DAFTAR PUSTAKA

Anca-Couce, A., 2016, Reaction Mechanisms And Multi-Scale Modelling Of Lignocellulosic Biomass Pyrolysis, *Prog. Energy Combust. Sci.*, **53**: 41-79.

Alabadi, A., Abbood, H. A., Li, Q., Jing, Ni., dan Tan, B., 2016, Imine-Linked Polymer Based Nitrogen-Doped Porous Activated Carbon for Efficient and Selective CO_2 Capture, *Sci. Rep.*, **6**(38614): 1-9.

Ali, M. M. S., El-Sai, N., Girgis, B. S., 2014, Evaluation and Modeling of High Surface Area Activated Carbon from Date Frond and Application on Some Pollutants, *Int. J. Comp. Eng. Res.*, **4**(1): 70-78.

Alnomsy, A. K., 2016, *Synthesis And Properties Of Pyridine Containing Drugs And Heterocycles*, Tesis tidak diterbitkan, University of Sussex, United Kingdom.

Ariyani, Putri, A. R., Eka, R. P., dan Fathoni, R., 2017, Pemanfaatan Kulit Singkong Sebagai Bahan Baku Arang Aktif dengan Variasi Konsentrasi NaOH dan Suhu, *Konversi*, **6**(1): 7-10.

Arlene, A., Suharto, I., dan Jessica, J. R., 2010, *Pengaruh Temperatur dan Ukuran Biji Terhadap Perolehan Minyak Kemiri pada Ekstraksi Biji Kemiri dengan Penekanan Mekanis*, Prosiding Seminar Nasional Teknik Kimia "Kejuangan" Pengembangan Teknologi Kimia untuk Pengolahan Sumber Daya Alam Indonesia, Yogyakarta.

Azwar, E., Mahari, W. A. W., Chuah, J. H., Vo, D. V. N., Ma, N. L., Lam, W. H., dan Lam, S. S., 2018, Transformation of biomass into carbon nanofiber for supercapacitor applicatione – A review, *Int. J. Hydrogen Energy*, **43**(45): 1-11.

Balci, S., Doğu, T., dan Yücel, H., 1994, Characterization of Activated Carbon Produced From Almond Shell and Hazelnut Shell, *J. Chem. Technol. Biotechnol.*, **60**(4): 419-426.

Basar, M. S., Caglayan, B. S., dan Aksoylu, A. E., 2015, *Ammonia-modified Activated Carbon Adsorbents for Selective CO_2 Adsorption*, Proceeding 2015 American Institute of Chemical Engineers (AIChE) Annual Meeting, Salt Lake City, Utah, U.S.A.

F., dan Frackowiak, E., 2010, *Carbons for Electrochemical Energy orage and Conversion Systems*, Taylor and Francis Group, United States America

Cao, Y., Huang, J., Li, Y., Qiu, S., Liu, J., Khasanov, A., Khan, M. A., Young, D. P., Peng, F., Cao, D., Peng, X., Hong, K., dan Guo, Z., 2016, One-pot Melamine Derived Nitrogen Doped Magnetic Carbon Nanoadsorbents with Enhanced Chromium Removal, *Carbon*, **109**: 640-649.

Ceballos, D. C. C., 2013, *Production of Bio-Coal and Activated Carbon from Biomass*, Tesis tidak diterbitkan, The University of Western Ontario, Ontario.

Cheenmatchaya, A., and Kungwankunakorn, S., 2014, Preparation of Activated Carbon Derived from Rice Husk by Simple Carbonization and Chemical Activation for Using as Gasoline Adsorbent, *International Journal of Environmental Science and Development*, **5**(2): 171-175.

Chen, L. C., Peng, P. Y., Lin, L. F., Yang, T. C. K., dan Huang, C. M., 2014, Facile Preparation of Nitrogen-Doped Activated Carbon for Carbon Dioxide Adsorption, *Aerosol Air Qual. Res.*, **14**(3): 916-927 .

Chen, X., Zhang, J., Zhang, B., Dong, S., Guo, X., Mu, X., dan Fei, B., 2017, A Novel Hierarchical Porous Nitrogen-Doped Carbon Derived from Bamboo Shoot for High Performance Supercapacitor, *Sci. Rep.*, **7**(7362): 1-11.

Cho, H., Madden, R., Nisanci, B., dan Török, B., 2015, The Paal–Knorr Reaction revisited. A Catalyst and Solvent-Free Synthesis Of Underivatized and N-Substitute Pyrroles, *Green Chem.*, **17**(2): 1088-1099.

Cuhadaroglu, D., dan Uygun, O. A., 2008, Production and Characterization of Activated Carbon from A Bituminous Coal by Chemical Activation, *Afr. J. Biotechnol.*, **7**(20): 3703-3710.

Dastgheib, S. A., dan Rockstraw, D. A., 2001, Pecan Shell Activated Carbon: Synthesis, Characterization, and Application for The Removal of Copper From Aqueous Solution, *Carbon*, **39**(12): 1849-1855.

Darmawan, S., Wistara, N. J., Pari, G., Maddu, A., dan Syafii, W., 2016, Characterization of Lignocellulosic Biomass as Raw Material for the Production of Porous Carbon-based Materials, *BioResources*, **11**(2): 3561-3574.

Demir, M., Saraswat, S. K., dan Gupta, R. B., 2017, Hierarchical Nitrogen-Doped Porous Carbon Derived from Lecithin for High-Performance Supercapacitors, *RSC Adv.*, **7**(67): 42430-42442.

[illegible], Xie, Y., Zou, K., dan Ji, X., 2016, Review On Recent Advances In [illegible]itrogen-Doped Carbons: Preparations and Applications In [illegible]upercapacitors, *J. Mater. Chem. A.*, **4**(4): 1144-1173.

Denholm, P., 2006, Improving The Technical, Environmental And Social Performance Of Wind Energy Systems Using Biomass-Based Energy Storage, *Renewable Energy*, **31**(9): 1355-1370.

Deraman, M., Nor, N. S. M., Basri, N. H., Dollah, B. N. M., Soltaninejad, S., Daik, R., Omar, R., Hashim, M. A., dan Othman, M. A. R., 2015, Graphene and Activated Carbon Based Supercapacitor Electrodes, *Adv. Mater. Res.*, **1112**: 231-235.

Esterlita, M. O., dan Herlina, N., 2015, Pengaruh Penambahan Aktivator $ZnCl_2$, KOH, dan H_3PO_4 dalam Pembuatan Karbon Aktif dari Pelepah Aren (Arenga Pinnata), *Jurnal Teknik Kimia USU*, **4**(1): 47-52.

Farmer, J. C., Mack, G. V., dan Fix, D. V., 1996, *The Use of Carbon Aerogel Electrodes for Deionizing Water and Treating Aqueous Process Wastes*, Fourth lnternatioal Congress on Environmentally Concious Design and Manufacturing, Cleveland, Ohio.

Gao, Y., Ying, J., Xu, X., dan Cai, L., 2018, Nitrogen-Enriched Carbon Nanofibers Derived from Polyaniline and Their Capacitive Properties, *Applied Science*, **8**(7): 2-13.

Geng, Z., Xiao, Q., Lu, H., Li, B., Wu, H., Lu, Y., dan Zhang, C., 2016, One-Step Synthesis of Microporous Carbon Monoliths Derived from Biomass with High Nitrogen Doping Content for Highly Selective CO_2 Capture, *Sci. Rep.*, **6**(30049): 1-8.

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.

Goto, T., Amano, Y., Machida, M., dan Imazeki, F., 2015, Effect of Polarity of Activated Carbon Surface, Solvent and Adsorbate on Adsorption of Aromatic Compounds from Liquid Phase, *Chem. Pharm. Bull.*, **63**(9): 726-730.

Gumelar, D., Hendrawan, Y., dan Yulianingsih, R., 2015, Pengaruh Aktivator dan Waktu Kontak Terhadap Kinerja Arang Aktif Berbahan Eceng Gondok (Eichornia crossipes) Pada Penurunan COD Limbah Cair Laundry, *Jurnal Keteknikan Pertanian Tropis dan Biosistem*, **3**(1): 15-23.

Guo, S., Liu, Q., Sun, J., Jin, H., 2018, A Review On The Utilization Of Hybrid Renewable Energy, *Renew. Sust. Energ. Rev.*, **91**: 1121-1147.

S. N., 2016, *Pembuatan dan Karakterisasi serta Uji Adsorpsi Karbon ktif Tempurung Kemiri (Aleurites moluccana) terhadap Metilen Biru*, kripsi tidak diterbitkan, Universitas Lampung, Bandar Lampung.

Halper, M. S., dan Ellenbogen, J. C., 2006, *Supercapacitors: A Brief Overview*, MITRE Nanosystems Group, McLean, Virginia, USA.

Han, J., Xu, G., Ding, B., Pan, J., Dou, H., dan MacFarlane, D. R., 2014, Porous Nitrogen-Doped Hollow Carbon Spheres Derived From Polyaniline For High Performance Supercapacitors, *J. Mater. Chem. A*, **2**(15): 5352-5357.

Henry, G. D., 2004, De Novo Synthesis Of Substituted Pyridines, *Tetrahedron*, **60**(29): 6043-6061.

Himmaty, I., dan Endarko, 2013, Pembuatan Elektroda dan Perancangan Sistem Capacitive Deionization untuk Mengurangi Kadar Garam pada Larutan Sodium Clorida (NaCl), *Berkala Fisika*, **16**(3): 67-74.

Hulicova, D., Kodama, M., dan Hatori, H., 2006, Electrochemical Performance of Nitrogen-Enriched Carbons in Aqueous and Non-Aqueous Supercapacitors, *Chem. Mater.*, **18**(9): 2318-2326.

Hung, J. J., 2012, *The Production of Activated Carbon from Coconut Shells Using Pyrolysis and Fluidized Bed Reactors*, Skripsi tidak diterbitkan, University of Arizona, USA.

Iro, Z. S., Subramani, C., dan Dash, S. S., 2016, A Brief Review on Electrode Materials for Supercapacitor, *Int. J. Electrochem. Sci.*, **11**(12)**:** 10628-10643.

ITIS, 2018, *Aleuritus moluccanus (L.) Willd Taxonomic Serial No.: 845627*, https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=845627#null, diakses 4 Maret 2018.

Jagtoyen, M., dan Deryshire, F., 1998, Activated Carbons from Yellow Poplar and White Oak by H_3PO_4 Activation, *Carbon*, **36**(7): 1085-1097.

Jeffery, G. H., Basset, J., Mendham, J., dan Denney, R. C., 1989, *Vogel's textbook of Quantitative Chemical Analysis 5th Edition*, Longman Group UK, England.

Jo, G., Choe, M., Lee, S., Park, W., Kahng, Y. H., dan Lee, T., 2012, The Application of Graphene As Electrodes in Electrical and Optical Devices, *Nanotechnology*, **23**(11): 1-19.

Labanni', A., Zakir, M. dan Maming, 2015, Sintesis dan Karakterisasi Karbon Nanopori Ampas Tebu (*Saccharum officinarum*) dengan Aktivator $ZnCl_2$ melalui Iradiasi Ultrasonik sebagai Bahan Penyimpan Energi Elektrokimia, *Indo. Chim. Acta*, **8**(1): 1- 9.

A., Delpeux-Ouldriane, S., Lust, E., dan Beguin, F., 2014, Ammonia Treatment of Activated Carbon Powders for Supercapacitor Electrode Application, *J. Electrochem. Soc.*, **161**(4): 568-575.

Lee, T., Zubir, Z. A., Jamil, F. Md., Matsumoto, A., dan Yeoh, F. Y., 2014, Combustion And Pyrolysis Of Activated Carbon Fibre From Oil Palm Empty Fruit Bunch Fibre Assisted Through Chemical Activation With Acid Treatment, *J. Anal. Appl. Pyrolysis.*, **110**(1): 408-418.

Leimkuehler, E. P., 2010, *Production, Characterization, and Applications of Activated Carbon*, Thesis tidak diterbitkan, University of Missouri.

Lempang, M., 2014, Pembuatan dan Kegunaan Arang Aktif, *Info Teknis EBONI*, **11**(2): 65-80.

Lestari, L. F. K. D., Ratnani, R. D., Suwardiyono dan Kholis, N., 2017, Pengaruh Waktu dan Suhu Pembuatan Karbon Aktif dari Tempurung Kelapa Sebagai Upaya Pemanfaatan Limbah dengan Suhu Tinggi Secara Pirolisis, *Inovasi Teknik Kimia*, **2**(1): 32-38.

Li, B., 2012, *Charaterization of Pore Structure and Surface Chemistry of Activated Carbons – A Review*, *Fourier Transform - Materials Analysis* Edited by Dr Salih Salih, InTech China, Shanghai, China.

Li, J. J., 2009, *Name Reactions 4th edition: A Collection of Detailed Mechanisms and Synthetic Applications*, Springer-Verlag Berlin Heidelberg, Heidelberg, Germany.

Li, Y., Xu, X., He, Y., Jiang, Y., dan Lin, K, 2017, Nitrogen Doped Macroporous Carbon as Electrode Materials for High Capacity of Supercapacitor, *Polymers*, **9**(2): 1-16.

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, *RSC Adv.*, **5**(41): 1-11.

Li, L., Ma, X., Chen, R., Wang, C., dan Lu, M., 2018, Nitrogen-Containing Functional Groups-Facilitated Acetone Adsorption by ZIF-8-Derived Porous Carbon, *Materials*, **11**(159): 1-15.

Liu, G., 2014, Development of A General Sustainability Indicator for Renewable Energy Systems: A review, *Renew. Sust. Energ. Rev.*, **31**: 611-621.

Liu, R., Pan, L., Jiang, J., Xi, X., Liu, X., dan Wu, D., 2016, Nitrogen-doped Carbon Microfiber with Wrinkled Surface for High Performance Supercapacitors, *Sci. Rep.*, **6**(21750): 1-6.

F., dan Staiti, P., 2010, Mesoporous Carbon Materials as Electrodes for lectrochemical Supercapacitors, *Int. J. Electrochem. Sci.*, **5**: 903-916.

Feng, S., dan Ji, S., 2017, Nitrogen-Doped Carbon with Hierarchical orous Structure for Electrocatalysis of Oxygen Reduction Reaction, *Int. Electrochem. Sci.*, **12**(8): 7869-7876.

Mabena, L. F., Ray, S. S., Mhlanga, S. D., dan Coville, N. J., 2011, Nitrogen-Doped Carbon Nanotubes as a Metal Catalyst Support, *Appl. Nanosci*., **1**(2): 67-77.

Masson, J-F., 2008, Brief Review Of The Chemistry Of Polyphosphoric Acid (PPA) and Bitumen, *Energy & Fuels*, **22**(4): 2637-2640.

McDougall, G. J., 1991, The Physical Nature And Manufacture Of Activated Carbon, *J. S. Afr. Inst. Min. Metal*., **91**(4): 109-120.

Mendez, M., Lisboa, A. C. L., dan Coutinho, A. R., 2008, Synthesis Of Activated Carbon Materials From Petroleum Coke, *Boletim Tecnico da PETROBRAS*, **51**(1): 45-65.

Michel, R., Mischler, N., Azambre, B., Finqueneisel, G., Machnikowski, J., Rutkowski, P., Zimny, T., dan Weber, J. V., 2006, Miscanthus×Giganteus Straw And Pellets As Sustainable Fuels and Raw Material For Activated Carbon, *Environ. Chem. Lett.*, **4**(4): 185-189.

Mohammad-Khah, A., dan Ansari, R., 2009, Activated Charcoal: Preparation, characterization and Applications, *Int. J. ChemTech. Res.*, **1**(4): 859-864.

Montoya, V. H., dan Petriciolet, A. B., 2012, *Lignocellulosic Precursors Used in The Synthesis of Activated Carbon: Characterization Techniques and Applications in The Wastewater Treatment*, InTech, Croatia.

Mopoung, S., dan Preechachan, P., 2010, Chemical and Surface Properties of Charcoal and Activated Carbon Prepared from Soybean Milk Residue, *NU Science Journal*, **6**(2): 135-146.

Nahil, M. A., dan Williams, P. T., 2012, Pore Characteristics Of Activated Carbons From The Phosphoric Acid Chemical Activation Of Cotton Stalks, *Biomass and Bioenergy*, **37**: 142-149.

Nightingale Jr., E. R., 1959, Phenomenological Theory of Ion Solvation. Effective Radii of Hydrated Ions, *J. Phys. Chem*., **63**(9): 1381-1387.

Nurdiati, D., dan Astuti, 2015, Sintesis Komposit PAni/Karbon dari Tempurung Kemiri (*Aleurites moluccana*) Sebagai Elektroda Kapasitor, *Jurnal Fisika Unand*, **4**(1): 51-57.

Patnukao, P., dan Pavasant, P., 2008, Activated Carbon from Eucalyptus camaldulensis Dehnbark Using Phosphoric Acid Activation, *Bioresour. Technol.*, **99**(17): 8540-8543.

Zhang, X., dan Yang, S., 2011, High Performance Supercapacitors Based n Highly Conductive Nitrogen-Doped Graphene Sheets, *Phys. Chem. hem. Phys.*, **13**(27): 12554-12558.

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.

Sahara, E., Sulihingtyas, W. D., dan Mahardika, I. P. A. S., 2017, Pembuatan dan Karakterisasi Arang Aktif dari Batang Tanaman Gumitir (Tagetes erecta) yang Diaktivasi dengan H_3PO_4, *Jurnal Kimia*, **11**(1): 1-9.

Sahira, J., Mandira, A., Prasad, P. B., dan Ram, P. R., 2013, Effects of Activating Agents on the Activated Carbons Prepared from Lapsi Seed Stone, *Res. J. Chem. Sci.*, **3**(5): 19-24.

Sandoval, E. M., Díaz, J. L. F., Salas, R. S., López, A. J. C., dan Urías, F. L., 2018, Two Sprayer CVD Synthesis of Nitrogen-Doped Carbon Sponge type Nanomaterials, *Sci. Rep.*, **8**(2983): 1-14.

Seixas. F. L., Golçanves, E. V., Olsen, M. H. N., Gimenes, M. L., dan Fernandes-Machado, N. R. C., 2017, Activated Carbon from Sugarcane Bagasse Prepared by Activation with CO_2 and Bio Oil Recuperation, *Chem. Eng. Trans.*, **57**: 1-6.

Shafeeyan, M. S., Daud, W. M. W., Houshmand, A., dan Shamiri, A., 2010, A Review On Surface Modification Of Activated Carbon For Carbon Dioxide Adsorption, *J. Anal. Appl. Pyrolysis*, **89**(2): 143-151.

Shang, T. X., Zhang, J., Fan, F. L., dan Jin, X. J., 2013, Nitrogen-Enriched Activated Carbons From Waste Particle Board Used As Electrode Materials for Supercapacitors: Effects of activating agent on surface characteristics, *RSC Adv*., **5**(63): 1-7.

Shu, J., Cheng, S., Xia, H., Zhang, L., Peng, J., Li, C., dan Zhang, S., 2017, Copper loaded on activated carbon as an efficient adsorbent for removal of methylene blue, *RSC Adv.*, **7**(24): 14395-14405.

Soleimani, M., dan Kaghazchi, T., 2007, Agricultural Waste Conversion to Activated Carbon by Chemical Activation with Phosphoric Acid, *J. Chem. Technol. Biotechnol.*, **30**(5): 649-654.

Song, J. H., Kim, C. M., Yang, E., Ham, M. H., dan Kim, I. S., 2017, The Effect of Doping Temperature on The Nitrogen Bonding Configuration of Nitrogen-Doped Graphene by Hydrothermal Treatment, *RSC Adv.*, **7**(34): 20738-20741.

Stö[illegible], Boehm, H. P., and Schlögl, R., 1991, Enhancement of The Catalytic ctivity of Activated Carbons in Oxidation Reactions by Thermal reatment with Ammonia or Hydrogen Cyanide and Observation of A uperoxide Species As A Possible Intermediate, *Carbon*, **29**(6): 707-720.

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

Surest, A. H., Kasih, J. A. F., dan Wisanti, A., 2008, Pengaruh Suhu, Konsentrasi Zat Aktivator dan Waktu Aktivasi Terhadap Daya Serap Karbon Aktif dari Tempurung Kemiri, *J. Tek. Kim.*, **15**(2): 17-21.

Taer, E., Zulkifli, Arif, E. N., dan Taslim, R., 2016, Analisa Kapasitansi Spesifik Elektroda Karbon Superkapasitor dari Kayu Karet terhadap Laju Scan berdasarkan Variasi Aktivasi HNO_3, *Jurnal Fisika dan Aplikasinya*, **1**(1): 29-34.

Tambunan, B. H., Saptoadi, H., dan Syamsiro, M., 2014, A Preliminary Study on Use of Candlenut Shell as a Renewable Source of Energy, Min Indonesia, *Journal of Ocean, Mechanical and Aerospace - Science and Engineering*, **9**: 17-20.

Tarascon, J. M., dan Simon, P., 2015, *Energy Storage Batteries and Supercapacitors Set: Electrochemical Energy Storage Volume 1*, ISTE, United Kingdom.

Timur, S., Kantarli, C., Ikizoglu, E., dan Yanik, J., 2006, Preparation of Activated Carbons from Oreganum Stalks by Chemical Activation, *Energy and Fuels*, **20**(6): 2636-2641.

Torres, D. S., Shiraishi, S., Morallon, E., dan Cazorla-Amoros, D., 2015, Improvement of Carbon Materials Performance By Nitrogen Functional Groups in Electrochemical Capacitors in Organic Electrolyte at Severe Conditions, *Carbon*, **82**: 205-213.

Tzankova, D., Vladimirova, S., Peikova, L., dan Georgieva, 2018, Synthesis Of Pyrrole and Substituted Pyrroles (Review), *J. Chem. Technol. Metall.*, **53**(3): 451-464.

Volkov, A. G., Paula, S., dan Deamer, D. W., 1997, Two Mechanisms of Permeation of Small Neutral Molecules and Hydrated Ions Across Phospholipid Bilayers, *Bioelectrochem. Bioenerg.*, **42**(2): 153-160.

Wachid, M. R. dan Setiarso, P., 2014, *Pembuatan Elektroda Pasta Karbon Termodifikasi Bentonit untuk Analisis Ion Logam Tembaga(II) secara Cyclic Voltammetry Stripping*, Prosiding Seminar Nasional Kimia, Universitas Negeri Surabaya, Surabaya.

W[illegible] D. W., Li, F., Yin, L. C., Lu, X., Chen, Z. G., Gentle, I. R., Lu, G. Q., dan [illegible]heng, H. M., 2012, Nitrogen-Doped Carbon Monolith for Alkaline [illegible]upercapacitors and Understanding Nitrogen-Induced Redox Transitions, *[illegible]hem. Eur. J.*, **18**(17): 5345- 5351.

Wulandari, R., 2017, *Penentuan Kapasitansi Spesifik Karbon Aktif Tempurung Kemiri (Alleurites mollucana) Hasil Modifikasi dengan HNO_3, H_2SO_4, dan H_2O_2 menggunakan Metode Cyclic Voltammetry*, Skripsi tidak diterbitkan, Universitas Hasanuddin, Makassar.

Xianglan, Z., Yan, Z., Shuangsheng, W., JingJing, Z., dan Wei, Z., 2010, Effect of Activation Agents on The Surface Chemical Properties and Desulphurization Performance of Activated Carbon, *Sci. China Technol. Sc.*, **53**(9): 2515-2520.

Xie, B., Chen, Y., Yu, M., Shen, X., Lei, H., Xie, T., Zhang, Y., dan Wu, Y., 2015, Carboxyl-Assisted Synthesis of NitrogenDoped Graphene Sheets for Supercapacitor Applications, *Nanoscale Res. Lett.*, (**10**)332: 1-11.

Xing, Z., Ju, Z., Zhao, Y., Wan, J., Zhu, Y., Qiang, Y., dan Qian, Y., 2016, One-Pot Hydrothermal Synthesis of Nitrogen-Doped Graphene As High Performance Anode Materials For Lithium Ion Batteries, *Sci. Rep.*, **6**(26146): 1-10.

Xu, G., Dou, H., Geng, X., Han, J., Chen, L., dan Zhu, H., 2017, Free Standing Three-Dimensional Nitrogen-Doped Carbon Nanowire Array for High-Performance Supercapacitors, *Chem.Eng. J.*, **308**: 222-228.

Xue, Y., Liu, J., Chen, H., Wang, R., Li, D., Qu, J., dan Dai, L., 2012, Nitrogen-Doped Graphene Foams as Metal-Free Counter Electrodes in High-Performance Dye-Sensitized Solar Cells, *Angew. Chem.*, **51**(48): 12124-12127.

Yakout, S. M., dan El-Deen, G. S., 2016, Characterization Of Activated Carbon Prepared By Phosphoric Acid Activation Of Olive Stones, *Arab. J. Chem.*, **9**: 1155-1162.

Yan-fen, L., Shu-rong, W., dan Xiao-qian, M., 2004, Study O Reaction Mechanism In Cellulose Pyrolisis, *Prepr. Pap.-Am. Chem. Soc., Div. FuelChem.*, **49**(1): 407-411.

Yang, H., Yan, R., Chen, H., Lee, D. H., dan Zheng, C., 2007, Characteristics of Hemicellulose, Cellulose and Lignin Pyrolysis, *Fuel*, **86**(2): 1781-1788.

Yang, M. Guo, L., Hu, G., Hu, X., Xu, L., Chen, J., Dai, W., dan Fan, M., 2015, Highly Cost-Effective Nitrogen-Doped Porous Coconut Shell-Based CO_2 Sorbent Synthesized by Combining Ammoxidation with KOH Activation, *Environ. Sci. Technol.*, **49**(11): 7063-7070.

, dan Zhou, Z., 2017, Recent Breakthroughs in Supercapacitors Boosted y Nitrogen-Rich Porous Carbon Materials, *Advanced Sciences*, **4**(8): 1-).

Yang, Y., Bremner, S., Menictas, C., Kay, M., 2018, Battery Energy Storage System Size Determination in Renewable Energy Systems: A review, *Renew. Sust. Energy Rev.*, **91**: 109-125.

Yassine, M., dan Fabris, D., 2017, Performance of Commercially Available Supercapacitors, *Energies*, **10**(9): 1-12.

Yu, A., Chabot, V., dan Zhang, J., 2013, *Electrochemical Supercapasitor For Energy Storage And Delivery – Fundamental and Application*, CRC Press Traylor and Francis Group, Boca Ranton.

Yu, D., Nagelli, E., Du, F., dan Dai, L., 2010, Metal-Free Carbon Nanomaterials Become More Active than Metal Catalysts and Last Longer, *J. Phys. Chem. Lett.*, **1**(14): 2165-2173.

Yu, X., dan Manthiram, A., 2017, Electrochemical Energy Storage with Mediator-Ion Solid Electrolytes, *Joule*, **1**(3): 453-462.

Zhang, H., Yang, J., Hou, H., Chen, S., dan Yao, H., 2017, Nitrogen-Doped Carbon Paper with 3D Porous Structure As A Fexible Free-standing Anode For Lithium-ion Batteries, *Sci. Rep.*, **6**(7769): 1-9.

Zhang, Y., Zhang, Y., Huang, J., Du, D., Xing, W., dan Yan, Z., 2016, Enhanced Capacitive Performance of N-Doped Activated Carbon from Petroleum Coke by Combining Ammoxidation with KOH Activation, *Nanoscale Res. Lett.*, **11**(245): 1-7.

Zhang, Y. C., You, Y., Xin, S., Yin, Y. X., Zhang, J., Wang, P., Zheng, X. S., Cao, F. F., dan Guo, Y. G., 2016, Rice Husk-Derived Hierarchical Silicon /Nitrogen Doped Carbon/Carbon Nanotube Spheres as Low Cost and High-Capacity Anodes for Lithium-Ion Batteries, *Nano Energy*, **25**: 120-127.

Zhong, C., Deng, Y., Hu, W., Qiao, J., Zhang, L., dan Zhang, J., 2015, A review of Electrolyte Materials and Compositions For Electrochemical Supercapacitors, *Chem. Soc. Rev.*, **44**(21)**:** 7484 -7539.

Zuo, B. X., Wang, Y., Huang, X., and Lu, Y., 2018, Hierarchical N- and O-Doped Porous Carbon Composites for High-Performance Supercapacitors, *J. Nanomater.*, **2018**: 1-12.

Zuo, S., Yang, J., Liu, J., dan Cai, X., 2009, Significance Of The Carbonization Of Volatile Pyrolytic Products On The Properties Of Activated Carbons rom Phosphoric Acid Activation Of Lignocellulosic Material, *Fuel rocess.Technol.*, **90**(7): 994-1001.

LAMPIRAN

Lampiran 1. Diagram Alir Penelitian

1.1 Prosedur Umum

Tempurung Kemiri

- dibersihkan kotoran yang menempel pada tempurung dan dilanjutkan dengan pengeringan di bawah sinar matahari
- dikarbonisasi pada suhu 600 ^{o}C selama 1-2 jam
- dihaluskan dan diayak dengan ukuran 200 mesh

Karbon Tempurung Kemiri

- diaktivasi dengan larutan H_3PO_4 25 % dengan perbandingan 10:1 (volume H_3PO_4 : massa karbon)
- dicuci dengan akuades hingga pH netral
- dikeringkan dalam oven pada suhu 110 ^{o}C selama 2 jam

Karbon Aktif Tempurung Kemiri

- direndam dalam larutan NH_4OH 25 %, dengan perbandingan 10:1 (metode aminasi)
- direndam dalam larutan HNO_3 6 N dengan perbandingan 10:1 dilanjutkan dengan perendaman dalam larutan NH_4OH 25 %, dengan perbandingan 10:1 (metode praoksidasi-aminasi)

Nitrogen Doped Carbon

1.2 Analisis Kadar Air

Tempurung Kemiri

- ditimbang sebanyak 0.5 gram kedalam cawan porselin yang telah diketahui beratnya
- dikeringkan dalam oven pada suhu 105 ^{o}C selama 3 jam
- didinginkan dalam desikator, dan timbang bobotnya
- dimasukkan kembali ke dalam oven selama 15 menit dan dinginkan kembali dalam desikator hingga bobot konstan

Hasil

Catatan: diulangi prosedur yang sama dengan sampel lain seperti KTK, KATK, NDC 1 dan NDC 2

1.3 Analisis Kadar Abu

Tempurung Kemiri

- ditimbang sebanyak 0.5 gram kedalam cawan porselin yang telah diketahui beratnya
- dikeringkan dalam oven pada suhu 600 ^{o}C selama 6 jam
- didinginkan dalam desikator, dan timbang bobotnya
- dimasukkan kembali ke dalam oven selama 30 menit dan dinginkan kembali dalam desikator hingga bobot konstan

Hasil

Catatan: diulangi prosedur yang sama dengan sampel lain seperti KTK, KATK, NDC 1 dan NDC 2

1.4 Analisis Kadar Senyawa Volatil

Tempurung Kemiri

- ditimbang sebanyak 0.5 gram kedalam cawan porselin yang telah diketahui beratnya
- dikeringkan dalam oven pada suhu 800 ^{o}C selama 7 menit
- didinginkan dalam desikator, dan timbang bobotnya
- dimasukkan kembali ke dalam oven selama 5 menit dan dinginkan kembali dalam desikator hingga bobot konstan

Hasil

Catatan: diulangi prosedur yang sama dengan sampel lain seperti KTK, KATK, NDC 1 dan NDC 2

1.5 Analisis Luas Permukaan

Karbon Tempurung kemiri

- ditimbang sebanyak 0.3 gram dan dicampurkan dengan 25 mL larutan metilen biru 4600 ppm
- distirer selama 30 menit
- disaring dan diukur absorbansi filtrat pada pada λ 664 nm

Hasil

Catatan: diulangi prosedur yang sama dengan sampel lain seperti KATK, NDC 1 dan NDC 2

1.6 Analisis Gugus Fungsi dengan FTIR

Tempurung kemiri

- ditimbang sebanyak 1-10 mg sampel dan dihaluskan
- dicampur dengan 100 mg KBr dan dicetak menjadi cakram tipis atau pelet lalu dianalisis.

Hasil

Catatan: diulangi prosedur yang sama dengan sampel lain seperti KATK, NDC 1 dan NDC 2

1.7 Analisis Gugus Fungsi dengan Titrasi Boehm

Karbon Tempurung kemiri

- ditimbang sebanyak 0,1 gram dimasukkan ke dalam 4 buah gelas kimia yang berisi larutan Na_2CO_3 0,05 N, $NaHCO_3$ 0,05 N, NaOH 0,05 N dan HCl 0,05 N masing-masing sebanyak 25 mL
- didiamkan selama 24 jam dan disaring

Filtrat | Endapan

- dipipet sebanyak 5 mL dari larutan Na_2CO_3, $NaHCO_3$ dan NaOH, kemudian ditambahkan HCl 0.05 N berlebih, lalu ditirasi balik dengan menggunakan larutan NaOH 0,05 N.
- dipipet sebanyak 5 mL dari larutan HCl dan ditambahkan NaOH 0.05 N berlebih, kemudian dititrasi balik dengan menggunakan HCl 0,05 N.

sil

1.8 Analisis Morologi dengan SEM

Nitrogen-Doped Carbon

- ditempelkan pada sel holder dengan perekat ganda
- dilapisi dengan logam emas dalam keadaan vakum
- dimasukkan pada tempatnya di dalam SEM dan dianalisis

Hasil

1.9 Penentuan Kadar N dengan Metode Asidimetri

Filtrat Sintesis NDC

- dipipet sebanyak 1 mL dan diencerkan hingga 250 mL.
- dititrasi dengan larutan HCl 0.1 M.
- dicatat volume HCl yang digunakan saat titik ekuivalen. mol NH_4OH sebagai N yang terdeposisi adalah selisih antara NH_4OH awal dan NH_4OH sisa

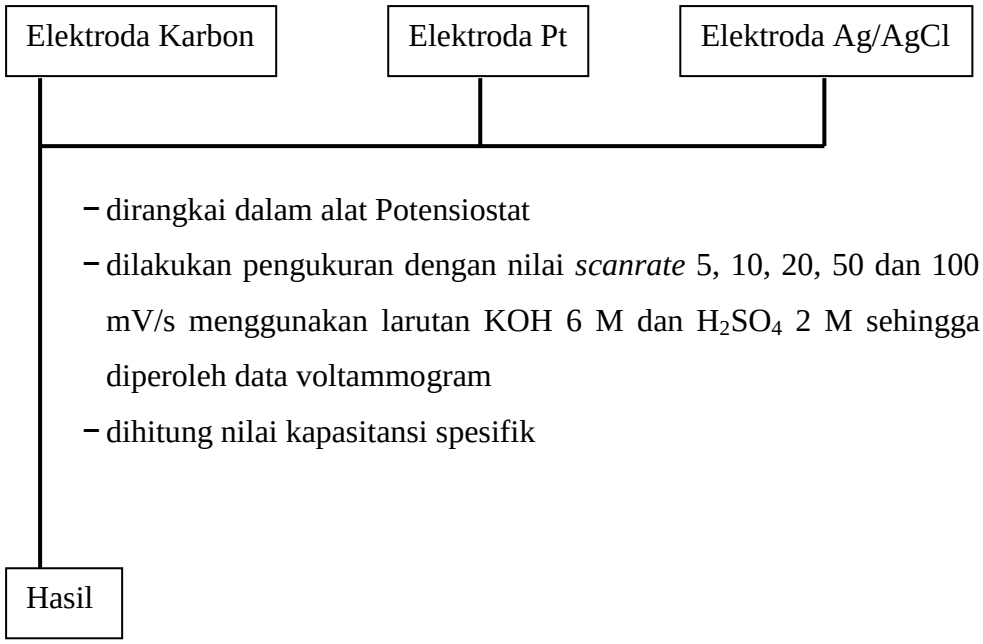
Hasil

1.10 Analisis Kapasitansi Spesifik

Karbon Aktif Tempurung Kemiri

- dicampur dengan karbon aktif komersial dan lilin paraffin dengan perbandingan 60 % : 10 % : 30 %.
- dipanaskan diatas *hotplate* dan diaduk hingga homogen
- dicetak dalam badan elektroda dan dikeringkan

ktroda Karbon

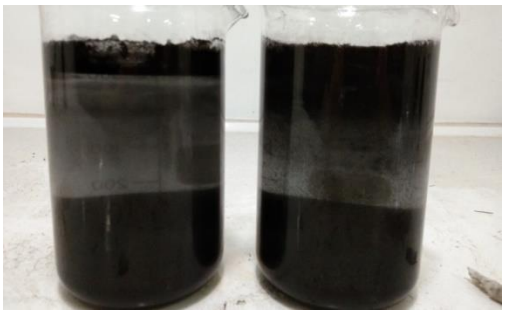


Lampiran 2. Dokumentasi Penelitian

Tempurung Kemiri

Karbon Tempurung Kemiri

Karbon Tempurung Kemiri ukuran 200 mesh



Aktivasi Karbon Tempurung Kemiri dengan H_3PO_4

Penyaringan Karbon Tempurung Kemiri teraktivasi H_3PO_4

Karbon Aktif Setelah Pengeringan pada suhu 105^{o}C selama 2 jam

Modifikasi Karbon Aktif Tempurung Kemiri dengan Larutan HNO_3 6 N

Sintesis NDC metode Aminasi dan Praoksidasi-Aminasi

Penyaringan sampel NDC metode Praoksidasi-Aminasi

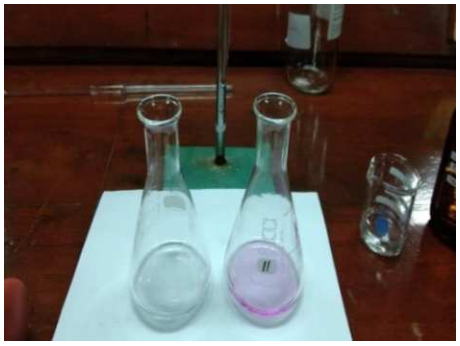
Penyaringan sampel NDC metode Aminasi

Analisis Kadar Air

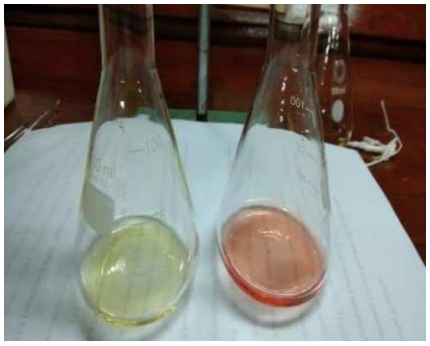
NDC yang telah dikeringkan pada suhu 105^{o}C selama 24 jam

Analisis Kadar Abu

Analisis Kadar Senyawa Volatil



Standarisasi NaOH dengan $H_2C_2O_4$



Standarisasi HCl dengan $Na_2B_4O_7$

Perendaman sampel pada Titrasi Boehm

Hasil Titrasi Boehm

Penentuan kadar NH_4OH pada Sintesis NDC (metode praoksidasi-aminasi)

Penentuan kadar NH_4OH pada Sintesis NDC (metode aminasi)

Elektroda karbon

Penentuan kapasitansi spesifik

Lampiran 3. Perhitungan Pembuatan Larutan Pereaksi

2.1 Pembuatan Larutan H_3PO_4 25% dari H_3PO_4 85%

$V_1 \times M_1 = V_2 \times M_2$

$V_1 \times 85\% = 250\ mL \times 25\%$

$V_1 = 73.5\ mL$

2.2 Pembuatan Larutan Na_2CO_3 0,05 N

gram = L × N × BE

gram = 0,25 L × 0,05 N × 106 g/eq = 1,3250 gram

2.3 Pembuatan Larutan $NaHCO_3$ 0,05 N

gram = L × N × BE

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

2.4 Pembuatan Larutan NaOH 0,05 N

gram = L × N × BE

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

2.5 Pembuatan Larutan HCl 0,05 N

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

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

$N = 12{,}06\ N$

$V_1 \times N_1 = V_2 \times N_2$

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

$V_1 = 1{,}03\ mL$

2.6 Pembuatan Larutan $Na_2B_4O_7$ 0,05 N

gram = L × N × BE

gram = 0,1 L × 0,05 N × 190,6 g/eq = 0,9530 gram

2.7 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

2.8 Pembuatan Larutan KOH 6 M

gram = L × M × BM

gram = 0,05 L × 6 M × 56 g/mol = 16.8 gram

2.9 Pembuatan Larutan H_2SO_4 1 M

$$M = \frac{\% \times bj \times 10}{BM}$$

$$M = \frac{98 \times 1{,}84\ g/mL \times 10}{98\ g/mol}$$

$$M = 18.4\ M$$

$V_1 \times M_1 = V_2 \times M_2$

$V_1 \times 18.4\ M = 50\ mL \times 2\ M$

$V_1 = 5.43\ mL = 5.5\ mL$

2.10 Pembuatan Larutan Metilen Biru 5000 ppm

mg metilen biru = 5000 ppm x 0,25 L

mg metilen biru = 1250 mg

2.11 Pembuatan Larutan Metilen Biru 50 ppm

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 500 \text{ ppm} = 100 \text{ mL} \times 50 \text{ ppm}$

$V_1 = 10 \text{ mL}$

2.12 Pembuatan Larutan Standar Metilen Biru 2, 4, 8, 16 dan 32 ppm

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 50 \text{ ppm} = 100 \text{ mL} \times 0.5 \text{ ppm}$

$V_1 = 1 \text{ mL}$

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 50 \text{ ppm} = 100 \text{ mL} \times 1 \text{ ppm}$

$V_1 = 2 \text{ mL}$

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 50 \text{ ppm} = 100 \text{ mL} \times 2 \text{ ppm}$

$V_1 = 4 \text{ mL}$

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 50 \text{ ppm} = 100 \text{ mL} \times 4 \text{ ppm}$

$V_1 = 8 \text{ mL}$

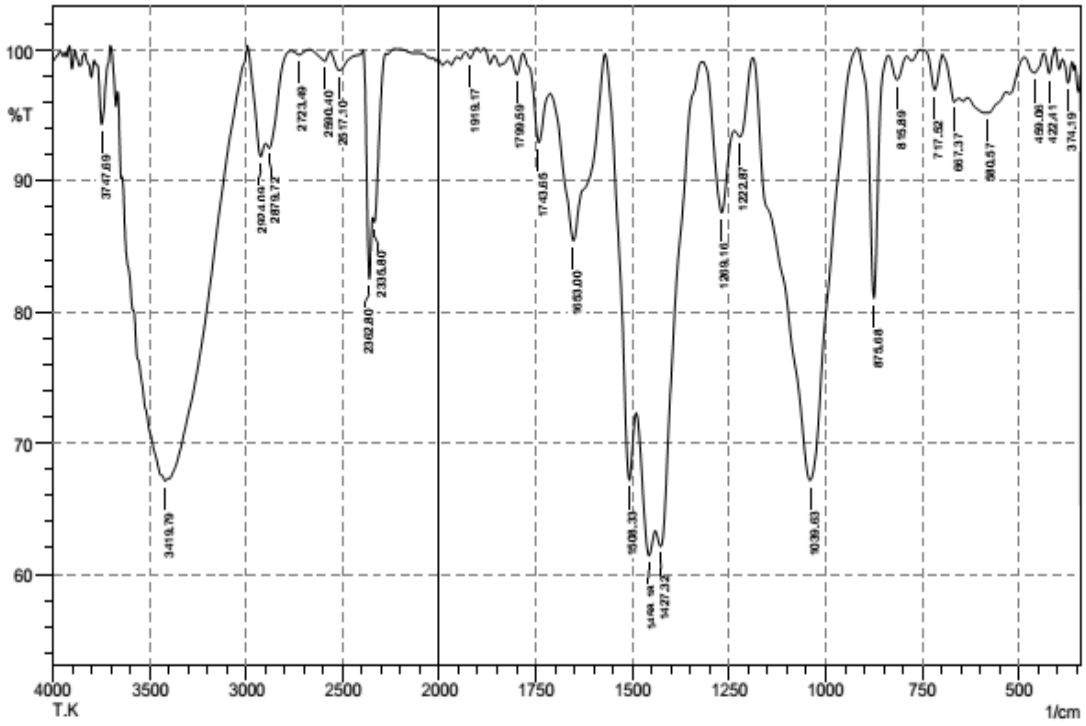
$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 50 \text{ ppm} = 100 \text{ mL} \times 8 \text{ ppm}$

$V_1 = 16 \text{ mL}$

Lampiran 4. Data Spektrum FTIR

1. Tempurung Kemiri



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	374.19	97.485	1.733	387.69	362.62	0.173	0.088
2	422.41	98.242	1.73	435.91	406.98	0.105	0.103
3	459.06	98.258	1.38	486.06	435.91	0.257	0.175
4	580.57	95.202	0.207	586.36	534.28	0.957	0.044
5	667.37	96.024	1.212	698.23	655.8	0.454	0.08
6	717.52	96.968	2.855	742.59	698.23	0.295	0.265
7	815.89	97.748	1.822	839.03	790.81	0.281	0.19
8	875.68	81.07	18.753	918.12	840.96	2.228	2.176
9	1039.63	67.172	32.628	1188.15	920.05	21.433	21.156
10	1222.87	93.402	2.077	1236.37	1190.08	0.942	0.271
11	1269.16	87.61	8.341	1315.45	1238.3	2.618	1.381
12	1427.32	62.152	5.292	1440.83	1323.17	10.809	0.769
13	1458.18	61.423	4.767	1490.97	1442.75	8.98	0.756
14	1508.33	67.176	10.544	1570.06	1492.9	6.926	1.442
15	1653	85.448	12.534	1712.79	1571.99	5.463	4.363
16	1743.65	92.964	5.032	1782.23	1714.72	1.128	0.583
17	1799.59	98.13	1.538	1816.94	1782.23	0.158	0.107
18	1919.17	99.385	0.604	1932.67	1903.74	0.036	0.036
19	2335.8	86.884	2.13	2345.44	2277.93	2.04	0.227
20	2362.8	82.541	8.898	2393.66	2347.37	2.317	0.895
21	2517.1	98.459	1.533	2567.25	2395.59	0.559	0.559
22	2590.4	99.159	0.836	2673.34	2567.25	0.171	0.177
23	2723.49	99.635	0.36	2767.85	2673.34	0.064	0.063
24	2879.72	92.529	1.406	2899.01	2769.78	2.086	0.278
25	2924.09	91.895	2.868	2991.59	2900.94	2.049	0.613
26	3419.79	67.138	1.418	3583.74	3402.43	26.701	2.353
27	3747.69	94.333	5.09	3772.76	3705.26	0.84	0.727

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No. of Scans;

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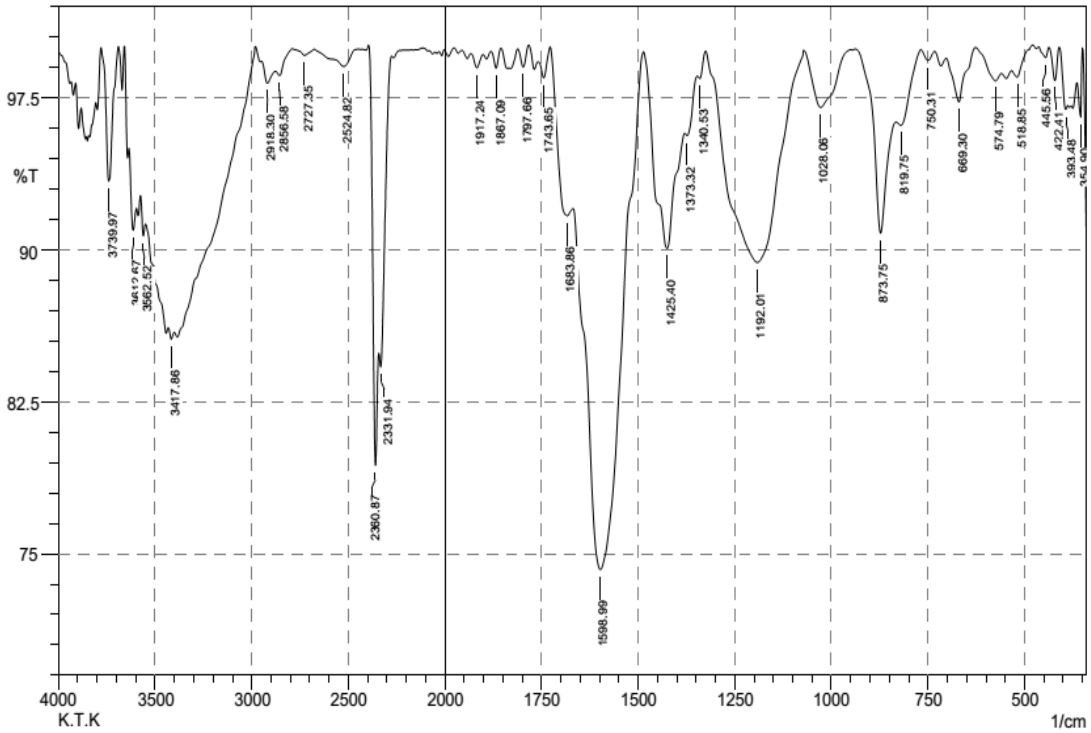
Apodization;

2. Karbon Tempurung Kemiri



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	354.9	96.561	2.933	364.55	351.04	0.137	0.085
2	393.48	96.949	0.709	410.84	389.62	0.167	0.034
3	422.41	98.362	1.659	437.84	410.84	0.089	0.091
4	445.56	99.5	0.516	462.92	437.84	0.03	0.032
5	518.85	98.542	0.679	534.28	489.92	0.173	0.053
6	574.79	98.354	0.656	626.87	559.36	0.282	0.093
7	669.3	97.307	2.403	704.02	626.87	0.439	0.351
8	750.31	99.364	0.493	769.6	732.95	0.064	0.041
9	819.75	96.155	0.832	831.32	769.6	0.606	0.111
10	873.75	90.83	6.89	937.4	833.25	1.889	1.015
11	1028.06	97.041	2.828	1070.49	950.91	0.838	0.772
12	1192.01	89.388	10.458	1325.1	1072.42	7.007	6.837
13	1340.53	98.461	0.46	1346.31	1325.1	0.092	0.018
14	1373.32	95.639	0.624	1379.1	1346.31	0.451	0.042
15	1425.4	90.079	7.384	1485.19	1381.03	2.959	1.908
16	1598.99	74.224	20.716	1666.5	1487.12	13.344	10.052
17	1683.86	91.687	2.477	1726.29	1668.43	1.596	0.516
18	1743.65	98.516	1.149	1759.08	1728.22	0.119	0.074
19	1797.66	99.024	0.993	1811.16	1782.23	0.058	0.061
20	1867.09	98.988	0.91	1880.6	1855.52	0.059	0.047
21	1917.24	98.988	0.686	1932.67	1901.81	0.088	0.044
22	2331.94	84.241	2.887	2341.58	2277.93	2.391	0.302
23	2360.87	79.369	10.801	2393.66	2343.51	2.906	1.106
24	2524.82	99.053	0.864	2677.2	2449.6	0.482	0.401
25	2727.35	99.611	0.314	2789.07	2677.2	0.106	0.069
26	2856.58	98.607	0.475	2877.79	2789.07	0.288	0.045
27	2918.3	98.229	0.869	2949.16	2877.79	0.418	0.127
28	3417.86	85.605	0.453	3431.36	3402.43	1.922	0.033
29	3562.52	90.706	1.221	3576.02	3550.95	0.989	0.072
30	3612.67	90.982	2.294	3633.89	3597.24	1.323	0.239
31	3739.97	93.395	5.409	3778.55	3712.97	1.015	0.712

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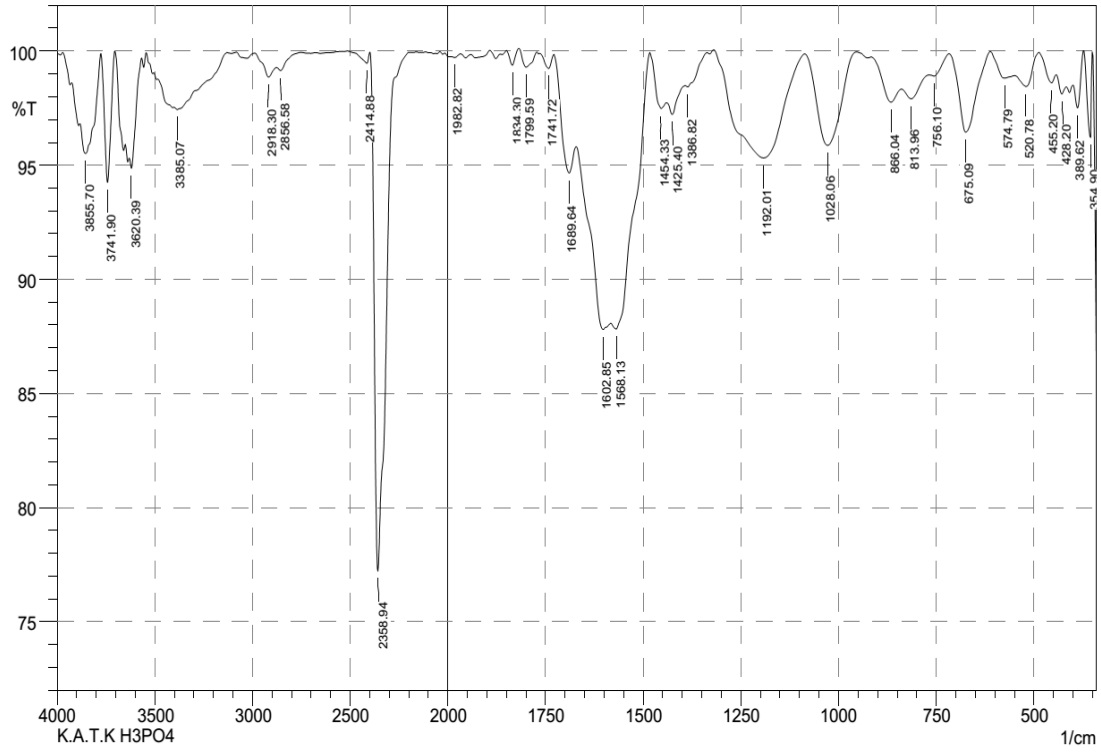
3. Karbon Aktif Tempurung Kemiri



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	354.9	96.216	3.768	374.19	351.04	0.189	0.189
2	389.62	97.519	1.644	401.19	374.19	0.192	0.106
3	428.2	98.118	0.546	443.63	416.62	0.184	0.031
4	455.2	98.61	0.615	487.99	443.63	0.164	0.059
5	520.78	98.456	0.95	549.71	487.99	0.28	0.128
6	574.79	98.818	0.54	611.43	549.71	0.229	0.082
7	675.09	96.454	3.471	717.52	613.36	0.772	0.742
8	756.1	98.911	0.264	767.67	717.52	0.159	0.033
9	813.96	97.911	0.644	839.03	767.67	0.514	0.092
10	866.04	97.767	1.063	916.19	839.03	0.49	0.166
11	1028.06	95.874	4.041	1085.92	954.76	1.223	1.178
12	1192.01	95.325	4.629	1317.38	1087.85	2.817	2.779
13	1386.82	98.437	0.206	1392.61	1336.67	0.224	0.032
14	1425.4	97.228	0.749	1440.83	1392.61	0.456	0.057
15	1454.33	97.484	0.956	1483.26	1440.83	0.32	0.104
16	1568.13	87.826	1.9	1581.63	1485.19	3.398	0.764
17	1602.85	87.805	1.997	1670.35	1583.56	3.619	0.39
18	1689.64	94.652	2.416	1728.22	1672.28	0.9	0.347
19	1741.72	99.239	0.64	1764.87	1728.22	0.069	0.051
20	1799.59	99.3	0.755	1818.87	1772.58	0.079	0.088
21	1834.3	99.39	0.684	1849.73	1818.87	0.035	0.045
22	1982.82	99.729	0.075	1992.47	1969.32	0.023	0.004
23	2358.94	77.219	22.717	2397.52	2202.71	6.951	6.903
24	2414.88	99.464	0.506	2513.25	2399.45	0.105	0.098
25	2856.58	99.149	0.251	2877.79	2754.35	0.216	0.011
26	2918.3	98.863	0.651	2989.66	2877.79	0.329	0.134
27	3385.07	97.442	0.256	3402.43	3130.47	1.819	0.331
28	3620.39	94.867	1.149	3630.03	3570.24	0.77	0.136
29	3741.9	94.25	5.686	3776.62	3707.18	0.889	0.87
30	3855.7	95.516	2.092	3882.71	3778.55	1.489	0.739

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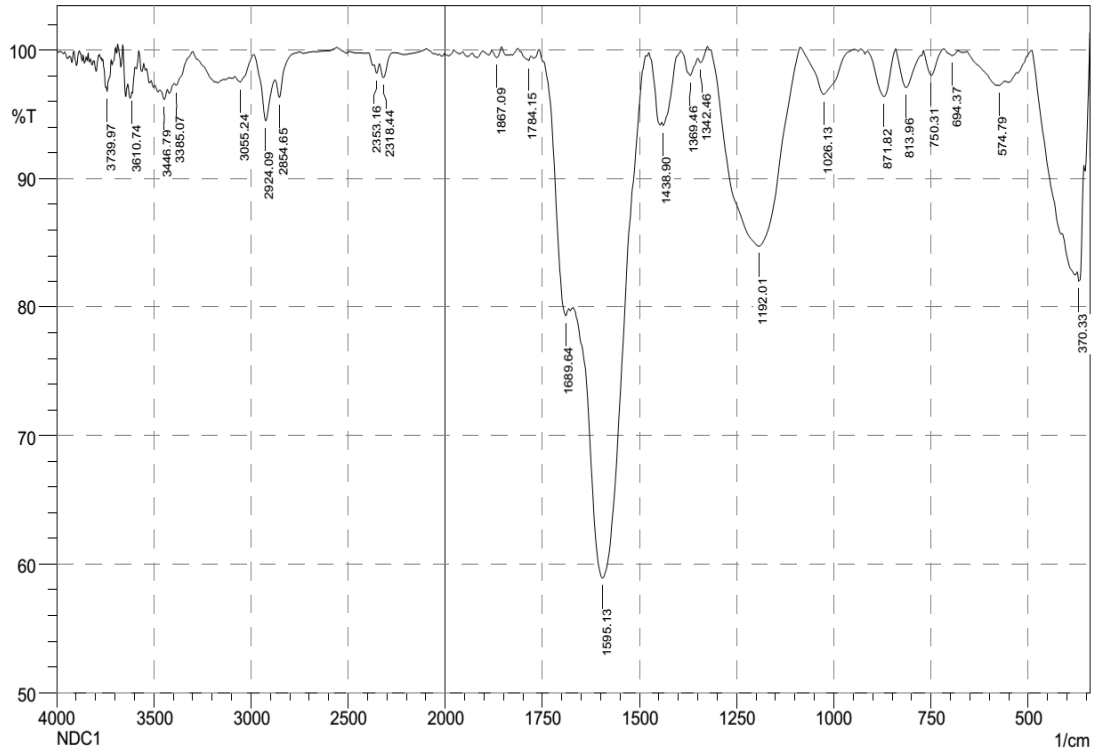
Apodization;

4. NDC 1 (NDC Metode Aminasi)



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	370.33	82.029	2.58	374.19	356.83	1.229	0.202
2	574.79	97.245	0.124	580.57	559.36	0.244	0.005
3	694.37	99.596	0.423	717.52	680.87	0.034	0.04
4	750.31	98.052	1.985	769.6	717.52	0.218	0.229
5	813.96	97.102	2.796	840.96	775.38	0.463	0.421
6	871.82	96.404	3.56	912.33	842.89	0.598	0.584
7	1026.13	96.586	3.556	1085.92	947.05	0.918	0.997
8	1192.01	84.748	15.373	1315.45	1087.85	9.835	9.947
9	1342.46	99.052	0.615	1350.17	1325.1	0.056	0.039
10	1369.46	98.014	1.614	1394.53	1350.17	0.219	0.155
11	1438.9	94.126	0.717	1442.75	1394.53	0.637	0.09
12	1595.13	58.935	29.005	1670.35	1485.19	24.018	14.954
13	1689.64	79.32	2.907	1745.58	1681.93	3.652	0.486
14	1784.15	99.188	0.436	1805.37	1778.37	0.064	0.032
15	1867.09	99.442	0.708	1880.6	1855.52	0.031	0.046
16	2318.44	97.866	1.312	2337.72	2264.43	0.357	0.161
17	2353.16	98.219	0.69	2366.66	2337.72	0.182	0.044
18	2854.65	96.336	1.718	2875.86	2750.49	0.728	0.177
19	2924.09	94.498	4.05	2983.88	2877.79	1.451	0.825
20	3055.24	97.526	0.904	3082.25	2985.81	0.708	0.213
21	3385.07	97.271	0.408	3394.72	3302.13	0.597	0.071
22	3446.79	96.168	0.761	3468.01	3431.36	0.557	0.061
23	3610.74	96.634	0.352	3612.67	3597.24	0.165	0.01
24	3739.97	96.793	0.61	3745.76	3734.19	0.146	0.014

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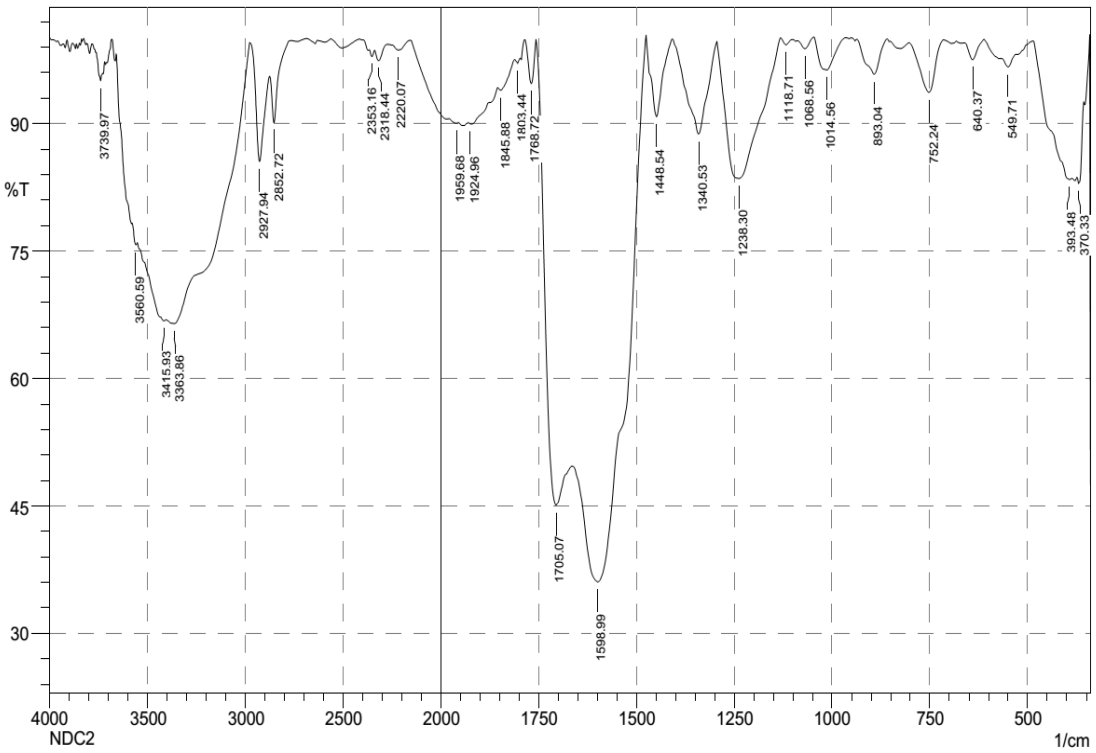
Resolution;
Apodization;

5. NDC 2 (NDC Metode Praoksidasi-Aminasi)



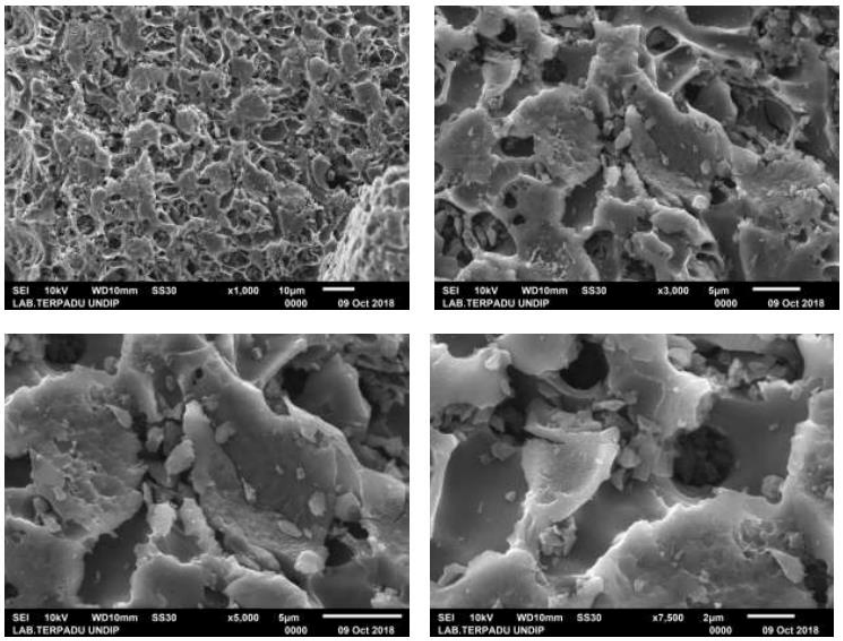
	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	370.33	82.958	1.691	372.26	356.83	0.964	0.147
2	393.48	83.426	1.118	484.13	387.69	4.877	0.986
3	549.71	96.703	1.234	569	530.42	0.448	0.099
4	640.37	97.548	2.164	661.58	611.43	0.276	0.221
5	752.24	93.704	6.03	802.39	715.59	1.23	1.123
6	893.04	95.849	4.119	935.48	860.25	0.746	0.735
7	1014.56	96.337	3.837	1045.42	966.34	0.678	0.734
8	1068.56	98.842	1.155	1089.78	1047.35	0.105	0.104
9	1118.71	99.309	0.738	1132.21	1101.35	0.045	0.049
10	1238.3	83.569	16.291	1294.24	1132.21	7.297	7.249
11	1340.53	88.817	10.841	1408.04	1296.16	2.976	2.836
12	1448.54	90.834	9.389	1475.54	1409.96	1.317	1.365
13	1598.99	36.085	31.114	1664.57	1477.47	54.988	26.721
14	1705.07	45.096	26.182	1755.22	1666.5	22.274	8.39
15	1768.72	94.711	5.218	1786.08	1757.15	0.36	0.351
16	1803.44	97.094	0.552	1811.16	1797.66	0.155	0.015
17	1845.88	93.958	0.881	1853.59	1811.16	0.874	0.115
18	1924.96	89.981	0.374	1928.82	1855.52	2.799	0.221
19	1959.68	90.072	0.145	1978.97	1955.82	1.033	0.014
20	2220.07	98.693	0.037	2249	2218.14	0.139	0.002
21	2318.44	97.436	1.435	2339.65	2272.15	0.482	0.189
22	2353.16	97.926	0.752	2366.66	2339.65	0.203	0.047
23	2852.72	90.125	6.371	2875.86	2765.92	1.873	0.808
24	2927.94	85.57	12.028	2976.16	2877.79	3.481	2.401
25	3363.86	66.481	3.549	3404.36	2978.09	50.031	12.631
26	3415.93	66.822	0.223	3433.29	3406.29	4.709	0.026
27	3560.59	75.742	0.979	3577.95	3552.88	2.927	0.09
28	3739.97	95.048	1.295	3763.12	3734.19	0.466	0.099

Date/Time; 9/27/2018 12:39:48 PM
No. of Scans;
Resolution;
Apodization;

Lampiran 5. Hasil SEM material NDC 1 dan NDC 2

KEMENTERIAN RISET TEKNOLOGI DAN PENDIDIKAN TINGGI
UNIVERSITAS DIPONEGORO
UPT LABORATORIUM TERPADU
Jalan Prof. Soedarto, SH Tembalang Semarang Kotak Pos 1269
Telepon (024) 76918147- Faksimile (024) 76918148, Website : http://labterpadu.undip.ac.id;
E-mail : labterpadu@live.undip.ac.id

Hasil Uji Citra SEM sbb:
NDC 1



KEMENTERIAN RISET TEKNOLOGI DAN PENDIDIKAN TINGGI
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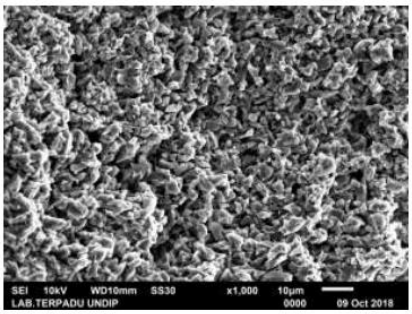
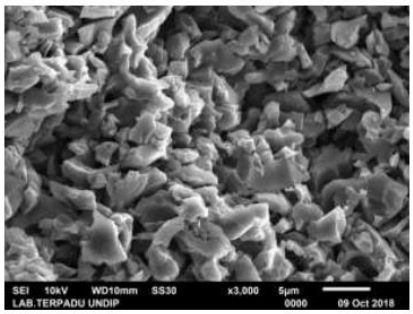
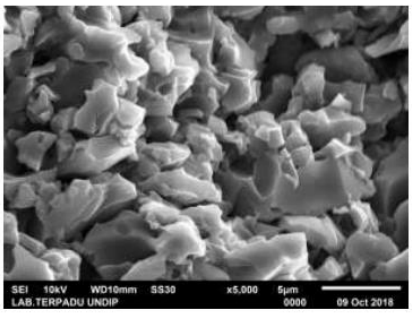
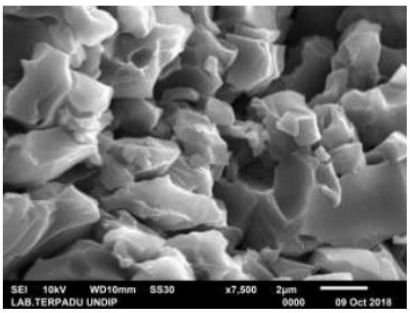
E-mail : labterpadu@live.undip.ac.id

Hasil Uji Citra SEM sbb:
NDC 2









Lampiran 6. Perhitungan Kadar Air

a. Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat uap air (B – C)	Barat awal sampel (B – A)	Kadar Air (%)
1	34.8915	35.4017	35.3885	35.3830	35.3781	35.3832	0.0185	0.5102	3.6260
2	43.5348	44.0354	44.0173	44.0160	44.0152	44.0161	0.0193	0.5006	3.8553
3	45.7465	46.2481	46.2310	46.2290	46.2278	46.2292	0.0189	0.5016	3.7679
Rata-rata Kadar Air									3.7497

$$\text{Kadar air (\%)} = \frac{\text{berat uap air}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0185\ \text{gram}}{0.5102\ \text{gram}} \times 100\ \% = 3.6260\ \%$$

b. Karbon Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat uap air (B – C)	Barat awal sampel (B – A)	Kadar Air (%)
1	46.6672	47.1676	47.1548	47.1533	47.1517	47.1533	0.0143	0.5004	2.8577
		48.4636	48.4520	48.4504	48.4488	48.4504	0.0132	0.5008	2.6358
		35.9867	35.9766	35.9734	35.971	35.9737	0.0130	0.5004	2.5979
Rata-rata Kadar Air									2.6971

$$\text{Kadar air (\%)} = \frac{\text{berat uap air}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0143\ \text{gram}}{0.5004\ \text{gram}} \times 100\ \% = 2.8577\ \%$$

c. Karbon Aktif Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat uap air (B – C)	Barat awal sampel (B – A)	Kadar Air (%)
1	45.2478	45.7479	45.7399	45.7397	45.7389	45.7395	0.0084	0.5001	1.6796
2	46.942	47.4437	47.4431	47.4313	47.4308	47.4351	0.0086	0.5017	1.7141
3	51.061	51.5622	51.5616	51.5523	51.5508	51.5549	0.0073	0.5012	1.4565
Rata-rata Kadar Air									1.6167

$$\text{Kadar air (\%)} = \frac{\text{berat uap air}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0084\ \text{gram}}{0.5001\ \text{gram}} \times 100\ \% = 1.6796\ \%$$

d. NDC 1

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat uap air (B – C)	Barat awal sampel (B – A)	Kadar Air (%)
1	45.7597	45.8601	45.8586	45.8580	45.8575	45.8580	0.0021	0.1004	2.0916
	2	43.6896	43.6886	43.6870	43.6867	43.6874	0.0022	0.1004	2.1912
	2	44.4410	44.4400	44.4386	44.4382	44.4389	0.0021	0.1008	2.0833
Rata-rata Kadar Air									2.1220

$$\text{Kadar air (\%)} = \frac{\text{berat uap air}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0021\ \text{gram}}{0.1004\ \text{gram}} \times 100\ \% = 2.0916\ \%$$

e. NDC 2

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat uap air (B – C)	Barat awal sampel (B – A)	Kadar Air (%)
1	46.6611	46.7618	46.7601	46.7595	46.759	46.7595	0.0023	0.1007	2.2840
2	35.487	35.5877	35.586	35.5855	35.585	35.5855	0.0022	0.1007	2.1847
3	43.59	43.6906	43.6897	43.6883	43.6862	43.6881	0.0025	0.1006	2.4851
Rata-rata Kadar Air									2.3179

$$\text{Kadar air (\%)} = \frac{\text{berat uap air}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0023\ \text{gram}}{0.1007\ \text{gram}} \times 100\ \% = 2.2840\ \%$$

Lampiran 7. Perhitungan Kadar Abu

a. Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat Abu (C – A)	Berat Awal Sampel (B – A)	Kadar Abu (%)
1	21.4563	21.9739	21.4907	21.4863	21.4863	21.4878	0.0315	0.5176	6.0858
2	21.0700	21.5718	21.1056	21.1006	21.0992	21.1018	0.0318	0.5018	6.3372
3	21.4560	21.9582	21.4934	21.4920	21.486	21.4905	0.0345	0.5022	6.8697
Rata-rata Kadar Abu									6.4309

$$\text{Kadar abu (\%)} = \frac{\text{berat abu}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0314\ \text{gram}}{0.5176\ \text{gram}} \times 100\ \% = 6.0793\ \%$$

b. Karbon Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat Abu (C – A)	Berat Awal Sampel (B – A)	Kadar Abu (%)
1	21.07	21.5702	21.1294	21.1211	21.1199	21.1235	0.0535	0.5002	10.6957
[illegible]	[illegible]	21.6345	21.1809	21.1793	21.1734	21.1779	0.0437	0.5003	8.7347
[illegible]	[illegible]	22.8092	22.3638	22.3568	22.3539	22.3582	0.0510	0.5020	10.1594
Rata-rata Kadar Abu									9.8633

$$\text{Kadar abu (\%)} = \frac{\text{berat abu}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0535\ \text{gram}}{0.5002\ \text{gram}} \times 100\ \% = 10.6957\ \%$$

c. Karbon Aktif Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat Abu (C – A)	Berat Awal Sampel (B – A)	Kadar Abu (%)
1	22.3073	22.8087	22.3138	22.3137	22.3138	22.3138	0.0065	0.5014	1.2964
2	22.3864	22.8873	22.3899	22.3886	22.3878	22.3888	0.0024	0.5009	0.4791
3	26.696	27.201	26.7026	26.7018	26.702	26.7021	0.0061	0.505	1.2079
Rata-rata Kadar Abu									0.9945

$$\text{Kadar abu (\%)} = \frac{\text{berat abu}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0065\ \text{gram}}{0.5014\ \text{gram}} \times 100\ \% = 1.2964\ \%$$

d. NDC 1

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat Abu (C – A)	Berat Awal Sampel (B – A)	Kadar Abu (%)
1	25.4037	25.5058	25.4047	25.4043	25.4042	25.4044	0.0007	0.1021	0.6856
		21.154	21.0547	21.0543	21.0542	21.0544	0.0009	0.1005	0.8955
		24.7227	24.6196	24.6193	24.6193	24.6194	0.0009	0.1042	0.8637
Rata-rata Kadar Abu									0.8149

$$\text{Kadar abu (\%)} = \frac{\text{berat abu}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0007\ \text{gram}}{0.1021\ \text{gram}} \times 100\ \% = 0.6856\ \%$$

e. NDC 2

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat Abu (C – A)	Berat Awal Sampel (B – A)	Kadar Abu (%)
1	21.0525	21.1531	21.0532	21.0526	21.0526	21.0528	0.0003	0.1006	0.2982
2	26.6736	26.775	26.6742	26.6737	26.6737	26.6739	0.000266667	0.1014	0.2958
3	24.6186	24.7198	24.6192	24.6188	24.6187	24.6189	0.0003	0.1012	0.2964
Rata-rata Kadar Abu									0.2968

$$\text{Kadar abu (\%)} = \frac{\text{berat abu}}{\text{berat awal sampel}} \times 100\ \% = \frac{0.0003\ \text{gram}}{0.1006\ \text{gram}} \times 100\ \% = 0.2982\ \%$$

Lampiran 8. Perhitungan Kadar Senyawa Volatil

a. Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat volatil (C – A)	B - A	Kadar Volatil (%)
1	26.6935	27.1948	26.7775	26.7397	26.7298	26.7490	0.0555	0.5013	11.0712
2	21.4568	21.9569	21.5511	21.5127	21.4945	21.5194	0.0626	0.5001	12.5175
3	21.1355	21.6360	21.2349	21.1847	21.1689	21.1962	0.0607	0.5005	12.1278
Rata-rata Kadar Volatil									11.9055

$$\text{Kadar Volatil (\%)} = \left(\frac{\text{berat volatil}}{\text{berat awal sampel}} \text{ x } 100\ \% \right)$$

$$\text{Kadar Volatil (\%)} = \left(\frac{0.0555 \text{ gram}}{0.5013 \text{ gram}} \text{ x } 100\ \% \right)$$

Kadar Volatil (%) = 11.0712 %

b. Karbon Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat volatil (C – A)	B - A	Kadar Volatil (%)
1	26.6970	27.1973	26.8985	26.7656	26.7352	26.7998	0.1028	0.5003	20.5476
2	21.4360	21.9364	21.6578	21.5190	21.4728	21.5499	0.1139	0.5004	22.7617
3	22.3080	22.8093	22.5175	22.3849	22.3472	22.4165	0.1085	0.5013	21.6437
Rata-rata Kadar Volatil									21.6510

$$\text{Kadar Volatil (\%)} = \left(\frac{\text{berat volatil}}{\text{berat awal sampel}} \text{ x } 100\ \% \right)$$

$$\text{Kadar Volatil (\%)} = \left(\frac{0.1027 \text{ gram}}{0.5003 \text{ gram}} \text{ x } 100\ \% \right)$$

Kadar Volatil (%) = 20.5476 %

c. Karbon Aktif Tempurung Kemiri

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat volatil (C – A)	B - A	Kadar Volatil (%)
1	21.0624	21.5633	21.3359	21.2868	21.1783	21.267	0.2046	0.5009	40.8464
2	22.3088	22.8096	22.5704	22.5139	22.4158	22.5000	0.1912	0.5008	38.1789
3	22.3064	22.8071	22.5745	22.5276	22.4141	22.5054	0.1990	0.5007	39.7443
Rata-rata Kadar Volatil									39.5899

$$\text{Kadar Volatil (\%)} = \left(\frac{\text{berat volatil}}{\text{berat awal sampel}} \text{ x } 100\ \% \right)$$

$$\text{Kadar Volatil (\%)} = \left(\frac{0.2046 \text{ gram}}{0.5009 \text{ gram}} \text{ x } 100\ \% \right)$$

Kadar Volatil (%) = 40.8464 %

d. NDC 1

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat volatil (C – A)	B - A	Kadar Volatil (%)
1	21.0536	21.1538	21.0544	21.0541	21.0540	21.0542	0.0006	0.1002	0.5988
2	24.6178	24.7182	24.6183	24.618	24.6178	24.6180	0.0002	0.1004	0.1992
3	25.5046	25.6047	25.5052	25.5047	25.5046	25.5048	0.0002	0.1001	0.1998
Rata-rata Kadar Volatil									0.3326

$$\text{Kadar Volatil (\%)} = \left(\frac{\text{berat volatil}}{\text{berat awal sampel}} \text{ x } 100\ \% \right)$$

$$\text{Kadar Volatil (\%)} = \left(\frac{0.0005 \text{ gram}}{0.1002 \text{ gram}} \text{ x } 100\ \% \right)$$

Kadar Volatil (%) = 0.5988 %

e. NDC 2

No	Berat Kosong Cawan (A)	Berat Cawan + Sampel (B)	Berat Akhir Penimbangan I	Berat Akhir Penimbangan II	Berat Akhir Penimbangan III	Rata-rata Berat Akhir (C)	Berat volatil (C – A)	B - A	Kadar Volatil (%)
1	26.6737	26.7773	26.6742	26.6738	26.6738	26.6739	0.0002	0.1036	0.1930
2	24.6183	24.719	24.6186	24.6184	24.6183	24.6184	0.0001	0.1007	0.0993
3	21.0539	21.154	21.0541	21.0540	21.0540	21.0540	0.000133333	0.1001	0.0999
Rata-rata Kadar Volatil									0.1307

$$\text{Kadar Volatil (\%)} = \left(\frac{\text{berat volatil}}{\text{berat awal sampel}} \text{ x } 100\ \% \right)$$

$$\text{Kadar Volatil (\%)} = \left(\frac{0.0002 \text{ gram}}{0.1036 \text{ gram}} \text{ x } 100\ \% \right)$$

Kadar Volatil (%) = 0.1930 %

Lampiran 9. Perhitungan Kadar Karbon Tetap

Sampel	Kadar Air	Kadar Abu	Kadar Volatil	Kadar Karbon Tetap
T.K	3.7497	6.4309	11.9035	77.9159
K.T.K	2.6971	9.8633	21.6510	65.7886
K.A.T.K	1.6167	0.9945	39.5899	57.7989
NDC 1	2.1220	0.8149	0.3326	96.7305
NDC 2	2.3179	0.2968	0.1307	97.2546

a. Tempurung Kemiri

Karbon tetap (%) = 100 % - (kadar air + kadar abu + zat menguap) %

Karbon tetap (%) = 100 % - (3.7497 + 6.4309 + 11.9035) %

Karbon tetap (%) = 77.9159 %

b. Karbon Tempurung Kemiri

Karbon tetap (%) = 100 % - (kadar air + kadar abu + zat menguap) %

Karbon tetap (%) = 100 % - (2.6971 + 9.8633 + 21.6510) %

on tetap (%) = 65.7886 %

c. Karbon Aktif Tempurung Kemiri

Karbon tetap (%) = 100 % - (kadar air + kadar abu + zat menguap) %

Karbon tetap (%) = 100 % - (1.6167 + 0.9945 + 39.5899) %

Karbon tetap (%) = 57.7989 %

d. NDC 1

Karbon tetap (%) = 100 % - (kadar air + kadar abu + zat menguap) %

Karbon tetap (%) = 100 % - (2.1220 + 0.8149 + 0.3326) %

Karbon tetap (%) = 96.7305 %

e. NDC 2

Karbon tetap (%) = 100 % - (kadar air + kadar abu + zat menguap) %

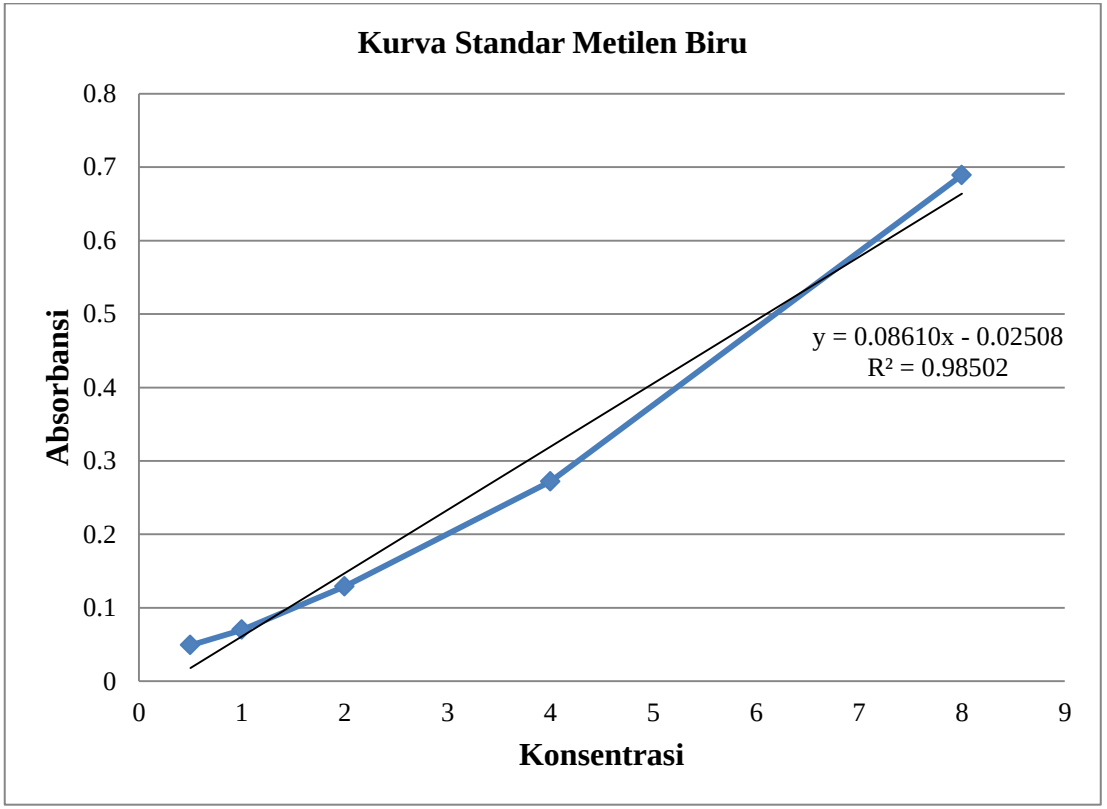
Karbon tetap (%) = 100 % - (2.3179 + 0.2968 + 0.1307) %

Karbon tetap (%) = 97.2546 %

Lampiran 10. Perhitungan Luas Permukaan dengan Metode Adsorpsi Metilen Biru

Penentuan Persamaan Regresi

Konsentrasi	Absorbansi
0.5	0.049
1	0.07
2	0.129
4	0.272
8	0.689



Penentuan konsentrasi awal metilen biru (C_0)

y = 0.0861 x - 0.02508

1.56 = 0.0861 x - 0.02508

x = 4602.4390 ppm

a. Karbon Tempurung Kemiri

Absorbansi	Faktor Pengenceran	Ce (mg/L)	Co (mg/L)	Volume Larutan (L)	Massa karbon (g)	Xm (mg/g)	S (m^2/g)
1.76	100	2073.2636	4602.4390	0.0250	0.3004	210.4839	778.8495
1.76	100	2073.2636	4602.4390	0.0250	0.3019	209.4382	774.9801
1.76	100	2073.2636	4602.4390	0.0250	0.3052	207.1736	766.6005
Rata - rata Luas Permukaan							**773.4767**

$$X_m = \frac{(C_o - C_e) \text{ x Volume Larutan}}{\text{massa karbon aktif}} = \frac{(4602.439 \text{ ppm} - 2073.263647 \text{ ppm}) \text{ x } 0.025 \text{ L}}{0.3004 \text{ gram}} = 210.4839 \ {}^{mg}/_{g}$$

$$S = \frac{X_m \,.\, N \,.\, a}{Mr} = \frac{210.4839 \ {}^{mg}/_{g} \text{ x } 6.02 \text{ x } 10^{23} \text{ mol}^{-1} \,.\, 197 \text{ x } 10^{-20} \text{ m}^2}{320{,}5 \ {}^{g}/_{mol}} = 778.8495 \ {}^{m^2}/_{g}$$

b. Karbon Aktif Tempurung Kemiri

Absorbansi	Faktor Pengenceran	Ce (mg/L)	Co (mg/L)	Volume Larutan (L)	Massa karbon (g)	Xm (mg/g)	S (m^2/g)
1.7	100	2003.5772	4602.4390	0.0250	0.3015	215.4943	797.3892
1.7	100	2003.5772	4602.4390	0.0250	0.3019	215.2088	796.3330
1.7	100	2003.5772	4602.4390	0.0250	0.3020	215.1376	796.0695
Rata - rata Luas Permukaan							**796.5972**

$$X_m = \frac{(C_o - C_e) \text{ x Volume Larutan}}{\text{massa karbon aktif}} = \frac{(4602.439 \text{ ppm} - 2003.5772 \text{ ppm}) \text{ x } 0.025 \text{ L}}{0.3015 \text{ gram}} = 215.4943 \ {}^{mg}/_{g}$$

$$S = \frac{X_m \,.\, N \,.\, a}{Mr} = \frac{215.4943 \ {}^{mg}/_{g} \text{ x } 6.02 \text{ x } 10^{23} \text{ mol}^{-1} \,.\, 197 \text{ x } 10^{-20} \text{ m}^2}{320{,}5 \ {}^{g}/_{mol}} = 797.3892 \ {}^{m^2}/_{g}$$

c. NDC 1

Absorbansi	Faktor Pengenceran	Ce (mg/L)	Co (mg/L)	Volume Larutan (L)	Massa karbon (g)	Xm (mg/g)	S (m^2/g)
1.68	100	1980.3484	4602.4390	0.0250	0.3026	216.6301	801.5922
1.68	100	1980.3484	4602.4390	0.0250	0.3035	215.9877	799.2151
.68	100	1980.3484	4602.4390	0.0250	0.3040	215.6324	797.9004
Rata - rata Luas Permukaan							**799.5692**

$$X_m = \frac{(C_o - C_e) \text{ x Volume Larutan}}{\text{massa karbon aktif}} = \frac{(4602.439 \text{ ppm} - 1980.3484 \text{ ppm}) \text{ x } 0.025 \text{ L}}{0.3024 \text{ gram}} = 216.6301 \ {}^{mg}/_{g}$$

$$S = \frac{X_m \,.\, N \,.\, a}{Mr} = \frac{216.6301 \ {}^{mg}/_{g} \text{ x } 6.02 \text{ x } 10^{23} \text{ mol}^{-1} \,.\, 197 \text{ x } 10^{-20} \text{ m}^2}{320{,}5 \ {}^{g}/_{mol}} = 801.5922 \ {}^{m^2}/_{g}$$

d. NDC 2

Absorbansi	Faktor Pengenceran	Ce (mg/L)	Co (mg/L)	Volume Larutan (L)	Massa karbon (g)	Xm (mg/g)	S (m^2/g)
1.66	100	1957.1196	4602.4390	0.0250	0.3021	218.9109	810.0318
1.66	100	1957.1196	4602.4390	0.0250	0.3022	218.8385	809.7639
1.66	100	1957.1196	4602.4390	0.0250	0.3046	217.1142	803.3835
Rata - rata Luas Permukaan							**807.7264**

$$X_m = \frac{(C_o - C_e) \text{ x Volume Larutan}}{\text{massa karbon aktif}} = \frac{(4602.439 \text{ ppm} - 1957.1196 \text{ ppm}) \text{ x } 0.025 \text{ L}}{0.3024 \text{ gram}} = 218.9109 \ {}^{mg}/_{g}$$

$$S = \frac{X_m \,.\, N \,.\, a}{Mr} = \frac{218.9109 \ {}^{mg}/_{g} \text{ x } 6.02 \text{ x } 10^{23} \text{ mol}^{-1} \,.\, 197 \text{ x } 10^{-20} \text{ m}^2}{320{,}5 \ {}^{g}/_{mol}} = 810.0318 \ {}^{m^2}/_{g}$$

Lampiran 11. Perhitungan Kadar Gugus Fungsi dengan Titrasi Boehm

a. Karbon Tempurung Kemiri

Penentunan 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	0.05150	0.0528	10	0.04914	8.1	0.3068	2.0784
2	25	5	0.05150	0.0528	10	0.04914	8.1	0.3068	2.0784
3	25	5	0.05150	0.0528	10	0.04914	8.1	0.3068	2.0784
4	25	5	0.05150	0.0528	10	0.04914	8.1	0.3068	2.0784
Rata - rata									**2.0784**

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

$$n_{carboxylic} = \frac{\left[5\ mL \times 0.0515\ N - (0.0528\ N \times 10\ mL - 0.04914\ N \times 8.1\ mL)\right] \frac{25\ mL}{5\ mL}}{0.3068\ gram}$$

$$n_{carboxylic} = \frac{\left[0.2575\ meq - (0.5280\ meq - 0.398034\ meq)\right] \frac{25\ mL}{5\ mL}}{0.3068\ gram}$$

$$\text{ylic} = \frac{\left[0.2575\ meq - 0.129966\ meq\right] \frac{25\ mL}{5\ mL}}{0.3068\ gram} = 2.0784\ \frac{meq}{gram}$$

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	0.0503	0.0528	10	0.04914	3.4	0.3178	-3.8000
2	25	5	0.0503	0.0528	10	0.04914	3.4	0.3178	-3.8000
3	25	5	0.0503	0.0528	10	0.04914	3.4	0.3178	-3.8000
4	25	5	0.0503	0.0528	10	0.04914	3.4	0.3178	-3.8000
Rata - rata									**-3.8000**

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

$$n_{lactonic} = \frac{[5\ mL \times 0.0503\ N - (0.0528\ N \times 10\ mL - 0.04914\ N \times 3.4\ mL)] \frac{25\ mL}{5\ mL}}{0.3178\ gram} - 2.0784\ \frac{meq}{gram}$$

$$n_{lactonic} = \frac{[0.2515\ meq - (0.5280\ meq - 0.167076\ meq)] \frac{25\ mL}{5\ mL}}{0.3178\ gram} - 2.07845502\ \frac{meq}{gram}$$

$$_{c} = -1.7216\ \frac{meq}{gram} - 2.0784\ \frac{meq}{gram} = -3.8000\ \frac{meq}{gram}$$

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	0.04914	0.0528	10	0.04914	7.4	0.3094	3.0360
2	25	5	0.04914	0.0528	10	0.04914	7.4	0.3094	3.0360
3	25	5	0.04914	0.0528	10	0.04914	7.4	0.3094	3.0360
4	25	5	0.04914	0.0528	10	0.04914	7.4	0.3094	3.0360
Rata - rata									**3.0360**

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

$$n_{phenolic} = \frac{[5\ mL \times 0.04914\ N - (0.0528\ N \times 10\ mL - 0.04914\ N \times 7.4\ mL)]\frac{25\ mL}{5\ mL}}{0.3094\ gram} - 2.0784\ \frac{meq}{gram} - (-3.8000\ \frac{meq}{gram})$$

$$n_{phenolic} = \frac{[0.2457\ meq - (0.5280\ meq - 0.363636\ meq)]\frac{25\ mL}{5\ mL}}{0.3094\ gram} - 2.0784\ \frac{meq}{gram} - (-3.8000\ \frac{meq}{gram})$$

$$_c = 1.3144\ \frac{meq}{gram} - 2.0784\frac{meq}{gram} - (-3.8000\ \frac{meq}{gram}) = 3.0360\ \frac{meq}{gram}$$

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	0.05157	0.04557	10	0.05157	5.7	0.3004	1.5995
2	25	5	0.05157	0.04557	10	0.05157	5.7	0.3004	1.5995
3	25	5	0.05157	0.04557	10	0.05157	5.8	0.3004	1.6853
4	25	5	0.05157	0.04557	10	0.05157	5.7	0.3004	1.5995
Rata - rata									1.6209

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

$$n_{total\ base} = \frac{[5\ mL \times 0.05157\ N - (0.04557\ N \times 10\ mL - 0.05157\ N \times 5.7\ mL)\ ]\ \frac{25\ mL}{5\ mL}}{0.3004\ gram}$$

$$n_{total\ base} = \frac{[0.25785\ meq - (0.4557\ meq - 0.293949\ meq)\ ]\ \frac{25\ mL}{5\ mL}}{0.3004\ gram}$$

$$base = \frac{[0.25785\ meq - 0.161751\ meq\ ]\ \frac{25\ mL}{5\ mL}}{0.3004\ gram} = 1.5995\ \frac{meq}{gram}$$

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	0.0501	0.0532	10	0.0458	8.5	0.2005	2.6882
2	25	5	0.0501	0.0532	10	0.0458	8.5	0.2005	2.6882
3	25	5	0.0501	0.0532	10	0.0458	8.5	0.2005	2.6882
4	25	5	0.0501	0.0532	10	0.0458	8.6	0.2005	2.8024
Rata - rata									**2.7168**

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	0.0532	10	0.0458	3.5	0.2008	-5.7186
2	25	5	0.05	0.0532	10	0.0458	3.4	0.2008	-5.8327
3	25	5	0.05	0.0532	10	0.0458	3.5	0.2008	-5.7186
4	25	5	0.05	0.0532	10	0.0458	3.5	0.2008	-5.8328
Rata - rata									**-5.7757**

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	0.04557	0.0532	10	0.0458	7.9	0.2015	4.4613
2	25	5	0.04557	0.0532	10	0.0458	8	0.2015	4.6890
3	25	5	0.04557	0.0532	10	0.0458	8	0.2015	4.5750
4	25	5	0.04557	0.0532	10	0.0458	8	0.2015	4.5750
Rata - rata									**4.5751**

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	0.0532	0.0458	10	0.0532	3.1	0.2052	-0.6598
2	25	5	0.0532	0.0458	10	0.0532	3.1	0.2052	-0.6598
3	25	5	0.0532	0.0458	10	0.0532	3.1	0.2052	-0.6598
4	25	5	0.0532	0.0458	10	0.0532	3	0.2052	-0.7894
Rata - rata									**-0.6922**

c. NDC 1

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	50	5	0.0501	0.0547	10	0.0528	6.9	0.3029	2.2390
2	50	5	0.0501	0.0547	10	0.0528	6.9	0.3029	2.2390
3	50	5	0.0501	0.0547	10	0.0528	6.8	0.3029	2.0647
4	50	5	0.0501	0.0547	10	0.0528	6.9	0.3029	2.2390
Rata - rata									**2.1954**

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	50	5	0.05	0.0547	10	0.0528	3.4	0.3062	-6.0757
2	50	5	0.05	0.0547	10	0.0528	3.4	0.3062	-6.0757
3	50	5	0.05	0.0547	10	0.0528	3.4	0.3062	-5.9014
4	50	5	0.05	0.0547	10	0.0528	3.4	0.3062	-6.0757
Rata - rata									**-6.0321**

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	50	5	0.0528	0.0547	10	0.0528	6.1	0.3019	5.1311
2	50	5	0.0528	0.0547	10	0.0528	6.1	0.3019	5.1311
3	50	5	0.0528	0.0547	10	0.0528	6.1	0.3019	5.1311
4	50	5	0.0528	0.0547	10	0.0528	6.1	0.3019	5.1311
Rata - rata									**5.1311**

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	1	0.0984	0.0528	5	0.0547	2.8	0.3169	-0.9813
2	25	1	0.0984	0.0528	5	0.0547	2.8	0.3169	-0.9813
3	25	1	0.0984	0.0528	5	0.0547	2.8	0.3169	-0.9813
4	25	1	0.0984	0.0528	5	0.0547	2.8	0.3169	-0.9813
Rata - rata									**-0.9813**

d. NDC 2

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	50	5	0.0501	0.0528	10	0.04914	9.6	0.303	6.4106
2	50	5	0.0501	0.0528	10	0.04914	9.6	0.303	6.4106
3	50	5	0.0501	0.0528	10	0.04914	9.6	0.303	6.4106
4	50	5	0.0501	0.0528	10	0.04914	9.6	0.303	6.4106
Rata - rata									**6.4106**

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	50	5	0.05014	0.0528	10	0.04914	5.3	0.3019	-6.9690
2	50	5	0.05014	0.0528	10	0.04914	5.4	0.3019	-6.8063
3	50	5	0.05014	0.0528	10	0.04914	5.3	0.3019	-6.9690
4	50	5	0.05014	0.0528	10	0.04914	5.3	0.3019	-6.9690
Rata - rata									**-6.9283**

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	50	1	0.04914	0.0528	5	0.04914	4.8	0.3023	4.0337
2	50	1	0.04914	0.0528	5	0.04914	4.8	0.3023	3.8709
3	50	1	0.04914	0.0528	5	0.04914	4.9	0.3023	4.8465
4	50	1	0.04914	0.0528	5	0.04914	4.9	0.3023	4.8465
Rata - rata									**4.3994**

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	50	5	0.0528	0.04914	10	0.0528	4.3	0.3016	-0.0119
2	50	5	0.0528	0.04914	10	0.0528	4.3	0.3016	-0.0119
3	50	5	0.0528	0.04914	10	0.0528	4.3	0.3016	-0.0119
4	50	5	0.0528	0.04914	10	0.0528	4.3	0.3016	-0.0119
Rata - rata									**-0.0119**

Lampiran 12. Perhitungan Kadar N pada NDC dengan Metode Asidimetri

Standarisasi NH_4OH dengan HCl 0.0532 N

N HCl = 0.0532 N		
	V NH_4OH (mL)	**V HCl (mL)**
	5	3.5
	5	3.5
	5	3.4
Volume Rata-rata	**5**	**3.4667**

$$N_{NH_3} = \frac{V_{HCl} \times N_{HCl}}{V_{NH_3}} \times \frac{250\ mL}{1\ mL}$$

$$N_{NH_3} = \frac{3.4667\ mL \times 0.0532\ N}{5\ mL} \times \frac{250\ mL}{1\ mL}$$

$$N_{NH_3} = 9.221422\ N$$

$$\text{mmol } NH_4OH \text{ awal} = \frac{N_{NH_3} \times V_{NH_3}}{\text{Valensi}}$$

$$\text{mmol } NH_4OH \text{ awal} = \frac{9.221422\ N \times 5\ mL}{1} = 46.1071 \text{ mmol}$$

Penentuan kadar N yang tedeposisi kedalam K.A.T.K

a. NDC 1 (NDC Metode Aminasi)

$$V_{HCl} = \frac{2.5\ mL + 2.5\ mL + 2.6\ mL}{3} = 2.5334\ mL$$

$$\text{mmol } NH_4OH \text{ sisa} = V_{HCl} \times N_{HCl} \times \text{Valensi} \times \frac{250\ mL}{110\ mL} \times \frac{100\ ml}{1\ ml}$$

$$\text{mmol } NH_4OH \text{ sisa} = 2.5334\ mL \times 0.0532\ N \times 1 \times \frac{250\ mL}{110\ mL} \times \frac{100\ ml}{1\ ml}$$

$$\text{mmol } NH_4OH \text{ sisa} = 30.6311 \text{ mmol}$$

Maka,

$$\text{mmol } NH_4OH \text{ bereaksi} = 46.1071 \text{ mmol} - 30.6311 \text{ mmol}$$

$$\text{mmol } NH_4OH \text{ bereaksi} = 15.4760 \text{ mmol}$$

$$\% N = \frac{[\text{ mol } NH_4OH_{awal} - \text{ mol } NH_4OH_{sisa}] \text{ x } 14 \frac{g}{mol} \text{ x } 100\%}{\text{massa karbon}}$$

$$\% N = \frac{15.4760 \text{ mmol x } 14 \frac{mg}{mmol} \text{ x } 100\%}{11254.1 \text{ mg}} = 1.9252 \%$$

b. NDC 2 (NDC Metode Praoksidasi-Aminasi)

$$V_{HCl} = \frac{0.5 \text{ mL} + 0.6 \text{ mL} + 0.5 \text{ mL}}{3} = 0.5334 \text{ mL}$$

$$\text{mmol } NH_4OH \text{ sisa} = V_{HCl} \text{ x } N_{HCl} \text{ x Valensi x } \frac{250 \text{ mL}}{110 \text{ mL}} \text{ x } \frac{100 \text{ ml}}{1 \text{ ml}}$$

$$\text{mmol } NH_4OH \text{ sisa} = 0.5334 \text{ mL x } 0.0532 \text{ N x } 1 \text{ x } \frac{1000 \text{ mL}}{110 \text{ mL}} \text{ x } \frac{100 \text{ ml}}{5 \text{ ml}}$$

$$\text{mmol } NH_4OH \text{ sisa} = 5.15943 \text{ mmol}$$

Maka,

$$\text{mmol } NH_4OH \text{ bereaksi} = 46.1071 \text{ mmol} - 5.1594 \text{ mmol}$$

$$\text{mmol } NH_4OH \text{ bereaksi} = 40.9477 \text{ mmol}$$

$$\% N = \frac{[\text{ mol } NH_4OH_{awal} - \text{ mol } NH_4OH_{sisa}] \text{ x } 14 \frac{g}{mol} \text{ x } 100\%}{\text{massa karbon}}$$

$$\% N = \frac{40.94767 \text{ mmol x } 14 \frac{mg}{mmol} \text{ x } 100\%}{11747.2 \text{ mg}} = 4.8800 \%$$

Lampiran 13. Perhitungan Kapasitansi Spesifik

a. Elekrolit H_2SO_4 1 M

Sampel	Scan rate (V/s)	I_c (A)	I_d (A)	Massa karbon (gram)	Kapasitansi spesifik (F/g)
KATK	0.1	9.06×10^{-9}	-4.52×10^{-9}	0.0183	7.4207×10^{-6}
	0.05	9.04×10^{-9}	-4.21×10^{-9}	0.0183	1.4480×10^{-5}
	0.02	9.02×10^{-9}	-4.19×10^{-9}	0.0183	3.6093×10^{-5}
	0.01	9.06×10^{-9}	-4.15×10^{-9}	0.0183	7.2185×10^{-5}
	0.005	9.54×10^{-9}	-4.46×10^{-9}	0.0183	1.5300×10^{-5}
NDC 1	0.1	0.0000616	0.0000129	0.0184	0.0264
	0.05	0.0000661	0.0000107	0.0184	0.0602
	0.02	0.0000617	0.00000914	0.0184	0.1428
	0.01	0.0000616	0.0000141	0.0184	0.2581
	0.005	0.000057	0.000014	0.0184	0.4673
NDC 2	0.1	0.00071	-0.000668	0.0193	0.7139
	0.05	0.000596	-0.00052	0.0193	1.1564
	0.02	0.000458	-0.000437	0.0193	2.3186
	0.01	0.000369	-0.000381	0.0193	3.8860
	0.005	0.000357	-0.00034	0.0193	7.2227

1. Penentuan Kapasitansi Spesifik KATK

1.1 Scan rate 100 mV/s

$$C_s = \frac{(9.06 \times 10^{-9} - (-4.52 \times 10^{-9})\ A}{0.1\ V/s \times 0.0183\ gram} = \frac{(13.58 \times 10^{-9})\ A}{0.1\ V/s \times 0.0183\ gram} = 7.4207 \times 10^{-6}\ F/g$$

1.2 Scan rate 50 mV/s

$$_s = \frac{(9.04 \times 10^{-9} - (-4.21 \times 10^{-9})\ A}{0.05\ V/s \times 0.0183\ gram} = \frac{(13.25 \times 10^{-9})\ A}{0.1\ V/s \times 0.0183\ gram} = 1.4480 \times 10^{-5}\ F/g$$

1.3 Scan rate 20 mV/s

$$C_s = \frac{(9.02 \times 10^{-9} - (-4.19 \times 10^{-9})) \text{ A}}{0.02 \text{ V/s} \times 0.0183 \text{ gram}} = \frac{(13.21 \times 10^{-9}) \text{ A}}{0.1 \text{ V/s} \times 0.0183 \text{ gram}} = 3.6092 \times 10^{-5} \text{ F/g}$$

1.4 Scan rate 10 mV/s

$$C_s = \frac{(9.06 \times 10^{-9} - (-4.15 \times 10^{-9})) \text{ A}}{0.01 \text{ V/s} \times 0.0183 \text{ gram}} = \frac{(13.21 \times 10^{-9}) \text{ A}}{0.1 \text{ V/s} \times 0.0183 \text{ gram}} = 7.2185 \times 10^{-5} \text{ F/g}$$

1.5 Scan rate 5 mV/s

$$C_s = \frac{(9.54 \times 10^{-9} - (-4.46 \times 10^{-9})) \text{ A}}{0.005 \text{ V/s} \times 0.0183 \text{ gram}} = \frac{(14 \times 10^{-9}) \text{ A}}{0.1 \text{ V/s} \times 0.0183 \text{ gram}} = 1.530 \times 10^{-4} \text{ F/g}$$

2. Penentuan Kapasitansi Spesifik NDC 1

2.1 Scan rate 100 mV/s

$$C_s = \frac{(0.0000616 - 0.0000129) \text{ A}}{0.1 \text{ V/s} \times 0.0184 \text{ gram}} = \frac{(0.0000745) \text{ A}}{0.1 \text{ V/s} \times 0.0184 \text{ gram}} = 0.0264 \text{ F/g}$$

2.2 Scan rate 50 mV/s

$$C_s = \frac{(0.0000661 - 0.0000107) \text{ A}}{0.05 \text{ V/s} \times 0.0184 \text{ gram}} = \frac{(0.0000768) \text{ A}}{0.05 \text{ V/s} \times 0.0184 \text{ gram}} = 0.0602 \text{ F/g}$$

2.3 Scan rate 20 mV/s

$$C_s = \frac{(0.0000617 - 0.00000914) \text{ A}}{0.02 \text{ V/s} \times 0.0184 \text{ gram}} = \frac{(0.00007084) \text{ A}}{0.02 \text{ V/s} \times 0.0184 \text{ gram}} = 0.1428 \text{ F/g}$$

2.4 Scan rate 10 mV/s

$$_s = \frac{(0.0000616 - 0.0000141) \text{ A}}{0.01 \text{ V/s} \times 0.0184 \text{ gram}} = \frac{(0.0000757) \text{ A}}{0.01 \text{ V/s} \times 0.0184 \text{ gram}} = 0.2581 \text{ F/g}$$

2.5 Scan rate 5 mV/s

$$C_s = \frac{(0.000057 - 0.000014)\ A}{0.005\ V/_S \times 0.0184\ gram} = \frac{(0.000071)\ A}{0.005\ V/_S \times 0.0184\ gram} = 0.4673\ F/_g$$

3. Penentuan Kapasitansi Spesifik NDC 2

3.1 Scan rate 100 mV/s

$$C_s = \frac{(0.00071 - (-0.000668)\ A}{0.1\ V/_S \times 0.0193\ gram} = \frac{(0.001378)\ A}{0.1\ V/_S \times 0.0193\ gram} = 0.7139\ F/_g$$

3.2 Scan rate 50 mV/s

$$C_s = \frac{(0.000596 - (-0.00052)\ A}{0.05\ V/_S \times 0.0193\ gram} = \frac{(0.001116)\ A}{0.05\ V/_S \times 0.0193\ gram} = 1.1564\ F/_g$$

3.3 Scan rate 20 mV/s

$$C_s = \frac{(0.000458 - (-0.000437)\ A}{0.02\ V/_S \times 0.0193\ gram} = \frac{(0.000895)\ A}{0.02\ V/_S \times 0.0193\ gram} = 2.3186\ F/_g$$

3.4 Scan rate 10 mV/s

$$C_s = \frac{(0.000369 - 0.000381)\ A}{0.01\ V/_S \times 0.0193\ gram} = \frac{(0.00075)\ A}{0.01\ V/_S \times 0.0193\ gram} = 3.8860\ F/_g$$

3.5 Scan rate 5 mV/s

$$C_s = \frac{(0.000357 - (-0.000340)\ A}{0.005\ V/_S \times 0.0193\ gram} = \frac{(0.000697)\ A}{0.005\ V/_S \times 0.0193\ gram} = 7.2227\ F/_g$$

b. Elekrolit KOH 6 M

Sampel	Scan rate (V/s)	I_c (A)	I_d (A)	Massa karbon (gram)	Kapasitansi spesifik (F/g)
KATK	0.1	0.0000525	0.0000217	0.018	0.0171
	0.05	0.0000529	0.0000216	0.018	0.0347
	0.02	0.000052	0.0000227	0.018	0.0813
	0.01	0.0000499	0.0000253	0.018	0.1366
	0.005	0.0000529	0.0000222	0.018	0.3411
NDC 1	0.1	0.000291	-0.000288	0.0187	0.3096
	0.05	0.000314	-0.000249	0.0187	0.6021
	0.02	0.000324	-0.000238	0.0187	1.5026
	0.01	0.000351	-0.000201	0.0187	2.9518
	0.005	0.000345	-0.000187	0.0187	5.6898
NDC 2	0.1	0.000093	-0.0000138	0.0182	0.0586
	0.05	0.000352	-0.000238	0.0182	0.6483
	0.02	0.000351	-0.000224	0.0182	1.5796
	0.01	0.000326	-0.000321	0.0182	3.5549
	0.005	0.000396	-0.000446	0.0182	9.2527

1. Penentuan Kapasitansi Spesifik KATK

1.1 Scan rate 100 mV/s

$$C_s = \frac{(0.0000525\text{-}0.0000217)\ A}{0.1\ {}^{V}/_{S}\ x\ 0.018\ gram} = \frac{(0.0000308)\ A}{0.1\ {}^{V}/_{S}\ x\ 0.018\ gram} = 0.0171\ {}^{F}/_{g}$$

1.2 Scan rate 50 mV/s

$$C_s = \frac{(0.0000529 - 0.0000216)\ A}{0.05\ {}^{V}/_{S}\ x\ 0.018\ gram} = \frac{(0.0000313)\ A}{0.05\ {}^{V}/_{S}\ x\ 0.018\ gram} = 0.0347\ {}^{F}/_{g}$$

1.3 Scan rate 20 mV/s

$$C_s = \frac{(0.000052 - 0.0000227)\ A}{0.02\ {}^{V}/_{S} \times 0.018\ gram} = \frac{(0.0000293)\ A}{0.02\ {}^{V}/_{S} \times 0.018\ gram} = 0.0813\ {}^{F}/_{g}$$

1.4 Scan rate 10 mV/s

$$C_s = \frac{(0.0000499 - 0.0000253)\ A}{0.01\ {}^{V}/_{S} \times 0.018\ gram} = \frac{(0.0000246)\ A}{0.01\ {}^{V}/_{S} \times 0.018\ gram} = 0.1366\ {}^{F}/_{g}$$

1.5 Scan rate 5 mV/s

$$C_s = \frac{(0.0000529 - 0.0000222)\ A}{0.005\ {}^{V}/_{S} \times 0.018\ gram} = \frac{(0.0000307)\ A}{0.005\ {}^{V}/_{S} \times 0.018\ gram} = 0.3411\ {}^{F}/_{g}$$

2. Penentuan Kapasitansi Spesifik NDC 1

2.1 Scan rate 100 mV/s

$$C_s = \frac{(0.000291 - (-0.000288)\ A}{0.1\ {}^{V}/_{S} \times 0.0187\ gram} = \frac{(0.000579)\ A}{0.1\ {}^{V}/_{S} \times 0.0187\ gram} = 0.3096\ {}^{F}/_{g}$$

2.2 Scan rate 50 mV/s

$$C_s = \frac{(0.000314-(-0.000249)\ A}{0.05\ {}^{V}/_{S} \times 0.0187\ gram} = \frac{(0.000563)\ A}{0.05\ {}^{V}/_{S} \times 0.0187\ gram} = 0.6021\ {}^{F}/_{g}$$

2.3 Scan rate 20 mV/s

$$C_s = \frac{(0.000324 - (-0.000238)\ A}{0.02\ {}^{V}/_{S} \times 0.0187\ gram} = \frac{(0.000562)\ A}{0.02\ {}^{V}/_{S} \times 0.0187\ gram} = 1.5026\ {}^{F}/_{g}$$

2.4 Scan rate 10 mV/s

$$_s = \frac{(0.000351 - (-0.000201)\ A}{0.01\ {}^{V}/_{S} \times 0.0187\ gram} = \frac{(0.000551)\ A}{0.01\ {}^{V}/_{S} \times 0.0187\ gram} = 2.9518\ {}^{F}/_{g}$$

2.5 Scan rate 5 mV/s

$$C_s = \frac{(0.000345 - (-0.000187)\ A}{0.005\ V/_S \times 0.0187\ gram} = \frac{(0.000532)\ A}{0.005\ V/_S \times 0.0187\ gram} = 5.6898\ F/_g$$

3. Penentuan Kapasitansi Spesifik NDC 2

3.1 Scan rate 100 mV/s

$$C_s = \frac{(0.000093 - (-0.0000138)\ A}{0.1\ V/_S \times 0.0182\ gram} = \frac{(0.0001068)\ A}{0.1\ V/_S \times 0.0182\ gram} = 0.0586\ F/_g$$

3.2 Scan rate 50 mV/s

$$C_s = \frac{(0.000352 - (-0.000238)\ A}{0.05\ V/_S \times 0.0182\ gram} = \frac{(0.00059)\ A}{0.05\ V/_S \times 0.0182\ gram} = 0.6483\ F/_g$$

3.3 Scan rate 20 mV/s

$$C_s = \frac{(0.000351 - (-0.000224)\ A}{0.02\ V/_S \times 0.0182\ gram} = \frac{(0.000575)\ A}{0.02\ V/_S \times 0.0182\ gram} = 1.5796\ F/_g$$

3.4 Scan rate 10 mV/s

$$C_s = \frac{(0.000326 - (-0.000321)\ A}{0.01\ V/_S \times 0.0182\ gram} = \frac{(0.000647)\ A}{0.01\ V/_S \times 0.0182\ gram} = 3.5549\ F/_g$$

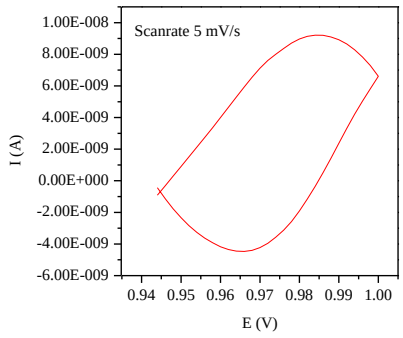
3.5 Scan rate 5 mV/s

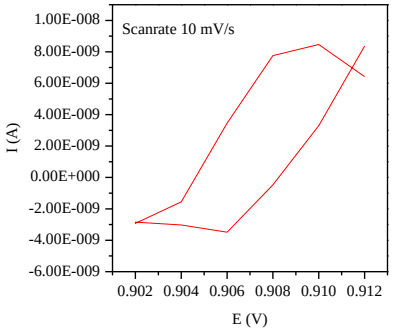
$$C_s = \frac{(0.000396 - (-0.000446)\ A}{0.005\ V/_S \times 0.0182\ gram} = \frac{(0.000842)\ A}{0.005\ V/_S \times 0.0182\ gram} = 9.2527\ F/_g$$

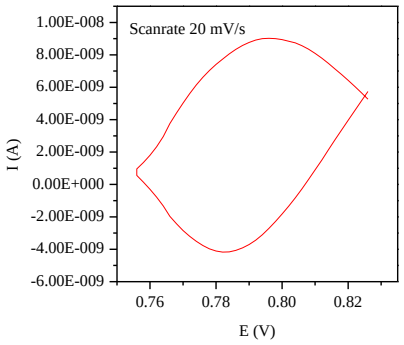
Lampiran 14. Grafik Voltammoram KATK, NDC 1 dan NDC 2

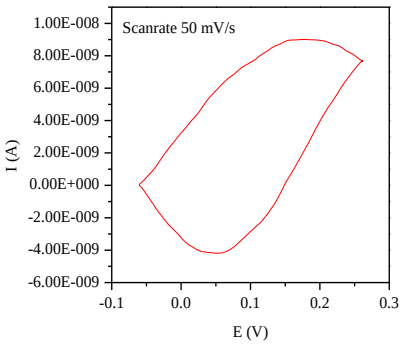
1. Grafik voltammogram kapasitansi Spesifik dalam elektrolit H_2SO_4 2 M

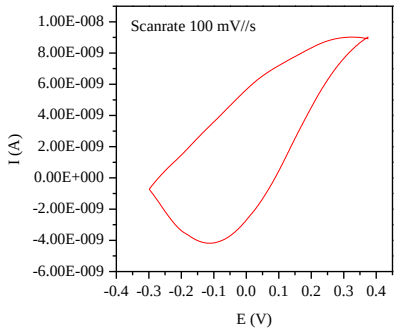
   a. KATK



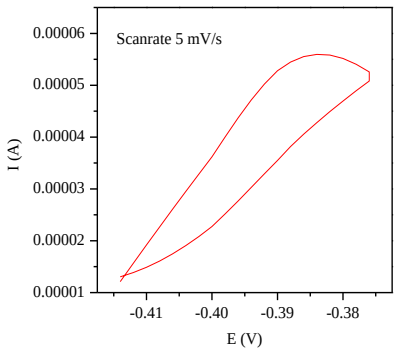


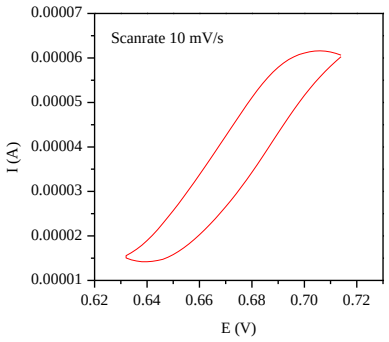


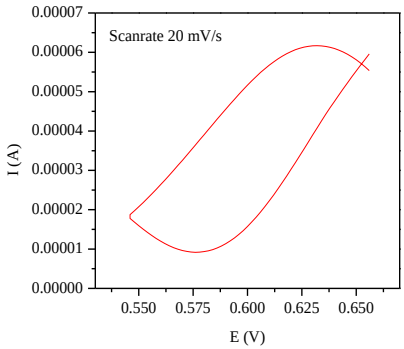


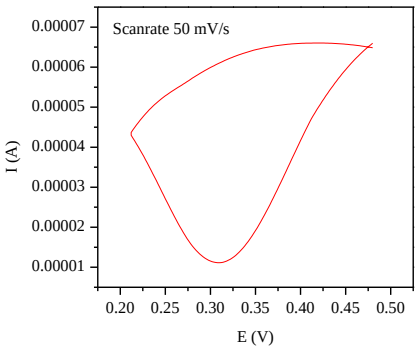


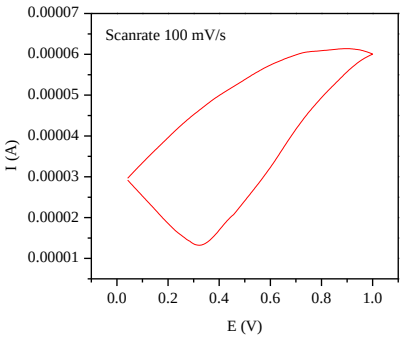
b. NDC 1



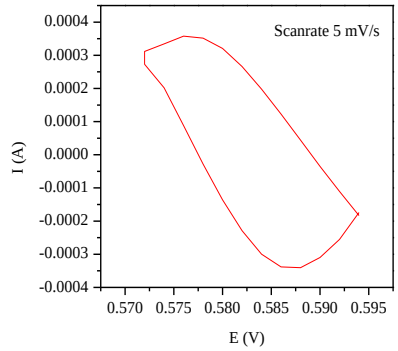


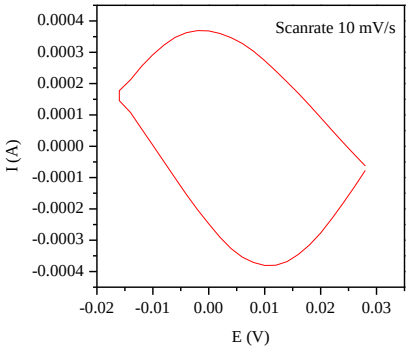


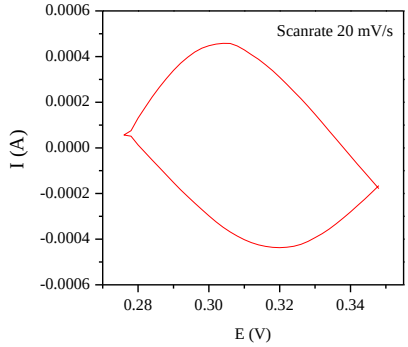


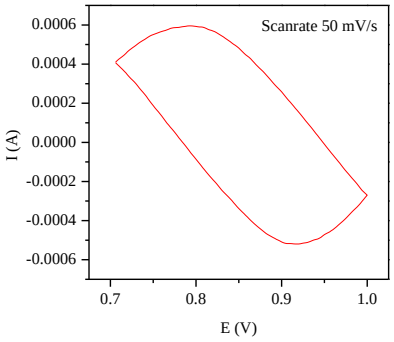


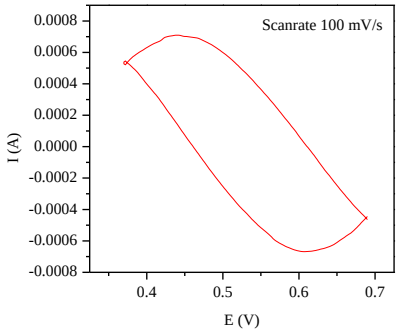
c. NDC 2





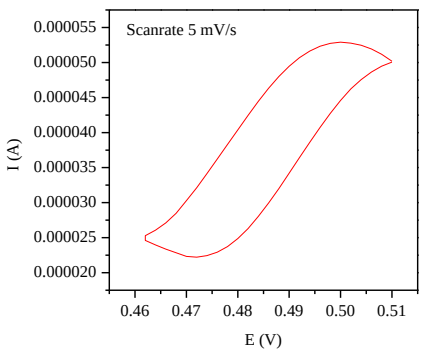


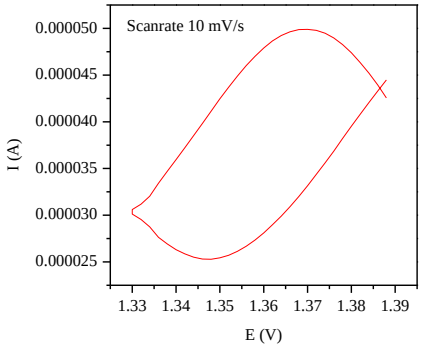


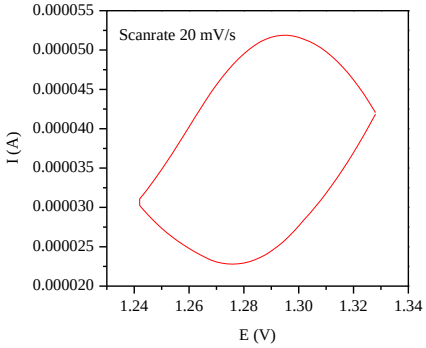


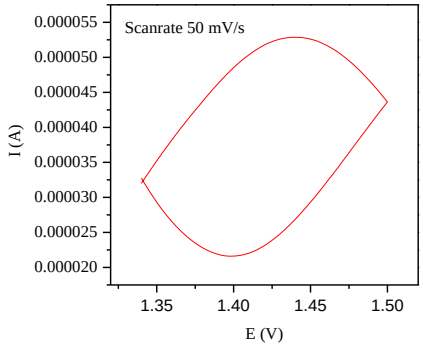
2. Garfik Voltammogram kapasitansi spesifik dalam elektrolit KOH 6 M

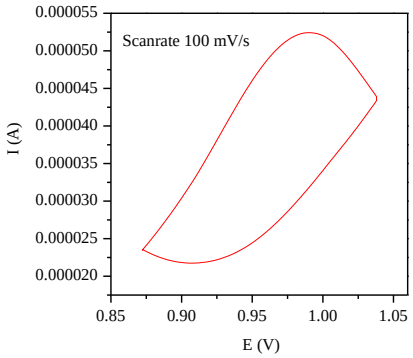
a. KATK



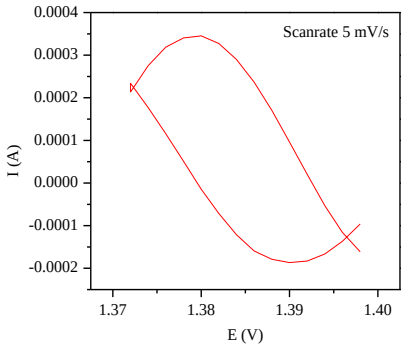


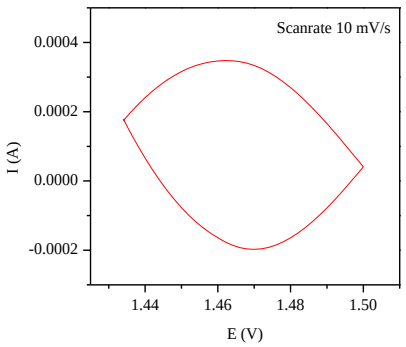


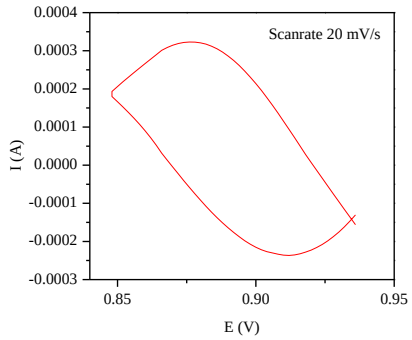


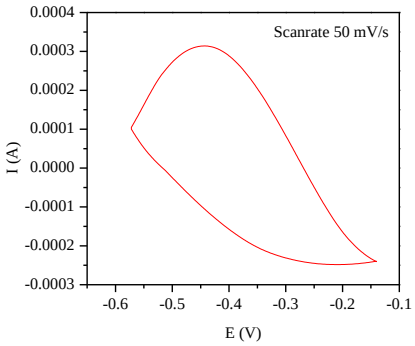


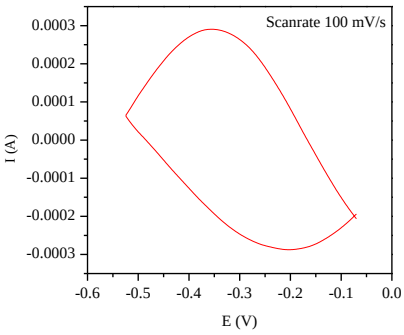
b. NDC 1











c. NDC 2