

8

Bibliographic references

- ANAND, P., MODAK, J.M., NATARAJAN, K.A. Biobeneficiation of bauxite using *Bacillus polymyxa*: calcium and iron removal. **International Journal of Mineral Processing**, v. 48, p. 51-60. 1996.
- ARAUJO, A.C., VIANA, P.R.M., PERES, A.E.C. Reagents in iron ores flotation. **Minerals Engineering**, v. 18, p. 219-224. 2004.
- BICCA, F.B., FLECK, L.C., AYUB, M.A.Z. Production of biosurfactant by hydrocarbon degrading *Rhodococcus ruber* and *Rhodococcus erythropolis*. **Revista de Microbiologia**, n. 30, p. 231-236. 1999.
- BOTERO, A.E.C., TOREM, M.L., MESQUITA, L.M.S. Fundamental studies of *Rhodococcus opacus* as a biocollector of calcite and magnesite. **Minerals Engineering**, v. 20, p. 1026 – 1032. 2007.
- BOTERO, A.E.C., TOREM, M.L., MESQUITA, L.M.S., Surface chemistry fundamentals of biosorption of *Rhodococcus opacus* and its effect in calcite and magnesite flotation. **Minerals Engineering**, v. 21, p. 83 – 92. 2008.
- BUENO, B. Y.M. **Removal of Pb, Cr and Cu by biosorption/bioflootation combined process using the bacterial strain *Rhodococcus Opacus*.** Doctoral thesis, Pontifical Catholic University of Rio de Janeiro, Department of Materials Science and Metallurgy. 2007 (In Portuguese).
- BULATOVIC, S.M. **Handbook of Flotation Reagents**, Elsevier, Amsterdam. 2007.
- CHANDRAPRABHA, M.N., NATARAJAN, K.A. Surface chemical and flotation behavior of chalcopyrite and pyrite in the presence of *Acidithiobacillus thiooxidans*. **Hydrometallurgy**, n. 83, p.146 – 152. 2006.

CHEMALE, F. and TAKEHARA, L. **Iron ores, Geology and Metallurgy.** São Paulo: Blucher, 2013 (In portuguese).

CLEMMER, J.B. Flotation of iron ore. **8th Annual Mining Symposium,** Duluth, Minnesota, USA. 1947.

COHEN R., AND EXEROWA, D. Surface forces and properties of foam films from rhamnolipid biosurfactants. **Advanced Colloid Interface Science,** n. 134 - 135, p. 24-34. 2007.

DEER, W.A, HOWIE, R.A, ZUSSMAN, J. **Mineral constituents of rocks – an introduction.** Lisboa: Foundation Calouste Gulbenkian. 558p. 1981.

DEO, N., NATARAJAN, K.A. and SOMASUNDARAN, P. Mechanisms of adhesion of *Paenibacillus polymyxa* onto hematite, corundum and quartz. **International Journal of Mineral Processing,** n. 62, p. 27-39. 2001.

DEO, N., NATARAJAN, K.A., Interaction of *Bacillus Polymyxa* with some oxide minerals with reference to mineral beneficiation and environmental control. **Minerals Engineering,** v. 10, p. 1339 – 1354. 1997.

DEO D. and NATARAJAN, K.A. Role of Corundum adapted strains of *Bacillus polymyxa* in the separation of hematite and alumina. **Minerals and Metallurgical Processing,** n. 16, p. 29-32. 1999.

DUBEL, J., SMITH, R.W., MISRA, M., CHEN, S., Microorganisms as chemical reagents: The hematite system. **Minerals Engineering,** v. 5, p. 547 – 556. 1992.

EL-MIDANY, A.A., ABDEL-KHALEK, M.A. Influence of bacteria-coal electrostatic interaction on coal cleaning. **International Journal of Mineral Processing,** n. 126, p. 30 -34. 2014.

FAHARAT, M., HIRAJIMA, T., SASAKI, K., AIBA, Y., DOI, K., Adsorption of *SIP E. coli* onto quartz and its applications in froth flotation, **Minerals Engineering,** n. 21, p. 389 – 395. 2008.

FARAHAT, M., TSUYOSHI, H., SASAKI, K., DOI, K. Adhesion of *Escherichia coli* onto quartz, hematite and corundum: extended DLVO theory

and flotation behavior. **Colloids and surfaces B: Biointerfaces**, n. 74, p. 140-149. 2009.

FAZAELOPOOR, MOHAMMAD H., KHOSHDAST, HAMID, RANJBAR, MOHAMMAD. Coal flotation using a biosurfactant from *Pseudomonas aeruginosa* as a frother. **Korean Journal Chemical Engineering**. DOI: 10.1007/s11814-010-0223-6. 2009.

FUERSTENAU, M.C., MILLER, J.D., GUTIERREZ, G. Selective flotation of iron ore. **Transactions of the Metallurgical Society of AIME**, n. 238, p. 200-203, 1967.

FUERSTENAU, M.C., HARPER, R.W., MILLER, J.D. Hydroxamate vs. fatty acid flotation of iron oxide. **Transactions of the Metallurgical Society of AIME**, n. 247, p. 69-73. 1970.

GARIP, SEBNEM, GOZEN, AYSEGUL CETIN, SEVERCAN, FERIDE. Use of Fourier transform infrared spectroscopy for rapid comparative analysis of *Bacillus* and *Micrococcus* isolates. **Food Chemistry**, n. 113, p. 1301 – 1307. 2009.

GOLDSTEIN, J.L., NEWBURY,D.E., ECHLIN,P., JOY,D.C.,ROMIG,A.D. Jr., LYMAN, C.E., FIORI,C., LIFSHIN,E. **Scanning electron microscopy and X-ray microanalysis**. 2.ed. New York: Plenum Press, 1992. 820p.

HIRAJIMA, T., AIBA, Y., FAHARAT, M., OKIBE, N., SASAKI, K., TSURUTA, T., DOI, K. Effect of Microorganisms on flocculation of quartz. **International Journal of Mineral Processing**, v. 102 - 103, p. 107 – 111. 2012.

HOSSEINI, T.R., KOLAHDOOZAN, M., TABATABAEI, Y.S.M., OLIAZADEH, M., NOAPARAST, M., ESLAMI, A., MANAFI, Z., ALFANTAZI, A. Bioflootation of Sarcheshmeh copper ore using *Thiobacillus Ferrooxidans* bacteria. **Minerals Engineering**. v. 18, p. 371 – 374. 2005.

IVSHINA, I.B., KUYUKINA, M.S., KRIVORUCHO A.V., PLEKHOV, O.A., NAIMARK, O.L., PODOROZHKO, E.A., and LOZINSKY V.I. Biosurfactant-enhanced immobilization of hydrocarbon-oxidizing

Rhodococcus ruber on sawdust. **Application of Microbiology Biotechnology**, v. 97, p. 5315-5327. 2013.

IWASAKI, I., COOKE, S.R.B, CHOI, H.S. Flotation characteristics of hematite, goethite and activated quartz with 18-carbon aliphatic acids and related compounds. **Transactions of the Metallurgical Society of AIME**, v. 217, p. 237-244. 1960.

JIA, C.Y., WEI, D.Z., LI, P.J., LI, X.J., TAI, P.D., LIU, W., GONG, Z.Q. Selective adsorption of *Mycobacterium Phlei* on pyrite and sphalerite. **Colloids and Surfaces B: Biointerfaces**, v. 83, p. 214-219, 2011.

KHOSHDAST, H., and SAM, A. Flotation frothers: review of their classification, properties and preparation. **The Open Mineral Processing Journal**, v. 4, p. 25 - 44. 2011.

KLEIN, C. **Mineral science**. 22. ed. John Wiley & sons, New York, 2002. 641p.

KRISHNAN, S.V., and IWASAKI, I. Pulp dispersion in selective desliming of iron ores. **International Journal of Mineral Processing**, v. 12, p. 1-13. 1984.

KUYUKINA, M.S., and IVSHINA, I.B. Multifunctional biosurfactant from non-pathogenic *Rhodococcus ruber* for diverse industrial applications. **Journal of biotechnology**. v. 150, p. 83-84. 2010.

MA, M. **Iron Ore Flotation**. Oxford, Elsevier. 2012.

MERMA, A.G. **Fundamental aspects in the apatite-quartz bioflotation system using the *Rhodococcus opacus* bacteria as bioreagent**. Doctoral Thesis. Department of Materials Engineering and Chemical and Metallurgical processes. Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro (in Portuguese), 2012.

MESQUITA, L.M.S., LINS, F.A.F., TOREM, M.L., Interaction of a hydrophobic bacterium strain in a hematite-quartz flotation system, **International Journal of Mineral Processing**, v. 71, p. 31 – 44. 2003.

NATARAJAN, K.A. AND DEO, N. Role of bacterial interaction and bioreagents in iron ore flotation. **International Journal of Mineral Processing**, v. 62, p. 143-157. 2001.

NATARAJAN, K.A. Microbially-induced mineral flotation and flocculation: prospects and challenges. **Proceedings of XXIII International Mineral Processing Congress**, p. 487 – 498. 2006.

NATIONAL DEPARTMENT OF MINERAL PRODUCTION. **Brazilian Mineral yearbook – XXXVIII**. Brasilia, 2010. ISBN 0100 – 9303. Available on: <http://www.dnpm.gov.br/portal/relatorios/amb/Completo.pdf>.

OKADA, K., AKAGI, Y., KOGURE, M., YOSHIOKA, N., Effects on surface charges of bubbles and fine particles on air flotation process. **The Canadian Journal of Chemical Engineering**, v. 68, p. 393 – 399. 1990.

PAKUDONE, S. USHA, NATARAJAN, K.A. Microbially induced separation of quartz from calcite using *Saccharomyces cerevisiae*. **Colloids and Surfaces B: Biointerfaces**, v. 88, p.45 – 50. 2011.

PARTRIDGE, A.C., SMITH, G.W. Flotation and adsorption characteristics of the hematite-dodecylamine-starch system. **Canadian Metallurgy Quarterly**, v. 10, p. 229-234. 1971.

PATRA, P., NATARAJAN, K.A., Microbially induced flotation and flocculation of pyrite and spharelite. **Colloids and surfaces B.: Biointerfaces**, v. 36, p. 91 – 99. 2006.

PATRA, P., NATARAJAN, K.A., Role of mineral specific bacterial proteins in selective flocculation and flotation. **International Journal Mineral Processing**, v. 88, p. 53 – 58. 2008.

PERES, A.E.C., DIAT, F.V., SALUM, M.J.G. Fundamental studies on pyrite, pyrrhotite and arsenopyrite floatability. **Turkiye XML Madencilik Kongresi, Turkey**, 1993.

PRAKASAN, M.R. SABARI, NATARAJAN, K.A. Microbially induced separation of quartz from hematite using sulfate reducing bacteria. **Colloids and Surfaces B: Biointerfaces**, v. 78, p. 163 – 170. 2010.

RAICHUR, A.M., MISRA, M. BUKKA, K., and SMITH R.W., Flocculation and flotation of coal by adhesion of hydrophobic *Mycobacterium phlei*, **Colloids and surfaces B: Biointerfaces**, v. 8, p. 13–24. 1996.

RAO, K.H., SUBRAMANIAN, S. Bioflootation and Bioflocculation of relevance to minerals bioprocessing. In: DONATI, E., SAND, W, **Microbial processing of metal sulfides**, p. 267 – 286. 2007.

RAO, M.K.Y., NATARAJAN, K.A., and SOMASUNDARAN, P. Effect of bacterial conditioning of sphalerite and galena with *Thiobacillus ferrooxidans* on their floatability. In: SMITH, R., MISRA, M. **Mineral Bioprocessing**. Ed. Berlin: Springer, p. 105–120. 1991.

SANTHIYA, D., SUBRAMANIAN, S. and NATARAJAN, K.A., Surface chemical studies on spharelite and galena using *Bacillus polymyxa* Part I: Microbially induced mineral separation. **Journal of colloid and interface Science**, v. 235, p. 289 – 297. 2001.

SARVAMANGALA, H., NATARAJAN, K.A. Microbially induced flotation of alumina, silica/calcite from haemite. **International Journal of Mineral Processing**, v. 99, p.70-77. 2011.

SHARMA, P.K., RAO, K.H., FORSSBERG, K.S.E. AND NATARAJAN, K.A. Surface chemical characterization of *Paenibacillus polymyxa* before and after adaptation to sulfide minerals. **International Journal of Mineral Processing**, v. 62, p. 3-25. 2001.

SHARMA, PRASHANT K. **Surfaces Studies Relevant to Microbial Adhesion and Bioflootation of Sulphide Minerals**. Doctoral Thesis. Lulea University of Technology, Department of Chemical and Metallurgical Engineering, Division of Mineral Processing. Lulea, Sweden. 2001. ISSN: 1402 – 1544 . ISRN: LTU – DT – 01/37 – SE. Available at: <http://epubl.ltu.se/1402-1544/2001/37/index-en.html>.

SHERGOLD, H.L, MELLGREN, O. Concentration of hematite at the iso-octane-water interface with dodecylamine as a collector. **Transactions of the Institution of Mining and Metallurgy**, v.80, p. 60-68. 1971.

SHERGOLD, H.L, PROSSER, A.P., MELLGREN, O. New region of floatability in the hematite-dodecylamine system. **Transactions of the Institution of Mining and Metallurgy**, v.77, p.166-170. 1968.

SMITH, R.W., HADDENHAM, R., SCHROEDER, C. Amphoteric surfactants as flotation collectors. **Transactions of the Metallurgical Society of AIME**, v. 254, 231-235. 1973.

SMITH, R.W., MISRA, M., CHEN, S. Adsorption of a hydrophobic bacterium onto dolomite: implications in the froth flotation of hematite. **Journal of the Society for Industrial Microbiology**, v. 11, p. 63 – 67. 1993.

SMITH, R.W., MIETTINEM, M., Microorganisms in flotation and flocculation: Future technology or laboratory curiosity? **Minerals Engineering**, v. 19, p. 548 – 553. 2006.

SOARES, V.A.A. **Characterization of frothers with different hydrocarbon chains and their influence over hematite surface**. Master dissertation. PPGEM-UFMG. 2012 (In Portuguese).

SOMASUNDARAN, P., HEALY, T.W., FUERSTENAU, D.W. Surfactant adsorption at the solid-liquid interface-dependence of mechanism on chain length. **The Journal Physical Chemistry**, v. 68, p. 3562-3566. 1964.

SOMASUNDARAN, P., DEO, N., NATARAJAN, K.A. Utility of bioreagents in mineral processing. **Minerals and Metallurgical Processing**, v. 17. 2000.

SUBRAMANIAN, S., SANTHIYA, D. and NATARAJAN, K.A. Surface modification studies on sulphide minerals using bioreagents **International Journal of Mineral Processing**, v. 72, p. 175-188. 2003.

VAN DER WAL, A., NORDE, A.A.J.B., ZEHNDER, B., LYKLEMA, J. A determination of the total charge in the cell walls of gram-positive bacteria. **Colloids and Surfaces B: Biointerfaces**, v. 9, p. 81–100. 1997.

VIJAYALAKSHMI, S.P., RAICHUR, A.M. The utility of *Bacillus subtilis* as a bioflocculant for fine coal. **Colloids and Surfaces B: Biointerfaces**, v. 29, p. 265 – 275. 2003.

VILNSKA, A., RAO, K.H., AND FORSSBERG, K.S.E. Microorganisms in flotation and flocculation of minerals—an overview. In: **XXIV International Mineral Processing Congress**, p. 22-39. 2008.

WILEY, J., SHERWOOD, L., WOOLVERTON, C. **Prescott's microbiology**. McGraw-Hill, 9th edition. 2013.

WILLS, B. **Mineral Processing Technology**: An Introduction to the practical aspects of ore treatment and mineral recovery. Elsevier Science & Technology books, 7. ed. 2006.

YANG, H., ZHANG, Q. and JIANG, Z. Adsorbability of *Mycobacterium phlei* on hematite surface. **Journal of University of Science and Technology Beijing**, v.14, p. 103 – 106. 2007.

YANG, H., QIONGYAO, T., CHUANLONG, W., ZHANG, J. Flocculation and flotation response of *Rhodococcus erythropolis* to pure minerals in hematite ores. **Minerals Engineering**, v. 45, p. 67-72. 2013.

ZHENG, X., AND SMITH, R.W. Dolomite depressants in the flotation of apatite and colophane from dolomite. **Minerals Engineering**, v. 10, p. 537-545. 1997.

ZHENG, X.P., SMITH, R.W., METHA, R.K., MISRA, M. and RAICHUR, A.M. Anionic flotation of apatite from dolomite modified by the presence of a bacterium. **Minerals and Metallurgical Processing**, v. 15, p. 52 – 56. 1998.

ZHENG, X., ARPS, P.J., SMITH, R.W. Adhesion of two bacteria onto dolomite and apatite: their effect on dolomite depression in anionic flotation. **International Journal Mineral Processing**, v. 62, p. 159 – 172. 2001.

9 Appendix

9.1.XR-Diffraction results

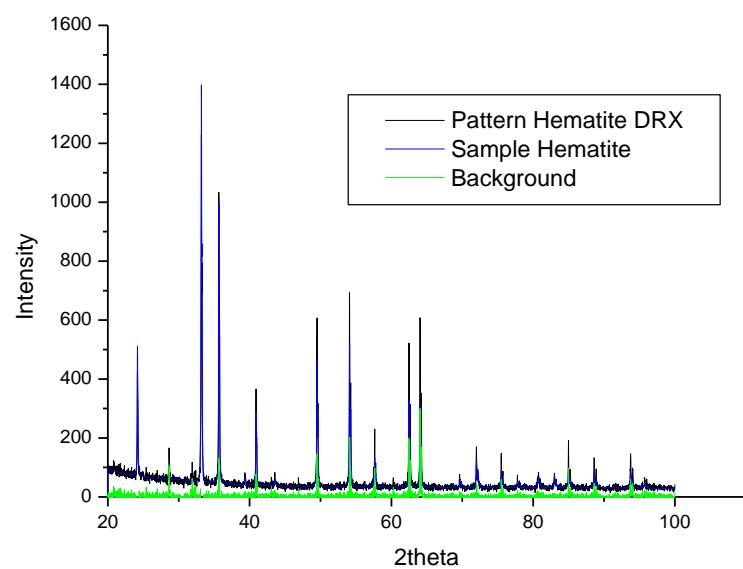
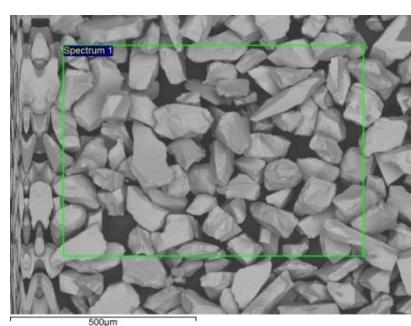


Figure 42 – X-Ray diffraction spectra for hematite sample and of pattern hematite spectra

9.2.EDS analyse for hematite sample

Electron Image

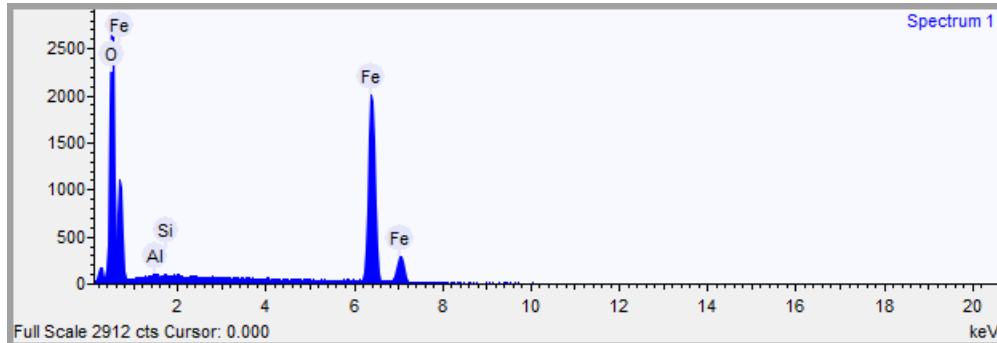
Image Width: 1.089 mm



Acquisition conditions

Acquisition time (s) 99.8 Process time 5

Accelerating voltage (kV) 15.0



Quantification Settings

Quantification method: All elements (normalised)

Coating element: None

Summary results

Element	Weight %	Weight % σ	Atomic %
Oxygen	31.022	0.325	60.998
Aluminium	0.144	0.070	0.168
Silicon	0.109	0.063	0.122
Iron	68.724	0.330	38.712

9.3.Flow meter calibration

Parameter	Value	Error	
A	9,26268	0,16773	
B	1,80127	0,01364	
R	SD	N	
0,99991	0,19527	5	<0.0001

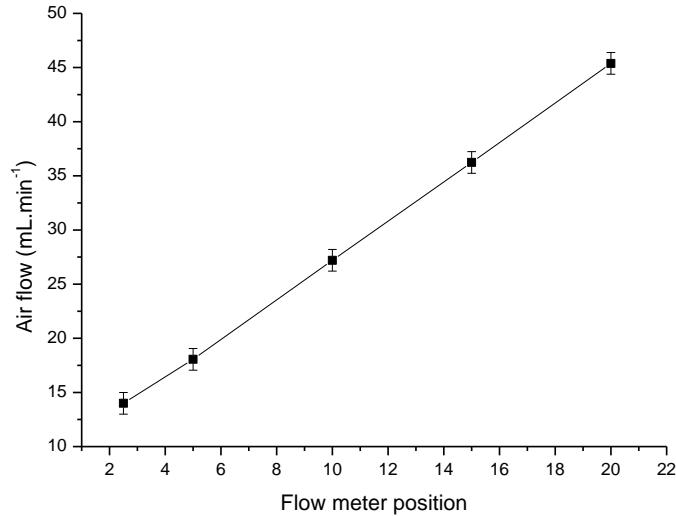


Figure 43 – Air flow meter calibration