## REFERENCES

Adipah, S. (2018) "Introduction of biodiesel as a sustainable resource," *Journal of Environmental Science and Public Health*, 03(01). Available at: https://doi.org/10.26502/jesph.96120050.

Atadashi, I.M., Aroua, M.K. and Aziz, A.A. (2011) "Biodiesel separation and purification: A Review," *Renewable Energy*, 36(2), pp. 437–443. Available at: https://doi.org/10.1016/j.renene.2010.07.019

Baudín, C. (2014) "Processing of alumina and corresponding composites," *Comprehensive Hard Materials*, pp. 31–72. Available at: https://doi.org/10.1016/b978-0-08-096527-7.00021-0.

Bondioli, P. and Della Bella, L. (2005) "An alternative spectrophotometric method for the determination of free glycerol in biodiesel," *European Journal of Lipid Science and Technology*, 107(3), pp. 153–157. Available at: https://doi.org/10.1002/ejlt.200401054.

BP Energy (2020) *Statistical Review of World Energy 2020 - 69th Edition*, 70, pp. 1–66.

Chen, J.C., Li, Q. and Elimelech, M. (2004) "In situ monitoring techniques for concentration polarization and fouling phenomena in membrane filtration," *Advances in Colloid and Interface Science*, 107(2-3), pp. 83–108. Available at: https://doi.org/10.1016/j.cis.2003.10.018.

Chozhavendhan, S. *et al.* (2020) "A review on influencing parameters of biodiesel production and purification processes," *Current Research in Green and Sustainable Chemistry*, 1-2, pp. 1–6. Available

Dharmawan, I.B. and Cakrawardana, C. (2021) "Dampak Kondisi Lingkungan dalam Penyimpanan Biodiesel Terhadap Kualitas Bahan Bakar B30," *JST (Jurnal Sains Terapan)*, 7(2), pp. 60–67. Available at: https://doi.org/10.32487/jst.v7i2.1281.

EIA (2022) "Country Executive Summary Analysis: Indonesia", pp. 1-14.

Griffiths, I.M., Kumar, A. and Stewart, P.S. (2014) "A combined network model for membrane fouling," *Journal of Colloid and Interface Science*, 432, pp. 10–18. Available at: https://doi.org/10.1016/j.jcis.2014.06.021.

Halimatussadiah, A. *et al.* (2021) "Progressive Biodiesel policy in Indonesia: Does the government's economic proposition hold?," *Renewable and Sustainable Energy Reviews*, 150, p. 111431. Available at: https://doi.org/10.1016/j.rser.2021.111431.

IEA (no date) *International energy outlook 2021*, pp. 1–42.

Kloprogge, J. (2019) "Spectroscopic methods in the study of Kaolin Minerals and their modifications," *Springer Mineralogy* [Preprint]. Available at: https://doi.org/10.1007/978-3-030-02373-7.

Komolikov, Y.I. and Blaginina, L.A. (2002) "Technology of Ceramic Micro and Ultrafiltration Membranes (Review)," *Refractories and Industrial Ceramics*, 43(5/6), pp. 181–187. Available at: https://doi.org/10.1023/a:1020523301886.

Koonaphapdeelert, S. and Li, K. (2007) "Preparation and characterization of hydrophobic ceramic hollow fibre membrane," *Journal of Membrane Science*, 291(1-2), pp. 70–76. Available at: https://doi.org/10.1016/j.memsci.2006.12.039.at: https://doi.org/10.1016/j.crgsc.2020.04.002.

Kumar, C.M., Roshni, M. and Vasanth, D. (2019) "Treatment of aqueous bacterial solution using ceramic membrane prepared from cheaper clays: A

detailed investigation of fouling and cleaning," *Journal of Water Process Engineering*, 29, p. 100797. Available at: https://doi.org/10.1016/j.jwpe.2019.100797.

L. Cot, et al., Inorganic membranes and solid state sciences, Solid State Sci. 2 (3) (2000) 313–334.

M. C. Gomes, W. M. Moreira, S. M. Paschoal, C. C. Sipoli, R. M. Suzuki, J. G. Sgorlon, and N. C. Pereira, "Modeling of fouling mechanisms in the biodiesel purification using ceramic membranes," *Separation and Purification Technology*, vol. 269, p. 118595, 2021.

M. Mathiyazhagan, A. Ganapathi, Factors affecting biodiesel production, Res. Plant Biol. 1 (2) (2011) 1–5

Maghami, M., Sadrameli, S.M. and Shamloo, M. (2018) "Glycerin purification using asymmetric nano-structured ceramic membranes from production of waste fish oil biodiesel," *Heat and Mass Transfer*, 54(9), pp. 2683–2690. Available at: https://doi.org/10.1007/s00231-018-2309-3.

Pagliero, M. *et al.* (2020) "Silanization of tubular ceramic membranes for application in membrane distillation," *Journal of Membrane Science*, 601, p. 117911. Available at: https://doi.org/10.1016/j.memsci.2020.117911.

Ristianingsih, Y., Hidayah, N. and Sari, F.W. (2016) "Pembuatan biodiesel Dari crude palm oil (CPO) Sebagai Bahan Bakar Alternatif melalui proses TRANSESTERIFIKASI Langsung," *Jurnal Teknologi Agro-Industri*, 2(1), pp. 38–46. Available at: https://doi.org/10.34128/jtai.v2i1.23.

Saleh J, Tremblay, A.Y. and Dubé, M.A. (2010) "Glycerol removal from biodiesel using membrane separation technology," *Fuel*, 89(9), pp. 2260–2266. Available at: https://doi.org/10.1016/j.fuel.2010.04.025.

Schnittger, J. *et al.* (2021) "Hydrophobic ceramic membranes in MD processes – impact of material selection and layer characteristics," *Journal of*

*Membrane Science*, 618, p. 118678. Available at: https://doi.org/10.1016/j.memsci.2020.118678.

Shuit, S.H. *et al.* (2012) "Membrane Technology as a promising alternative in biodiesel production: A Review," *Biotechnology Advances*, 30(6), pp. 1364–1380. Available at: https://doi.org/10.1016/j.biotechadv.2012.02.009.

Solikhah, M.D., Amri, K. and Karuana, F. (2022) "Pedoman Penanganan dan Penyimpanan Biodiesel dan Campuran Biodiesel (B30)." Khairil Amri.

Stojković, I.J. *et al.* (2014) "Purification technologies for crude biodiesel obtained by alkali-catalyzed transesterification," *Renewable and Sustainable Energy Reviews*, 32, pp. 1–15. Available at: https://doi.org/10.1016/j.rser.2014.01.005.

Tantawy, M.A. and Ali Alomari, A. (2019) 'Extraction of alumina from Nawan kaolin by acid leaching', *Oriental Journal of Chemistry*, 35(3), pp. 1013–1021. doi:10.13005/ojc/350313.

Utama, N.A. *et al.* (2014) "The end of fossil fuel era: Supply-demand measures through energy efficiency," *Procedia Environmental Sciences*, 20, pp. 40–45. Available at: https://doi.org/10.1016/j.proenv.2014.03.007.

Vasanth, D., Pugazhenthi, G. and Uppaluri, R. (2013) "Performance of low cost ceramic microfiltration membranes for the treatment of oil-in-water emulsions," *Separation Science and Technology*, 48(6), pp. 849–858. Available at: https://doi.org/10.1080/01496395.2012.712598.

"World energy outlook 2019" (2019) *World Energy Outlook* [Preprint]. Available at: https://doi.org/10.1787/caf32f3b-en.

X. Tan, S. Liu, K. Li, Preparation and characterization of inorganic hollow fiber membranes, J. Membr. Sci. 188 (1) (2001) 87–95

Wang, Y. et al. (2009) "Refining of biodiesel by ceramic membrane separation," Fuel Processing Technology, 90(3), pp. 422–427. Available at: https://doi.org/10.1016/j.fuproc.2008.11.004.

Zhan, W. *et al.* (2019) "Hydrophobic agglomeration behaviors of clay minerals as affected by siloxane structure", *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 568, pp. 36–42. doi:10.1016/j.colsurfa.2019.01.061.

Z. Hendren, Novel Ceramic Membranes for Membrane Distillation: Surface Modification, Performance Comparison with PTFE Membranes, and Treatment of Municipal Wastewater, 2011. Durham

# APPENDIX

## Appendix 1. Microfiltration Experiment, Membrane Cleaning, Membrane Modification, Glycerol Rejection Rate Documentation



Figure 1. Microfiltration Experiment Set up



Figure 2. Membrane Cleaning after Microfiltration Experiment

Figure 3. Microfiltration Experiment Pressure Gauge at 0.5 kg/cm$^2$
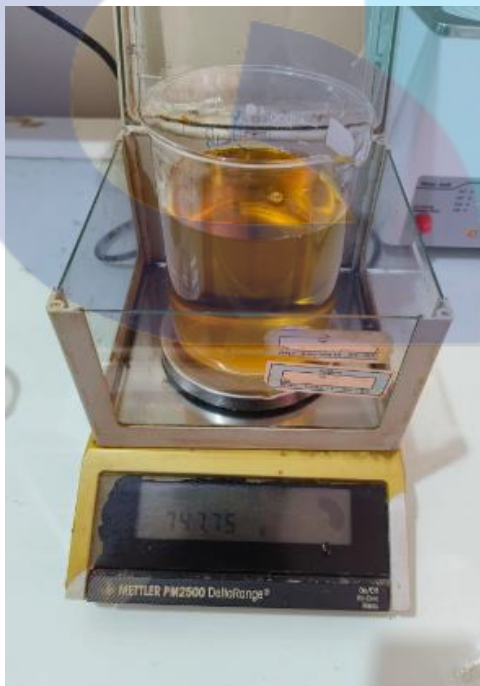


Figure 4. Weighing Biodiesel for Microfiltrtion Experiment

Figure 5. Benzalkonium Chloride for Membrane Cleaning



Figure 5. After Immersing the Ceramic Membranes in the Trichloromethylsilanes 7% v/v in Ethyl Acetate Solution

Figure 6. Rinsing the Ceramic Membranes with Ethyl Acetate after immersing



Figure 7. Drying the Ceramic Membranes in Oven at 60 Celcius for 12 hours

Figure 8. Working Solution, Acetic Acid 1.6 M, Ammonium Acetate 4 M, Glycerol
Stock Solution, Glycerol Working Solution for Standard Curve Calibration



Figure 9. pH Universal Indicator Shows the Buffer Solution pH is between 5.0-6.0

Figure 7. Glycerol Standard Calibration Curve Solution to be Analyzed Using UV-Vis
Spectrophotometer
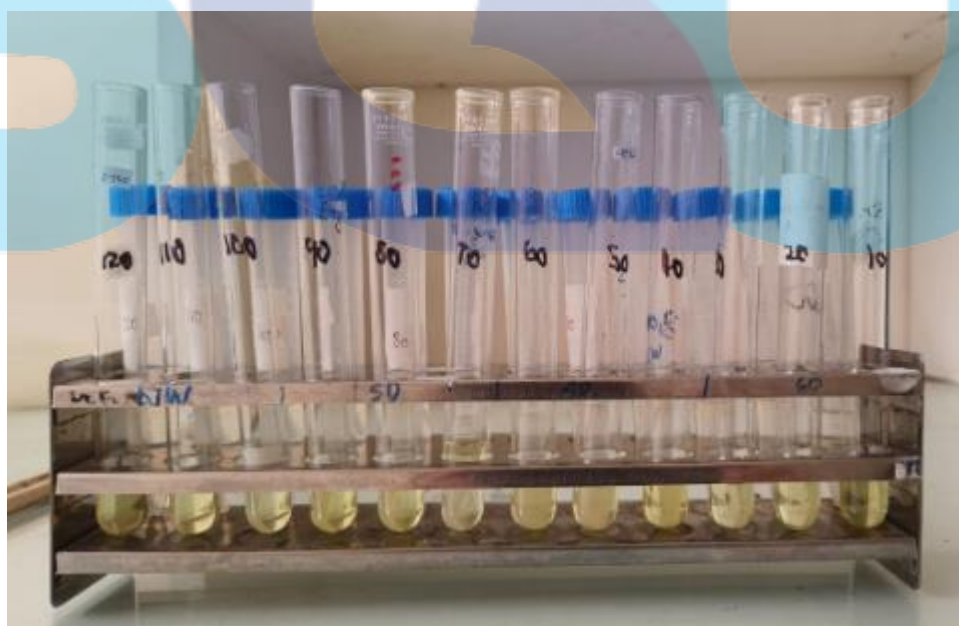


Figure 7. Glycerol Concentration in the Permeate Sample to be Analyzed Using UV-
Vis Spectrophotometer

**Appendix 2. Biodiesel Permeate Flux with Alumina-Kaolin Membrane**

Transmembrane Pressure = 0.5 kg/cm$^2$

Retentate Flow Rate = 120 ml/min

Membrane inner diameter = 6.5 mm

Membrane length = 66.17 mm

Active area of flow = 0.00135053 m$^2$
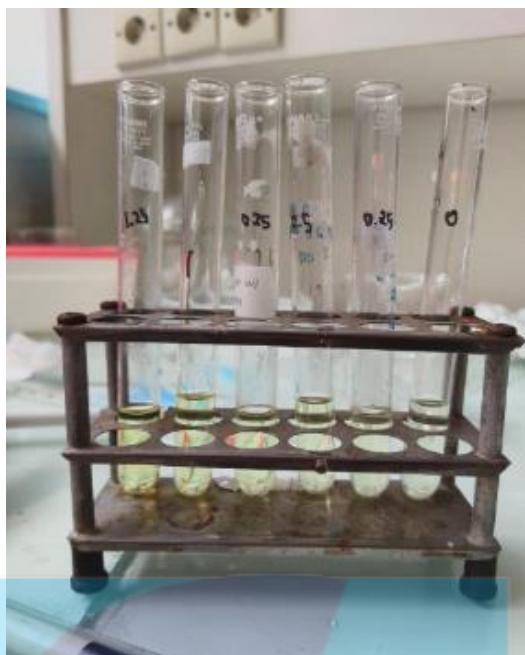
Stable Permeate Flux = 24.287 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 4.2 | 0.0042 | 18.659 |
| 20 | 0.17 | 4.8 | 0.0048 | 21.325 |
| 30 | 0.17 | 5.3 | 0.0053 | 23.546 |
| 40 | 0.17 | 5.6 | 0.0056 | 24.879 |
| 50 | 0.17 | 5.7 | 0.0057 | 25.323 |
| 60 | 0.17 | 5.6 | 0.0056 | 24.879 |
| 70 | 0.17 | 5.8 | 0.0058 | 25.768 |
| 80 | 0.17 | 5.7 | 0.0057 | 25.323 |
| 90 | 0.17 | 5.4 | 0.0054 | 23.991 |
| 100 | 0.17 | 5.6 | 0.0056 | 24.879 |
| 110 | 0.17 | 5.5 | 0.0055 | 24.435 |
| 120 | 0.17 | 5.3 | 0.0053 | 23.546 |

**Appendix 3. Biodiesel Permeate Flux with Alumina-Kaolin Membrane (Maharani (2022))**

Transmembrane Pressure = 0.5 kg/cm$^2$

Retentate Flow Rate = 72.5 ml/min

Membrane inner diameter = 5 mm

Membrane length = 80 mm

Active area of flow = 0.001256 m2

Stable Permeate Flux = 12.4 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 8.6 | 0.0086 | 41.08 |
| 20 | 0.17 | 6.6 | 0.0066 | 31.53 |
| 30 | 0.17 | 6.1 | 0.0061 | 29.14 |
| 40 | 0.17 | 5.9 | 0.0059 | 28.18 |

| 50 | 0.17 | 4.6 | 0.0046 | 21.97 |
| 60 | 0.17 | 4.0 | 0.004 | 19.11 |
| 70 | 0.17 | 3.6 | 0.0036 | 17.20 |
| 80 | 0.17 | 3.4 | 0.0034 | 16.24 |
| 90 | 0.17 | 3.0 | 0.003 | 14.33 |
| 100 | 0.17 | 3.0 | 0.003 | 14.33 |
| 110 | 0.17 | 2.6 | 0.0026 | 12.42 |
| 120 | 0.17 | 2.2 | 0.0022 | 10.51 |

## Appendix 4. Biodiesel-Glycerol 1000 ppm Permeate Flux with Alumina-Kaolin Membrane

Transmembrane Pressure = 0.5 $kg/cm^2$

Membrane inner diameter = 6.5 mm

Membrane length = 66.17 mm

Active area of flow = 0.00135053 $m^2$

Stable Permeate Flux = 22.214 $L/m^2.h$

| Feed Composition | Mass (g) | Concentration (ppm) |
| --- | --- | --- |
| Glycerol | 0.5 | 1000 ppm |
| Water | 1 | 2000 ppm |
| Biodiesel | 498.5 | |

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
| --- | --- | --- | --- | --- |
| 10 | 0.17 | 5 | 0.005 | 22.214 |
| 20 | 0.17 | 4.9 | 0.0049 | 21.769 |
| 30 | 0.17 | 4.2 | 0.0042 | 18.659 |
| 40 | 0.17 | 4.8 | 0.0048 | 21.325 |
| 50 | 0.17 | 4.7 | 0.0047 | 20.881 |
| 60 | 0.17 | 4.9 | 0.0049 | 21.769 |
| 70 | 0.17 | 5 | 0.005 | 22.214 |
| 80 | 0.17 | 4.6 | 0.0046 | 20.436 |
| 90 | 0.17 | 4.9 | 0.0049 | 21.769 |
| 100 | 0.17 | 5 | 0.005 | 22.214 |
| 110 | 0.17 | 4.8 | 0.0048 | 21.325 |
| 120 | 0.17 | 5.2 | 0.0052 | 23.102 |

## Appendix 5. Biodiesel-Glycerol 10000 ppm Permeate Flux with Alumina-Kaolin Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 6.5 mm

Membrane length = 66.17 mm

Active area of flow = 0.00135053 m$^2$

Stable Permeate Flux = 19.844 L/m$^2$.h

| Feed Composition | Mass (g) | Concentration (ppm) |
|---|---|---|
| Glycerol | 5 | 10000 ppm |
| Water | 10 | 20000 ppm |
| Biodiesel | 485 | |

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 4.9 | 0.0049 | 21.769 |
| 20 | 0.17 | 5.2 | 0.0052 | 23.102 |
| 30 | 0.17 | 5.2 | 0.0052 | 23.102 |
| 40 | 0.17 | 4.4 | 0.0044 | 19.548 |
| 50 | 0.17 | 4.6 | 0.0046 | 20.436 |
| 60 | 0.17 | 5.4 | 0.0054 | 23.991 |
| 70 | 0.17 | 5 | 0.005 | 22.214 |
| 80 | 0.17 | 5.5 | 0.0055 | 24.435 |
| 90 | 0.17 | 4.7 | 0.0047 | 20.881 |
| 100 | 0.17 | 4.6 | 0.0046 | 20.436 |
| 110 | 0.17 | 4.4 | 0.0044 | 19.548 |
| 120 | 0.17 | 4.4 | 0.0044 | 19.548 |

## Appendix 6. Biodiesel Permeate Flux after Cleaning with Alumina-Kaolin Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 6.5 mm

Membrane length = 66.17 mm

Active area of flow = 0.00135053 m$^2$

Stable Permeate Flux = 23.842 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 3.2 | 0.0032 | 14.217 |
| 20 | 0.17 | 3.9 | 0.0039 | 17.327 |
| 30 | 0.17 | 4.4 | 0.0044 | 19.548 |
| 40 | 0.17 | 4.3 | 0.0043 | 19.104 |
| 50 | 0.17 | 4.7 | 0.0047 | 20.881 |
| 60 | 0.17 | 4.9 | 0.0049 | 21.769 |
| 70 | 0.17 | 5 | 0.005 | 22.214 |
| 80 | 0.17 | 5.4 | 0.0054 | 23.991 |
| 90 | 0.17 | 5.4 | 0.0054 | 23.991 |
| 100 | 0.17 | 5.2 | 0.0052 | 23.102 |
| 110 | 0.17 | 5.4 | 0.0054 | 23.991 |
| 120 | 0.17 | 5.5 | 0.0055 | 24.435 |

## Appendix 7. Biodiesel Permeate Flux with Alumina Commercial Membrane (Maharani (2022))

Transmembrane Pressure = 0.5 kg/cm2

Membrane inner diameter = 5 mm

Membrane length = 80 mm

Active area of flow = 0.001256 m2

Stable Permeate Flux = 35.83 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 8 | 0.008 | 38.217 |
| 20 | 0.17 | 7 | 0.007 | 33.439 |
| 30 | 0.17 | 8.7 | 0.0087 | 41.561 |
| 40 | 0.17 | 7.6 | 0.0076 | 36.306 |
| 50 | 0.17 | 7.8 | 0.0078 | 37.261 |
| 60 | 0.17 | 7.9 | 0.0079 | 37.739 |
| 70 | 0.17 | 8.1 | 0.0081 | 38.694 |
| 80 | 0.17 | 8.2 | 0.0082 | 39.172 |
| 90 | 0.17 | 7.7 | 0.0077 | 36.783 |
| 100 | 0.17 | 7.7 | 0.0077 | 36.783 |
| 110 | 0.17 | 7.4 | 0.0074 | 35.350 |
| 120 | 0.17 | 7.4 | 0.0074 | 35.350 |

## Appendix 8. Biodiesel Permeate Flux with Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Retentate Flow Rate = 200 ml/min

Membrane inner diameter = 6.5 mm

Membrane length = 66.17 mm

Active area of flow = 0.00135053 m$^2$

Stable Permeate Flux = 23.842 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (mL) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 57.2 | 0.0572 | 267.687 |
| 20 | 0.17 | 52.7 | 0.0527 | 246.628 |
| 30 | 0.17 | 49.1 | 0.0491 | 229.780 |
| 40 | 0.17 | 45.8 | 0.0458 | 214.337 |
| 50 | 0.17 | 44.3 | 0.0443 | 207.317 |
| 60 | 0.17 | 45.5 | 0.0455 | 212.933 |
| 70 | 0.17 | 41.1 | 0.0411 | 192.342 |
| 80 | 0.17 | 38.5 | 0.0385 | 180.174 |
| 90 | 0.17 | 35.9 | 0.0359 | 168.006 |
| 100 | 0.17 | 33.6 | 0.0336 | 157.243 |
| 110 | 0.17 | 30.5 | 0.0305 | 142.735 |
| 120 | 0.17 | 28.7 | 0.0287 | 134.312 |

## Appendix 9. Biodiesel-Glycerol 1000 ppm Permeate Flux with Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 7 mm

Membrane length = 58.33 mm

Active area of flow = 0.001282093 m$^2$

Stable Permeate Flux = 40.56 L/m$^2$.h

| Feed Composition | Mass (g) | Concentration (ppm) |
|---|---|---|
| Glycerol | 0.75 | 1000 ppm |
| Water | 1.5 | 2000 ppm |
| Biodiesel | 797.75 | |

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (mL) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 37.8 | 0.0378 | 176.898 |
| 20 | 0.17 | 35 | 0.035 | 163.795 |
| 30 | 0.17 | 32.3 | 0.0323 | 151.159 |
| 40 | 0.17 | 28.7 | 0.0287 | 134.312 |
| 50 | 0.17 | 24.1 | 0.0241 | 112.784 |
| 60 | 0.17 | 21.4 | 0.0214 | 100.149 |
| 70 | 0.17 | 18.7 | 0.0187 | 87.513 |
| 80 | 0.17 | 14.8 | 0.0148 | 69.262 |
| 90 | 0.17 | 10.5 | 0.0105 | 49.138 |
| 100 | 0.17 | 9.7 | 0.0097 | 45.395 |
| 110 | 0.17 | 8.5 | 0.0085 | 39.779 |
| 120 | 0.17 | 7.8 | 0.0078 | 36.503 |

## Appendix 10. Biodiesel Permeate Flux (after cleaning with benzalkonium chloride) with Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 7 mm

Membrane length = 58.33 mm

Active area of flow = 0.001282093 m$^2$

Stable Permeate Flux = 90.165 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 27 | 0.027 | 126.355849 |
| 20 | 0.17 | 26.1 | 0.0261 | 122.1439873 |
| 30 | 0.17 | 24 | 0.024 | 112.3163102 |
| 40 | 0.17 | 23.7 | 0.0237 | 110.9123563 |
| 50 | 0.17 | 21.3 | 0.0213 | 99.68072529 |
| 60 | 0.17 | 20.4 | 0.0204 | 95.46886366 |
| 70 | 0.17 | 19.7 | 0.0197 | 92.19297128 |
| 80 | 0.17 | 20.7 | 0.0207 | 96.87281753 |
| 90 | 0.17 | 19.3 | 0.0193 | 90.32103277 |
| 100 | 0.17 | 19.4 | 0.0194 | 90.7890174 |
| 110 | 0.17 | 19.3 | 0.0193 | 90.32103277 |
| 120 | 0.17 | 19.1 | 0.0191 | 89.38506352 |

## Appendix 11. Biodiesel-Glycerol 1000 ppm (after cleaning with benzalkonium chloride) Permeate Flux with Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 7 mm

Membrane length = 58.33 mm

Active area of flow = 0.001282093 m$^2$

Stable Permeate Flux = 37.55 L/m$^2$.h

| Feed Composition | Mass (g) | Concentration (ppm) |
|---|---|---|
| Glycerol | 0.5 | 1000 ppm |
| Water | 1 | 2000 ppm |
| Biodiesel | 498.5 | |

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 20.2 | 0.0202 | 94.53 |
| 20 | 0.17 | 19.7 | 0.0197 | 92.19 |
| 30 | 0.17 | 16.9 | 0.0169 | 79.09 |
| 40 | 0.17 | 17.8 | 0.0178 | 83.30 |
| 50 | 0.17 | 10.9 | 0.0109 | 51.01 |
| 60 | 0.17 | 12.6 | 0.0126 | 58.97 |
| 70 | 0.17 | 11 | 0.011 | 51.48 |
| 80 | 0.17 | 10.2 | 0.0102 | 47.73 |

| 90 | 0.17 | 9.3 | 0.0093 | 43.52 |
| 100 | 0.17 | 9.1 | 0.0091 | 42.59 |
| 110 | 0.17 | 8 | 0.008 | 37.44 |
| 120 | 0.17 | 7 | 0.007 | 32.76 |

## Appendix 12. Biodiesel Permeate Flux (after cleaning with Sodium Lauryl Sulfate) with Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 7 mm

Membrane length = 58.33 mm

Active area of flow = 0.001282093 m$^2$

Stable Permeate Flux = 17.315 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 1.7 | 0.0017 | 7.96 |
| 20 | 0.17 | 1.5 | 0.0015 | 7.02 |
| 30 | 0.17 | 1.7 | 0.0017 | 7.96 |
| 40 | 0.17 | 3.1 | 0.0031 | 14.51 |
| 50 | 0.17 | 2.5 | 0.0025 | 11.70 |
| 60 | 0.17 | 3 | 0.003 | 14.04 |
| 70 | 0.17 | 3.1 | 0.0031 | 14.51 |
| 80 | 0.17 | 3.4 | 0.0034 | 15.91 |
| 90 | 0.17 | 3.7 | 0.0037 | 17.32 |
| 100 | 0.17 | 3.8 | 0.0038 | 17.78 |
| 110 | 0.17 | 3.7 | 0.0037 | 17.32 |
| 120 | 0.17 | 3.6 | 0.0036 | 16.85 |

## Appendix 13. Biodiesel Permeate Flux with Modified Alumina-Kaolin Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Retentate Flow Rate = 105 ml/min

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 16.878 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 4.3 | 0.0043 | 15.442 |
| 20 | 0.17 | 4.6 | 0.0046 | 16.519 |
| 30 | 0.17 | 4.9 | 0.0049 | 17.596 |
| 40 | 0.17 | 5.1 | 0.0051 | 18.315 |
| 50 | 0.17 | 4.8 | 0.0048 | 17.237 |
| 60 | 0.17 | 4.7 | 0.0047 | 16.878 |
| 70 | 0.17 | 5.3 | 0.0053 | 19.033 |
| 80 | 0.17 | 4.6 | 0.0046 | 16.519 |
| 90 | 0.17 | 4.3 | 0.0043 | 15.442 |
| 100 | 0.17 | 4.6 | 0.0046 | 16.519 |
| 110 | 0.17 | 4.8 | 0.0048 | 17.237 |
| 120 | 0.17 | 4.7 | 0.0047 | 16.878 |

## Appendix 14. Biodiesel-Glycerol 1000 ppm Permeate Flux with Modified Alumina-Kaolin Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 16.878 L/m$^2$.h

| Feed Composition | Mass (g) | Concentration (ppm) |
|---|---|---|
| Glycerol | 0.5 | 1000 ppm |
| Water | 1 | 2000 ppm |
| Biodiesel | 498.5 | |

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 4.6 | 0.0046 | 16.519 |
| 20 | 0.17 | 4.8 | 0.0048 | 17.237 |
| 30 | 0.17 | 4.5 | 0.0045 | 16.160 |
| 40 | 0.17 | 4.7 | 0.0047 | 16.878 |
| 50 | 0.17 | 4.2 | 0.0042 | 15.083 |
| 60 | 0.17 | 4.7 | 0.0047 | 16.878 |
| 70 | 0.17 | 4.7 | 0.0047 | 16.878 |
| 80 | 0.17 | 4.3 | 0.0043 | 15.442 |

| 90 | 0.17 | 4.5 | 0.0045 | 16.160 |
| 100 | 0.17 | 4.4 | 0.0044 | 15.801 |
| 110 | 0.17 | 4.5 | 0.0045 | 16.160 |
| 120 | 0.17 | 4.5 | 0.0045 | 16.160 |

## Appendix 15. Biodiesel-Glycerol 10000 ppm Permeate Flux with Modified Alumina-Kaolin Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 16.878 L/m$^2$.h

| Feed Composition | Mass (g) | Concentration (ppm) |
|---|---|---|
| Glycerol | 5 | 10000 ppm |
| Water | 10 | 20000 ppm |
| Biodiesel | 485 | |

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 3.3 | 0.0033 | 11.851 |
| 20 | 0.17 | 3.8 | 0.0038 | 13.646 |
| 30 | 0.17 | 4.2 | 0.0042 | 15.083 |
| 40 | 0.17 | 4.3 | 0.0043 | 15.442 |
| 50 | 0.17 | 4.1 | 0.0041 | 14.723 |
| 60 | 0.17 | 4.3 | 0.0043 | 15.442 |
| 70 | 0.17 | 4.1 | 0.0041 | 14.723 |
| 80 | 0.17 | 3.9 | 0.0039 | 14.005 |
| 90 | 0.17 | 4.2 | 0.0042 | 15.083 |
| 100 | 0.17 | 4.1 | 0.0041 | 14.723 |
| 110 | 0.17 | 4.2 | 0.0042 | 15.083 |
| 120 | 0.17 | 4.2 | 0.0042 | 15.083 |

## Appendix 16. Biodiesel before Cleaning Permeate Flux with Modified Alumina-Kaolin Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 13.886 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 1.8 | 0.0018 | 6.464 |
| 20 | 0.17 | 3.8 | 0.0038 | 13.646 |
| 30 | 0.17 | 4.1 | 0.0041 | 14.723 |
| 40 | 0.17 | 4.3 | 0.0043 | 15.442 |
| 50 | 0.17 | 3.9 | 0.0039 | 14.005 |
| 60 | 0.17 | 4 | 0.004 | 14.364 |
| 70 | 0.17 | 3.9 | 0.0039 | 14.005 |
| 80 | 0.17 | 3.9 | 0.0039 | 14.005 |
| 90 | 0.17 | 3.8 | 0.0038 | 13.646 |
| 100 | 0.17 | 4 | 0.004 | 14.364 |
| 110 | 0.17 | 3.9 | 0.0039 | 14.005 |
| 120 | 0.17 | 3.7 | 0.0037 | 13.287 |

**Appendix 17. Biodiesel after Cleaning Permeate Flux with Modified Alumina-Kaolin Membrane**

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 16.399 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 3.9 | 0.0039 | 14.005 |
| 20 | 0.17 | 4.4 | 0.0044 | 15.801 |
| 30 | 0.17 | 3.8 | 0.0038 | 13.646 |
| 40 | 0.17 | 4.3 | 0.0043 | 15.442 |
| 50 | 0.17 | 4.2 | 0.0042 | 15.083 |
| 60 | 0.17 | 4.5 | 0.0045 | 16.160 |
| 70 | 0.17 | 4.2 | 0.0042 | 15.083 |

| 80 | 0.17 | 4.6 | 0.0046 | 16.519 |
| 90 | 0.17 | 4.4 | 0.0044 | 15.801 |
| 100 | 0.17 | 4.5 | 0.0045 | 16.160 |
| 110 | 0.17 | 4.4 | 0.0044 | 15.801 |
| 120 | 0.17 | 4.8 | 0.0048 | 17.237 |

## Appendix 18. Biodiesel Permeate Flux with Modified Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Retentate Flow Rate = 105 ml/min

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 29.96 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 17.3 | 0.0173 | 72.653 |
| 20 | 0.17 | 16.4 | 0.0164 | 68.874 |
| 30 | 0.17 | 15.6 | 0.0156 | 65.514 |
| 40 | 0.17 | 10.6 | 0.0106 | 44.516 |
| 50 | 0.17 | 9.9 | 0.0099 | 41.576 |
| 60 | 0.17 | 8.6 | 0.0086 | 36.117 |
| 70 | 0.17 | 8.6 | 0.0086 | 36.117 |
| 80 | 0.17 | 7.9 | 0.0079 | 33.177 |
| 90 | 0.17 | 7 | 0.007 | 29.397 |
| 100 | 0.17 | 6.8 | 0.0068 | 28.557 |
| 110 | 0.17 | 7.3 | 0.0073 | 30.657 |
| 120 | 0.17 | 7.3 | 0.0073 | 30.657 |

## Appendix 19. Biodiesel-Glycerol 1000 ppm Permeate Flux with Modified Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Retentate Flow Rate = 105 ml/min

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 26.038 L/m$^2$.h

| Feed Composition | Mass (g) | Concentration (ppm) |
|---|---|---|
| Glycerol | 0.5 | 1000 ppm |
| Water | 1 | 2000 ppm |
| Biodiesel | 498.5 | |

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 12.8 | 0.0128 | 53.755 |
| 20 | 0.17 | 9.8 | 0.0098 | 41.156 |
| 30 | 0.17 | 10.8 | 0.0108 | 45.356 |
| 40 | 0.17 | 10.8 | 0.0108 | 45.356 |
| 50 | 0.17 | 8.5 | 0.0085 | 35.697 |
| 60 | 0.17 | 8.3 | 0.0083 | 34.857 |
| 70 | 0.17 | 5.7 | 0.0057 | 23.938 |
| 80 | 0.17 | 7.1 | 0.0071 | 29.817 |
| 90 | 0.17 | 8.3 | 0.0083 | 34.857 |
| 100 | 0.17 | 7.3 | 0.0073 | 30.657 |
| 110 | 0.17 | 6.2 | 0.0062 | 26.038 |
| 120 | 0.17 | 5.1 | 0.0051 | 21.418 |

**Appendix 20. Biodiesel-Glycerol 1000 ppm (Repetition) Permeate Flux with Modified Alumina Commercial Membrane**

Transmembrane Pressure = 0.5 kg/cm$^2$

Retentate Flow Rate = 105 ml/min

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 19.46 L/m$^2$.h

| Feed Composition | Mass (g) | Concentration (ppm) |
|---|---|---|
| Glycerol | 0.5 | 1000 ppm |
| Water | 1 | 2000 ppm |
| Biodiesel | 498.5 | |

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 6 | 0.006 | 25.198 |
| 20 | 0.17 | 5.7 | 0.0057 | 23.938 |
| 30 | 0.17 | 5.8 | 0.0058 | 24.358 |
| 40 | 0.17 | 5.9 | 0.0059 | 24.778 |
| 50 | 0.17 | 5.8 | 0.0058 | 24.358 |
| 60 | 0.17 | 5.5 | 0.0055 | 23.098 |
| 70 | 0.17 | 5.3 | 0.0053 | 22.258 |
| 80 | 0.17 | 5.1 | 0.0051 | 21.418 |
| 90 | 0.17 | 5.2 | 0.0052 | 21.838 |
| 100 | 0.17 | 5.1 | 0.0051 | 21.418 |
| 110 | 0.17 | 4.5 | 0.0045 | 18.898 |
| 120 | 0.17 | 4.3 | 0.0043 | 18.058 |

## Appendix 21. Biodiesel before Cleaning Permeate Flux with Modified Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 29.58 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 18.4 | 0.0184 | 77.273 |
| 20 | 0.17 | 17.3 | 0.0173 | 72.653 |
| 30 | 0.17 | 15.5 | 0.0155 | 65.094 |
| 40 | 0.17 | 14.3 | 0.0143 | 60.055 |
| 50 | 0.17 | 13.1 | 0.0131 | 55.015 |
| 60 | 0.17 | 12.2 | 0.0122 | 51.235 |
| 70 | 0.17 | 11.3 | 0.0113 | 47.456 |
| 80 | 0.17 | 10.1 | 0.0101 | 42.416 |
| 90 | 0.17 | 8.1 | 0.0081 | 34.017 |
| 100 | 0.17 | 6.7 | 0.0067 | 28.137 |
| 110 | 0.17 | 6.4 | 0.0064 | 26.878 |
| 120 | 0.17 | 6.6 | 0.0066 | 27.718 |

## Appendix 22. Biodiesel after Cleaning Permeate Flux with Modified Alumina Commercial Membrane

Transmembrane Pressure = 0.5 kg/cm$^2$

Membrane inner diameter = 6.583 mm

Membrane length = 80.83 mm

Active area of flow = 0.001670806 m$^2$

Stable Permeate Flux = 27.72 L/m$^2$.h

| Time (min) | Time Interval (h) | Permeate Volume (mL) | Permeate Volume (L) | Permeate Flux (L/m2.h) |
|---|---|---|---|---|
| 10 | 0.17 | 13.6 | 0.0136 | 57.115 |
| 20 | 0.17 | 11.9 | 0.0119 | 49.976 |
| 30 | 0.17 | 10.4 | 0.0104 | 43.676 |
| 40 | 0.17 | 9.4 | 0.0094 | 39.476 |
| 50 | 0.17 | 8 | 0.008 | 33.597 |
| 60 | 0.17 | 7.7 | 0.0077 | 32.337 |
| 70 | 0.17 | 6.9 | 0.0069 | 28.977 |
| 80 | 0.17 | 6.6 | 0.0066 | 27.718 |
| 90 | 0.17 | 6.2 | 0.0062 | 26.038 |
| 100 | 0.17 | 6.6 | 0.0066 | 27.718 |
| 110 | 0.17 | 6.5 | 0.0065 | 27.298 |
| 120 | 0.17 | 6.7 | 0.0067 | 28.137 |

## Appendix 23. Glycerol Rejection Rate Calculation

- **Preparation of the Standard Curve**
  - Concentration of glycerol reference Solution = 0.03 mg/ml = 30 ppm
  - Final standard sample volume = 2 ml
  - Concentration of standard samples

$$[Standard] = \frac{[Reference] \times Volume\ Glycerol\ Reference\ Solution}{Final\ Volume}$$

Example of calculation:

| | |
|---|---|
| Volume of glycerol reference solution | = 0 ml |
| Volume of working solvent | = 2 ml |
| Final volume | = 2 ml |
| Glycerol reference concentration | = 30 ppm |

Concentration of Standard:

$$[Standard] = \frac{30\ ppm \times 0\ ml}{2\ ml} = 0\ ppm$$

| Working Solvent (ml) | Glycerol Working Solution (ml) | Final Volume (ml) | Concentration of Std Solution (ppm) | Abs value at λ =410 nm |
|---|---|---|---|---|
| 2 | 0 | 2 | 0 | 0 |
| 1.75 | 0.25 | 2 | 3.75 | 0.065 |
| 1.5 | 0.5 | 2 | 7.5 | 0.122 |
| 1.25 | 0.75 | 2 | 11.25 | 0.235 |
| 1 | 1 | 2 | 15 | 0.356 |
| 0.75 | 1.25 | 2 | 18.75 | 0.454 |
| 0.5 | 1.5 | 2 | 22.5 | 0.562 |
| 0.25 | 1.75 | 2 | 26.25 | 0.668 |
| 0 | 2 | 2 | 30 | 0.777 |



$y = 0.4011x - 0.0412$
$R^2 = 0.9933$
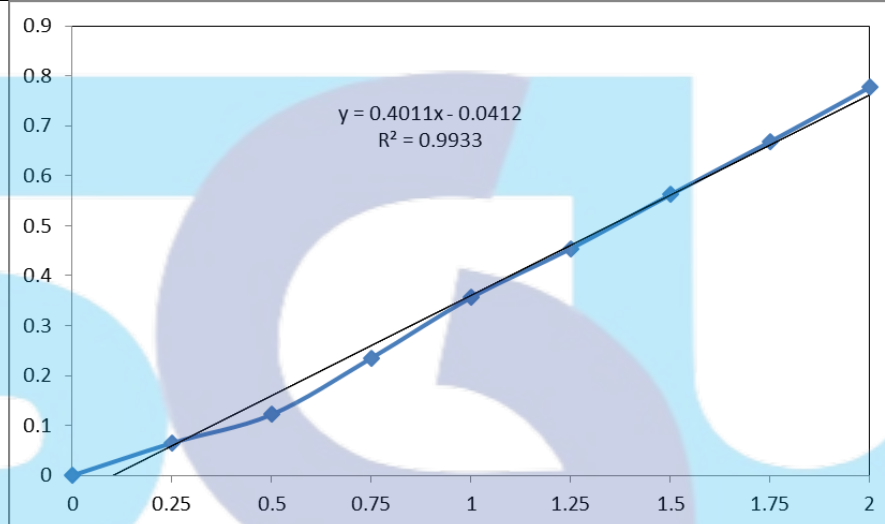
- **Dilution Factor (DF) Calculation**
  Assumption of Biodiesel density = 1 g/ml
  a. 1st Dilution Factor : Liquid-Liquid Extraction of glycerol using hexane (non-polar)
     and ethanol aqueous solution (polar)

| Weight of Permeate Sample | : | 1 g |
|---|---|---|
| Maximum concentration in the permeate sample | : | 1000 mg/l = 1 mg/ml |
| Volume of Hexane phase (non-polar; contain biodiesel) | : | 4 ml |
| Volume of working solvent phase (polar; contain glycerol) | : | 4 ml |
| Concentration of glycerol in polar phase | : | 1 mg/ 4 ml = 0.25 mg/ml |

$$Dilution\ Factor\ (DF) = \frac{Final\ Volume\ of\ Diluted\ Solution}{Initial\ Volume\ of\ Undiluted\ Sample} = \frac{4\ ml}{1\ ml} = 4$$

  b. 2nd Dilution Factor : Sample Dilution before UV-Vis Spectrophotometer Reading

| Sample Initial Volume | : | 4 ml |
|---|---|---|
| Volume taken from the Sample to be diluted | : | 0.5 ml |
| Volume of Final Solution | : | 2 ml |
| Concentration of glycerol in the transferred solution | : | 0.25 mg/ml |
| Concentration of glycerol the final solution | : | 0.0625 mg/ml |

$$Dilution\ Factor\ (DF) = \frac{Final\ Volume\ of\ Diluted\ Solution}{Initial\ Volume\ of\ Undiluted\ Sample} = \frac{2\ ml}{0.5\ ml} = 4$$

Thus, the total dilution factor used in this experiment become:

$$Dilution\ Factor\ (DF) = 1st\ DF \times 2nd\ DF = 4 \times 4 = 16$$

Calculation of Glycerol Standard Curve Concentration and Glycerol Permeate Concentration

Calculation to convert the sample absorbance value into concentration of glycerol according to the standard curve (ppm) were done based on the linear regression of the standard curve, y = 0.4011x - 0.0412. Where x is the standard curve glycerol concentration, y is the absorbance value. The calculation is done as the following example: y: 0.173

$$x = \frac{y+0.0412}{0.4011} = \frac{0.173+0.0412}{0.4011} = 0.534\ ppm$$

Then calculate the standard curve glycerol concentration (ppm) with the dilution factor as following example, $Cp$ = Glycerol Standard Curve $\times$ (DF = 16), 0.534 ppm x 16 = 8.544 ppm

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Calculation of Glycerol Rejection Rate

Calculation was done based on the equation below: where $C_P$ is the glycerol

concentration in the permeate sample and $C_f$ is the glycerol concentration in the feed

$$R = \left(1 - \frac{C_p}{C_f}\right) \times 100\%$$

Example of the calculation: $(1 - \frac{8.544\ ppm}{1000\ ppm}) x 100\% = 99.146\%$

**Appendix 24. Modified Alumina-Kaolin Glycerol Rejection Rate**

**Biodiesel-Glycerol 1000 ppm**

| Time (min) | Abs value at λ =410 nm | Std Curve Glycerol Concentration (ppm) | Permeate Glycerol Concentration (ppm) | Glycerol Rejection Rate (%) |
|---|---|---|---|---|
| 10 | 0.245 | 0.714 | 11.417 | 98.858 |
| 20 | 0.211 | 0.629 | 10.060 | 98.994 |
| 30 | 0.228 | 0.671 | 10.738 | 98.926 |
| 40 | 0.235 | 0.689 | 11.018 | 98.898 |
| 50 | 0.208 | 0.621 | 9.941 | 99.006 |
| 60 | 0.211 | 0.629 | 10.060 | 98.994 |
| 70 | 0.199 | 0.599 | 9.582 | 99.042 |
| 80 | 0.256 | 0.741 | 11.855 | 98.814 |
| 90 | 0.268 | 0.771 | 12.334 | 98.767 |
| 100 | 0.345 | 0.963 | 15.406 | 98.459 |
| 110 | 0.28 | 0.801 | 12.813 | 98.719 |
| 120 | 0.248 | 0.721 | 11.536 | 98.846 |

**Biodiesel-Glycerol 10000 ppm**

| Time (min) | Abs value at λ =410 nm | Std Curve Glycerol Concentration (ppm) | Permeate Glycerol Concentration (ppm) | Glycerol Rejection Rate (%) |
|---|---|---|---|---|
| 10 | 0.222 | 0.656 | 10.499 | 99.895 |
| 20 | 0.169 | 0.524 | 8.385 | 99.916 |
| 30 | 0.168 | 0.522 | 8.345 | 99.917 |
| 40 | 0.147 | 0.469 | 7.507 | 99.925 |
| 50 | 0.107 | 0.369 | 5.912 | 99.941 |
| 60 | 0.107 | 0.369 | 5.912 | 99.941 |
| 70 | 0.133 | 0.434 | 6.949 | 99.931 |
| 80 | 0.147 | 0.469 | 7.507 | 99.925 |
| 90 | 0.206 | 0.616 | 9.861 | 99.901 |
| 100 | 0.171 | 0.529 | 8.465 | 99.915 |
| 110 | 0.187 | 0.569 | 9.103 | 99.909 |
| 120 | 0.186 | 0.566 | 9.063 | 99.909 |

## Appendix 25. Modified Alumina Commercial Glycerol Rejection Rate

**Biodiesel-Glycerol 1000 ppm**

| Time (min) | Abs value at λ =410 nm | Std Curve Glycerol Concentration (ppm) | Permeate Glycerol Concentration (ppm) | Glycerol Rejection Rate (%) |
|---|---|---|---|---|
| 10 | 0.173 | 0.534 | 8.545 | 99.146 |
| 20 | 0.126 | 0.417 | 6.670 | 99.333 |
| 30 | 0.135 | 0.439 | 7.029 | 99.297 |
| 40 | 0.105 | 0.364 | 5.832 | 99.417 |
| 50 | 0.124 | 0.412 | 6.590 | 99.341 |
| 60 | 0.118 | 0.397 | 6.351 | 99.365 |
| 70 | 0.154 | 0.487 | 7.787 | 99.221 |
| 80 | 0.134 | 0.437 | 6.989 | 99.301 |
| 90 | 0.181 | 0.554 | 8.864 | 99.114 |
| 100 | 0.178 | 0.546 | 8.744 | 99.126 |
| 110 | 0.188 | 0.571 | 9.143 | 99.086 |
| 120 | 0.24 | 0.701 | 11.217 | 98.878 |

# Curriculum Vitae

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## Education
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- 2021: Fachhochschule Südwestfalen, Soest, Germany (majoring in Chemical Engineering as part of the double degree program)
- 2015-2018: SMKFK Penabur Jakarta
- 2015-2012: SMPK 1 Penabur Jakarta
- 2006-2012: SD Harapan Bangsa

## Internship Experience
- 04/2021 - 08/2021: Internship at Apotheke im Centr-o-med, Datteln, Germany in the Pharmacy Lab
- 12/2019 - 02/2020: Internship at PT Dankos Farma, Pulo Gadung, East Jakarta in the Cephalosporin Department
- 06/2017 - 08/2017: Internship at Royal Progress Hospital, Sunter, North Jakarta in the Pharmacy

## Organization Experience
- 2019-2020: Head of SGU Association of Chemical Engineering Student (ACES)

## Key Skills and Interest
- Interests (Sports, Drawing, Reading)
- Computer Skills (Microsoft Excel, Word, PPT)
- Languages (Bahasa (Mother language), English (Fluent), German (A2))
- .