BAB V
KESIMPULAN DAN SARAN

5.1. Kesimpulan

Pada proses *leaching spent catalyst* Ni/γ-Al_2O_3, dapat disimpulkan bahwa:

1. Konsentrasi asam organik berpengaruh terhadap persentase *recovery* ion logam Ni^{2+} dan Al^{3+}, konsentrasi asam organik terbaik untuk semua jenis asam organik adalah 2 M.
2. Waktu ekstraksi berpengaruh terhadap persentase *recovery* ion logam Ni^{2+} dan Al^{3+}, waktu ekstraksi terbaik adalah 240 menit.
3. Jenis asam organik berpengaruh terhadap persentase *recovery* ion logam Ni^{2+} dan Al^{3+}, jenis asam organik yang paling efektif sebagai *leachant* adalah asam sitrat.
4. Kondisi terbaik diperoleh pada *leaching* menggunakan asam sitrat dengan konsentrasi 2 M dan waktu ekstraksi 240 menit, dimana diperoleh nilai ion logam Ni^{2+} sebesar 1,099 % dan ion logam Al^{3+} sebesar 5,627 %.
5. Asam anorganik (asam sulfat) lebih efektif digunakan sebagai *leachant* dibanding asam organik.

5.2. Saran

1. Variasi konsentrasi asam organik yang digunakan lebih beragam agar dapat diketahui konsentrasi asam organik optimum dalam proses *leaching spent catalyst* Ni/γ-Al_2O_3.
2. Analisis SEM (*scanning electron microscope*) perlu dilakukan untuk mengetahui karakteristik padatan *spent catalyst* Ni/γ-Al_2O_3 setelah proses *leaching*.
3. Perlu adanya variasi lain seperti ukuran partikel dan densitas *pulp* agar dapat diketahui efeknya terhadap proses *leaching spent catalyst* Ni/γ-Al_2O_3.

DAFTAR PUSTAKA

Antonsen DH, Meshri DT. (2005). Nickel compounds. In: Kirk-Othmer Encyclopedia of Chemical Technology, 5th ed. New York: John Wiley & Sons, 16:1–28.

Arslanoğlu, H. and Yaraş, A. (2019). Recovery of precious metals from spent Mo–Co–Ni/Al2O3 catalyst in organic acid medium: Process optimization and kinetic studies', *Petroleum Science and Technology*. Taylor & Francis, 37(19), pp. 2081–2093. doi: 10.1080/10916466.2019.1618867.

Astuti, W., Hirajima, T., Sasaki, K., & Okibe, N. (2016). Comparison of effectiveness of citric acid and other acids in leaching of low-grade Indonesian saprolitic ores. *Minerals Engineering*, *85*, 1–16. https://doi.org/10.1016/j.mineng.2015.10.001

Batti, N. R., & Mandre, N. R. (2020). Recovery and Characterization of Nickel Oxalate and Oxide Obtained from Spent Methanation Catalysts. *Metallurgical and Materials Transactions B: Process Metallurgy and Materials Processing Science, 51*(3), 1225–1232. https://doi.org/10.1007/s11663-020-01828-6

Behera, S. K., Panda, S. K., Pradhan, N., Sukla, L. B., & Mishra, B. K. (2012). Extraction of nickel by microbial reduction of lateritic chromite overburden of Sukinda, India. *Bioresource Technology*, *125*, 17–22. https://doi.org/10.1016/j.biortech.2012.08.076

Bruice, Paula Yurkanis. (2004). Organic Chemistry 4th Edition; Prentice-Hall: Santa Barbara

Buckle, K.A, Edwards, RA. Fleet, GH. (1978). Ilmu Pangan dan Gizi.

Daintith, John, ed. (2008). "Aluminium ethanoate (aluminium acetate)". A Dictionary of Chemistry (6th ed.). Oxford University Press. ISBN 9780191726569.

Dawood, M. M. (2009). Recovery of Molybdenum from Spent Catalyst by Leaching Process, Master Thesis, Chemical Engineering Nahrain University, Iraq

Gustiana, H. S. E. A. (2018). Pelindian Nikel dari Nikel Laterit Pomalaa Menggunakan Asam Asetat. *Tesis Sarjana S-2 Program Studi Teknik Kimia, Magister Teknik Proses Pengolahan Mineral*, *April*, 1–7.

He, L. P. et al. (2017). 'Recovery of Lithium, Nickel, Cobalt, and Manganese from Spent Lithium-Ion Batteries Using l -Tartaric Acid as a Leachant', ACS Sustainable Chemistry and Engineering, 5(1), pp. 714–721. doi: 10.1021/acssuschemeng.6b02056

Hewitt, P.G. (2003). Conseptual Integrated Science Chemistry. San Fransisco: Pearson Education, Inc.

Jin Bo, Pinghe Yin, Yibong Ma, Ling Zha O. (2005). Production of Lactic Acid and Fungal Biomassa by Rhizopus Fungi from Food Processing Waste Streams, Jurnal Ind. Microbiol. Biotechnol, 32: 678 – 686, Enviromental Biotechnology, Australia.

Kagambega, N., Galvez, R., & Ouattara, A. (2017). Three Commercial organic Acids for the Leaching of Metals from Tailings. *Scholars Journal of Engineering and Technology*, *5*(SJET), 629–638. https://doi.org/10.21276/sjet.2017.5.11.5

Kasmiyatun, M., & Jos, B. (2008). Ekstraksi Asam Sitrat Dan Asam Oksalat : Pengaruh Trioctylamine Sebagai Extracting Power Dalam Berbagai Solven Campuran Terhadap Koefisien Distribusi. *Reaktor*, *12*(2), 107. https://doi.org/10.14710/reaktor.12.2.107-116

Kirk, R.E. and Othmer, D.F. (1994). Encyclopedia of Chemical Technology, 3rd ed., Vol. 1, The Inter Science Encyclopedia, Inc., New York.

Koleżyński, A., Handke, B. and Drozdz-Cieå la, E. (2013) 'Crystal structure, electronic structure, and bonding properties of anhydrous nickel oxalate', Journal of Thermal Analysis and Calorimetry, 113(1), pp. 319–328. doi: 10.1007/s10973-012-2844-y.

Li, L., Ge, J., Chen, R., Wu, F., Chen, S., & Zhang, X. (2010). Environmental Friendly Leaching Reagent for Cobalt and Lithium Recovery from Spent Lithium-Ion Batteries. Waste Management, 30(12), pp.2615-2621.

Li, L., Zhai, L., Zhang, X., Lu, J., Chen, R., Wu, F., & Amine, K. (2014). Recovery of Valuable Metals from Spent Lihtium Ion Batteries by Ultrasonic-Assisted Leaching Process. Journal of Power Source; 262, 380-385.

Marafi, M., Kam, E. K. T., Stanislaus, A., & Absi-Halabi, M. (1996). Rejuvenation of residual oil hydrotreating catalysts by leaching of foulant metals: Modelling of the metal leaching process. *Applied Catalysis A: General*, *147*(1), 35–46. https://doi.org/10.1016/S0926-860X(96)00207-4

McDonald, R. G., & Whittington, B. I. (2008). Atmospheric acid leaching of nickel laterites review. Part II. Chloride and bio-technologies. *Hydrometallurgy*, *91*(1–4), 56–69. https://doi.org/10.1016/j.hydromet.2007.11.010

McKenzie, D. I., Denys, L., & Buchanan, A. (1987). The solubilization of nickel, cobalt and iron from laterites by means of organic chelating acids at low pH. *International Journal of Mineral Processing*, *21*(3–4), 275–292. https://doi.org/10.1016/0301-7516(87)90059-7

M.S. Sonmez, R.V. Kumar. (2009). Leaching of waste battery paste components. Part 1: Lead citrate synthesis from PbO and PbO_2, Hydrometallurgy 95, 53–60.

Munyai, A. H., Fosso-kankeu, E., & Waanders, F. (2016). *Mobility of Metals from Mine Tailings using Different Types of Organic Acids : Batch Leaching Experiment*. *5*(11), 520–527. https://doi.org/10.21275/ART20162804

Ojha, Priyanka & Ojha, C & Sharma, V. (2007). Influence of physico-chemical factors on leaching of chemical additives from aluminium foils used for packaging of food materials. Journal of environmental science & engineering. 49. 62-6.

Petrus, H. B. T. M., Wanta, K. C., Setiawan, H., Perdana, I., & Astuti, W. (2018). Effect of pulp density and particle size on indirect bioleaching of Pomalaa nickel laterite using metabolic citric acid. *IOP Conference Series: Materials Science and Engineering*, *285*(1). https://doi.org/10.1088/1757-899X/285/1/012004

Poesponegoro, M. & Liang, O.B. (1991). Fermentasi asam sitrat dari tetes tebu secara biak rendam dengan Aspergillus niger, Jurnal Kimia Terapan Indonesia, 1(2), 35-40.

Ripin DHB. (2011). pKa. Dalam: Caron S (Editor) Practical Synthetic Organic Chemistry: Reactions, Principles, and Techniques. Hoboken: John Wiley & Sons

Shadafza, D., Ogawa, T. & Fazeli, A. (1976). Comparison of citric acid production from beet molasses and date syrup with Aspergillus niger, Jorunal of Fermentation Technology, 54, 67-75.

Setiabudi, A., Hardian, R. and Muzakir, A. (2012). Karakterisasi Material; Prinsip dan Aplikasinya dalam Penelitian Kimia. Universitas Pendidikan Indonesia. Bandung.

Soccol, C.R., Vandenberghe, L.P., Rodrígues, C. & Pandey, A. (2006). New perspective for citric acid production and application, Food Technology and Biotechnology, 44(2), 141-149.

Somogyi, M. (1952). Notes on sugar determination, Journal of Biological Chemistry. 195, 19–23.

Subaer, (2015). Pengantar Fisika Geopolimer. Jakarta: DP2M Dikti.

Tang, J. A., & Valix, M. (2006). Leaching of low grade limonite and nontronite ores by fungi metabolic acids. *Minerals Engineering*, *19*(12), 1274–1279. https://doi.org/10.1016/j.mineng.2006.04.009

Teclu, D., Tivchev, G., Laing, M. & Wallis, M. (2009). Determination of the elemental composition of molase and its suitability as a carbon source for growth of sulphate-reducing bacteria, Journal of Hazardous Material, 161, 1157-1165.

Tzeferis, P. G., & Agatzini-Leonardou, S. (1994). Leaching of nickel and iron from Greek non-sulphide nickeliferous ores by organic acids. *Hydrometallurgy*, *36*(3), 345–360. https://doi.org/10.1016/0304-386X(94)90031-0

Ul-Haq, I., Ali, S., Qadeer, M.A. & Iqbal, J. (2002). Citric acid fermentation by mutant strain of Aspergillus niger GCMC-7 using molase based medium, Electronic Journal of Biotechnology, 5(3), 125-132.

Urík, M., Polák, F., Bujdoš, M., Pifková, I., Kořenková, L., Littera, P., & Matúš, P. (2018). Aluminium Leaching by Heterotrophic Microorganism Aspergillus niger: An Acidic Leaching? *Arabian Journal for Science and Engineering*, *43*(5), 2369–2374. https://doi.org/10.1007/s13369-017-2784-8

Vachon, P., Tyagl, R. D., Auclalr, J., & Wliklnsont, K. J. (1994). *Environmental Science & Technology Volume 28 issue 1 1994 [doi 10.1021_es00050a005] Vachon, Pascale.; Tyagi, Rajeshwar D.; Auclair, Jean Christian.; -- Chemical and biological leaching of aluminum f.pdf*. *28*(1), 26–30.

Valix, M. Tang, J.Y., Cheung W.H. (2004). Biological leaching of nickel laterites: use of synchrotron based X-ray diffraction in elucidating the amenability of laterite minerals to fungi metabolic acids, Paper presented to CHEMECA 2004, Sydney.

Vandenberghe, L.P., Soccol, C.R., Pandey, A. & Lebeault, J-M. (1999). Microbial production of citric acid. Brazilian Archives of Biology and Technology, 42(2), 263-276.

Wanta, K. C., Perdana, I., & Petrus, H. T. B. M. (2016). Evaluation of shrinking core model in leaching process of Pomalaa nickel laterite using citric acid as leachant at atmospheric conditions. *IOP Conference Series: Materials Science and Engineering*, *162*(1). https://doi.org/10.1088/1757-899X/162/1/012018

Wanta, Kevin Cleary, Eng, M., Susanti, R. F., & Ph, D. (2017). *Studi Kinetika Proses Leaching Nikel Laterit Dalam Suasana Asam Pada Kondisi Atmosferis*. 1–30.

Wanta, Kevin Cleary, Petrus, H. T., Perdana, I., & Astuti, W. (2017). Uji Validitas Model Shrinking Core terhadap Pengaruh Konsentrasi Asam Sitrat dalam Proses Leaching Nikel Laterit. *Jurnal Rekayasa Proses*, *11*(1), 30. https://doi.org/10.22146/jrekpros.23321

Wiley Online Library. (2003). Ullmann's Encyclopedia of Industrial Chemistry (6th, completely revised edition.). Weinheim, Germany: Wiley-VCH.

Yan, Y., Gao, J., Wu, J., & Li, B. (2014). Effects of Inorganic and Organic Acids on Heavy Metals Leaching in Contaminated Sediment. *An Interdisciplinary Response to Mine Water Challenges*, *10*, 406–410.