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RECOVERY OF THE ORGANIC SOLVENTS FROM THE MULTICOMPONENT MIXTURE IN THE PROCESS OF THE FRACTIONAL DISTILLATION AND THE VACUUM DISTILLATION

ODZYSKIWANIE ROZPUSZCZALNIKÓW ORGANICZNYCH Z MIESZANINY WIELOSKŁADNIKOWEJ W PROCESIE DESTYLACJI FRAKCYJNEJ I DESTYLACJI PRÓŻNIOWEJ

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Abstract

In these times of sustainability, the purification and regeneration of used solvents is attracting a lot of interest for environmental reasons and to reduce production costs. The article presents research on the separation of organic solvents such as acetonitrile, methanol, acetone, and toluene from a multicomponent mixture of liquid organic waste. This is an element of the circular economy and prevents the emission of volatile organic compounds into the environment. In order to separate the mixture and recover the solvents, fractional distillation and vacuum distillation were used together with pre-treatment of the waste using sorption on silica gel and calcium oxide. The analysis of the waste composition and the mixture after the separation was performed by gas chromatography coupled with a mass spectrometer (GC-MS). As a result of the research, the acetonitrile concentration increased to 90.7% after fractional distillation.

Keywords: fractional distillation, vacuum distillation, organic solvents, acetonitrile

Streszczenie

Aktualnie w czasach zrównoważonego rozwoju oczyszczanie i regeneracja zużytych rozpuszczalników cieszy się dużym zainteresowaniem ze względów środowiskowych i w celu obniżenia kosztów produkcji. W artykule przedstawiono badania nad wydzielaniem rozpuszczalników organicznych takich jak acetonitryl, metanol, aceton i toluen z wieloskładnikowej mieszaniny ciekłych odpadów organicznych. Jest to element gospodarki o obiegu zamkniętym i zapobiega emisji lotnych związków organicznych do środowiska. W celu rozdzielenia mieszaniny i odzyskania rozpuszczalników zastosowano destylację frakcyjną i destylację próżniową wraz z wstępną obróbką odpadów metodą sorpcji na żelu krzemionkowym i tlenku wapnia. Analizę składu odpadów oraz frakcji po rozdziale mieszaniny przeprowadzono metodą chromatografii gazowej sprzężonej ze spektrometrem mas (GC-MS). W wyniku przeprowadzonych prób stężenie acetonitrylu po destylacji frakcyjnej wzrosło do 90,7%.

Słowa kluczowe: destylacja frakcyjna, destylacja próżniowa, rozpuszczalniki organiczne, acetonitryl

REFERENCES

[1] Calvo-Flores F.G., Monteagudo-Arrebola M.J., Dobado J.A., Isac-García J., 2018. *Green and Bio-Based. Green and Bio-Based Solvents*. Top Curr Chem (Z), 18, 376:18. DOI: 10.1007/s41061-018-0191-6.
[2] Clark J.H., Farmer T.J., Hunt A.J., Sherwood J., 2015. *Opportunities for Bio-Based solvents created as petrochemical and fuel products transition towards renewable resources*. Int. J. Mol. Sci., 16, 17101-17159. DOI:10.3390/ijms160817101.

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[3] Brouwer T., Schuur B., 2020. *Bio-based solvents as entrainers for extractive distillation in aromatic/aliphatic and olefin/paraffin separation*. Green Chem., 22, 5369-5375. DOI: 10.1039/D0GC01769H.
[4] Chaudhary A., Dwivedi A., Upadhyayula S., 2021. Chapter 28 – *Supercritical fluids as green solvents.* Handbook of Greener Synthesis of Nanomaterials and Compounds, 1, 891-916. DOI: 10.1016/B978-0-12-821938-6.00028-1.
[5] Dolzhenko A.V., 2021. *Green solvents for eco-friendly synthesis of bioactive heterocycles*, 2021. Green Synthetic Approaches for Biologically Relevant Heterocycles (Second Edition). 2, 393-470. DOI: 10.1016/B978-0-12-820792-5.00007-X.
[6] Manochio C., Andrade B.R., Rodriguez R.P., Moraes B.S., 2017. *Ethanol from biomass: A comparative overview*. Renew Sustain Energy Rev 80, 743-755. DOI: 10.1016/j.rser.2017.05.063.
[7] Ndaba B., Chiyanzu I., Marx S., 2015. *n-Butanol derived from biochemical and chemical routes: A review*. Biotechnol Rep, 8, 1-9. DOI: 10.1016/j.btre.2015.08.001.
[8] Clark J.H., Hunt A., Topi C., Paggiola G., Sherwood J., 2017. *Sustainable solvents. CHAPTER 6: an appendix of solvent data sheets*. Royal Society of Chemistry, Green Chem Ser No. 49. DOI: 10.1039/9781782624035.
[9] Akhtar M.K., Dandapani H., Thiel K., Jones P.R., 2015. *Microbial production of 1-octanol: A naturally excreted biofuel with diesel-like properties*. Metab. Eng. Commun., 2, 1-5. DOI: 10.1016/j.meteno.2014.11.001.
[10] Acrylonitrile (ACN): 2023, *World Market Outlook up to 2032*, Report, Merchant Research and Consulting Ltd.
[11] Aboagye E.A., Chea J.D., Yenkie K.M., 2021. *Systems level roadmap for solvent recovery and reuse in industries*. iScience, 24, 10, 1-29. DOI: 10.1016/j.isci.2021.103114.
[12] Godbole S.P., Wappelhorst R.L., Jacobson P.A., 2001. *Purification and recovery of acetonitrile*, United States Patent 6326508, Application Number: 09/654631.
[13] Ohba K., Takano K., Iida M., Abe S., Masudo T., Kishizaki O., Ishibashi R., Yamashita Y., 2019. *Purification process for hydrolysable organic solvent*. United States Patent Application Publication, Pub . No US 2019 / 0009267 A1.
[14] Clarke C.J., Tu W-Ch., Levers O., Bröhl A., Hallett J.P., 2018. *Green and Sustainable Solvents in Chemical Processes.* Rev., 118, 2, 747–800. DOI: 10.1021/acs.chemrev.7b00571.
[15] Chea J.D., Lehr A.L., Stengel J.P., Savelski M.J., Slater C., Yenkie K.M., 2020. *Evaluation of Solvent Recovery Options for Economic Feasibility through a Superstructure-Based Optimization Framework*. Ind. Eng. Chem. Res., 59, 13, 5931-5944. DOI: 10.1021/acs.iecr.9b06725.
[16] Wang Y., Cui P., Ma Y., Zhang Z., 2015. *Extractive distillation and pressure-swing distillation for THF/ethanol separation. J Chem Technol Biotechnol*., 90, 1463-1472. DOI: 10.1002/jctb.4452.
[17] Frolkova A., Frolkova A., Gaganov I., 2021. *Extractive and auto-extractive distillation of azeotropic mixtures*. Chem. Eng. Technol. 44, 8, 1397–1402. DOI: 10.1002/ceat.202100024.
[18] Jun Qi, Yafang Li, Jiaxing Xue, Ruiqi Qiao, Zhishan Zhang, Qunsheng Li, 2020. *Comparison of heterogeneous azeotropic distillation and energy-saving extractive distillation for separating the acetonitrile-water mixtures*. Separation and Purification Technology, 238, 116487, ISSN 1383-5866, https://doi.org/10.1016/j.seppur.2019.116487.
[19] Lu Qi, Jinlong Li, Ao Yang, Xiuguang Yi, and Weifeng Shen, 2022. *Toward a Sustainable Azeotrope Separation of Acetonitrile/Water by the Synergy of Ionic Liquid-Based Extractive Distillation*, Heat Integration, and Multiobjective Optimization. Industrial & Engineering Chemistry Research 61 (27), 9833-9846. DOI: 10.1021/acs.iecr.2c01285.
[20] Yasen Dai, Xiangyu Zhou, Xiaojun Chu, Chen Li, Zihao Su, Zhaoyou Zhu, Peizhe Cui, Jianguang Qi, and Yinglong Wang, 2022. *Effect of Entrainer Thermodynamic Properties on the Separation of Ternary Mixtures Containing Two Minimum Boiling Azeotropes by Extractive Distillation*. Industrial & Engineering Chemistry Research 61 (41), 15273-15288. DOI: 10.1021/acs.iecr.2c02306.
[21] Yang D., Li M., Lou Ch., Wan D., Yun Y., 2022. S*plit heat pump distillation based on two-stage compression for separating an acetone-water mixture*. Chem. Eng. Technol. 45,1, 159-166. DOI: 10.1002/ceat.202100289.