PROGRAMME

Konferens i Mineralteknik
Conference in Minerals Engineering

7–8 February 2023

Mineralteknik/Mineral Processing

ltu.se/minpro

LULEÅ TEKNISKA UNIVERSITET

PROGRAMME – CONFERENCE IN

Tuesday, February 7, 2023

10.00 – 10.30	Registration and coffee
10.30 – 11.15	Jan ROSENKRANZ, Luleå University of Technology *Welcome, Recent Developments in Mineral Processing at LTU* Tommy KARLKVIST, Saeed Chehreh CHELGANI, LTU *Education in Minerals Engineering at LTU* Thomas AIGLSPERGER, LTU *CAMM – Center of Advanced Mining and Metallurgy*
11.15 – 12.15	Keynote: Laurindo de Salles LEAL FILHO, UNIVERSITY OF SÃO PAULO, Brazil *Concentration of Iron Ore via Reverse Cationic Flotation of Silicates: Challenges and Solutions*
12.15 – 13.15	Lunch at Bistron

Session 1 - Flotation

Session chair: Tommy Karlkvist

13.15 – 13.45	Hyunjung KIM, HANYANG UNIVERSITY *A Research Trend on Biocollector-Based Flotation*
13.45 – 14.15	Saeed Chehreh CHELGANI, LTU *Flotation Using Green Chemicals*
14.15 – 14.45	Andrew DIXON, FLSMIDTH *High-Efficiency Mineral Flotation Using REFLUX™ Flotation Cell*
14.45 – 15.15	Coffee break

Session 2 – Characterization methods

Session chair: Mehdi Parian

15.15 – 15.45	Alan R. BUTCHER, GTK *A new mineralogical, petrographic, isotopic and geochemical workflow for the characterization of spodumene - implications for mineral processing*
15.45 – 16.15	Carolina MÅNBRO, LTU *Chemical and Mineralogical Characterisation of Iron Ore Drillcore using μ-XRF*
16.15 – 16.45	Ronja SUVELA, OULU UNIVERSITY *Development and Application of Selective Analysis Methods for the Determination of Xanthates in Process and Environmental Water Samples*
16.45 – 17.15	Andrew H. MENZIES, BRUKER NANO *The Search for Gold: Benefits of Combining Micro-XRF and SEM Analytical Techniques*
19.00 – 24.00	Dinner at Bistron

A research trend on biocollector-based flotation

Hyunjung Kim[a],*, Allan Gomez-Flores[a], Gilsang Hong[a], Hyun-Su Park[a], Sadia Ilyas[a], and Levie Mweene[a]

[a] Department of Earth Resources and Environmental Engineering, Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul 04763, Republic of Korea

*Corresponding author. Tel.: +82-2-2220-0541, Fax: +82-2-2220-3119, E-mail: kshjkim@hanyang.ac.kr

ABSTRACT

Much research has been reported on the development of a new collectors that possess strong selectivity to specific minerals; most of the research is oriented to investigating via either combining pre-existing collectors or transforming a functional group of a collector. Some research has shown an intriguing outcome. Nevertheless, in most cases the approaches in the research are still based on chemical collectors that are mostly persistent when they are released to the environment. Given the most urgent mission, Carbon Neutrality by 2050, and the corresponding change of companies' business plan to environmental, social, and governance, developing eco-friendly collectors is inevitable. Until now, bio-based collectors are regarded as one of the most promising alternatives, and relevant works have sporadically been reported. In this presentation, the research trend on the bio-based collector flotation will be introduced, and the limitations and future challenges will be discussed.

1 Introduction

The separation of valuable minerals from nonvaluable minerals is essential to produce various materials such as cellphones, batteries, and construction materials. Flotation is a widely used separation process in which collectors are employed to modify the surface properties of valuable minerals, increasing their attachment to bubbles. The main mechanism through which collectors accomplish this is by inducing hydrophobicity on the mineral surfaces. However, because collectors can be toxic to organisms and the environment, it is important to consider cleaner alternatives when developing mineral processing industries. Quaternary amines, sodium isopropyl xanthate, sodium di-ethyl dithiophosphate, and alkyl hydroxamate are commonly used collectors, but are toxic and hazardous in nature [1]. Microorganisms and their extracellular polymeric substances have been explored as alternative collectors in flotation experiments [1] as they can adhere to mineral surfaces, modifying them and influencing their attachment to bubbles. In this review, we will examine the current trends and state of biocollector-based flotation as a means of achieving selective, environmentally friendly, and economically viable mineral separation.

2 Materials and methods

In December 2022, a search was conducted on the SCOPUS database using the keywords "bio collector" "flotation" "mineral". The search yielded a total of 33 documents, of which 20 were

relevant to the topic of interest. The selected articles were then analyzed using text analytics algorithms with the R software.

3 Results and discussion

Figure 1 shows a word cloud of the words that appeared at least 20 times across the articles. Figure 2 presents a bar chart of the 20 most frequently repeated words in the word cloud. According to the figures, pyrite and chalcopyrite were the most frequently mentioned minerals, while ferrooxidans was the most frequently mentioned microorganism species name.

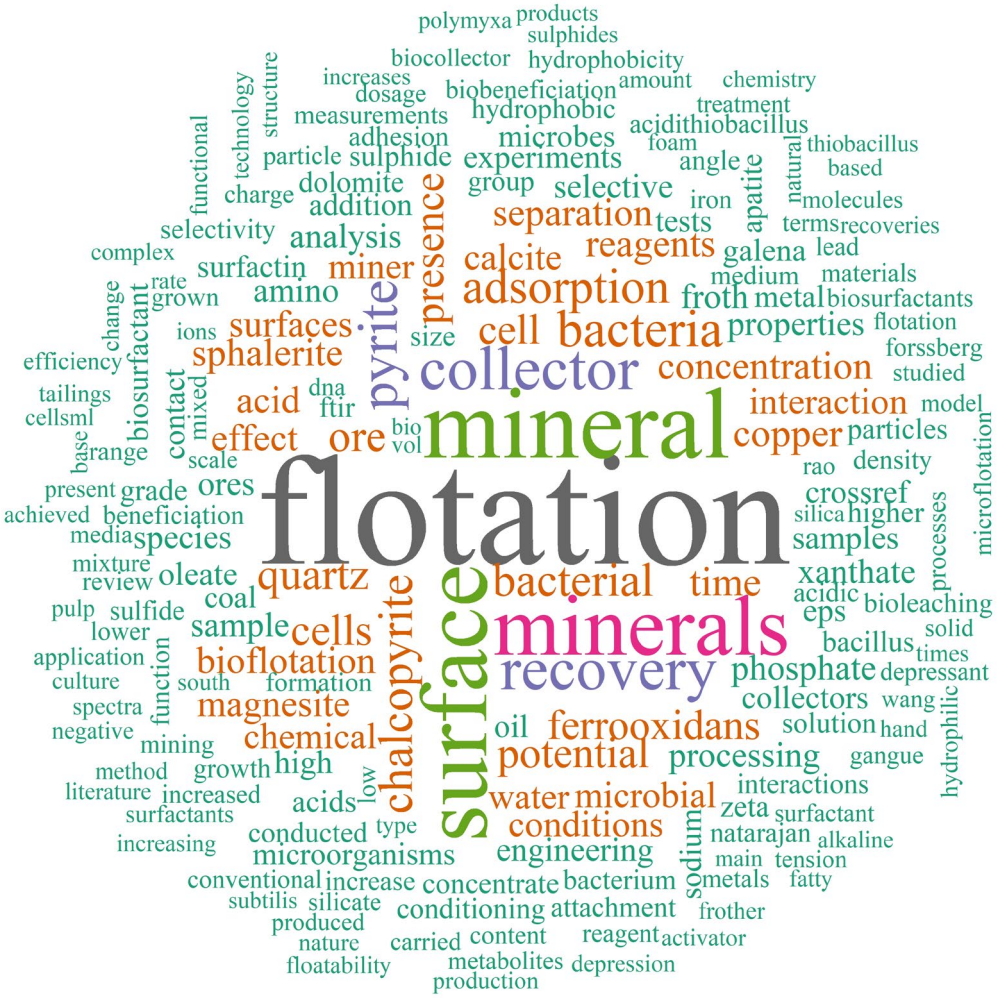

Figure 1. Word cloud of terms with a frequency of 20 times (data from 2000 to 2022).

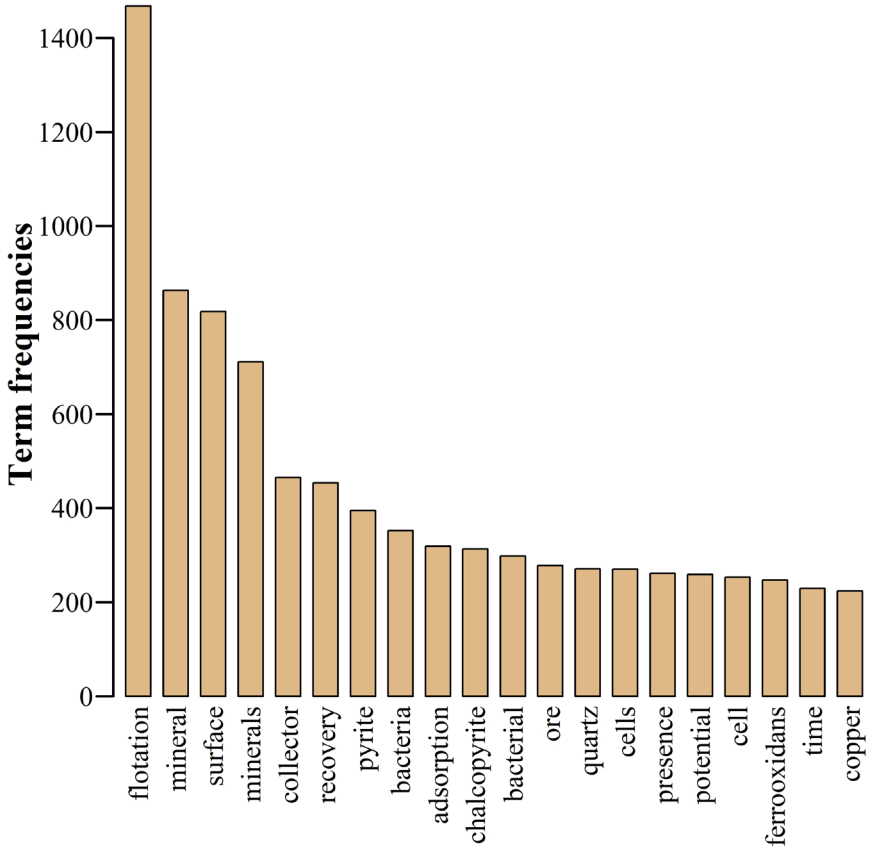

Figure 2. Word cloud of terms with a frequency of 20 times (data from 2000 to 2022).

Figure 3 illustrates the average particle size range used in flotation tests. The particle ranges of 30-78 µm and 78-126 µm were the most frequent. This suggests that intermediate size ranges were predominantly used in flotation tests, while fine and coarse sizes were under-represented.

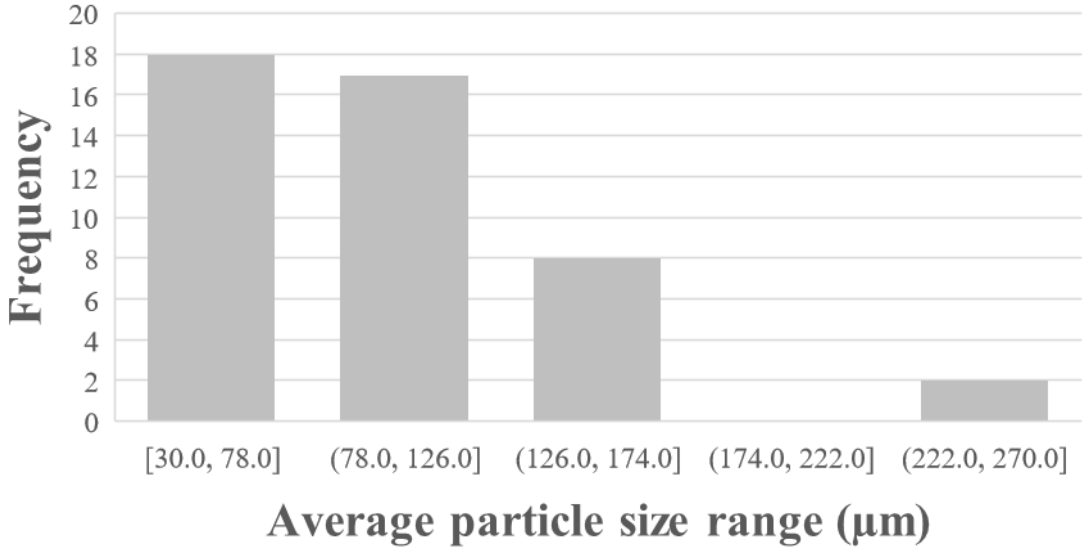

Figure 3. Average particle size range used in flotation tests (data from 2013 to 2023).

Figure 4 shows the pH range in flotation tests. The distribution appears to be roughly normal. Most flotation tests were conducted in the range of 6.4-8.1.

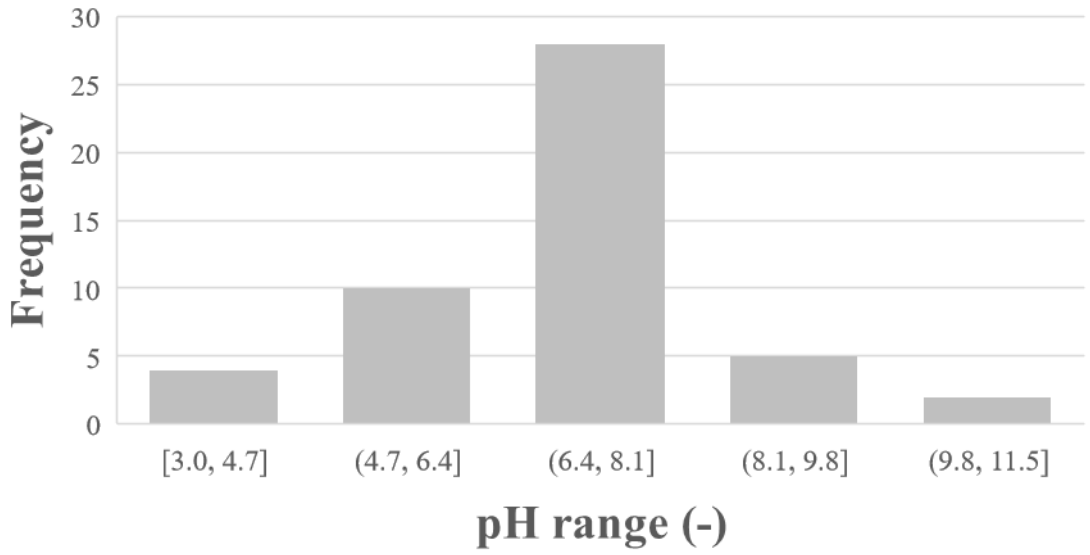

Figure 4. pH range in flotation tests (data from 2013 to 2023).

Figure 5 shows the collectors used in flotation tests. Most of tests were conducted without the addition of any conventional collector. This indicates that microorganisms, including their extracellular substances, were likely used to modify mineral surfaces. In fact, the role of microorganisms in flotation was found to be primarily as a collector, rather than as a depressant (data not shown in this document).

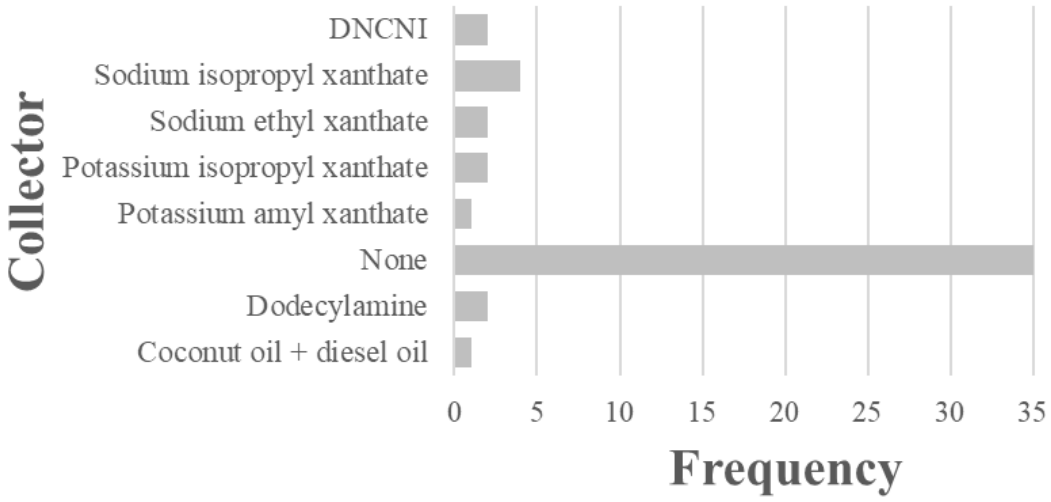

Figure 5. Collectors used in flotation tests (data from 2013 to 2023).

Figure 6 presents a topic modeling of the articles in which four distinct topics were generated. Figure 7 illustrates the probability that the articles used in this review belong to one of the four topics. According to the figures, stibnite, barite, chalcopyrite, and magnesite flotations were

frequently studied. Ferrooxidans was the microorganism most frequently used. Additionally, topics 3 and 4 were the most repeated among the articles.

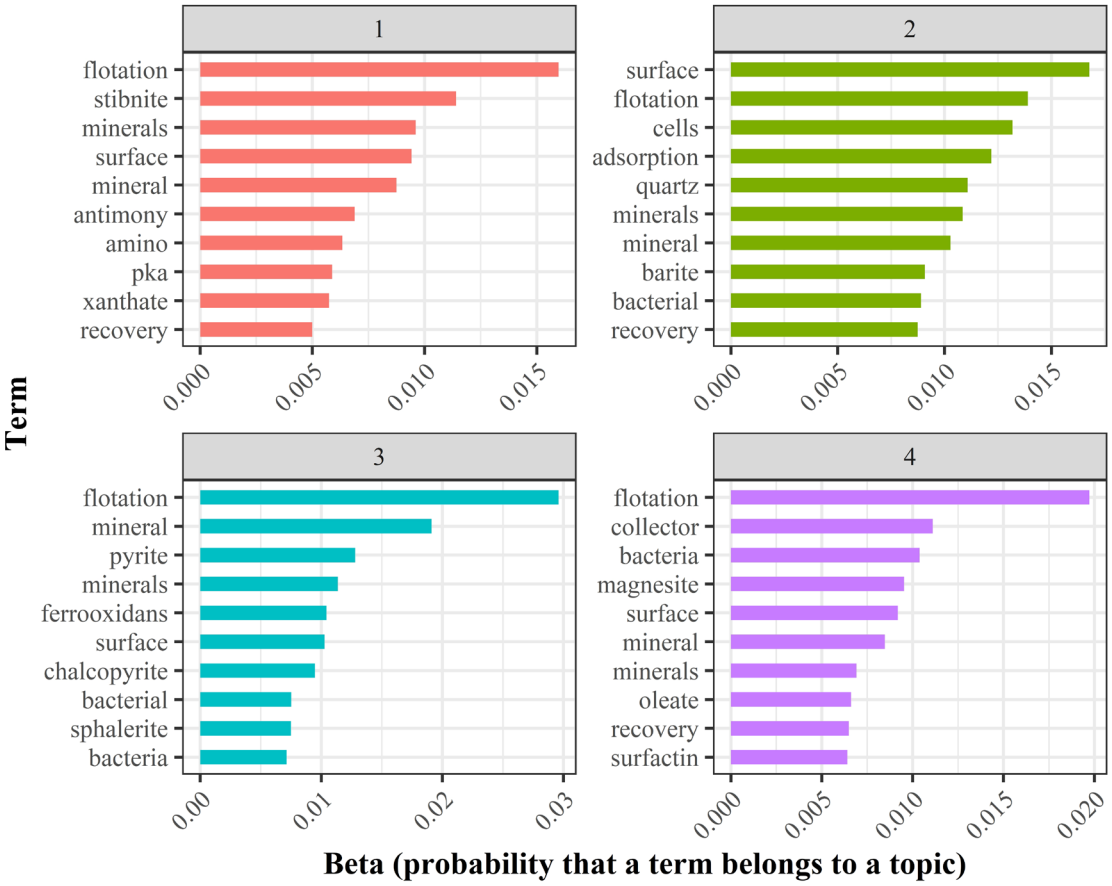

Figure 6. Grouped terms using topic modeling from articles (data from 2000 to 2022).

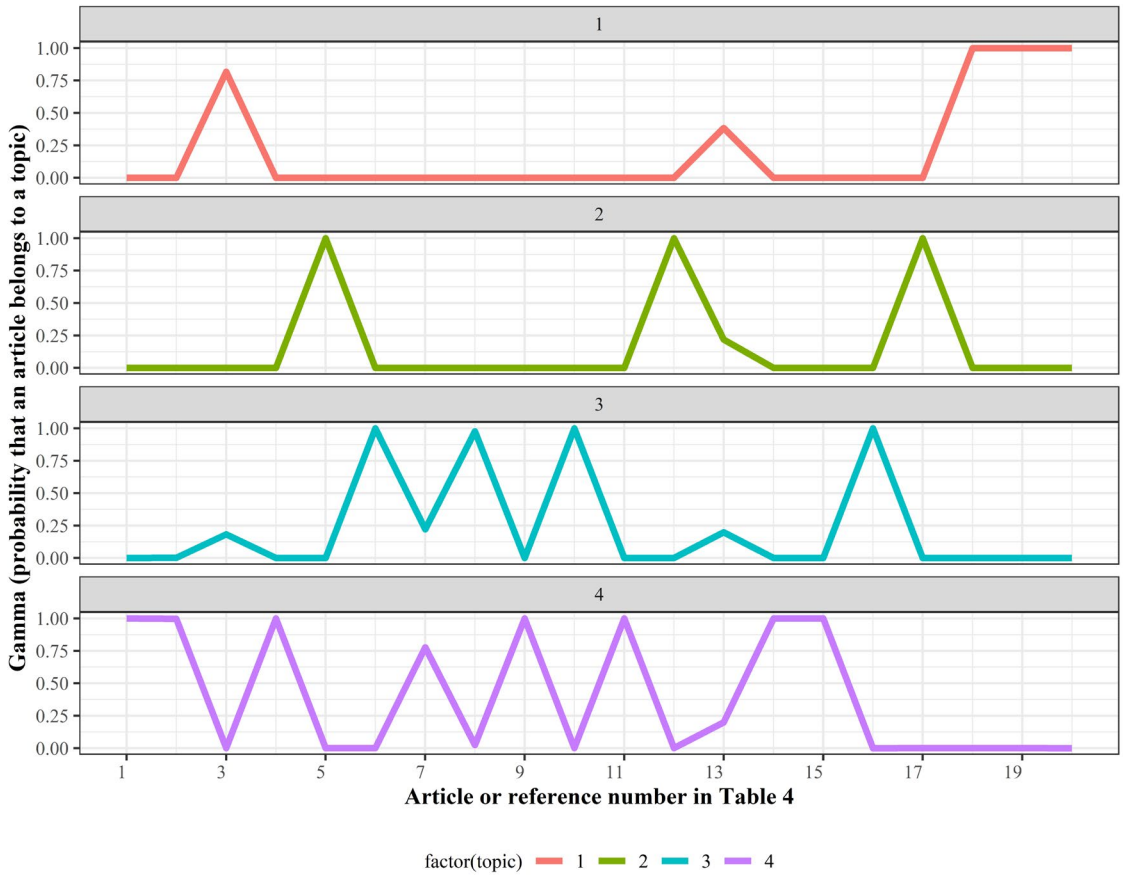

Figure 7. Articles per topic probability from topic modeling (data from 2000 to 2022).

Figure 8 displays a bigram of the correlation between words found across the articles. As shown, PIPX (potassium isopropyl xanthate) was often used to contrast biocollector-based flotation (which uses microorganisms and their extracellular substances are amphoteric) [2, 3]. Additionally, biocollector-based flotation was primarily studied at a laboratory scale, and its performance was found to be related to chemical and conditioning factors. The authors Priyanka Dhar (Norwegian University of Science and Technology) and A J Davis (North Staffordshire Polytechnic) were also frequently cited, likely due to their early significant contributions to the topic.

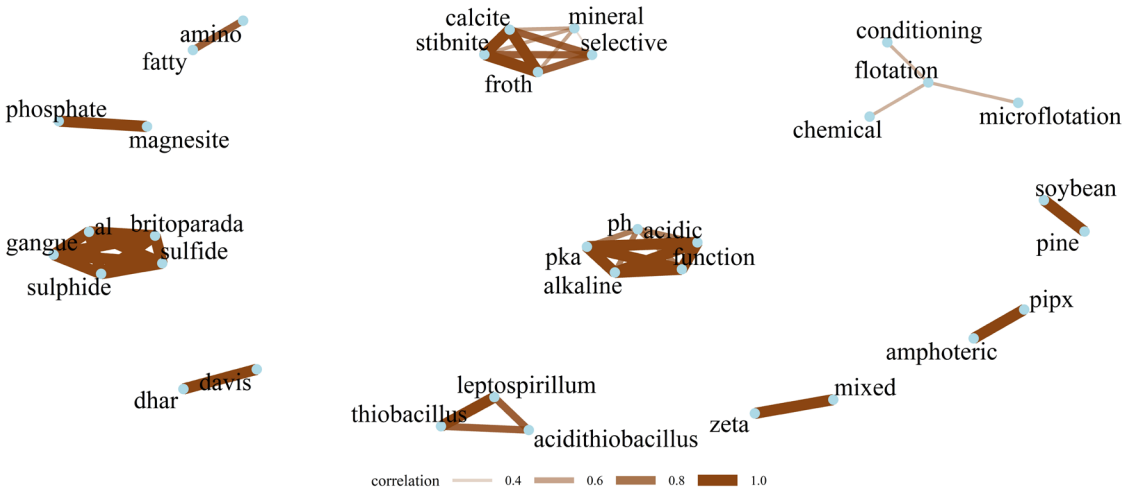

Figure 8. Co-occurrence network analysis based on Spearman's correlation displaying words with a frequency of 20 having a correlation coefficient equal or more than 0.25 (data from 2000 to 2022).

4 Conclusions

It is important to clearly identify in article tittles whether microorganisms and their substances are being used as biocollectors or biodepressants. Stibnite, barite, chalcopyrite, and magnesite have been frequently used in biocollector-based flotation. Ores were rarely used for flotation tests. Similarly, (*Acidithiobacillus, Leptospirillum, Thiobacillus) ferrooxidans* is the microorganism species name that has been most used. However, future research should also explore the use of other minerals, ores, and microorganisms. Additionally, it is important to study the physicochemical aspects of the interactions between microorganisms and minerals, as well as the impact of pulp conditions on biocollector-based flotation.

Acknowledgements
This work was supported by the framework of international cooperation program managed by the National Research Foundation of Korea (NRF-2022K2A9A2A12000254).

References

[1] Behera, S. K., Panda, S. K., & Mulaba-Bafubiandi, A. F. (2022). Valorization of copper smelter slag through the recovery of metal values by a synergistic bioprocess system of bio-flotation and bio-leaching. Environmental Quality Management.
[2] Bleeze, B., Zhao, J., & Harmer, S. L. (2018). Selective attachment of Leptospirillum ferrooxidans for separation of chalcopyrite and pyrite through bio-flotation. Minerals, 8(3), 86.
[3] Behera, S. K., & Mulaba-Bafubiandi, A. F. (2017). Microbes assisted mineral flotation a future prospective for mineral processing industries: A review. Mineral Processing and Extractive Metallurgy Review, 38(2), 96-105.