# DAFTAR PUSTAKA


Abulizi, A,. Yang, G.H., Okitzu, K., dan Zhu, J.J., 2014, Synthesis of $MnO_2$ Nanoparticles From Sonochemicals Reduction of $MnO_4^-$ in Water Under Different pH Conditions, Journal Ultrasonics Sonochemistry, **30**(3): 1-6.

Alif, A., Maming, dan Zakir, M., 2014, Sintesis dan Karakterisasi Karbon Nanopori Ampas Tebu (Saccharum officianarum) dengan Aktivator NaOH Melalui Iradiasi Ultrasonik Sebagai Bahan Penyimpan Energi Elektrokimia, *Indo. Chim. Acta*, **l7** (2) 39-46.

Amin, A., Khairi, N., dan Allo, E.K., 2019, Sintesis dan Karakterisasi dari Limbah Cangkang Udang Sebagai Stabilizer Terhadap Ag Nanopartikel, *Journal of Chem*, **4**(2): 86-91.

Ariyanto., Teguh., Prasetyo, I., dan Rochmadi., 2012, Pengaruh Struktur Pori Terhadap Kapastansi Elektroda Superkapasitor yang Dibuat Dari Karbon Nanopori, *Jurnal Reaktor*, **14**(1): 25-32.

Ariningsih, T., 2016 Prospek Penerapan Teknologi Nano dalam Pertanian dan Pengolahan Pangan di Indonesia, *Jurnal Forum Penelitian Agro Ekonomi*, **34**(1): 1-20.

Austin, G. T., 2006, *Industri Proses Kimia*, Erlangga, Jakarta.

Beguin, F., Presser.V., Balducci, A., dan Frackowiak, E., 2014, Carbons and Elektrolites for Advanced Supercapacitors, *Journal Chemistry and Technical Electrochemistry*, DOI: 10.1002/adma.201304137: 1-33.

Bonelli, P.R., P.A.D. Rocca, E.G. Cerrella, A.L. dan Cukierman., 2001, Effect of Pyrolisis Temperatur on Composition, Surface Properties and Thermal Degradation Rates of Brazil Nutshells, *Journal Bioresource Tech*, **76**: 15-22.

Budiono, A., Suhartana, dan Gunawan., 2009, Pengaruh Aktivasi Arang Tempurung Kelapa dengan Asam Sulfat dan Asam Posfat untuk Adsorpsi Fenol, *E-Journal* Universitas Diponegoro, **55**(2): 1-12.

Chen, Q., Chen, J., Zhou, Y., Song, C., Tian, Q., Xu, J., dan Wong, C.P., 2018, Enhancing Pseudocapacitive Kinetics of Nanostructured $MnO_2$ Through Anchoring onto Biomassderived Porous Carbon, *Applied Surface Science*, 440 : 1027–1036.

Chen, M.D., Wumale, T., Li, W.L., Song, H.H., Song, R.R., 2015, "Electrochemical Performance of Cotton Stalk Based Activated Carbon

Electrodes Modified by $MnO_2$ for Supercapacitor", *Journal Mat. Tech*., **30**: A2-A7.

Das, R., Nath, S.S., Chakdar, D., dan Gope, G., 2009, Preparation of Silver Nanoparticles and their Characterization Synthesis of Silver Nanoparticles, *Journal of Materials Online*: 1-9.

Eso, R., Luvil., da Ririn., 2021, Efek Variasi Konsentrasi Zat Aktivator $H_3PO_4$ Terhadap Morfologi Permukaan dan Gugus Fungsi Karbon Aktif Cangkang Kemiri, *Jurnal Gravitasi*, **20**(1): 19-23.

Faujiah, F., 2012. *Pemanfaatan Karbon Aktif dari Limbah Padat Industri Agar-Agar sebagai Adsorben Logam Berat dan Bahan Organik dari Limbah Industri Tekstil*, Skripsi tidak diterbitkan, Institut Pertanian Bogor, Bogor.

Feng., 2014, $MnO_2$ Prepared by Hydrothermal Method and Electrochemical Performance as Anode for Lithium-Ion Battery, *Nanoscale Research Letters*, **9**(1): 290.

Fitriani, 2017, Deposis Secara Redoks Nanopartikel $MnO_2$ Pada Permukaan Karbon Aktif Tongkol Jagung dan Potensialnya Sebagai Elektroda Pseudokapasitor, *Skripsi*, Jurusan Kimia FMIPA, Universitas Hasanuddin, Makassar.

Goertzen, S.L., Theriault, K.D., Oikcle, A.M., Tarasuk, A.C., dan Andreas, H.A., 2010, Standardization of The Boehm titration. Part I. $CO_2$ Expulsion and Endpoint Determination, *Carbon*, **48**(4): 1252 – 1261.

Hammad, E.N., Salem, S.S., Mohamed, A.A., dan Dougdoug, W.E., 2022, Enviromental Impacts of Ecofriendly Iron Oxide Nanoparticles on Dyes Removal and Antibacterial Activity, *Journal Biochemistry and Biotechnologi*, **10**: 1-15.

Handayani, A. W., 2010, *Penggunaan Selulosa Daun Nanas Sebagai Adsoorben Logam Berat Cd (II).* Surakarta: Universitas Sebelas Maret.

Huang, M., Fei L., Dong, F., Zhang, X., dan Li, L., 2015, $MnO_2$-Based Nanostructures for High-Performance Supercapacitors, *Journal of Materials Chemistry A: Materials for Energy and Sustainability* **3**(21): 380-423.

Husin, A. A., 2003, *Limbah Untuk Bahan Bangunan*, Jakarta.

Irvina, F.W.H., Danik, W.A., dan Fatimah, 2009, *X-Ray Difraction (XRD), Skripsi,* Program Studi Kimia Fakultas Teknik, Universitas Sebelas Maret.

Jaganyi, D., Altaf, M., dan Wekesa, I., 2013, Synthesis and Characterization of Whisker-Shaped $MnO_2$ Nanostructure at Room Temperature, *Appl Nanosci*, **3**: 329-333.

Jeffery, G.H., Basset, J., Mendham, J., dan Denney, R.C., 1989, *Vogel's textbook of Quantitative Chemical Analysis*, Longman Group UK, England.

Kim, H., Watthanaphanit, A., dan Saito, N., 2015, Synthesis of Colloidal $MnO_2$ with a Sheet-like Structure by One-pot Plasma Discharge in Permanganate Aqueous Solution, *Journal Royal Society of Chemistry*, **6**: 2826-2834.

Krisnawati, H., Kallio, M. dan Kanninen, M. 2011, *Aleurites moluccana (L.) Willd.: ekologi, silvikultur dan produktivitas*, CIFOR, Bogor, Indonesia.

Lempang, M., 2009, *Sifat-sifat Arang Aktif Tempurung Kemiri dan Aplikasinya Sebagai Komponen Media Tumbuh Pada Tanaman Mekina*, Skripsi Sekolah Pascasarjana ITB.

Lempang, M., Syafii, W., dan Pari, G., 2011, Struktur dan Komponen Arang Serta Arang Aktif Tempurung Kemiri, *Jurnal Penelitian Hasil Hutan*, **29**(**3**): 278-294.

Lempang, M., dan Tikupadang, H., 2013, Aplikasi Arang Aktif Tempurung Kemiri Sebagai Komponen Media Tumbuh Semai Melina, *Jurnal Penelitian Kehutanan Wallacea*, **2**(2): 121-137.

Li, Y., Zhang, X., Yang, R., Li, G., dan Hu, C., 2012, The Role of $H_3PO_4$ In The Preparation Of Activated Carbon From NaOH-Treated Rice Husk Residue, *The Royal Society of Chemistry*, **5**(41): 1 – 11.

Liu, Z., Xu, K., Sun, H., dan Yin, S., 2015, One-Step Synthesis of Single-Layer $MnO_2$ Nanosheets with Multi-Role Sodium Dodecyl Sulfate for High-Performance Pseudocapasitors, *Small Journal*, **10** : 1-10.

Luziana, F., 2018, *Modifikasi Karbon Aktif Dari Tempurung kemiri Dengan Teknik Pelapisan Magnetit Sebagai Adsorben Kristal Violet*, Skripsi tidak diterbitkan, Universitas Bandar Lampung, Lampung.

Mahmudi, M., Widiyastuti, W., Nurlilasari, P., Affandi, S., dan Setyawan, H., 2018, Manganes Dioxide Nanoparticles Synthesized by Electrochemical Method and its Catalytic Towards Oxygen Reduction Reaction, *Journal of the Ceramic Society of Japan*, **126** (11): 906-913.

Marsh, H. dan Rodriguez-Reinoso, F., 2006, *Activate Carbon*, Elsevier Science, Amsterdam.

Manocha, S. M., 2003, Porous Carbon, *Sdhana*, **28**(**1**): 335-348.

Maulana, A.I., 2021, Pengaruh Suhu Terhadap Kualitas Karbon Tempurung Kemiri Teraktivasi $H_3PO_4$ Sebagai Bahan Elektroda Superkapasitor, *Skripsi*, Jurusan Kimia, Fakultas Matimatika dan Ilmu Pengetahuan Alam, Universitas Hasanuddin.

Meisrilestari Y., Rahmat Khomaini, R. dan Wijayanti, H., 2013, Pembuatan Arang Aktif Dari Tempurung kemiri Dengan Aktivasi Secara Fisika, Kimia Dan Fisika-Kimia *Konversi,* **2** (1): 45-47.

Meng, F., Yan, X., Zhu, Y., dan Si, P., 2013, Controlable synthesis of $MnO_2$/polyaniline nanocomposite and its electrochemical capasitive property, *Nanoscale Research Letter*, **8**: 1-8.

Moon, S.A., Salunke, B.P., Alkotaini, B., Sethiyamoonthi, E., Kim, B. S., 2014, Biological Synthesis of Manganese Dioxide Nanoparticles by Kalopanax Pictus Plant Extract, *The Institution of Engineering and Technology*, ISSN 1751-8741, 1-6.

Mon, I., Yerimadesi., dan Hardel., 2012, *Kimia Fisika*, UNP PRES, Padang.

Muhammadiyah, A.N.M., 2019, Pengaruh Larutan Elektrolit Alkali Sulfat terhadap Kapasitansi Spesifik Karbon Tempurung Kemiri (Aleurites Moluccana) Teraktivasi H3PO4, *Skripsi*, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Hasanuddin.

Nursiti., Wibowo, E.H., Safitri, A.W., Supriyono., dan Oktaviani, R., 2018, Elektrolisis Nanokomposit α- $MnO_2$/C dan Fabrikasinya Untuk Aplikasi Superkapasitor, *Jurnal Chemurgy*, **2**(1): 6-11.

Okitsu, K., Iwatani, M., Okano, K., Uddin, M.D.H., dan Nishimura, R., 2016, Mechanism of Sonochemical Reduction of Permanganate to Manganese Dioxide in Aqueous Alcohol Solutions: Reactivities of Reducing Species Formed by Alcohol Sonolysis, *Journal Ultrasonics Sonochemistry*, (31): 456-462.

Osvaldo Z.S., dan Faizal, M, 2012, Pengaruh Konsentrasi Asam dan Waktu pada Proses Hidrolisis dan Fermentasi Pembuatan Bioetanol dari Alang-Alang, *Jurnal Teknik Kimia*, **2**(18) : 52-62.

Pall, S.L., Jana, U., Manna, P.K., Mohanta, G.P., dan Manavalan, R., 2011, Nanoparticle An Overview of Preparation and Characterization, *Journal of Applied Pharmaceutical Science*, **1**(6): 228-234.

Prasetiowati, A.L., dan Prasetya, A.T., dan Wardani, S., 2018, Sintesis Nanopartikel Perak dengan Bioreduktor Ekstrak Daun Belimbing Wuluh Sebagai Antibakteri, *Indonesian Journal of Chemical Science*, **7**(2): 160-166.

Putri, G.K., dan Nurhidayanti, D., 2017, Sintesis $MnO_2$ dengan Metode Elektrokimia Sebagai Elektrokatalisis Pada Metal Air Battery, *Skripsi Jurusan Teknik Kimia*, Fakutan Teknologi Industri, Universitas Teknologi Sepuluh November Subaya.

Rahman, T., Fadhilulloh, M.A., Nandiyanto,A.B.D., dan Mudzakir, A., *Sintesis Karbon Nanopartikel*, Jurnal Integrasi Proses, **5**(3): 120-131.

Reuters, T., 1986, *Method 401 - Determination of the Weight Percent of Volatile Organic Compounds in Waste Products (Gravimetric Purge and Trap)*, State of California Air Resources Board, California, USA.

Rosman, R., dan Djauhariya, E., 2008, Status Teknologi Budidaya Kemiri, *Balai Penelitian Tanaman Obat dan Aromatik*, Bogor.

Safii F.F., dan Mitarlis., 2013, Pemanfaatan Limbah Padat pada Proses Sintesis Pembuatan Furfural dari Sekam Padi Sebagai Arang Aktif, *Journal of Chemistry*, **2**(2):8-16.

Sandi, A. P., dan Astuti, 2014, Pengaruh Waktu Aktivasi menggunakan $H_3PO_4$ terhadap Struktur dan Ukuran Pori Karbon Berbasis Arang Tempurung Kemiri (*Aleurites Moluccana*), *Jurnal Fisika Unand*, **3**(2): 115 - 120.

Sapputra, G.P.A., dan Noerochim, L., 2014, Pengaruh Waktu Hidrotermal pada Proses Sintesis Lithium Mangan Oksida Spinel ($LiMn_2O_4$) Nanopartikel Terhadap Efisiensi Adsorpsi dan Desorpsi Ion Lithium dari Lumpur Sidoarjo, *Jurnal Teknik Pomits*. **3**(2): 164-167.

Sari, W.P., Sumantri, D., Imam, D.N.A., dan Sunarintyas, S., 2014, Pemeriksaan Komposisi Glass Fiber Komersil dengan Teknik X-Ray Fluorescence Spectrofotometer (XRF), *Jurnal B-Dent*, **1**(2): 156-162.

Saridewi, N., Arief, S., dan Alif, A., 2015, Sintesis Nanomaterial Mangan Oksida dengan Metode Bebas Pelarut, *Jurnal Kimia Valensi*, **1**(2): 117-123.

Sembiring, M. T., dan T. S. Sinaga, 2003, *Arang Aktif (Pengenalan dan Proses Pembuatannya)*, Laporan Penelitian, Jurusan Teknik Industri Fakultas Teknik Universitas Sumatera Utara, Medan.

Sekine, T., Narushima, H., Suzuki, T., Takayama, T., Kudo, H., dan Katsumura, Y., 2004, Technetium(IV) Oxide Colloids Produced by Radiolytic Reactions in Aqueous Pertechnetate Solution, *Coll. Surf.: Physicochem. Eng. Aspects*, 249: 105-109.

Senthilkumar, S.T., Senthilkumar B., Balaji, S., Sanjeeviraja C., dan Selvan, R.K., 2011, Preparation of activated carbon from sorghum pith and its structural and electrochemical properties, *Materials Research Bulletin*, **46** : 413-419.

Shi, Q., Zhang, J., Zhang, C., Nie, W., dan Zhang, H., 2009, Adsorption of Basic Violet 14 in Aqueous Solution Using $KMnO_4$-Modifiet Activated Carbon, *Journal of Colloid and Interface Science*, **343**: 188-193.

Shoba, A., Kavitha, B., Aswathaman, H., dan Kumar, N.S., 2021, Synthesis, Characterization and Electrochemical Sensors Application of $MnO_2$ Nanoparticles, *Materials Today*, doi.org/10.1016/j.matpr.2021.05.476: 1-6.

Sivakumar, S., dan Prabu, L.N., 2021, Synthesis and Characterization of α-$MnO_2$ nanoparticles for Supercapacitor application, Materials Today Proceeding, https://doi.org/10.1016/j.matpr.2021.03.528: 1-4.

Smisek, M. dan Cerny, S., 1970, *Active Carbon Manufacture, Properties and Aplications*, Elsevier Pub Comp., New York.

Sudrajat, R., dan Pari, G., 2011, *Arang Aktif: Teknologi Pengolahan dan Masa Depannya*, Badan Penelitian dan Pengembangan Kehutanan, Jakarta.

Sulaiman, N.H., Malau, L.A., Lubis, F.H., Harahap, N.B., Manalu, F.R., dan Kembaren, A., 2017, Pengolahan Tempurung Kemiri Sebagai Karbon Aktif dengan Variasi Aktivator Asam Fosfat, *Jurnal Einstein*, **5**(2): 38-41.

Surest, A.Z., Kasih, J.A.F., dan Wisanti, A., 2008, Pengaruh Suhu, Konsentrasi Zat Aktivator dan Waktu Aktivasi Terhadap Daya Serap Karbon Aktif Dari Tempurung Kemiri, *Jurnal Teknik Kimia*, **2**(15): 17-22.

SNI 06-3730-1995, *Arang Aktif Teknis*, Badan Standarisasi Nasional.

Tarayana, M., 2002, *Arang Aktif (Pengenalan dan Proses Pembuatannya)*, Skripsi tidak diterbitkan, Jurusan Teknik Industri, FT-USU.

Uner, M., 2015, Characterization and Imaging of Solid Lipid Nanoparticle and Nanostructured Lipid Carriers, *Handbook of Nanoparticles*, 117-141.

Wang, J.W., Chen, Y., dan Chen, B.Z., 2015, A Synthesis Method of $MnO_2$/Activated Carbon Composite for Elektrochemical Supercapasitors, *Journal of the Elektrochemical*, **162**(8): 1654-1661.

Wang, M., Zhang, L., Huang, W., Xiu, T., Zhuang, C., dan Shi, J., 2017, The Catalytic Oxidation Removal of Low-Concentration HCHO at High Space Velocity by Partially Crystallized Mesoporous $MnO_x$, *Chemical Engineering Journal*, **320**: 2-10.

Wianto, T., Sari, N., Darminto., dan Pratapa, S., 2010, Sintesis dan Karakterisasi Nanosilika Sebagai Upaya Pemanfaatan Potensi Sumberdaya Banjarbaru, *Jurnal Fisika Fluks*, **7**(1): 53-65.

Yao, B., Chandrasekaran, S., Zhang, J., Xiao, W., Qian, F., Zhu, C., Duoss, E.B., Spadaccini, C.M., Worsley, M.A., dan Li, Y., 2019, Efficient 3D Printed Pseudo-capacitive Electrodes with Ultrahigh $MnO_2$ Loading, *Joule*, **3**: 1-12, Elsevier Inc. https://doi.org/10.1016/j.joule.2018.09.020.

Zakir, M., Botohala, L., Rammang, M., Fauziah, S., dan Abdussamad, B, 2013. Elektrodeposisi Logam Mn Pada Permukaan Karbon Aktif Sekam Padi dengan Iradiasi Ultrasonik, *Indonesia Chemica Acta*, **6**(2): 9-18.

Zakir, M., dan Sekine, T., 2009, Oxidation Reaction of $Tc(IV)O_2.nH_2O$ Nanocolloid Induced by Ultrasonic Wave. *Indo. Chim. Acta*, **2**(1): 46-47.

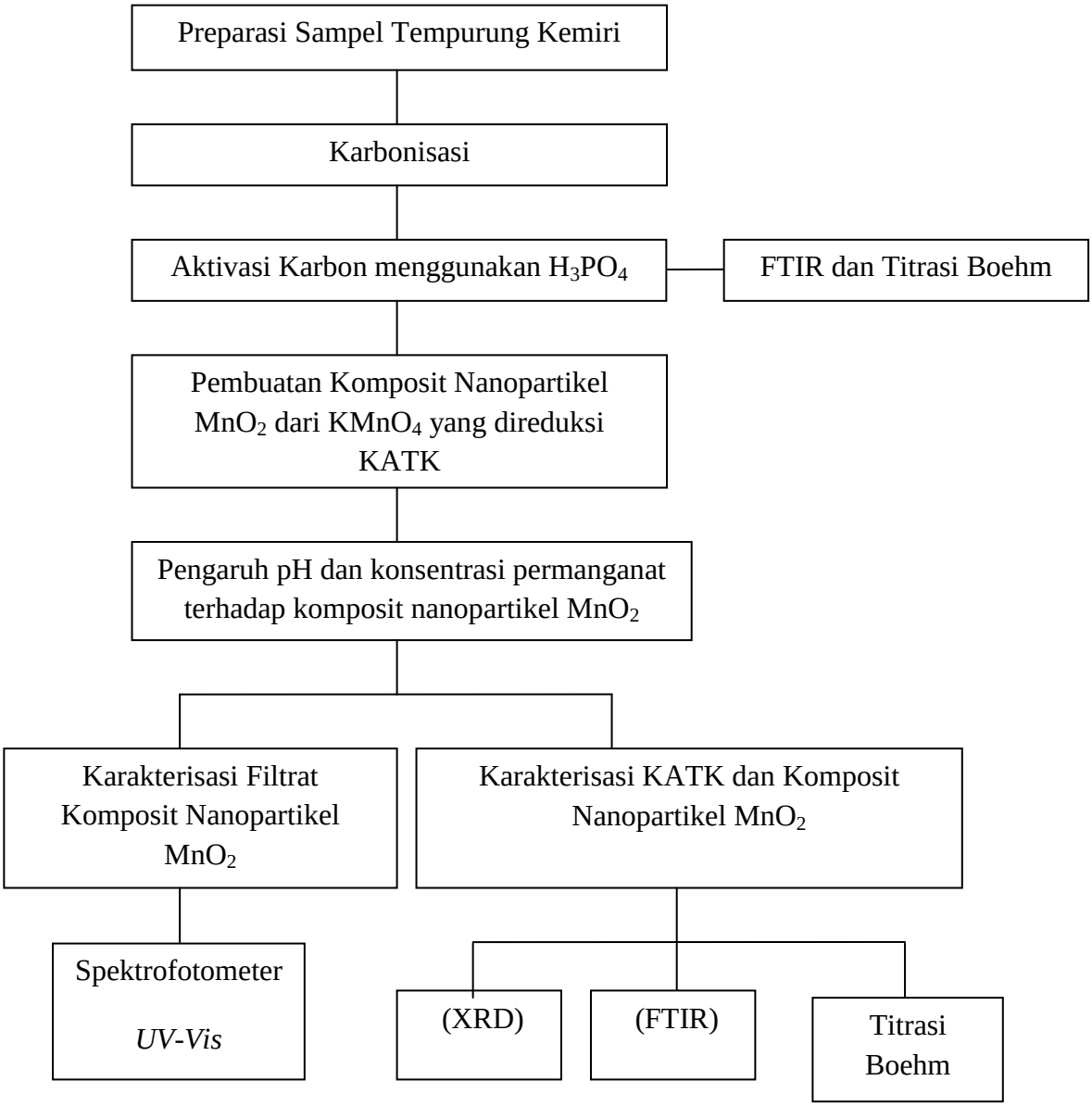
Zakir, M., Sekine, T., Takayama, T., Kudo, H., Lin, M., dan Katsumura, Y., 2005, Technetium(IV) Oxide Colloids and the Precursor Produced by Bremstrahlung Irrradiation of Aqueous Pertechnetate Solution, *J. Nuclear and Radiochem. Sci.* **6**(3): 243-247.

Zhang, X., Sun, X., Zhang, H., Zhang, D., dan Ma, Y., 2012, Development of redox deposition of birnessite-type MnO2 on activated carbon as high-performance electrode for hybrid supercapacitors, *Journal Materials Chemistry and Physics*, **137**: 290-296.

Zhang, G., Sun, Y., Zhou, P., Xu, Y., Su, A., dan Qu, J., 2017, Characteristics of Activated Carbon Modified with Alkaline $KMnO_4$ and its Performance in Catalytic Reforming of Greenhouse Gases $CO_2/CH_4$, *Journal of $CO_2$ Utilization*, **20**: 129-140.

## LAMPIRAN

**Lampiran 1.** Diagram Alir Penelitian



**Lampiran 2.** Bagan Kerja

## 1.1 Prosedur Umum

Tempurung Kemiri

- dibersihkan kotoran yang menempel pada tempurung dan dilanjutkan dengan pengeringan di bawah sinar matahari.
- dikarbonisasi pada suhu 700 $^{o}$C selama 180 menit.
- diayak dengan ukuran partikel 150 mesh.

Karbon Tempurung Kemiri (KTK)

- diaktivasi dengan larutan $H_3PO_4$ 10 % dengan perbandingan 5:1 (volume $H_3PO_4$ : massa karbon).
- diaduk kemudian didiamkan selama 24 jam pada suhu kamar.
- disaring menggunakan corong Buchner dengan kertas saring Whatman no. 42, hingga pH netral.
- dipirolisis dalam tanur pada suhu 850 $^{o}$C selama 30 menit
- dibilas dengan aquades
- dikeringkan dalam oven pada suhu 110 $^{o}$C selama 3 jam.

Karbon Aktif Tempurung Kemiri (KATK)

**1.2 Pengaruh Konsentrasi $KMnO_4$**

0,25 gram KATK

- dimasukan ke dalam gelas kimia yang masing-masing berisi 100 mL $KMnO_4$ 0,0024 M; 0,0032 M; 0,0040 M; 0,0048 M; 0,0056 M.
- diaduk menggunakan shaker lalu diukur menggunakan UV-Vis (diulangi setiap satu jam selama proses reduksi).
- diperoleh konsentrasi optimum.

Hasil

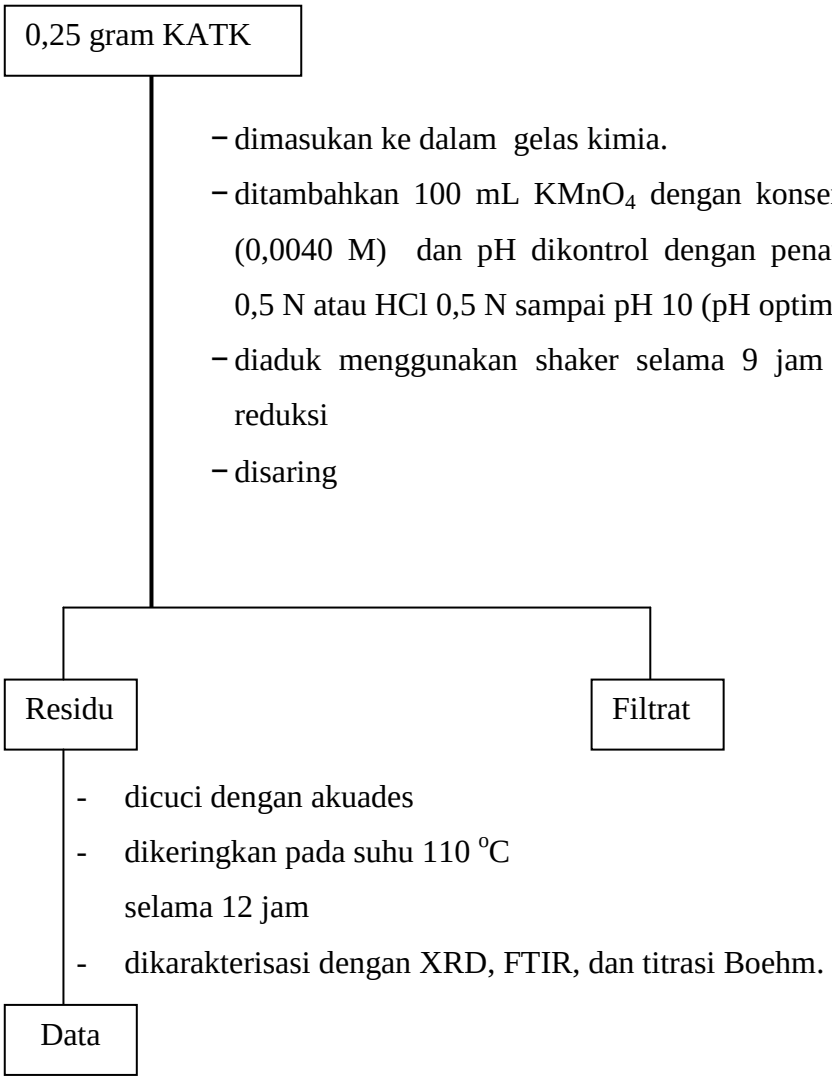
**1.3 Pengaruh pH**

0,25 gram KATK

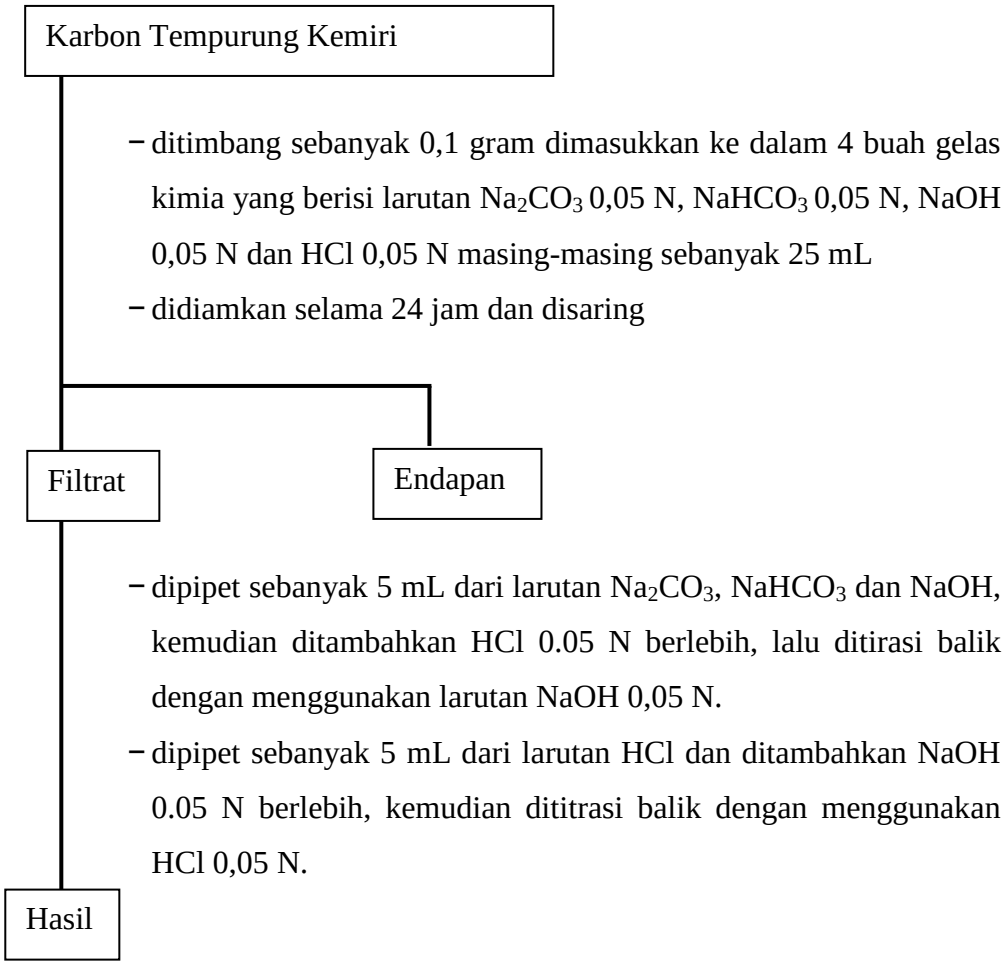
- dimasukkan ke dalam lima gelas kimia yang berbeda.
- ditambahkan masing-masing gelas kimia 100 mL $KMnO_4$ konsentrasi optimum (0,0040 M).
- diatur masing-masing pada pH 3, 4, 7, 9, 10 (dengan penambahan NaOH 0,5 N atau HCl 0,5 N).
- diaduk menggunakan shaker lalu diukur menggunakan UV-Vis (diulangi setiap satu jam selama proses reduksi).
- diperoleh pH optimum.

Hasil

### 1.4 Sintesis Nanopartikel $MnO_2$ pada Kondisi Optimum



### 1.5 Analisis Gugus Fungsi denganTitrasi Boehm




Catatan: diulangi prosedur yang sama dengan sampel KATK dan $MnO_2$/AC.

**Lampiran 3. Perhitungan Pembuatan Larutan Pereaksi**

**1. Pembuatan Larutan $H_3PO_4$ 10% dari $H_3PO_4$ 85%**

$V_1 \times M_1 = V_2 \times M_2$

$V_1 \times 85\% = 500\ mL \times 10\%$

$V_1 = 58{,}82\ mL$

**2. Pembuatan Larutan $Na_2CO_3$ 0,05 N**

gram = L × N × BE

gram = 0,25 L × 0,05 N × 53 g/eq =0,6625 gram

**3. Pembuatan Larutan $NaHCO_3$ 0,05 N**

gram = L × N × BE

gram = 0,25 L × 0,05 N × 84,007 g/eq = 1,0500 gram

**4. Pembuatan Larutan NaOH 0,05 N**

gram = L × N × BE

gram = 0,25 L × 0,05 N × 40 g/eq = 0,5000 gram

**5. PembuatanLarutan HCl 0,05 N**

$$N = \frac{\% \times bj \times 10}{BE}$$

$$N = \frac{37 \times 1{,}19\ g/mL \times 10}{36{,}5\ g/eq}$$

N= 12,06 N

$V_1 \times N_1 = V_2 \times N_2$

$V_1 \times 12{,}06\ N = 250\ mL \times 0{,}05\ N$

$V_1 = 1{,}03\ mL$

**6. Pembuatan Larutan $Na_2B_4O_{7.\ 10}H_2O$ 0,05 N**

gram = L × N × BE

gram = 0,1 L × 0,05 N × 191 g/eq = 0,9550 gram

**7. Pembuatan Larutan $H_2C_2O_4$ 0,05 N**

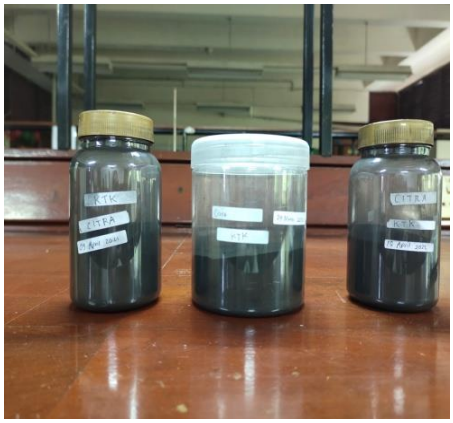
gram = L × N × BE

gram = 0,1 L × 0,05 N × 63 g/eq = 0,3150 gram

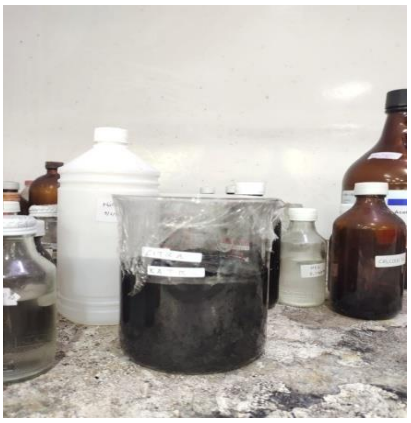
**Lampiran 4. Dokumentasi Penelitian**

**Tempurung Kemiri**


**KarbonTempurung Kemiri**



**Karbon Tempurung Kemiri ukuran 150 mesh**

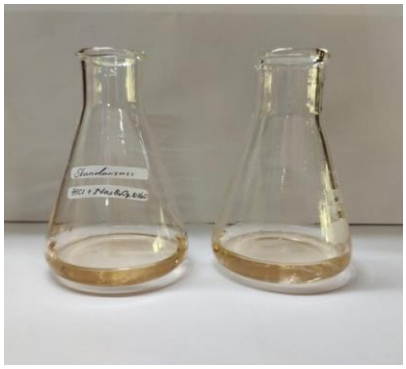


**Aktivasi KarbonTempurung Kemiri dengan $H_3PO_4$**

**Penyaringan Karbon Tempurung Kemiri teraktivasi $H_3PO_4$**

**Karbon Aktif Setelah Pengeringan pada suhu 110 $^{o}$C selama 3 jam**

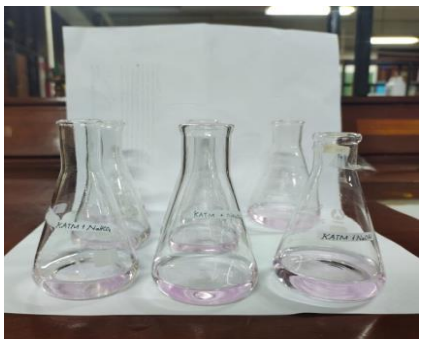
**Standarisasi NaOH dengan $H_2C_2O_4$**



**Standarisasi HCl dengan $Na_2B_4O_{7.\ 10}H_2O$**

**Perendaman sampel pada Titrasi Boehm**

**Hasil Titrasi Boehm**



**Hasil Titrasi Boehm (Asam Total)**

**Hasil Titrasi Boehm (Basa Total)**

**Optimasi pH**

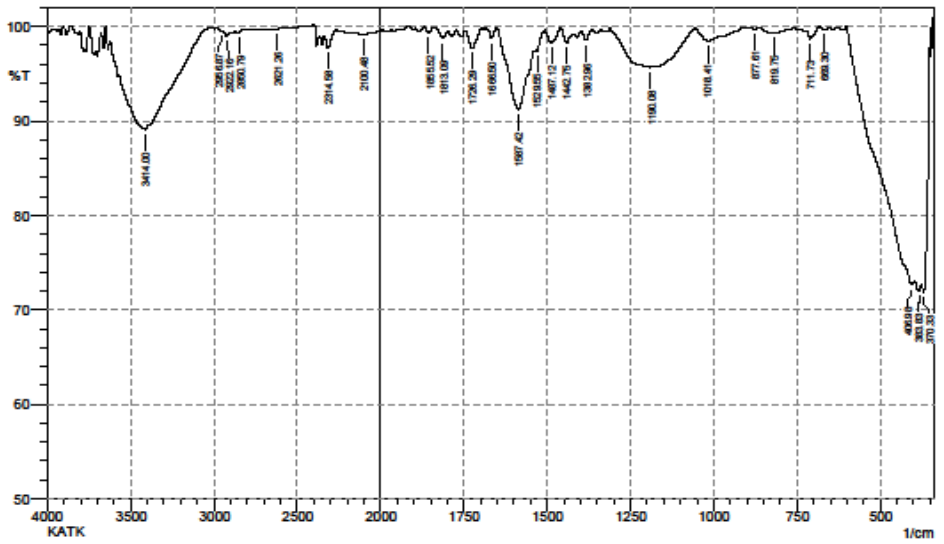
**Optimasi Konsentrasi**

**Sintesis pada konsentrasi dan pH optimum**

**$MnO_2$/AC**

## Lampiran 5. Hasil Karakterisasi FTIR KTK, KATK, $MnO_2$/AC

SHIMADZU




| No. | Peak | Intensity | Corr. Intensity | Base (H) | Base (L) | Area | Corr. Area |
|---|---|---|---|---|---|---|---|
| 1 | 370.33 | 71.839 | 7.053 | 376.12 | 351.04 | 2.485 | 0.859 |
| 2 | 383.83 | 71.996 | 0.736 | 397.34 | 378.05 | 2.714 | 0.054 |
| 3 | 406.98 | 72.674 | 1.36 | 601.79 | 399.26 | 15.397 | 1.443 |
| 4 | 669.3 | 99.636 | 0.272 | 684.73 | 651.94 | 0.031 | 0.017 |
| 5 | 711.73 | 98.664 | 1.067 | 727.16 | 684.73 | 0.132 | 0.093 |
| 6 | 819.75 | 99.298 | 0.538 | 864.11 | 761.88 | 0.212 | 0.139 |
| 7 | 877.61 | 99.731 | 0.141 | 908.47 | 864.11 | 0.034 | 0.012 |
| 8 | 1018.41 | 98.481 | 1.423 | 1055.06 | 908.47 | 0.565 | 0.51 |
| 9 | 1190.08 | 95.689 | 4.134 | 1311.59 | 1056.99 | 3.226 | 3.029 |
| 10 | 1382.96 | 98.521 | 1.029 | 1398.39 | 1365.6 | 0.131 | 0.068 |
| 11 | 1442.75 | 98.253 | 1.332 | 1458.18 | 1421.54 | 0.18 | 0.106 |
| 12 | 1487.12 | 98.252 | 1.47 | 1508.33 | 1458.18 | 0.229 | 0.172 |
| 13 | 1529.55 | 97.373 | 0.418 | 1533.41 | 1508.33 | 0.166 | 0.005 |
| 14 | 1587.42 | 91.26 | 7.232 | 1653 | 1535.34 | 2.667 | 1.949 |
| 15 | 1666.5 | 98.723 | 1.126 | 1683.86 | 1653 | 0.087 | 0.067 |
| 16 | 1726.29 | 97.716 | 1.939 | 1745.58 | 1697.36 | 0.282 | 0.218 |
| 17 | 1813.09 | 98.739 | 0.903 | 1834.3 | 1797.66 | 0.122 | 0.07 |
| 18 | 1855.52 | 99.341 | 0.552 | 1869.02 | 1842.02 | 0.049 | 0.037 |
| 19 | 2100.48 | 99.225 | 0.03 | 2115.91 | 2065.76 | 0.165 | 0.005 |
| 20 | 2314.58 | 97.713 | 1.542 | 2337.72 | 2270.22 | 0.403 | 0.213 |
| 21 | 2621.26 | 99.759 | 0.024 | 2632.83 | 2563.4 | 0.059 | 0.003 |
| 22 | 2850.79 | 99.293 | 0.231 | 2870.08 | 2794.85 | 0.159 | 0.02 |
| 23 | 2922.16 | 99.023 | 0.484 | 2949.16 | 2870.08 | 0.24 | 0.068 |
| 24 | 2956.87 | 99.515 | 0.074 | 2983.88 | 2949.16 | 0.055 | 0.004 |
| 25 | 3414 | 89.114 | 1.05 | 3568.31 | 3392.79 | 7.239 | 1.001 |

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Date/Time; 5/24/2022 11:26:09 AM
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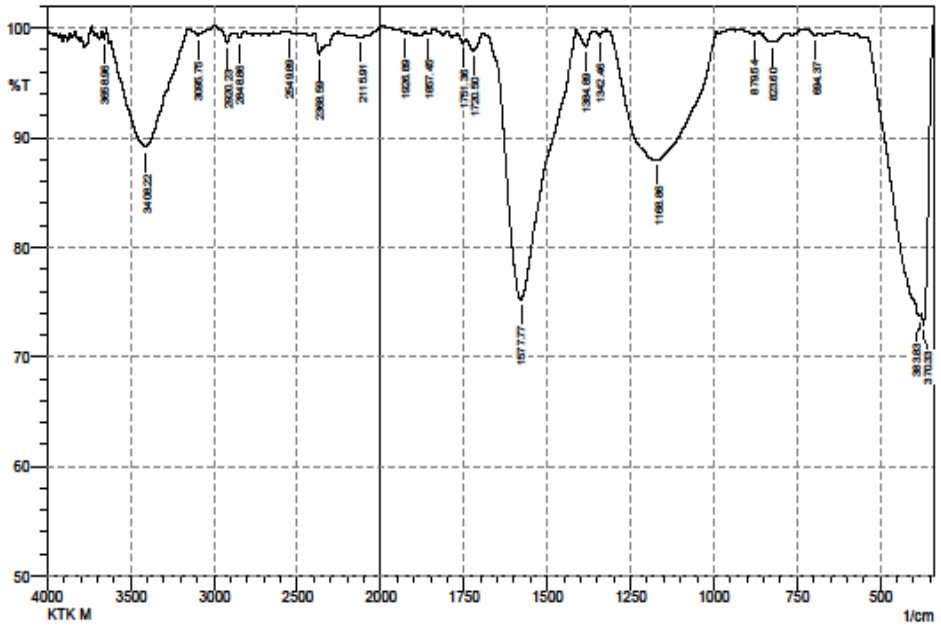


| No. | Peak | Intensity | Corr. Intensity | Base (H) | Base (L) | Area | Corr. Area |
|---|---|---|---|---|---|---|---|
| 1 | 370.33 | 72.9229 | 5.4205 | 376.12 | 343.33 | 2.6658 | 0.6109 |
| 2 | 383.83 | 73.7166 | 1.096 | 536.21 | 378.05 | 12.0808 | 1.2944 |
| 3 | 694.37 | 99.3242 | 0.2672 | 715.59 | 682.8 | 0.0675 | 0.0165 |
| 4 | 823.6 | 98.7339 | 0.7695 | 852.54 | 783.1 | 0.2991 | 0.1523 |
| 5 | 879.54 | 99.3664 | 0.359 | 921.97 | 864.11 | 0.0936 | 0.038 |
| 6 | 1168.86 | 87.9488 | 11.7779 | 1321.24 | 993.34 | 11.7225 | 11.3254 |
| 7 | 1342.46 | 99.2245 | 0.5491 | 1361.74 | 1321.24 | 0.0758 | 0.0361 |
| 8 | 1384.89 | 98.3453 | 1.4621 | 1413.82 | 1361.74 | 0.2043 | 0.162 |
| 9 | 1577.77 | 75.2018 | 24.3616 | 1680 | 1413.82 | 15.2786 | 14.8411 |
| 10 | 1720.5 | 97.9015 | 1.2896 | 1741.72 | 1693.5 | 0.3111 | 0.1471 |
| 11 | 1751.36 | 98.5906 | 0.5598 | 1770.65 | 1741.72 | 0.1287 | 0.0326 |
| 12 | 1857.45 | 99.4718 | 0.2524 | 1867.09 | 1842.02 | 0.0445 | 0.0176 |
| 13 | 1926.89 | 99.5748 | 0.1795 | 1944.25 | 1915.31 | 0.0403 | 0.0127 |
| 14 | 2115.91 | 99.1567 | 0.1233 | 2137.13 | 2088.91 | 0.1643 | 0.0143 |
| 15 | 2368.59 | 97.5883 | 1.1381 | 2397.52 | 2351.23 | 0.3206 | 0.0972 |
| 16 | 2549.89 | 99.5927 | 0.0627 | 2571.11 | 2538.32 | 0.0521 | 0.0046 |
| 17 | 2848.86 | 99.0591 | 0.5181 | 2870.08 | 2819.93 | 0.1429 | 0.0541 |
| 18 | 2920.23 | 98.6553 | 0.9697 | 2956.87 | 2889.37 | 0.2191 | 0.1132 |
| 19 | 3095.75 | 99.382 | 0.2252 | 3120.82 | 3076.46 | 0.0978 | 0.0233 |
| 20 | 3408.22 | 89.1474 | 8.025 | 3562.52 | 3159.4 | 12.4542 | 8.3466 |
| 21 | 3658.96 | 98.9845 | 0.845 | 3670.54 | 3645.46 | 0.0672 | 0.0499 |

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Resolution;
Apodization;

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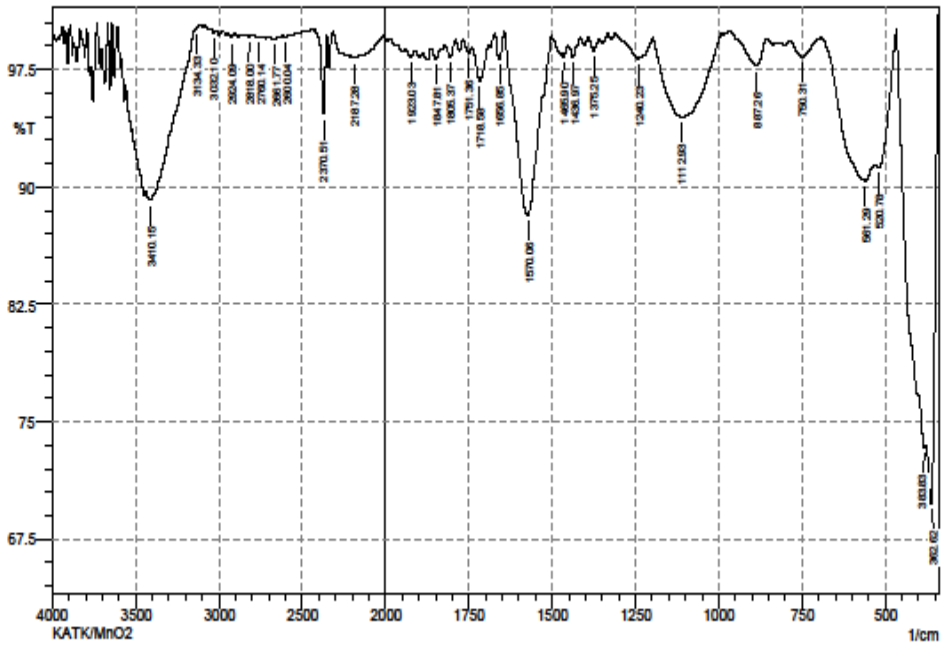


| No. | Peak | Intensity | Corr. Intensity | Base (H) | Base (L) | Area | Corr. Area |
|---|---|---|---|---|---|---|---|
| 1 | 362.62 | 69.75 | 13.931 | 376.12 | 343.33 | 3.696 | 1.499 |
| 2 | 383.83 | 73.363 | 1.891 | 466.77 | 378.05 | 7.773 | 1.742 |
| 3 | 520.78 | 91.234 | 1.432 | 530.42 | 468.7 | 1.627 | 0.427 |
| 4 | 561.29 | 90.415 | 2.425 | 690.52 | 532.35 | 4.625 | 1.332 |
| 5 | 750.31 | 98.321 | 1.103 | 785.03 | 692.44 | 0.453 | 0.229 |
| 6 | 887.26 | 97.738 | 1.684 | 945.12 | 854.47 | 0.568 | 0.337 |
| 7 | 1112.93 | 94.447 | 5.22 | 1197.79 | 991.41 | 3.329 | 3.048 |
| 8 | 1240.23 | 98.206 | 1.457 | 1309.67 | 1197.79 | 0.551 | 0.4 |
| 9 | 1375.25 | 98.687 | 0.8 | 1392.61 | 1357.89 | 0.138 | 0.06 |
| 10 | 1436.97 | 98.265 | 1.008 | 1454.33 | 1415.75 | 0.196 | 0.078 |
| 11 | 1465.9 | 98.31 | 0.357 | 1469.76 | 1454.33 | 0.099 | 0.017 |
| 12 | 1570.06 | 88.169 | 0.742 | 1573.91 | 1504.48 | 1.986 | 0.107 |
| 13 | 1656.85 | 98.149 | 1.698 | 1672.28 | 1645.28 | 0.129 | 0.11 |
| 14 | 1718.58 | 96.732 | 2.217 | 1739.79 | 1691.57 | 0.475 | 0.256 |
| 15 | 1751.36 | 98.538 | 0.568 | 1766.8 | 1739.79 | 0.134 | 0.033 |
| 16 | 1805.37 | 98.333 | 0.891 | 1822.73 | 1789.94 | 0.177 | 0.065 |
| 17 | 1847.81 | 98.166 | 0.764 | 1863.24 | 1822.73 | 0.247 | 0.062 |
| 18 | 1923.03 | 98.315 | 0.442 | 1940.39 | 1913.39 | 0.171 | 0.027 |
| 19 | 2187.28 | 98.227 | 0.152 | 2206.57 | 2156.42 | 0.373 | 0.018 |
| 20 | 2370.51 | 94.673 | 5.126 | 2420.66 | 2353.16 | 0.579 | 0.544 |
| 21 | 2600.04 | 99.581 | 0.109 | 2619.33 | 2576.9 | 0.067 | 0.01 |
| 22 | 2661.77 | 99.449 | 0.087 | 2671.41 | 2642.48 | 0.061 | 0.006 |
| 23 | 2760.14 | 99.553 | 0.098 | 2794.85 | 2744.71 | 0.083 | 0.011 |
| 24 | 2818 | 99.572 | 0.144 | 2835.36 | 2794.85 | 0.063 | 0.013 |
| 25 | 2924.09 | 99.539 | 0.316 | 2945.3 | 2904.8 | 0.053 | 0.027 |
| 26 | 3032.1 | 99.849 | 0.177 | 3049.46 | 3016.67 | 0.008 | 0.012 |
| 27 | 3134.33 | 100.133 | 0.038 | 3138.18 | 3111.18 | -0.026 | 0.005 |
| 28 | 3410.15 | 89.178 | 0.278 | 3415.93 | 3143.97 | 7.34 | 0.741 |

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Resolution;
Apodization;

**Lampiran 6. Hasil Karakterisasi UV-Vis**

**Data UV-Vis filtrat hasil reduksi larutan $KMnO_4$ oleh KATK pada variasi konsentrasi.**

1. 0,25 gram 0,0024 M

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 570 | 3,310 |
| | | 550 | 3,669 |
| | | 505 | 9,999 |
| | | 365 | 2,820 |
| | | 315 | 2,804 |
| | | 295 | 3,027 |
| | | 230 | 3,707 |
| 2 | 1 jam | 545 | 2,959 |
| | | 525 | 3,318 |
| | | 310 | 2,548 |
| | | 210 | 3,461 |
| 3 | 2 jam | 545 | 2,439 |
| | | 525 | 2,554 |
| | | 310 | 2,225 |
| 4 | 3 jam | 545 | 1,800 |
| | | 525 | 1,887 |
| | | 310 | 1,875 |
| 5 | 4 jam | 545 | 1,362 |
| | | 525 | 1,403 |
| | | 310 | 1,584 |
| 6 | 5 jam | 545 | 1,018 |
| | | 525 | 1,049 |
| | | 310 | 1,361 |
| **7** | **7 jam** | **320** | **1,029** |
| 8 | 9 jam | 325 | 0,932 |
| 9 | 12 jam | 325 | 0,914 |
| 10 | 14 jam | 325 | 0,897 |
| 11 | 15 jam | 320 | 0,865 |

2. 0,25 gram 0,0032 M

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 570 | 4,758 |
| | | 500 | 9,999 |
| | | 365 | 3,224 |
| | | 335 | 2,820 |
| | | 295 | 3,259 |

| | | | |
|---|---|---|---|
| | | 235 | 3,730 |
| 2 | 1 jam | 550 | 3,597 |
| | | 520 | 9,999 |
| | | 365 | 2,558 |
| | | 315 | 2,691 |
| | | 210 | 3,538 |
| 3 | 2 jam | 545 | 2,951 |
| | | 365 | 2,379 |
| | | 310 | 2,576 |
| | | 205 | 3,490 |
| 4 | 3 jam | 545 | 1,819 |
| | | 525 | 1,860 |
| | | 365 | 1,893 |
| | | 310 | 2,026 |
| 5 | 4 jam | 545 | 1,514 |
| | | 525 | 1,522 |
| | | 365 | 1,852 |
| | | 320 | 1,863 |
| 6 | 5 jam | 525 | 1,444 |
| | | 495 | 1,474 |
| | | 370 | 1,841 |
| | | 320 | 1,834 |
| **7** | **7 jam** | **320** | **1,750** |
| 8 | 9 jam | 365 | 1,270 |
| | | 325 | 1,310 |
| 9 | 12 jam | 295 | 0,941 |
| 10 | 14 jam | 295 | 0,840 |
| 11 | 15 jam | 290 | 0,825 |

3. 0,25 gram 0,0040 M

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 575 | 4,069 |
| | | 555 | 3,768 |
| | | 365 | 3,343 |
| | | 350 | 2,676 |
| | | 315 | 2886 |
| | | 295 | 3,327 |
| | | 240 | 3,824 |
| 2 | 1 jam | 570 | 3,042 |
| | | 500 | 9,999 |
| | | 365 | 2,833 |
| | | 315 | 2,763 |
| | | 295 | 3,087 |
| | | 230 | 3,608 |
| | | 220 | 3,641 |

| | | | |
|---|---|---|---|
| 3 | 2 jam | 550 | 2,971 |
| | | 520 | 9,999 |
| | | 365 | 2,488 |
| | | 310 | 2,665 |
| | | 225 | 3,438 |
| 4 | 3 jam | 545 | 2,880 |
| | | 525 | 4,618 |
| | | 365 | 2,216 |
| | | 315 | 2,559 |
| | | 210 | 3,388 |
| 5 | 4 jam | 545 | 2,666 |
| | | 525 | 3,127 |
| | | 365 | 2,035 |
| | | 310 | 2,474 |
| | | 210 | 3,274 |
| 6 | 5 jam | 545 | 2,425 |
| | | 525 | 2,641 |
| | | 310 | 2,374 |
| | | 205 | 3,301 |
| 7 | 7 jam | 545 | 1,856 |
| | | 525 | 1,977 |
| | | 310 | 2,057 |
| **8** | **9 jam** | **310** | **1,862** |
| 9 | 12 jam | 370 | 1,823 |
| | | 315 | 1,843 |
| | | 295 | 1,856 |
| 10 | 14 jam | 365 | 1,779 |
| | | 320 | 1,827 |
| 11 | 15 jam | 315 | 1,142 |

4. 0,25 gram 0,0048 M

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 565 | 4,747 |
| | | 545 | 4,097 |
| | | 500 | 9,999 |
| | | 370 | 3,661 |
| | | 320 | 2,992 |
| | | 295 | 3,275 |
| | | 245 | 3,671 |
| 2 | 1 jam | 570 | 3,913 |
| | | 545 | 4,222 |
| | | 490 | 9,999 |
| | | 365 | 3,059 |
| | | 320 | 2,669 |
| | | 310 | 2,685 |

| | | | |
|---|---|---|---|
| | | 295 | 3,078 |
| | | 230 | 3,626 |
| 3 | 2 jam | 570 | 3,479 |
| | | 500 | 9,999 |
| | | 370 | 2,931 |
| | | 305 | 2,668 |
| | | 295 | 3,023 |
| | | 235 | 3,545 |
| | | 220 | 3,563 |
| 4 | 3 jam | 545 | 9,999 |
| | | 520 | 9,999 |
| | | 365 | 2,796 |
| | | 310 | 2,669 |
| | | 295 | 2,950 |
| | | 225 | 3,432 |
| | | 210 | 3,541 |
| 5 | 4 jam | 545 | 2,943 |
| | | 525 | 2,946 |
| | | 370 | 2,435 |
| | | 310 | 2,510 |
| | | 205 | 3,323 |
| 6 | 5 jam | 545 | 2,116 |
| | | 525 | 2,159 |
| | | 365 | 2,115 |
| | | 310 | 2,269 |
| 7 | 7 jam | 525 | 1,452 |
| | | 365 | 1,773 |
| | | 320 | 1,790 |
| | | 295 | 1,794 |
| 8 | 9 jam | 525 | 1,308 |
| | | 370 | 1,993 |
| | | 320 | 1,947 |
| | | 295 | 1,982 |
| **9** | **12 jam** | **315** | **1,647** |
| 10 | 14 jam | 365 | 1,139 |
| | | 320 | 1,216 |
| 11 | 15 jam | 315 | 1,113 |
| 12 | 27 jam | 295 | 0,964 |
| 13 | 29 jam | 285 | 0,858 |

5. 0,25 gram 0,0056 M

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 565 | 9,999 |
| | | 535 | 9,999 |
| | | 480 | 9,999 |

| | | | |
|---|---|---|---|
| | | 375 | 3,553 |
| | | 345 | 2,745 |
| | | 305 | 2,909 |
| | | 285 | 3,259 |
| | | 240 | 3,732 |
| | | 230 | 3,688 |
| 2 | 1 jam | 570 | 3,436 |
| | | 560 | 3,457 |
| | | 550 | 3,565 |
| | | 365 | 3,137 |
| | | 315 | 2,806 |
| | | 295 | 3,186 |
| | | 230 | 3,702 |
| 3 | 2 jam | 570 | 9,999 |
| | | 370 | 3,145 |
| | | 310 | 2,753 |
| | | 290 | 3,018 |
| | | 230 | 3,554 |
| 4 | 3 jam | 565 | 3,425 |
| | | 545 | 9,999 |
| | | 535 | 9,999 |
| | | 370 | 2,914 |
| | | 320 | 2,696 |
| | | 295 | 3,019 |
| | | 235 | 3,557 |
| 5 | 4 jam | 565 | 3,015 |
| | | 545 | 4,000 |
| | | 520 | 9,999 |
| | | 365 | 2,767 |
| | | 355 | 2,366 |
| | | 315 | 2,638 |
| | | 295 | 2,911 |
| | | 230 | 3,416 |
| | | 215 | 3,447 |
| 6 | 5 jam | 545 | 3,194 |
| | | 525 | 3,414 |
| | | 365 | 2,641 |
| | | 325 | 2,599 |
| | | 310 | 2,617 |
| | | 295 | 2,785 |
| | | 210 | 3,412 |
| 7 | 7 jam | 545 | 1,917 |
| | | 525 | 1,978 |
| | | 365 | 2,018 |
| | | 310 | 2,158 |
| 8 | 9 jam | 545 | 1,071 |

| | | | |
|---|---|---|---|
| | | 525 | 1,124 |
| | | 310 | 1,603 |
| 9 | 12 jam | 545 | 0,695 |
| | | 525 | 0,733 |
| | | 310 | 1,345 |
| 10 | 14 jam | 525 | 0,526 |
| | | 315 | 1,233 |
| **11** | **15 jam** | **320** | **1,220** |
| 12 | 27 jam | 320 | 1,038 |
| 13 | 29 jam | 310 | 1,012 |

**Data UV-Vis filtrat hasil reduksi larutan $KMnO_4$ oleh KATK pada variasi pH.**

1. 0,25 gram 0,0040 M (pH 3)

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 545 | 2,738 |
| | | 525 | 4,138 |
| | | 310 | 2,741 |
| | | 210 | 3,701 |
| 2 | 30 menit | 545 | 0,912 |
| | | 525 | 0,965 |
| | | 310 | 1,260 |
| 3 | 1 jam | 545 | 0,474 |
| | | 525 | 0,507 |
| | | 485 | 0,495 |
| | | 325 | 0,975 |
| **4** | **1,5 jam** | **335** | **0,960** |
| 5 | 2 jam | 335 | 0,949 |
| 6 | 2,5 jam | 335 | 0,935 |
| 7 | 3 jam | 335 | 0,892 |
| 8 | 4 jam | 330 | 0,876 |

2. 0,25 gram 0,0040 M (pH 4)

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 550 | 2,863 |
| | | 525 | 3,916 |
| | | 320 | 3,071 |
| | | 210 | 4,011 |
| 2 | 1 jam | 545 | 1,664 |
| | | 525 | 1,762 |
| | | 310 | 1,791 |
| 3 | 2 jam | 545 | 0,883 |

| | | | |
|---|---|---|---|
| | | 525 | 0,920 |
| | | 310 | 1,260 |
| 4 | 2,5 jam | 545 | 0,636 |
| | | 525 | 0,662 |
| | | 505 | 0,667 |
| | | 325 | 1,123 |
| **5** | **3 jam** | **345** | **1,173** |
| 6 | 4 jam | 335 | 1,079 |
| 7 | 5 jam | 335 | 1,047 |
| 8 | 6 jam | 335 | 1,010 |
| 9 | 7 jam | 330 | 0,965 |

3. 0,25 gram 0,0040 M (pH 7)

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 570 | 4,278 |
| | | 555 | 9,999 |
| | | 520 | 9,999 |
| | | 365 | 3.343 |
| | | 345 | 3,002 |
| | | 335 | 2,992 |
| | | 320 | 3,047 |
| | | 294 | 3,542 |
| | | 235 | 4,118 |
| 2 | 1 jam | 545 | 3,466 |
| | | 520 | 9,999 |
| | | 365 | 2,566 |
| | | 345 | 2,688 |
| | | 310 | 2,945 |
| | | 225 | 3,607 |
| | | 215 | 3,927 |
| 3 | 2 jam | 545 | 2,999 |
| | | 525 | 3,153 |
| | | 310 | 2,845 |
| | | 210 | 3,782 |
| 4 | 3 jam | 545 | 2,335 |
| | | 525 | 2,466 |
| | | 310 | 2,392 |
| 5 | 4 jam | 545 | 1,896 |
| | | 525 | 1,959 |
| | | 310 | 2,078 |
| 6 | 5 jam | 545 | 1,345 |
| | | 525 | 1,370 |
| | | 310 | 1,751 |
| **7** | **6 jam** | **320** | **1,415** |
| 8 | 7 jam | 330 | 1,249 |

| | | | |
|---|---|---|---|
| 9 | 8 jam | 325 | 1,147 |
| 10 | 9 jam | 320 | 0,854 |

4. 0,25 gram 0,0040 M (pH 9)

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 565 | 3,570 |
| | | 555 | 3,491 |
| | | 485 | 9,999 |
| | | 365 | 3,082 |
| | | 325 | 2,705 |
| | | 295 | 3,283 |
| | | 245 | 3,730 |
| | | 235 | 3,774 |
| 2 | 1 jam | 550 | 2,727 |
| | | 525 | 9,999 |
| | | 365 | 2,518 |
| | | 325 | 2,951 |
| | | 315 | 2,972 |
| | | 225 | 3,843 |
| 3 | 2 jam | 550 | 2,624 |
| | | 525 | 3,768 |
| | | 365 | 2,172 |
| | | 305 | 2,689 |
| | | 215 | 3,540 |
| 4 | 3 jam | 545 | 2,568 |
| | | 525 | 2,960 |
| | | 310 | 2,674 |
| | | 210 | 3,782 |
| 5 | 4 jam | 545 | 2,306 |
| | | 525 | 2,605 |
| | | 310 | 2,497 |
| | | 205 | 3,549 |
| 6 | 5 jam | 545 | 1,758 |
| | | 525 | 1,905 |
| | | 310 | 2,195 |
| | | 205 | 3,783 |
| 7 | 6 jam | 545 | 1,257 |
| | | 525 | 1,333 |
| | | 310 | 1,823 |
| 8 | 7 jam | 545 | 1,013 |
| | | 525 | 1,075 |
| | | 310 | 1,650 |
| 9 | 8 jam | 545 | 0,701 |
| | | 525 | 0,746 |
| | | 310 | 1,424 |

| | | | |
|---|---|---|---|
| **10** | **9 jam** | **330** | **1,554** |
| 11 | 10 jam | 325 | 1,432 |
| 12 | 11 jam | 325 | 1,422 |
| 13 | 13 jam | 320 | 1,347 |

5. 0,25 gram 0,0040 M (pH 10)

| Pengukuran ke- | Jam | Panjang Gelombang | Absorbansi |
|---|---|---|---|
| 1 | 0 menit | 570 | 3,911 |
| | | 550 | 4,011 |
| | | 495 | 9,999 |
| | | 365 | 3,193 |
| | | 330 | 2,705 |
| | | 315 | 2,791 |
| | | 290 | 3,350 |
| | | 240 | 2,937 |
| 2 | 1 jam | 545 | 2,957 |
| | | 520 | 9,999 |
| | | 365 | 3,036 |
| | | 325 | 2,820 |
| | | 305 | 2,903 |
| | | 235 | 3,779 |
| 3 | 2 jam | 545 | 2,740 |
| | | 525 | 3,710 |
| | | 365 | 2,743 |
| | | 345 | 2,620 |
| | | 325 | 2,719 |
| | | 315 | 2,790 |
| | | 295 | 3,041 |
| | | 220 | 3,810 |
| 4 | 3 jam | 550 | 2,620 |
| | | 525 | 3,001 |
| | | 365 | 2,657 |
| | | 330 | 2,670 |
| | | 310 | 2,748 |
| | | 295 | 2,957 |
| | | 210 | 3,597 |
| 5 | 4 jam | 545 | 2,425 |
| | | 525 | 2,684 |
| | | 365 | 2,568 |
| | | 305 | 2,722 |
| | | 295 | 2,823 |
| | | 205 | 3,618 |
| 6 | 5 jam | 545 | 1,857 |
| | | 525 | 1,989 |
| | | 350 | 2,872 |

| | | | |
|---|---|---|---|
| | | 315 | 3,223 |
| 7 | 6 jam | 545 | 1,345 |
| | | 525 | 1,439 |
| | | 310 | 2,732 |
| 8 | 7 jam | 545 | 1,109 |
| | | 525 | 1,192 |
| | | 345 | 2,516 |
| | | 320 | 2,575 |
| 9 | 8 jam | 545 | 0,826 |
| | | 525 | 0,894 |
| | | 505 | 0,908 |
| | | 320 | 2,318 |
| **10** | **9 jam** | **340** | **2,559** |
| 11 | 10 jam | 365 | 2,344 |
| | | 330 | 2,551 |
| 12 | 11 jam | 355 | 2,123 |
| | | 330 | 2,218 |
| 13 | 13 jam | 365 | 1,893 |
| | | 330 | 2,083 |

**Lampiran 7.** Perhitungan $MnO_4^-$ dalam Larutan dan Kadar $MnO_2$ Variasi Konsentrasi $KMnO_4$.

**A = ε x B x C**

A: Absorbansi
B : Tebal kuvet (1 cm)
C : konsentrasi
ε : 526: 2,40 x $10^3$
546 : 2,38 x $10^3$

**1. Konsentrasi 0,0024 M**

- A = ε x B x C (1 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{3,318}{1 \text{ cm. } 2,40 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00138 M**

- A = ε x B x C (2 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2,554}{1 \text{ cm. } 2,40 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00106 M**

- A = ε x B x C (3 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,887}{1 \text{ cm. } 2,40 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00078 M**

- A = ε x B x C (4 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,403}{1 \text{ cm. } 2,40 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00058 M**

- A = ε x B x C (5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,049}{1 \text{ cm. } 2,40 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00043 M**

**2. Konsentrasi 0,0032 M**

- A = ε x B x C (2 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2,951}{1 \text{ cm. } 2,38 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00123 M**

- A = ε x B x C (3 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,860}{1 \text{ cm. } 2,40 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00077 M**

- A = ε x B x C (4 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,522}{1 \text{ cm. } 2,40 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00063 M**

- A = ε x B x C (5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,444}{1 \text{ cm. } 2,40 \text{ x } 10^3 \text{ ml/mmol. cm}}$$

C = **0,00060 M**

### 3. Konsentrasi 0,004 M

- A = ε x B x C (3 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{4,618}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00192 M**

- A = ε x B x C (4 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{3,127}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00130 M**

- A = ε x B x C (5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2,641}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00110 M**

- A = ε x B x C (7 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,977}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00082 M**

### 4. Konsentrasi 0,0048 M

- A = ε x B x C (4 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2,946}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00122 M**

- A = ε x B x C (5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2,159}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00089 M**

- A = ε x B x C (7 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,452}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00060 M**

- A = ε x B x C (9 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,308}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00054 M**

**5. Konsentrasi 0,0056 M**

- A = ε x B x C (5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{3,414}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00142 M**

- A = ε x B x C (7 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,978}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00082 M**

- A = ε x B x C (9 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,124}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00046 M**

- A = ε x B x C (12 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{0,733}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00030 M**

- A = ε x B x C (14 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{0,526}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00021 M**

**Tabel Fraksi [$MnO_4^-$] dalam larutan % variasi konsentrasi**

| Konsentrasi $KMnO_4$ | Jam | Fraksi [$MnO_4^-$] dalam larutan % |
|---|---|---|
| 0,0024 M | 1 | 57,5 |
| | 2 | 44,16 |
| | 3 | 32,5 |
| | 4 | 24,16 |
| | 5 | 17,61 |
| | | |
| 0,0032 M | 2 | 38,43 |
| | 3 | 24,06 |
| | 4 | 19,68 |
| | 5 | 18,75 |
| | | |
| 0,0040 M | 3 | 47,5 |
| | 4 | 32,5 |
| | 5 | 27,5 |
| | 7 | 20,5 |
| | | |
| 0,0048 M | 4 | 25,41 |
| | 5 | 18,54 |
| | 7 | 12,5 |
| | 9 | 11,25 |
| | | |
| 0,0056 M | 5 | 25,35 |
| | 7 | 14,64 |
| | 9 | 8,21 |
| | 12 | 5,35 |
| | 14 | 3,75 |

**Kadar $MnO_2$**

1. **0,0024 M**

- **1 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,0024 M

R 0,00102 M 0,00102 M

S 0,00138 M **0,00102 M**

- **2 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00138 M

R 0,00032 M 0,00032 M

S 0,00106 M **0,00032 M**

- **3 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00106 M

R 0,00028 M 0,00028 M

S 0,00078 M **0,00028 M**

- **4 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00078 M

R 0,0002 M 0,0002 M

S 0,00058 M **0,0002 M**

- **5 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00058M

R 0,00015 M 0,00015 M

S 0,00043 M **0,00015 M**

Jumlah $MnO_4^-$ yang bereaksi:

0,00102 M + 0,00032 M + 0,00028 M + 0,0002 M + 0,00015 M = **0,00197 M.**

$$\frac{\text{C awal-C bereaksi}}{\text{C awal}} \text{ x } 100\ \%$$

$$\frac{0{,}0024\text{ M}-0{,}00197\text{ M}}{0{,}0024\text{ M}} \text{ x } 100\ \% = \mathbf{17{,}91\%}$$

2. **0,0032 M**

- **2 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,0032 M

R 0,00197 M 0,00197 M

S 0,00123 M **0,00197 M**

- **3 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00123 M

R 0,00046 M 0,00046 M

S 0,00077 M **0,00046 M**

- **4 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00077 M

R 0,00014 M 0,00014 M

S 0,00063 M **0,00014 M**

- **5 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00063 M

R 0,00003 M 0,00003 M

S 0,00060 M **0,00003 M**

Jumlah $MnO_4^-$ yang bereaksi:

0,00197 M + 0,00046 M + 0,00014 M + 0,00003 M = **0,0026 M.**

$$\frac{\text{C awal-C bereaksi}}{\text{C awal}} \text{ x } 100\ \%$$

$$\frac{0{,}0032\text{ M}-0{,}0026\text{ M}}{0{,}0032\text{ M}} \text{ x } 100\ \% = \mathbf{18{,}75\%}$$

**3. 0,004 M**

- **3 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,004 M

R 0,00208 M 0,00208 M

S 0,00192 M **0,00208 M**

- **4 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00192 M

R 0,00062 M 0,00062 M

S 0,00130 M **0,00062 M**

- **5 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00130 M

R 0,0002 M 0,0002 M

S 0,00110 M **0,0002 M**

- **7 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00110 M

R 0,00028 M 0,00028 M

S 0,00082 M **0,00028 M**

Total $MnO_4^-$ yang bereaksi

0,00208 M + 0,00062 M + 0,0002 M + 0,00028 M = **0,00318 M.**

$$\frac{\text{C awal-C bereaksi}}{\text{C awal}} \text{ x } 100\ \%$$

$$\frac{0{,}004\text{ M}-0{,}00318\text{ M}}{0{,}004\text{ M}} \text{ x } 100\ \% = \mathbf{20{,}5\%}$$

**Tabel kadar $MnO_2$ pada penggunaan variasi konsentrasi $KMnO_4$**

| Konsentrasi $KMnO_4$ | Kadar $MnO_2$ |
|---|---|
| **0,0024 M** | **17,91 %** |
| **0,0032 M** | **18,75 %** |
| **0,0040 M** | **20,5 %** |
| **0,0048 M** | **11,25 %** |
| **0,0056 M** | **3,75 %** |

**Lampiran 8.** Perhitungan $MnO_4^-$ dalam Larutan dan Kadar $MnO_2$ Variasi pH.

**1. pH 3**

- A = ε x B x C (0 menit)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{4{,}138}{1\text{ cm. }2{,}40 \text{ x } 10^3\text{ ml/mmol. cm}}$$

C = **0,00172 M**

- A = ε x B x C (30 menit)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{0{,}965}{1\text{ cm. }2{,}40 \text{ x } 10^3\text{ ml/mmol. cm}}$$

C = **0,00040 M**

- A = ε x B x C (1 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{0,507}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00021 M**

**2. pH 4**

- A = ε x B x C (0 menit)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{3,916}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00163 M**

- A = ε x B x C (1 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,762}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00073 M**

- A = ε x B x C ( 2 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{0,920}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00038 M**

- A = ε x B x C ( 2,5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{0,660}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00027 M**

**3. pH 7**

- A = ε x B x C (2 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{3,153}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00131 M**

- A = ε x B x C (3 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2,466}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00102 M**

- A = ε x B x C 4 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,959}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00081 M**

- A = ε x B x C 5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1,370}{1 \text{ cm. } 2,40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00057 M**

**4. pH 9**

- A = ε x B x C (2 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{3{,}768}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00157 M**

- A = ε x B x C (3 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2{,}960}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00123 M**

- A = ε x B x C (4 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2{,}605}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00108 M**

- A = ε x B x C (5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1{,}905}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00079 M**

- A = ε x B x C (6 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1{,}333}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00055 M**

- A = ε x B x C (7 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1{,}075}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00044 M**

- A = ε x B x C (8 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{0.746}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00031 M**

**5. pH 10**

- A = ε x B x C (2 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{3{,}710}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00154 M**

- A = ε x B x C (3 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{3{,}001}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00125 M**

- A = ε x B x C (4 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{2{,}684}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00111 M**

- A = ε x B x C (5 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1{,}989}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00082 M**

- A = ε x B x C (6 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1{,}439}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00059 M**

- A = ε x B x C (7 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{1{,}192}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00049 M**

- A = ε x B x C (8 jam)

$$C = \frac{A}{B.\varepsilon}$$

$$C = \frac{0.894}{1 \text{ cm. } 2{,}40 \times 10^3 \text{ ml/mmol. cm}}$$

C = **0,00037 M**

| pH Larutan | waktu | Fraksi $[MnO_4^-]$ dalam larutan % |
|---|---|---|
| 3 | 0 (menit) | 43 |
| | 30 (menit) | 10 |
| | 1 jam | 5,25 |
| | | |
| 4 | 0 (menit) | 40,75 |
| | 1 jam | 18,25 |
| | 2 jam | 9,5 |
| | 2,5 jam | 6,75 |
| | | |
| 7 | 2 jam | 32,75 |
| | 3 jam | 25,5 |
| | 4 jam | 20,25 |
| | 5 jam | 14,25 |
| | | |
| 9 | 2 jam | 39,25 |
| | 3 jam | 30,75 |
| | 4 jam | 27 |
| | 5 jam | 19,75 |
| | 6 jam | 13,75 |
| | 7 jam | 11 |
| | 8 jam | 7,75 |
| | | |
| 10 | 2 jam | 38,5 |
| | 3 jam | 31,25 |
| | 4 jam | 27,75 |
| | 5 jam | 20,5 |
| | 6 jam | 14,75 |
| | 7 jam | 12,25 |
| | 8 jam | 9,25 |

**Kadar $MnO_2$**

**1. pH 3**

- **0 Menit**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,004 M

R 0,00228 M 0,00228 M

S 0,00172 M **0,00228 M**

- **30 Menit**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00172 M

R 0,00132 M 0,00132 M

S 0,00040 M **0,00132 M**

- **1 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00040 M

R 0,00019 M 0,00019 M

S 0,00021 M **0,00019 M**

Total $MnO_4^-$ yang bereaksi

0,00228 M + 0,00132 M + 0,00019 M

= **0,00379 M.**

$$\frac{\text{C awal-C bereaksi}}{\text{C awal}} \times 100\ \%$$

$$\frac{0{,}004\ \text{M}-0{,}00379\ \text{M}}{0{,}004\ \text{M}} \times 100\ \% = \mathbf{5{,}25\%}$$

**2. pH 4**

- **0 Menit**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,004 M

R 0,00237 M 0,00237 M

S 0,00163 M **0,00237 M**

- **1 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00163 M

R 0,0009 M 0,0009 M

S 0,00073 M **0,0009 M**

- **2 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00073 M

R 0,00035 M 0,00035 M

S 0,00038 M **0,00035 M**

- **2,5 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00038 M

R 0,00011 M 0,00011 M

S 0,00027 M **0,00011 M**

Total $MnO_4^-$ yang bereaksi

0,00237 M + 0,0009 M+ 0,00035 M+ 0,00011 M = **0,00373 M.**

$$\frac{\text{C awal-C bereaksi}}{\text{C awal}} \times 100\ \%$$

$$\frac{0{,}004\ \text{M}-0{,}00373\ \text{M}}{0{,}004\ \text{M}} \times 100\ \% = \mathbf{6{,}75\%}$$

**3. pH 7**

- **2 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,004 M

R 0,00269 M 0,00269 M

S 0,00131 M **0,00269 M**

- **3 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00131 M

R 0,00029M 0,00029 M

S 0,00102 M **0,00029 M**

- **4 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00102 M

R 0,00021 M 0,00021 M

S 0,00081 M **0,00021 M**

- **5 Jam**

**$MnO_4^-$ ⟶ $MnO_2$**

A 0,00081 M

R 0,00024 M 0,00024 M

S 0,00057 M **0,00024 M**

Total $MnO_4^-$ yang bereaksi

0,00269 M + 0,00029 M + 0,00021 M + 0,00024 M = **0,00343 M.**

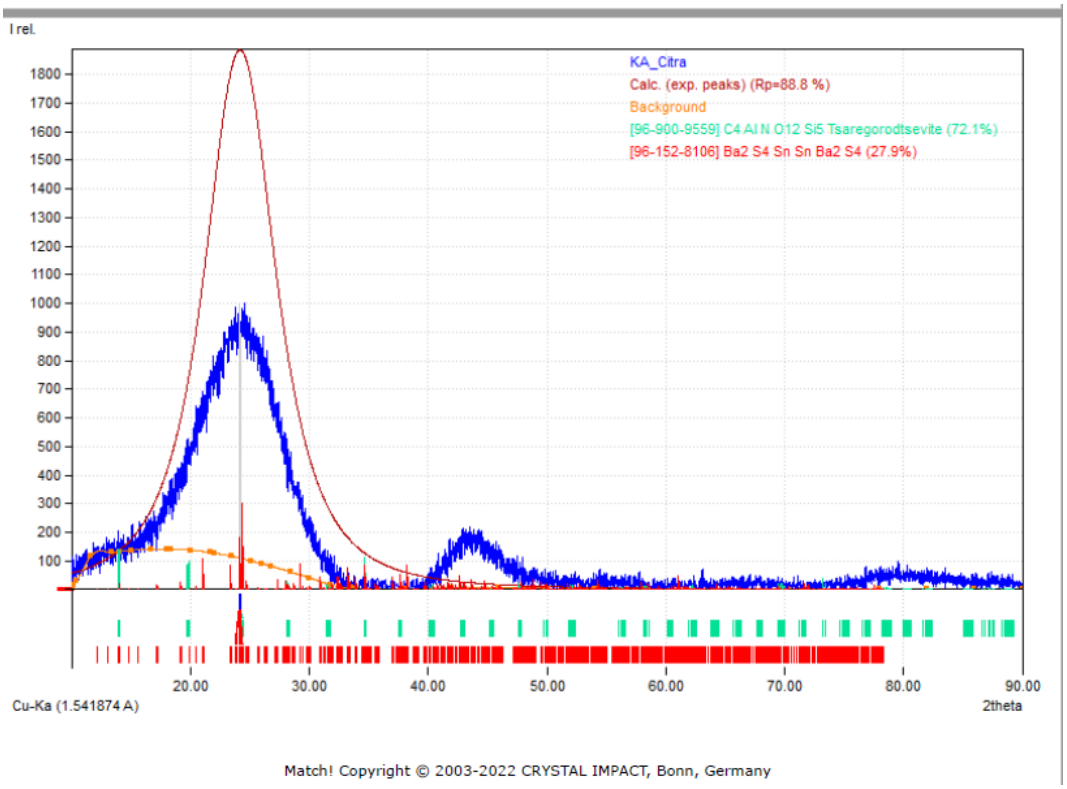
$$\frac{\text{C awal-C bereaksi}}{\text{C awal}} \times 100\ \%$$

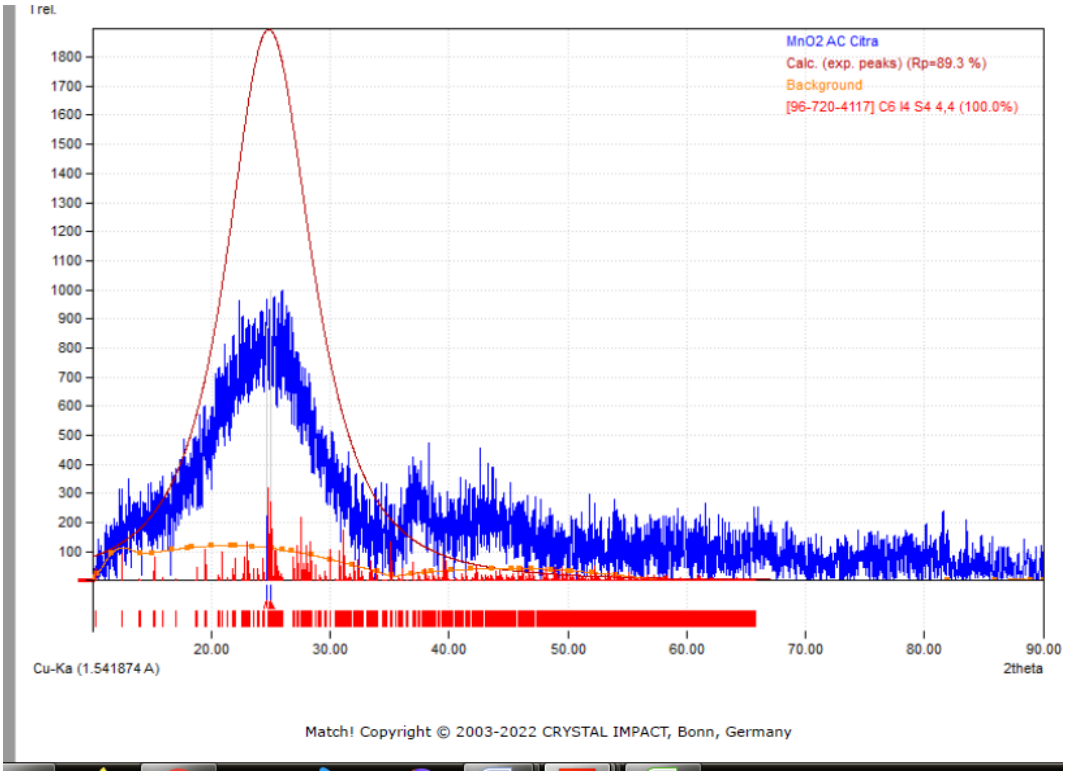
$$\frac{0{,}004\ \text{M}-0{,}00343\ \text{M}}{0{,}004\ \text{M}} \times 100\ \% = \mathbf{14{,}25\%}$$

**Tabel kadar $MnO_2$ pada penggunaan variasi pH**

| pH Larutan | Kadar $MnO_2$ |
|---|---|
| **3** | **5,25 %** |
| **4** | **6,75 %** |
| **7** | **14,25 %** |
| **9** | **16,95 %** |
| **10** | **26,65 %** |
| **12** | **0 %** |

## Lampiran 9. Hasil Karakterisasi XRD



**Lampiran 10. Perhitungan Kadar Gugus Fungsi dengan Titrasi Boehm**

**a. KarbonTempurung Kemiri**

**Penentuan Kadar Karboksilat**

| No | V. Sampel (Vs) (mL) | V. Titran $NaHCO_3$ (Vp) (mL) | N. $NaHCO_3$ | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Carboxyl (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.05 | 0.0480 | 10 | 0.0520 | 5.5 | 0.1004 | 2.7888 |
| 2 | 25 | 5 | 0.05 | 0.0480 | 10 | 0.0520 | 5.9 | 0.1004 | 3.8247 |
| 3 | 25 | 5 | 0.05 | 0.0480 | 10 | 0.0520 | 5.8 | 0.1004 | 3.5657 |
| Rata – rata | | | | | | | | | **3.3930** |

$$n_{carboxylic} = \frac{\left[V_{NaHCO_3} N_{NaHCO_3} - (N_{HCl} V_{HCl} - N_{NaOH} V_{NaOH})\right] \frac{V_p}{V_s}}{w}$$

$$n_{carboxylic} = \frac{[5\ mL \times 0.0500\ N - (0.0480\ N \times 10\ mL - 0.0520\ N \times 5.5\ mL)] \frac{25\ mL}{5\ mL}}{0.1004\ gram}$$

$$n_{carboxylic} = \frac{[0.2500\ meq - (0.4800\ meq - 0.2860\ meq)] \frac{25\ mL}{5\ mL}}{0.1004\ gram}$$

$$n_{carboxylic} = \frac{[0.2500 \text{ meq} - 0.1940 \text{ meq}]\frac{25 \text{ mL}}{5 \text{ mL}}}{0.1004 \text{ gram}} = 2.7888 \ \frac{\text{meq}}{\text{gram}}$$

**Penentuan Kadar Lakton**

| No | V. Sampel (Vs) (mL) | V. Titran $Na_2CO_3$ (Vp) (mL) | N. $Na_2CO_3$ | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Lactone (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.05 | 0.0480 | 10 | 0.0520 | 6.5 | 0.1002 | 1.9962 |
| 2 | 25 | 5 | 0.05 | 0.0480 | 10 | 0.0520 | 6.5 | 0.1002 | 1.9962 |
| 3 | 25 | 5 | 0.05 | 0.0480 | 10 | 0.0520 | 6.3 | 0.1002 | 1.4772 |
| Rata – rata | | | | | | | | | **1.8232** |

$$n_{lactonic} = \frac{\left[V_{Na_2CO_3} N_{Na_2CO_3} - (N_{HCl} V_{HCl} - N_{NaOH} V_{NaOH})\right]\frac{V_p}{V_s}}{w} - n_{carboxylic}$$

$$n_{lactonic} = \frac{[5 \text{ mL x } 0.0500 \text{ N } - (0.0480 \text{ N x } 10 \text{ mL} - 0.0520 \text{ N x } 6.5 \text{ mL})]\frac{25 \text{ mL}}{5 \text{ mL}}}{0.1002} - 3.3930 \ \frac{\text{meq}}{\text{gram}}$$

$$n_{lactonic} = \frac{[0.2500 \text{ meq} - (0.4800 \text{ meq} - 0.3380 \text{ meq})]\frac{25 \text{ mL}}{5 \text{ mL}}}{0.1002 \text{ gram}} - 3.3930 \frac{\text{meq}}{\text{gram}}$$

$$n_{lactonic} = 5.3892 \ \frac{meq}{gram} - 3.3930 \ \frac{meq}{gram} \ = \ 1.9962 \ \frac{meq}{gram}$$

**Penentuan Kadar Fenol**

| No | V. Sampel (Vs) (mL) | V. Titran NaOH (Vp) (mL) | N. NaOH | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Phenolic (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.0520 | 0.0480 | 10 | 0.0520 | 5 | 0.1004 | -3.2241 |
| 2 | 25 | 5 | 0.0520 | 0.0480 | 10 | 0.0520 | 4.9 | 0.1004 | -3.4832 |
| 3 | 25 | 5 | 0.0520 | 0.0480 | 10 | 0.0520 | 5 | 0.1004 | -3.2241 |
| Rata – rata | | | | | | | | | **-3.3104** |

$$n_{phenolic} = \frac{[V_{NaOH}N_{NaOH}-(N_{HCl}V_{HCl}- N_{NaOH}V_{NaOH})]\frac{V_p}{V_s}}{w} - n_{carboxylic} - n_{lactonic}$$

$$n_{phenolic} = \frac{[5 \text{ mL x } 0.0520 \text{ N } - (0.0480 \text{ N x } 10 \text{ mL} - 0.0520 \text{ N x } 5 \text{ mL})]\frac{25 \text{ mL}}{5 \text{ mL}}}{0.1004 \text{ gram}} - 3.3930 \ \frac{meq}{gram} - 1.8232 \ \frac{meq}{gram}$$

$$n_{phenolic} = \frac{[0.2600 \text{ meq} - (0.4800 \text{ meq} - 0.2600 \text{ meq})]\frac{25 \text{ mL}}{5 \text{ mL}}}{0.1004 \text{ gram}} - 3.3930 \ \frac{meq}{gram} - 1.8232 \ \frac{meq}{gram}$$

$$n_{phenolic} = 1.9920 \ \frac{meq}{gram} - 3.3930 \ \frac{meq}{gram} - 1.8232 \ \frac{meq}{gram} = -3.2241 \ \frac{meq}{gram}$$

**Penentuan Kadar Basa Total**

| No | V. Sampel (Vs) (mL) | V. Titran HCl (Vp) (mL) | N. HCl | N. NaOH | V. NaOH (mL) | N. HCl | V. HCl (mL) | Massa Karbon (g) | n total base (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 3.4 | 0.1002 | 0.5888 |
| 2 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 3.3 | 0.1002 | 0.3493 |
| 3 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 3.2 | 0.1002 | 0.1147 |
| Rata – rata | | | | | | | | | **0.3509** |

$$n_{total\ base} = \frac{[V_{HCl}N_{HCl} - (N_{NaOH}V_{NaOH} - N_{HCl}V_{HCl})]\frac{V_p}{V_s}}{w}$$

$$n_{total\ base} = \frac{[5 \text{ mL x } 0.0480 \text{ N } - (0.0520 \text{ N x } 7.5 \text{ mL} - 0.0476 \text{ N x } 3.4 \text{ mL})]\frac{25 \text{ mL}}{5 \text{ mL}}}{0.1002 \text{ gram}}$$

$$n_{total\ base} = \frac{[0.2400 \text{ meq} - (0.3900 \text{ meq} - 0.1618 \text{ meq})]\frac{25 \text{ mL}}{5 \text{ mL}}}{0.1002 \text{ gram}}$$

$$n_{total\ base} = \frac{[0.2400\ \text{meq} - 0.2282\ \text{meq}\ ]\frac{25\ \text{mL}}{5\ \text{mL}}}{0.1002\ \text{gram}} = 0.5888\frac{\text{meq}}{\text{gram}}$$

**b. Karbon Aktif Tempurung Kemiri**

**Penentuan Kadar Karboksilat**

| No | V. Sampel (Vs) (mL) | V. Titran $NaHCO_3$ (Vp) (mL) | N. $NaHCO_3$ | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Carboxyl (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 9.6 | 0.1002 | 13.0089 |
| 2 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 9.6 | 0.1002 | 13.0089 |
| 3 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 9.5 | 0.1002 | 12.7544 |
| Rata – rata | | | | | | | | | **12.9240** |

$$n_{carboxylic} = \frac{\left[V_{NaHCO_3} N_{NaHCO_3} - (N_{HCl} V_{HCl} - N_{NaOH} V_{NaOH})\right]\frac{V_p}{V_s}}{w}$$

$$n_{carboxylic} = \frac{[5\ \text{mL x}\ 0.0500\ \text{N} - (0.0476\ \text{N x}\ 10\ \text{mL} - 0.0507\ \text{N x}\ 9.6\ \text{mL})]\frac{25\ \text{mL}}{5\ \text{mL}}}{0.1002\ \text{gram}}$$

$$n_{carboxylic} = \frac{[0.2500\ \text{meq} - (0.4760\ \text{meq} - 0.4867\ \text{meq})]\frac{25\ \text{mL}}{5\ \text{mL}}}{0.1002\ \text{gram}}$$

$$n_{carboxylic} = \frac{[0.2500\ meq - (-0.0107\ meq)]\frac{25\ mL}{5\ mL}}{0.1002\ gram} = 13.0089\ \frac{meq}{gram}$$

**Penentuan Kadar Lakton**

| No | V. Sampel (Vs) (mL) | V. Titran $Na_2CO_3$ (Vp) (mL) | N. $Na_2CO_3$ | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Lactone (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 9.4 | 0.1002 | -0.4240 |
| 2 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 9.6 | 0.1002 | 0.0849 |
| 3 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 9.5 | 0.1002 | -0.1695 |
| Rata – rata | | | | | | | | | **-0.1695** |

$$n_{lactonic} = \frac{\left[V_{Na_2CO_3} N_{Na_2CO_3} - (N_{HCl} V_{HCl} - N_{NaOH} V_{NaOH})\right]\frac{V_p}{V_s}}{w} - n_{carboxylic}$$

$$n_{lactonic} = \frac{[5\ mL \times 0.0500\ N - (0.0476\ N \times 10\ mL - 0.0507\ N \times 9.4\ mL)]\frac{25\ mL}{5\ mL}}{0.1002} - 12.9240\ \frac{meq}{gram}$$

$$n_{lactonic} = \frac{[0.2500\ meq - (0.4760\ meq - 0.4765\ meq)]\frac{25\ mL}{5\ mL}}{0.1002\ gram} - 12.9240\ \frac{meq}{gram}$$

$$n_{lactonic} = 12.5 \frac{meq}{gram} - 12.9240 \frac{meq}{gram} = -0.4240 \frac{meq}{gram}$$

**Penentuan Kadar Fenol**

| No | V. Sampel (Vs) (mL) | V. Titran NaOH (Vp) (mL) | N. NaOH | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Phenolic (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.0520 | 0.0476 | 10 | 0.0507 | 8 | 0.1001 | -3.2840 |
| 2 | 25 | 5 | 0.0520 | 0.0476 | 10 | 0.0507 | 8.1 | 0.1001 | -3.0342 |
| 3 | 25 | 5 | 0.0520 | 0.0476 | 10 | 0.0507 | 8 | 0.1001 | -3.2840 |
| Rata – rata | | | | | | | | | **-3.2007** |

$$n_{phenolic} = \frac{[V_{NaOH}N_{NaOH} - (N_{HCl}V_{HCl} - N_{NaOH}V_{NaOH})]\frac{V_p}{V_s}}{w} - n_{carboxylic} - n_{lactonic}$$

$$n_{phenolic} = \frac{[5\ mL \times 0.0520\ N - (0.0476\ N \times 10\ mL - 0.0507\ N \times 8\ mL)]\frac{25\ mL}{5\ mL}}{0.1001\ gram} - 12.9240\frac{meq}{gram} - (-0.1695\frac{meq}{gram})$$

$$n_{phenolic} = \frac{[0.2600\ meq - (0.4760\ meq - 0.4056\ meq)]\frac{25\ mL}{5\ mL}}{0.1001\ gram} - 12.9240\ \frac{meq}{gram} - (-0.1695\ \frac{meq}{gram})$$

$$n_{phenolic} = 9.4705 \frac{meq}{gram} - 12.9240 \frac{meq}{gram} - (-0.1695 \frac{meq}{gram}) = -3.2840 \frac{meq}{gram}$$

**Penentuan Kadar Basa Total**

| No | V. Sampel (Vs) (mL) | V. Titran HCl (Vp) (mL) | N. HCl | N. NaOH | V. NaOH (mL) | N. HCl | V. HCl (mL) | Massa Karbon (g) | n total base (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 2.8 | 0.1003 | -0.8374 |
| 2 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 2.8 | 0.1003 | -0.8374 |
| 3 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 2.8 | 0.1003 | -0.8374 |
| Rata – rata | | | | | | | | | **-0.8374** |

$$n_{total\ base} = \frac{[V_{HCl}N_{HCl} - (N_{NaOH}V_{NaOH} - N_{HCl}V_{HCl})]\frac{V_p}{V_s}}{w}$$

$$n_{total\ base} = \frac{[5\ mL \times 0.0480\ N - (0.0520\ N \times 7.5\ mL - 0.0476\ N \times 2.8\ mL)]\frac{25\ mL}{5\ mL}}{0.1003\ gram}$$

$$n_{total\ base} = \frac{[0.2400\ meq - (0.3900\ meq - 0.1332\ meq)]\frac{25\ mL}{5\ mL}}{0.1003\ gram}$$

$$n_{total\ base} = \frac{[0.2400\ \text{meq} - 0.2568\ \text{meq}]\frac{25\ \text{mL}}{5\ \text{mL}}}{0.1003\ \text{gram}} = -0.8374\ \frac{\text{meq}}{\text{gram}}$$

**c. $MnO_2$/AC**

**Penentuan Kadar Karboksilat**

| No | V. Sampel (Vs) (mL) | V. Titran $NaHCO_3$ (Vp) (mL) | N. $NaHCO_3$ | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Carboxyl (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 10,2 | 0.1002 | 14.5259 |
| 2 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 10,2 | 0.1002 | 14.5259 |
| 3 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 10,2 | 0.1002 | 14.5259 |
| Rata – rata | | | | | | | | | **14.5259** |

$$n_{carboxylic} = \frac{\left[V_{NaHCO_3} N_{NaHCO_3} - (N_{HCl} V_{HCl} - N_{NaOH} V_{NaOH})\right]\frac{V_p}{V_s}}{w}$$

$$n_{carboxylic} = \frac{[5\ \text{mL} \times 0.0500\ \text{N} - (0.0476\ \text{N} \times 10\ \text{mL} - 0.0507\ \text{N} \times 10{,}2\ \text{mL})]\frac{25\ \text{mL}}{5\ \text{mL}}}{0.1002\ \text{gram}}$$

$$n_{carboxylic} = \frac{[0.2500\ \text{meq} - (0.4760\ \text{meq} - 0.5171\ \text{meq})]\frac{25\ \text{mL}}{5\ \text{mL}}}{0.1002\ \text{gram}}$$

$$n_{carboxylic} = \frac{[0.2500\ meq - (-0.0411\ meq)]\frac{25\ mL}{5\ mL}}{0.1002\ gram} = 14{,}5259\ \frac{meq}{gram}$$

**Penentuan Kadar Lakton**

| No | V. Sampel (Vs) (mL) | V. Titran $Na_2CO_3$ (Vp) (mL) | N. $Na_2CO_3$ | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Lactone (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 10,4 | 0.1002 | 0.5040 |
| 2 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 10,4 | 0.1002 | 0.5040 |
| 3 | 25 | 5 | 0.05 | 0.0476 | 10 | 0.0507 | 10,3 | 0.1002 | 0.0748 |
| Rata – rata | | | | | | | | | **0.0585** |

$$n_{lactonic} = \frac{\left[V_{Na_2CO_3} N_{Na_2CO_3} - (N_{HCl} V_{HCl} - N_{NaOH} V_{NaOH})\right]\frac{V_p}{V_s}}{w} - n_{carboxylic}$$

$$n_{lactonic} = \frac{[5\ mL \times 0.0500\ N - (0.0476\ N \times 10\ mL - 0.0507\ N \times 10{,}4\ mL)]\frac{25\ mL}{5\ mL}}{0.1002} - 14.5259\ \frac{meq}{gram}$$

$$n_{lactonic} = \frac{[0.2500\ meq - (0.4760\ meq - 0.5272\ meq)]\frac{25\ mL}{5\ mL}}{0.1002\ gram} - 14.5259\ \frac{meq}{gram}$$

$$n_{lactonic} = 15.0299 \frac{meq}{gram} - 14.5259 \frac{meq}{gram} = 0.5040 \frac{meq}{gram}$$

**Penentuan Kadar Fenol**

| No | V. Sampel (Vs) (mL) | V. Titran NaOH (Vp) (mL) | N. NaOH | N. HCl | V. HCl (mL) | N. NaOH | V. NaOH (mL) | Massa Karbon (g) | n Phenolic (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.0520 | 0.0476 | 10 | 0.0507 | 9.2 | 0.1001 | -2.0893 |
| 2 | 25 | 5 | 0.0520 | 0.0476 | 10 | 0.0507 | 8.9 | 0.1001 | -2.8478 |
| 3 | 25 | 5 | 0.0520 | 0.0476 | 10 | 0.0507 | 9.2 | 0.1001 | -2.0893 |
| Rata – rata | | | | | | | | | **-2.3421** |

$$n_{phenolic} = \frac{[V_{NaOH}N_{NaOH} - (N_{HCl}V_{HCl} - N_{NaOH}V_{NaOH})]\frac{V_p}{V_s}}{w} - n_{carboxylic} - n_{lactonic}$$

$$n_{phenolic} = \frac{[5\ mL \times 0.0520\ N - (0.0476\ N \times 10\ mL - 0.0507\ N \times 9.2\ mL)]\frac{25\ mL}{5\ mL}}{0.1001\ gram} - 14.5259\frac{meq}{gram} - (0.0585\frac{meq}{gram})$$

$$n_{phenolic} = \frac{[0.2600\ meq - (0.4760\ meq - 0.4664\ meq)]\frac{25\ mL}{5\ mL}}{0.1001\ gram} - 14.5259\ \frac{meq}{gram} - (0.0585\ \frac{meq}{gram})$$

$$n_{phenolic} = 12.4950\ \frac{meq}{gram} - 14.5259\ \frac{meq}{gram} - (0.0585\ \frac{meq}{gram}) = -2.0893\ \frac{meq}{gram}$$

**Penentuan Kadar Basa Total**

| No | V. Sampel (Vs) (mL) | V. Titran HCl (Vp) (mL) | N. HCl | N. NaOH | V. NaOH (mL) | N. HCl | V. HCl (mL) | Massa Karbon (g) | n total base (meq/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 3.2 | 0.1002 | 0.1147 |
| 2 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 3.2 | 0.1002 | 0.1147 |
| 3 | 25 | 5 | 0.0480 | 0.0520 | 7.5 | 0.0476 | 3.2 | 0.1002 | 0.1147 |
| Rata – rata | | | | | | | | | 0.1147 |

$$n_{total\ base} = \frac{[V_{HCl}N_{HCl}-(N_{NaOH}V_{NaOH}- N_{HCl}V_{HCl})]\frac{V_p}{V_s}}{w}$$

$$n_{total\ base} = \frac{[5\text{ mL x }0.0480\text{ N }-(0.0520\text{ N x }7.5\text{ mL}-0.0476\text{ N x }3.2\text{ mL})]\frac{25\text{ mL}}{5\text{ mL}}}{0.1003\text{ gram}}$$

$$n_{total\ base} = \frac{[0.2400\text{ meq }-(0.3900\text{ meq}-0.1523\text{ meq})]\frac{25\text{ mL}}{5\text{ mL}}}{0.1003\text{ gram}}$$

$$n_{total\ base} = \frac{[0.2400\text{ meq} - 0.2377\text{ meq}]\frac{25\text{ mL}}{5\text{ mL}}}{0.1003\text{ gram}} = 0.1147\frac{\text{meq}}{\text{gram}}$$