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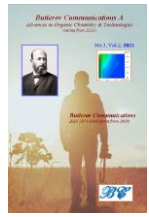

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Application of the flotation process for the enrichment of ilmenite ores from Vietnam

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Keywords: ilmenite ore, flotation, sodium oleate, foam fraction, chamber product, concentration and degree of concentration of ilmenite, acidity of the medium, collector.

Abstract

Possibility of ilmenite enrichment of Ha Tinh deposit (Vietnam) ores by flotation method has been studied. Results obtained during the research can be used for industrial dressing of ilmenite ores. Ilmenite concentrates formed in the flotation concentration process are further used in process of their further processing to obtain titanium-containing materials and alloys. At present, gravity methods and electromagnetic separation are used to enrich ilmenite ores of Vietnamese deposits, however, these methods do not allow to ensure completeness of ilmenite separation from rutile. It is shown that to obtain ilmenite concentrates with a high content and degree of enrichment, flotation is carried out for 8 minutes with the addition of 0.27-0.36 g/l of sodium oleate (NaOl) at pH = 6-9. When studying the effect of medium acidity on the flotation characteristics of ore, it was found that the best results are achieved in pH range 5.5-7.0. Under these conditions, NaOl concentration is 0.36 g/l, and titanium enrichment degree is more than 80%, while the concentration TiO_2 reaches ~45%. When studying of titanium concentration effect in ilmenite ore on flotation concentration efficiency, it was shown that when the concentration of TiO_2 in the ore is more than 25%, the titanium concentration degree does not practically change and does not exceed 86%. Thus, flotation process can be used for further enrichment of concentrates obtained by electromagnetic separation method. At the same time, enriched concentrates are obtained that meet requirements for both the titanium content and the degree of enrichment.

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References

[1] Cui Hgo Chan Thien, Yu.V. Kirichenko. Mineral potential of Subsea deposits in the South China Sea of Vietnam. *Mining.* **2020**. No.1. P.140-143. DOI: http://dx.doi.org/10.30686/1609-9192-2020-1-140-143 (Russian)

[2] B.X. Nam, H.S. Giao. Status of development orientations for mining titanium placers in Vietnam. *Горные науки и технологии.* **2016**. No.1. P.40-50. DOI: 10.17073/2500-0632-2016-1-40-50

[3] Yu.V. Kirichenko, A.S. Kashirsky, G.S. Ivashchenko. Analysis of the environmental impact of the development of underwater solid mineral deposits. *Mining.* **2019**. No.3. P.92-97. DOI: 10.30686/1609-9192-2019-3-145-92-97 (Russian)

[4] Nassgewinnung B: Der Nassabbau. *Springer-Verlag Berlin Heidelberg.* **2008**. https://doi.org/10.1007/978-3-540-49695-3_5

[5] G.A. Nurok. Technology of mining minerals from the bottom of lakes, seas and oceans. *Moscow: Nedra.* **1979**. 381p. https://www.twirpx.org/file/108897/ (Russian)

[6] V.T. Nguyen, V.T. Tran. Industrial-scale titanium-zircon placer potential in the red sand dunes of the Phan Thiet formation in South Trung Bo coastlines. *Journal of Geology, Series A.* Hanoi, Vietnam. **2008**. Iss.308. P.18-24.

[7] T.T. Dang, X.N. Bui. Research of the process parameters and suitable mining sequence of ilmenite ore(Ti) in coastal sand dunes. *Journal of Mining Industry.* Hanoi, Vietnam. **2008**. Iss.6. P.22-24.

[8] H. Zhang, J. Zeng, H. Xie, C. Guan, L. Chen. Enhanced separation for ilmenite tailings with a novel HGMS-flotation process. *Separation Science and Technology.* **2020**. Vol.55. No.4. P.752-760. https://doi.org/10.1080/01496395.2019.1567546

[9] K. Shu, L. Xu, H. Wu, S. Fang, Z. Wang, Y. Xu, Z. Zhang. Effects of ultrasonic pre-treatment on the flotation of ilmenite and collector adsorption. *Minerals Engineering.* **2019**. Vol.137. No.15. P.124-132. https://doi.org/10.1016/j.mineng.2019.04.001

[10] J. Zhaia, P. Chena, W. Suna, W. Chenc, S. Wanc. A review of mineral processing of ilmenite by flotation. *Minerals Engineering.* **2020**. Vol.157 Article 106558. https://doi.org/10.1016/j.mineng.2020.106558

[11] J. Caia, J. Deng, S. Wena, Y. Zhanga, D. Wua, H. Luoa, G. Chengd. Surface modification and flotation improvement of ilmenite by using sodium hypochlorite as oxidant and activator. *Journal of Materials Research and Technology*. **2020**. No.9(3). P.3368-3377. https://doi.org/10.1016/j.jmrt.2020.01.031

[12] Y. Du, Q. Meng, Z. Yuan, X. Zhao, Y. Xu. Impact of acid surface pretreatment on the flotation of ilmenite and titanaugite and its functional mechanism. *Powder Technology.* **2020**. Vol.376. P.622-630. https://doi.org/10.1016/j.powtec.2020.08.057

[13] K.P. Galvin, J. Zhou, A.J. Price, P. Agrwal, S.M. Iveson. Single-stage recovery and concentration of mineral sands using a REFLUX^{TM} Classifier. *Minerals Engineering.* **2016**. Vol.93. P.32-40. https://doi.org/10.1016/j.mineng.2016.04.010

[14] X. Guo, S. Dai, Q. Wang. Influence of different comminution flowsheets on the separation of vanadium titano-magnetite. *Minerals Engineering.* **2020**. Vol.149. P.106-268. https://doi.org/10.1016/j.mineng.2020.106268

[15] X. Guo, S. Cui, S. Dai et al. Investigation of microcrack formation in vanadiumtitanium magnetite using different crushing processes. *J. Southern African Instit. Min. Metall.* **2019**. Vol.119. P.811-816.

[16] G.A. Shevchenko, V.G. Shevchenko, V.A. Baranov, V.N. Spassky. The enrichment technology of slag from metallurgical processing of copper ore concentrate. *Journal of Geology, Geography and Geoecology.* **2019**. Vol.28(3). P.537-545. https://doi.org/10.15421/111950

[17] Z. Yuan, X. Zhao, Q. Meng, Y. Zhang, L. Li. Study on surface magnetization recover ilmenite from titanaugite using surfactant sodium oleate. *Separation Science and Technology.* **2020**. Vol.55. No.15. P.2812-2821. https://doi.org/10.1080/01496395.2019.1641522

[18] S. Fang, L. Xu, H. Wu, J. Tian, Z. Lu, W. Sun, Y. Hu. Adsorption of Pb(II)/benzohydroxamic Acid Collector Complexes for Ilmenite Flotation. *Miner. Eng.* **2018**. Vol.126. P.16-23. https://doi.org/10.1016/j.mineng.2018.06.022
[19] Y. Yang, L. Xu, Y. Liu, Y. Han. Flotation Separation of Ilmenite from Titanaugite Using Mixed Collectors. *Sep. Sci. Technol.* **2016**. Vol.51. P.1840-1846. https://doi.org/10.1080/01496395.2016.1183678
[20] J. Tian, L. Xu, Y. Yang, J. Liu, X. Zeng, W. Deng. Selective Flotation Separation of Ilmenite from Titanaugite Using Mixed Anionic/cationic Collectors. *Int. J. Miner. Process.* **2017**. Vol.166. P.102-107. https://doi.org/10.1016/j.minpro.2017.07.006
[21] Q. Meng, Z. Yuan, L. Yu, Y. Xu, Y. Du, C. Zhang. Selective Depression of Titanaugite in the Ilmenite Flotation with Carboxymethyl Starch. *Applied Surface Science.* **2018**. Vol.440. P.955-962. https://doi.org/10.1016/j.apsusc.2018.01.234
[22] J. Shibata, D. Fuerstenau. Flocculation and Flotation Characteristics of Fine Hematite with Sodium Oleate. *Int. J. Miner. Process.* **2003**. Vol.72. P.25-32. https://doi.org/10.1016/S0301-7516(03)00085-1
[23] C. Liu, Q. Feng, G. Zhang, W. Ma, Q. Meng, Y. Chen. Effects of Lead Ions on the Flotation of Hemimorphite Using Sodium Oleate. *Miner. Eng.* **2016**. Vol.89. P.163-167. https://doi.org/10.1016/j.mineng.2016.02.002
[24] D. Horta, M.B. Mello Monte, F.L. Salles Leal. The Effect of Dissolution Kinetics on Flotation Response of Apatite with Sodium Oleate. *Int. J. Miner. Process*. **2016**. Vol.146. P.97-106. https://doi.org/10.1016/j.minpro.2015.12.003
[25] P.J. Thistlethwaite, M.S. Hook. Diffuse Reflectance Fourier Transform Infrared Study of the Adsorption of Oleate/Oleic Acid onto Titania. *Langmuir.* **2000**. Vol.16. P.4993-4998. https://doi.org/10.1021/la991514i
[26] M. Irannajad, A. Mehdilo, O.S. Nuri. Influence of Microwave Irradiation on Ilmenite Flotation Behavior in the Presence of Different Gangue Minerals. *Sep. Purif. Technol.* **2014**. Vol.132. P.401-412. https://doi.org/10.1016/j.seppur.2014.05.046
[27] W. Wang, H. Wang, Q. Wu, Y. Zheng, Y. Cui, W. Yan, J. Deng, T. Peng. Comparative Study on Adsorption and Depressant Effects of Carboxymethyl Cellulose and Sodium Silicate in Flotation. *J. Mol. Liq.* **2018**. Vol.268. P.140-148. https://doi.org/10.1016/j.molliq.2018.07.048
[28] X. Yang, P. Roonasi, A. Holmgren. A Study of Sodium Silicate in Aqueous Solution and Sorbed by Synthetic Magnetite Using in Situ ATR-FTIR Spectroscopy. *J. Colloid Interface Sci.* **2008**. Vol.328. P.41-47. DOI: 10.1016/j.jcis.2008.08.061
[29] C. Van Oss, R. Giese, P. Costanzo. DLVO and Non-DLVO Interactions in Hectorite. *Clay Clay Miner.* **1990**. Vol.38. P.151-159. doi:10.1346/CCMN.1990.0380206
[30] Y. Hu, J. Dai. Hydrophobic Aggregation of Alumina in Surfactant Solution. *Miner. Eng.* **2003**. Vol.16. P.1167-1172. https://doi.org/10.1016/j.mineng.2003.07.018
[31] S.H. Le, T.B. Kieu, V.A. Karelin. Flotation enrichment of ilmenite ores from Vietnam. Chemistry and chemical technology in the XXI century: materials of the XXII International scientific-practical conference of students and young scientists named after prominent chemists L.P. Kulev and N.M. Kizhner, dedicated to the 125th anniversary of the founding of the Tomsk Polytechnic University (Tomsk, May 17-20, 2021). Tomsk Polytechnic University. *Tomsk: Publishing house of the Tomsk Polytechnic University.* **2021**. Vol.2 P.118. (Russian)
[32] Le Son Hai, N.V. Karelina. Features of enrichment of ilmenite concentrates from Vietnam. Chemistry and chemical technology in the XXI century materials of the XXI International scientific-practical conference of students and young scientists named after outstanding chemists L.P. Kulev and N.M. Kizhner, dedicated to the 110th anniversary of the birth of Professor A.G. Stromberg, September 21-24, 2020, Tomsk. National Research Tomsk Polytechnic University. *Tomsk: TPU Publishing House.* **2020**. P.457-458. (Russian)
[33] Le Son Hai, N.V. Karelina. Ilmenite ore in Vietnam and enrichment peculiarities of ilmenite concentrates from Vietnam. Scientific initiative of foreign students and

graduate students of Russian universities, collection of reports of the X All-Russian Scientific and Practical Conference, Tomsk, April 22-24, 2020 National Research Tomsk Polytechnic University (TPU). *Tomsk: TPU Publishing House.* **2020**. P.125-130. (Rus)

[34] Le Son Hai, N.V. Karelina. Processing of ilmenite concentrates from Vietnam. Physical and technical problems in science, industry and medicine. Russian and international experience in personnel training collection of abstracts of the X International Scientific and Practical Conference, Tomsk, September 09-11, 2020: National Research Tomsk Polytechnic University, School of Nuclear Technology Engineering, Russian Basic Research Foundation; ed. team I.V. Shamanin, V.P. Krivobokov, A.G. Goryunov, V.A. Karelin. *Tomsk: Wind.* **2020**. P.137-138. (Russian)

[35] Le Son Hai, N.V. Karelina. Flotation enrichment of titanium-containing sands from Vietnam. Isotopes: technologies, materials and application collection of abstracts of the VI International Scientific Conference of Young Scientists, Postgraduates and Students, Tomsk, October 26-29, 2020: National Research Tomsk Polytechnic University (TPU). *Tomsk: TPU.* **2020**. P.77. (Russian)

[36] Le Hai Son, Le Thi Mai Huong, N.V. Karelina, V.A. Karelin. Research of the fluorination process of Rutile concentrate. *Vietnam Conference on Nuclear Science and Technology. Long City, Quang Ninh, Vietnam.* August 07-09. **2019**. P.231-232.

[37] Son Hai Le, Thuan Bach Kieu, Vladimir A. Karelin, Ivan I. Zherin, Nadezhda V. Karelina, Andrey A. Smorokov. Application of the flotation process for the enrichment of ilmenite ores from Vietnam. *Butlerov Communications.* **2021**. Vol.67. No.8. P.1-9. DOI: 10.37952/ROI-jbc-01/21-67-8-1 (Russian)