 300 g/t FLOMIN™ BHA 5478-2 and (right) without BHA.

- At 28 wt% moisture content, a dosage of 1000 g/t of FLOMIN™ BHA 5478-2 was necessary to achieve similar results.

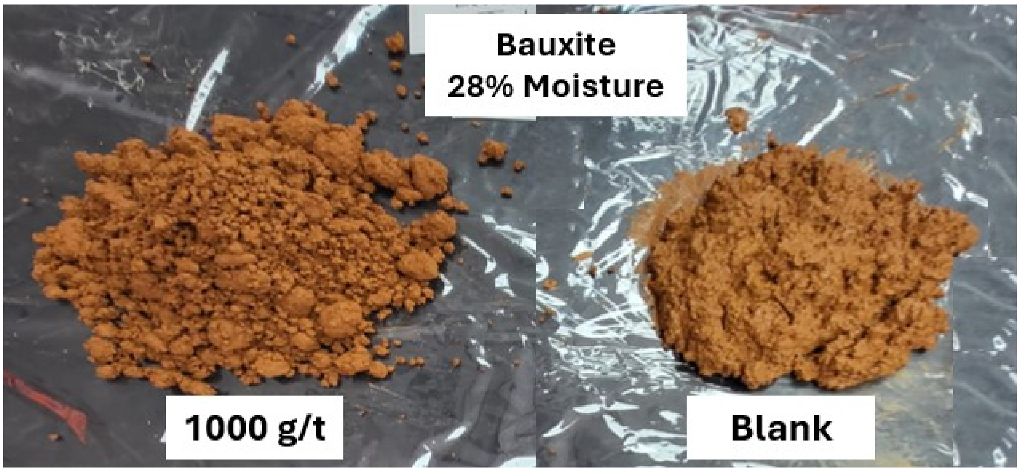

Figure 6. Appearance of bauxite from Indonesia at 28 wt% Moisture (left) with 1000 g/t FLOMIN™ BHA 5478-2 and (right) without BHA.

These findings confirm that BHA dosage must be adjusted based on the actual moisture content of the ore to maintain optimal handling performance.

4. Conclusions

This study has led to the development of a new class of reagent specifically designed to improve the handling of wet bauxite: FLOMIN™ BHA (Bauxite Handling Aid). These innovative products demonstrate performance equal to or even exceeding that of conventional available SAPs proposed on the market, while potentially overcoming one of their major limitations – the undesirable poisoning effect of the Bayer process.

Nevertheless, at this stage, the investigation of the potential poisoning effects of the Bauxite Handling Aid (BHA) is limited to slurry viscosity and the presence of insoluble materials in the digestion liquor. Further work is required to evaluate its impact on solid/liquid separation and on the total organic content within the Bayer liquor. Additionally, other potential poisoning effects should be considered, such as the influence on precipitation and final alumina quality.

A key advantage of FLOMIN™ BHA lies in its unique behaviour during processing. It degrades during the grinding stage by the attack of caustic solutions into by-products that act as dispersants, thereby contributing to a reduction in the viscosity of the resulting slurry, so it also acts as a grinding aid. This dual functionality – improving handling during the early stages and enhancing dispersion downstream – positions FLOMIN™ BHA as a high-value additives within the Bayer process.

While a series of results obtained at laboratory scale are highly encouraging, one of the next critical steps is to validate this new technology in other process areas and then under real industrial conditions. Field trials by alumina producers will be essential to confirm the operational benefits of FLOMIN™ BHA and to assess its potential for large-scale implementation in the industry.

5. References

1. Francisco Cabrejos, Effect of Moisture Content on the Flowability of Crushed Ores. *EPJ Web Conf.* 2017, *140*, 08011, DOI: 10.1051/epjconf/201714008011.
2. Christof Lanzerstorfer, Influence Of The Moisture Content On The Flowability Of Fine-Grained Iron Ore Concentrate. *World Academy of Science, Engineering and Technology International Journal of Chemical and Molecular Engineering* 2017, *11*.
3. Jens Plinke, Jan-Dirk Prigge and Kenneth C. Williams, Development of New Analysis Methods for the Characterization and Classification of Wet Sticky Ores. *Powder Technology* 2016, *294*, 252–258, DOI: 10.1016/j.powtec.2016.02.044.
4. G.P.T. Dzinomwa, C.J. Wood and D.J.T. Hill, Fine Coal Dewatering Using pH-and Temperature-Sensitive Superabsorbent Polymers. *Polymers for Advanced Technologies* 1997, *8*, DOI:10.1002/(SICI)1099-1581(199712)8:12<767::AID-PAT717>3.3.CO;2-7.
5. Michael J. Carr, Alan W. Roberts and Craig A. Wheeler, A Revised Methodology for the Determination of Bulk Material Cohesion and Adhesion. *Advanced Powder Technology* 2019, *30*, 2110–2116, DOI: 10.1016/j.apt.2019.06.025.
6. Jiangnan Dun, Frederick Osei-Yeboah, Pierre Boulas, Yiqing Lin and Changquan Calvin Sun, A Systematic Evaluation of Dual Functionality of Sodium Lauryl Sulfate as a Tablet Lubricant and Wetting Enhancer. *International Journal of Pharmaceutics* 2018, *552*, 139–147, DOI: 10.1016/j.ijpharm.2018.09.056.
7. Takehiro Kojima and James A. Elliott, Effect of Silica Nanoparticles on the Bulk Flow Properties of Fine Cohesive Powders. *Chemical Engineering Science* 2013, *101*, 315–328, DOI: 10.1016/j.ces.2013.06.056.
8. Ahmad Almaya and Aktham Aburub, Effect of Particle Size on Compaction of Materials with Different Deformation Mechanisms with and without Lubricants. *AAPS PharmSciTech* 2008, *9*, 414–418, DOI: 10.1208/s12249-008-9059-3.

9. Jun Yang, Ales Sliva, Amit Banerjee, Rajesh N. Dave and Robert Pfeffer, Dry Particle Coating for Improving the Flowability of Cohesive Powders. *Powder Technology* 2005, *158*, 21–33, DOI: 10.1016/j.powtec.2005.04.032.
10. Nadia Salih, Jumat Salimon, Emad Yousif and Bashar Mudhaffar Abdullah, Biolubricant Basestocks from Chemically Modified Plant Oils: Ricinoleic Acid Based-Tetraesters. *Chemistry Central Journal* 2013, *7*, 128, DOI: 10.1186/1752-153X-7-128.
11. Xiaofang Ma and Guohua Wen, Development History and Synthesis of Super-Absorbent Polymers: A Review. *J Polym Res* 2020, *27*, 136, DOI: 10.1007/s10965-020-02097-2.
12. Sheila Devasahayam, M. Anas Ameen, T. Vincent Verheyen and Sri Bandyopadhyay, Brown Coal Dewatering Using Poly (Acrylamide-Co-Potassium Acrylic) Based Super Absorbent Polymers. *Minerals* 2015, *5*, 623–636, DOI: 10.3390/min5040512.
13. Stevin H. Gehrke, Lii Hurng Lyu and Kristopher Barnthouse, Dewatering Fine Coal Slurries by Gel Extraction. *Separation Science and Technology* 1998, *33*, 1467–1485, DOI: 10.1080/01496399808545061.
14. Amal Sahi, Khadija El Mahboub, Tikou Belem, Abdelkabir Maqsoud and Mamert Mbonimpa, Dewatering of Mine Tailings Slurries Using Superabsorbent Polymers (SAPs) Reclaimed from Industrial Reject of Baby Diapers: A Preliminary Study. *Minerals* 2019, *9*, 785, DOI: 10.3390/min9120785.
15. Sophia Joseph-Soly, Ataollah Nosrati and Jonas Addai-Mensah, Improved Dewatering of Nickel Laterite Ore Slurries Using Superabsorbent Polymers. *Advanced Powder Technology* 2016, *27*, 2308–2316, DOI: 10.1016/j.apt.2016.07.010.
16. Aida Farkish and Mamadou Fall, Rapid Dewatering of Oil Sand Mature Fine Tailings Using Super Absorbent Polymer (SAP). *Minerals Engineering* 2013, *50–51*, 38–47, DOI: 10.1016/j.mineng.2013.06.002.
17. Anis Roshani, Mamadou Fall and Kevin J. Kennedy, Impact of Drying on Geo-Environmental Properties of Mature Fine Tailings Pre-Dewatered with Super Absorbent Polymer. *International Journal of Environmental Science and Technology*. 2017, *14*, 453–462, DOI: 10.1007/s13762-016-1162-5.
18. Hely Simões Gurgel and Ivo André Homrich Schneider, Application of SAP to Improve the Handling Properties of Iron Ore Tailings of High Cohesiveness: Could a Reagent Help the Decommissioning Process of a Dam? *Mining* 2024, *4*, 733–746, DOI: 10.3390/mining4040041.
19. N. Gurulaxmi Srikakulapu, Sai Srikar Cheela, Virendra K. Bari, Asim Kumar Mukherjee and Atul K. Bhatnagar, Effect of Polymer Flow Aids on LD Iron Ore Flowability. *Powder Technology* 2021, *377*, 523–533, DOI: 10.1016/j.powtec.2020.09.023.
20. N. Gurulaxmi Srikakulapu, Sai Srikar Cheela, Dilip Makhija and Narayan Sharma, Improved Flowability of Iron Ore Using Superabsorbent Polymers. *Powder Technology* 2020, *364*, 321–331, DOI: 10.1016/j.powtec.2020.01.089.