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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

DAFTAR PUSTAKA

A., P., & Clark, J. H. (2014). Green chemistry, biorefineries and second generation strategies for re-use of waste: an overview. In *Advances in Biorefi neries* (pp. 3–33). https://doi.org/10.1533/9780857097385.1.3

Abdullah, N. A., Putra, N., Hakim, I. I., & Koestoer, R. A. (2017). A review of improvements to the liquid collection system used in the pyrolysis process for producing liquid smoke. *International Journal of Technology*, *8*(7), 1197–1206. https://doi.org/10.14716/ijtech.v8i7.745

Achmadi, s s, Mubarik, n r, Nursyamsi, R., & Septiaji, P. (2013). Characterization of Redistilled liquid smoke of oil palm shells and its application as fish preservatives. *Journal of Applied Sciences*, *13*(3), 401–408. https://doi.org/103.3923/jas.2013.401.408

Affandi, F., & Hadisi, H. (2011). Pengaruh Metode Aktivasi Zeolit Alam Sebagai Bahan Penurun Temperatur Campuran Beraspal Hangat. *Jurnal Jalan-Jembatan*, *28*(1), 1–8.

Aich, S., Nandi, B. K., & Bhattacharya, S. (2022). Effects of eucalyptus leaves blending on combustion characteristics of an Indian reject coal. *Energy Sources, Part A: Recovery, Utilization and Environmental Effects*, *44*(1), 1437–1448. https://doi.org/10.1080/15567036.2019.1644397

Akhtar, J., & Saidina Amin, N. (2012). A review on operating parameters for optimum liquid oil yield in biomass pyrolysis. *Renewable and Sustainable Energy Reviews*, *16*(7), 5101–5109. https://doi.org/10.1016/j.rser.2012.05.033

Al-rumaihi, A., Shahbaz, M., Mckay, G., Mackey, H., & Al-ansari, T. (2022). A review of pyrolysis technologies and feedstock : A blending approach for plastic and biomass towards optimum biochar yield. *Renewable and Sustainable Energy Reviews*, *167*(March), 112715. https://doi.org/10.1016/j.rser.2022.112715

Alabbad, E. A. (2021). Efficacy assessment of natural zeolite containing wastewater on the adsorption behaviour of Direct Yellow 50 from; equilibrium, kinetics and thermodynamic studies. *Arabian Journal of Chemistry*, *14*(4), 103041. https://doi.org/10.1016/j.arabjc.2021.103041

Ali, R., Aslam, Z., Shawabkeh, R. A., Asghar, A., & Hussein, I. A. (2020). BET, FTIR, and RAMAN characterizations of activated carbon from waste oil fly ash. *Turkish Journal of Chemistry*, *44*(2), 279–295. https://doi.org/10.3906/KIM-1909-20

Andrews, J. M. (2001). Determination of minimum inhibitory concentrations. *Journal of Antimicrobial Chemotherapy*, *48*(SUPPL. 1), 5–16. https://doi.org/10.1093/jac/48.suppl_1.5

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Apaydın Varol, E., & Mutlu, Ü. (2023). TGA-FTIR Analysis of Biomass Samples Based on the Thermal Decomposition Behavior of Hemicellulose, Cellulose, and Lignin. *Energies*, *16*(9). https://doi.org/10.3390/en16093674

Arifin, F., Warsito, A., & Syakur, A. (2011). Perancangan Pembangkit Tegangan Tinggi Impuls Untuk Aplikasi Pengolahan Limbah Cair Industri Minuman Ringan Dengan Teknologi Plasma Lucutan Korona. *Transient*, 1–7.

Ariyani, D., Mujiyanti, D. R., & Harlianto, D. U. Y. . (2015). Studi Kajian Kandungan Senyawa Asap Cair dari Sekam Padi. *Prosiding Seminar Nasional Kimia*, 128–133.

Asip, F., Mardhiah, R., & Husna. (2008). Uji Efektifitas Cangkang Telur dalam Mengadsorbsi Ion Fe dengan Proses Batch. *Jurnal Teknik Kimia*, *15*(2), 22–26.

Astuti, W. (2018). Adsorpsi Menggunakan Material Berbasis Lignoselulosa. In *Unnes Press*.

Awe, A. A., Opeolu, B. O., Fatoki, O. S., Ayanda, O. S., Jackson, V. A., & Snyman, R. (2020). Preparation and characterisation of activated carbon from Vitis vinifera leaf litter and its adsorption performance for aqueous phenanthrene. *Applied Biological Chemistry*, *63*(1), 1–17. https://doi.org/10.1186/s13765-020-00494-1

Azlia Metta, S. (2014). Sintesis ZSM-5 dari Coal Fly Ash (CFA) dengan Sumber. *Jurnal Rekayasa Proses*, *8*(2), 62.

Balasundram, V., Ibrahim, N., Samsudin, M. D. H., Kasmani, R. M., Hamid, M. K. A., Isha, R., & Hasbullah, H. (2017). Thermogravimetric studies on the catalytic Pyrolysis of rice husk. *Chemical Engineering Transactions*, *56*, 427–432. https://doi.org/10.3303/CET1756072

Balsora, H. K., Kartik, S., Rainey, T. J., Abbas, A., Joshi, J. B., Sharma, A., & Chakinala, A. G. (2021). Kinetic modelling for thermal decomposition of agricultural residues at different heating rates. *Biomass Conversion and Biorefinery*, 3281–3295. https://doi.org/10.1007/s13399-021-01382-4

Baskorowati, L., Susanto, M., Kartikawati, N., & Rimbawanto, A. (2012). Variation of seed production and viability in a full-sib trial of melaleuca cajuputi sub sp . Cajuputi in gunungkidul. *Journal of Forestry Research*, *9*(2), 73–80. https://doi.org/DOI:10.20886/ijfr.2012.9.2.73-80

Basu, P. (2010). Biomass Gasification and Pyrolysis. In *Biomass Gasification and Pyrolysis*. https://doi.org/10.1016/C2009-0-20099-7

Basu, P. (2013). Biomass Gasification, Pyrolysis and Torrefaction: Practical Design and Theory. In *Biomass Gasification, Pyrolysis and Torrefaction: Practical Design and Theory* (2nd ed.). Elsevier. https://doi.org/10.1016/C2011-0-07564-6

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Bergaya, F., Theng, B. K. G., & Lagaly, G. (2006). Handbook of Clay Science. In *Developments in Clay Science* (Vol. 1, Issue 2). Elsevier. https://doi.org/10.1016/S1572-4352(05)01039-1

Berger, A. H., & Bhown, A. S. (2011). Comparing physisorption and chemisorption solid sorbents for use separating CO2 from flue gas using temperature swing adsorption. *Energy Procedia*, *4*, 562–567. https://doi.org/10.1016/j.egypro.2011.01.089

Bhatnagar, A., Barthen, R., Tolvanen, H., & Konttinen, J. (2021). Bio-oil stability through stepwise pyrolysis of groundnut shells: Role of chemical composition, alkali and alkaline earth metals, and storage conditions. *Journal of Analytical and Applied Pyrolysis*, *157*(January). https://doi.org/10.1016/j.jaap.2021.105219

Bläker, C., Muthmann, J., Pasel, C., & Bathen, D. (2019). Characterization of Activated Carbon Adsorbents – State of the Art and Novel Approaches. *ChemBioEng Reviews*, *6*(4), 119–138. https://doi.org/10.1002/cben.201900008

Bo Chin Chiang, Ming Yen Wey, W. Y. Y. (2000). Control of incinerator organics by fluidized bed activated carbon adsorber. Journal of Environmental Engineering. *Journal of Environmental Engineering*, *126*(11), 985–992. https://doi.org/https://doi.org/10.1061/(ASCE)0733-9372(2000)126:11(985)

Bohács, K., Faitli, J., Bokányi, L., & Mucsi, G. (2017). Control of Natural Zeolite Properties by Mechanical Activation in Stirred Media Mill. *Archives of Metallurgy and Materials*, *62*(2), 1399–1406. https://doi.org/10.1515/amm-2017-0216

Bouzgarrou, O., Baron, R., & Sadok, S. (2020). Determination of the quality of liquid smoked tilapia fillets based on physicochemical analysis. *Journal of Food Measurement and Characterization*, *14*(2), 978–991. https://doi.org/10.1007/s11694-019-00347-6

Bow, Y., Lestari, S. P., Sihombing, S. R., Kharissa, S. A., Salam, Y. A., & Srijaya Negara Bukit Besar-Palembang, J. (2018). Processing of Low Density Polyethylene (Ldpe) and Polypropylene (Pp) Waste Into Alternative Liqui. *Jurnal Kinetika*, *9*(03), 1–6. https://jurnal.polsri.ac.id/index.php/kimia/index

Bressan, S., Picoli, T., Mendes, C., Lopes, M. G., Neutzling, K., Gilberto, D., Hübner, S. D. O., & Fischer, G. (2017). *Microbial Pathogenesis Melittin and its potential in the destruction and inhibition of the bio fi lm formation by Staphylococcus aureus , Escherichia coli and Pseudomonas aeruginosa isolated from bovine milk*. *112*, 57–62. https://doi.org/10.1016/j.micpath.2017.09.046

Budaraga, I. K., & Putra, D. P. (2021). Analysis antioxidant IC50 liquid smoke of cocoa skin with several purification methods. *IOP Conference Series: Earth and Environmental*

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Science, *757*(1). https://doi.org/10.1088/1755-1315/757/1/012053

Budaraga, I Ketut, Marlida, Y., & Bulanin, U. (2016). *Characteristics of Cinnamon Liquid Smoke Produced Using Several Purification Techniques*. *3*(2), 16–21.

Buvaneswari, K., & Singanan, M. (2020). Review on scanning electron microscope analysis and adsorption properties of different activated carbon materials. *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2020.09.426

Byrappa, K., & Kumar, B. V. S. (2007). Characterization of zeolites by infrared spectroscopy. *Asian Journal of Chemistry*, *19*(6), 4933–4935.

Cakicioglu-Ozkan, F., & Ulku, S. (2005). The effect of HCl treatment on water vapor adsorption characteristics of clinoptilolite rich natural zeolite. *Microporous and Mesoporous Materials*, *77*(1), 47–53. https://doi.org/10.1016/j.micromeso.2004.08.013

Chaihad, N., Karnjanakom, S., Abudula, A., & Guan, G. (2022). Zeolite-based cracking catalysts for bio-oil upgrading: A critical review. *Resources Chemicals and Materials*, *1*(2), 167–183. https://doi.org/10.1016/j.recm.2022.03.002

Chen, D., Cen, K., Zhuang, X., Gan, Z., Zhou, J., Zhang, Y., & Zhang, H. (2022). Insight into biomass pyrolysis mechanism based on cellulose, hemicellulose, and lignin: Evolution of volatiles and kinetics, elucidation of reaction pathways, and characterization of gas, biochar and bio-oil. *Combustion and Flame*, *242*. https://doi.org/10.1016/j.combustflame.2022.112142

Chen, Y., Zhang, X., Chen, W., Yang, H., & Chen, H. (2017). Bioresource Technology The structure evolution of biochar from biomass pyrolysis and its correlation with gas pollutant adsorption performance. *Bioresource Technology*, *246*(August), 101–109. https://doi.org/10.1016/j.biortech.2017.08.138

Chen, Z., Zhu, Q., Wang, X., Xiao, B., & Liu, S. (2015). Pyrolysis behaviors and kinetic studies on Eucalyptus residues using thermogravimetric analysis. *Energy Conversion and Management*, *105*, 251–259. https://doi.org/10.1016/j.enconman.2015.07.077

Darmadji, P. (1996). Aktivitas Anti Bakteri Asap Cair yang Diproduksi dari Bermacam - macam Limbah Pertanian. *Agritech*, *16*(4), 19–22.

Datta, R. (1981). Acidogenic fermentation of lignocellulose–acid yield and conversion of components. *Biotechnology and Bioengineering*, *23*(9), 2167–2170. https://doi.org/10.1002/bit.260230921

David, E., & Kopa, J. (2021). *Ef fi cient removal of tar from gas fraction resulting from thermo-chemical conversion of biomass using coal fl y ash e based catalysts*. *171*. https://doi.org/10.1016/j.renene.2021.02.110

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Demirbas, A. (2004). Effects of temperature and particle size on bio-char yield from pyrolysis of agricultural residues. *Journal of Analytical and Applied Pyrolysis*, *72*(2), 243–248. https://doi.org/10.1016/j.jaap.2004.07.003

Derbe, T., Temesgen, S., & Bitew, M. (2021). A Short Review on Synthesis, Characterization, and Applications of Zeolites. *Advances in Materials Science and Engineering*, *2021*, 1–17. https://doi.org/10.1155/2021/6637898

Ding, S., & Liu, Y. (2020). Adsorption of CO 2 from fl ue gas by novel seaweed-based KOH-activated porous biochars. *Fuel*, *260*(August 2019), 116382. https://doi.org/10.1016/j.fuel.2019.116382

Duan, D., Chen, D., Huang, L., Zhang, Y., Zhang, Y., Wang, Q., Xiao, G., Zhang, W., Lei, H., & Ruan, R. (2021). Activated carbon from lignocellulosic biomass as catalyst : A review of the applications in fast pyrolysis process. *Journal of Analytical and Applied Pyrolysis*, *158*(June), 105246. https://doi.org/10.1016/j.jaap.2021.105246

Ekanayake, D., & Loganathan, P. (2021). Enhanced Removal of Nutrients , Heavy Metals , and PAH from Synthetic Stormwater by Incorporating Different Adsorbents into a Filter Media. *Water Air Soil Pollut*, *232*(96), 1–12. https://doi.org/https://doi.org/10.1007/s11270-021-05059-6

Emami Moghaddam, S. A., Harun, R., Mokhtar, M. N., & Zakaria, R. (2018). Potential of Zeolite and Algae in Biomass Immobilization. *BioMed Research International*, *2018*. https://doi.org/10.1155/2018/6563196

Essumang, D. K., Dodoo, D. K., & Adjei, J. K. (2014b). Effective reduction of PAH contamination in smoke cured fish products using charcoal filters in a modified traditional kiln. *Food Control*, *35*(1), 85–93. https://doi.org/10.1016/j.foodcont.2013.06.045

Everett, D. H., & Koopal, L. K. (2001). Definitions and terminology and Symbols in Colloid and Surface Chemistry. In *international union of pure and applied chemistry: Vol. I*. https://doi.org/10.4324/9781315197449-2

Faaij, A. (2006). Modern biomass conversion technologies. *Mitigation and Adaptation Strategies for Global Change*. https://doi.org/10.1007/s11027-005-9004-7

Fahmi Puteri Perdani, Riyanto, C. A., & Martono, Y. (2021). Karakterisasi Karbon Aktif Kulit Singkong (Manihot esculenta Crantz) Berdasarkan Variasi Konsentrasi H3PO4 dan Lama Waktu Aktivasi. *IJCA (Indonesian Journal of Chemical Analysis)*, *4*(2), 72–81. https://doi.org/10.20885/ijca.vol4.iss2.art4

Fauzan, & Ikhwanus, M. (2017). Pemurnian Asap Cair Tempurung Kelapa Melalui Distilasi Dan Filtrasi Menggunakan Zeolit Dan Arang Aktif. *Prosiding Seminar Nasional Sains*

UNIVERSITAS
GADJAH MADA
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Dan Teknologi, *0*(0), 1–2. https://jurnal.umj.ac.id/index.php/semnastek/article/view/1976

Fauziati, F., & Sampepana, E. (2016). Karakterisasi Komponen Aktif Asap Cair Cangkang Sawit Hasil Pemurnian. *Jurnal Riset Teknologi Industri*, *9*(1), 64–72. https://doi.org/10.26578/jrti.v9i1.1705

Fukuda, S. (2013). Bio-oil Production from Vacuum Pyrolysis of Palm Empty Fruit Bunch : Effect of Operating Conditions and Process Energy Balance. *Journal of Sustainable Energy & Environment*, *4*, 27–31.

Fullana, A., Contreras, J. A., Striebich, R. C., & Sidhu, S. S. (2005). Multidimensional GC/MS analysis of pyrolytic oils. *Journal of Analytical and Applied Pyrolysis*, *74*(1–2), 315–326. https://doi.org/10.1016/j.jaap.2004.11.036

Fuss, V. L. B., Bruj, G., Dordai, L., Roman, M., Cadar, O., & Becze, A. (2021). Evaluation of the impact of different natural zeolite treatments on the capacity of eliminating/reducing odors and toxic compounds. *Materials*, *14*(13). https://doi.org/10.3390/ma14133724

Garba, A. (2020). Biomass Conversion Technologies for Bioenergy Generation: An Introduction. In *Biomass* (pp. 1–16). IntechOpen. https://doi.org/http://dx.doi.org/10.5772/intechopen.93669

Gea, S., Haryono, A., Andriayani, A., Sihombing, J. L., Pulungan, A. N., Nasution, T., Rahayu, R., & Hutapea, Y. A. (2020a). applied sciences The Stabilization of Liquid Smoke through Hydrodeoxygenation Over Nickel Catalyst Loaded on Sarulla Natural Zeolite. *Apllied Sciences*, *10*(4126), 1–17. https://doi.org/10.3390/app10124126

Ghaemi, F., Abdullah, L. C., & Ariffin, H. (2019). Chapter 2. Lignocellulose Structure and the Effect on Nanocellulose Production. In *Lignocellulose for Future Bioeconomy*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-816354-2.00002-5

Gressangga, W., Suhartana, S., & Siahaan, P. (2011). Studi Kemampuan Adsorpsi Zeolit Alam Terdealuminasi terhadap Senyawa Fenol dan 2-Metoksifenol pada Asap Cair Sekam Padi: Eksperimen dan Komputasi AB Initio. *Jurnal Kimia Sains Dan Aplikasi*, *14*(3), 94–99. https://doi.org/10.14710/jksa.14.3.94-99

Guedes, R. E., Luna, A. S., & Torres, A. R. (2018). Operating parameters for bio-oil production in biomass pyrolysis: A review. *Journal of Analytical and Applied Pyrolysis*, *129*(November 2017), 134–149. https://doi.org/10.1016/j.jaap.2017.11.019

Guo, Y., & Wang, Q. (2022). Fabrication and Characterization of Activated Carbon from Phyllostachys edulis Using Single-Step KOH Activation with Different Temperatures. *Processes*, *10*(1712), 1–14. https://doi.org/https://doi.org/10.3390/pr10091712

Gupta, G. K., Gupta, P. K., & Mondal, M. K. (2019). Experimental process parameters

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

optimization and in-depth product characterizations for teak sawdust pyrolysis. *Waste Management*, *87*, 499–511. https://doi.org/10.1016/j.wasman.2019.02.035

H.Spliethoff. (2010). *Power Generation from Solid Fuels* (1st ed.). Springer. https://doi.org/DOI 10.1007/978-3-642-02856-4

Hameed, Z., Naqvi, S. R., Naqvi, M., Ali, I., Taqvi, S. A. A., Gao, N., Hussain, S. A., & Hussain, S. (2020). A Comprehensive Review on Thermal Coconversion of Biomass, Sludge, Coal, and Their Blends Using Thermogravimetric Analysis. *Journal of Chemistry*, *2020*. https://doi.org/10.1155/2020/5024369

Handayani, T., Xyzquolyna, D., & Eke, S. (2018). Karakteristik Asap Cair Tongkol Jagung dengan Pemurnian Menggunakan Arang Aktif. *Entropi*, *13*(2), 121–126.

Hanum, F., O Bani, & Wirani, L. I. (2017). Characterization of Activated Carbon from Rice Husk by HCl Activation and Its Application for Lead (Pb) Removal in Car Battery Wastewater. *IOP Conf. Ser.: Mater. Sci. Eng*, *755*(1). https://doi.org/10.1088/1742-6596/755/1/011001

Hazrat, M. A., Rasul, M. G., & Khan, M. M. K. (2015). A study on thermo-catalytic degradation for production of clean transport fuel and reducing plastic wastes. *Procedia Engineering*, *105*(Icte 2014), 865–876. https://doi.org/10.1016/j.proeng.2015.05.108

Hedayati, M. S., Abida, O., & Li, L. Y. (2021). Adsorption of polycyclic aromatic hydrocarbons by surfactant-modified clinoptilolites for landfill leachate treatment. *Waste Management*, *131*(May), 503–512. https://doi.org/10.1016/j.wasman.2021.06.033

Hedayati, M. S., & Li, L. Y. (2020). Removal of polycyclic aromatic hydrocarbons from aqueous media using modified clinoptilolite. *Journal of Environmental Management*, *273*(July), 111113. https://doi.org/10.1016/j.jenvman.2020.111113

Heidarinejad, Z., Dehghani, M. H., Heidari, M., Javedan, G., Ali, I., & Sillanpää, M. (2020). Methods for preparation and activation of activated carbon: a review. *Environmental Chemistry Letters*, *18*(2), 393–415. https://doi.org/10.1007/s10311-019-00955-0

Helfiansah, R., Sastrohamidjojo, H., & Riyanto. (2013). Isolasi, identifikasi dan pemurnian senyawa 1,8-Sineol minyak kayu putih (Malaleuca leucadendron). *ASEAN Journal of System Engineering*, *1*(1), 19–24.

Hendra, D., K Waluyo, T., & Sokanandi, A. (2014). Karakterisasi dan pemanfaatan asap cair dari tempurung buah bintaro (carbera manghas linn.) Sebagai koagulan getah karet. *Jurnal Penelitian Hasil Hutan*, *32*(1), 27–35. https://doi.org/10.20886/jphh.2014.32.1.27-35

Hermiati, E., Mangunwidjaja, D., Sunarti, T. C., & Suparno, O. (2010). *Pemanfaatan biomassa lignoselulosa ampas tebu untuk produksi bioetanol*. *29*(4), 121–130.

UNIVERSITAS
GADJAH MADA
**Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Hernawan, Wahono, S. K., Maryana, R., & Pratiwi, D. (2015). Modification of Gunungkidul Natural Zeolite as Bioethanol Dehydrating Agents. *Energy Procedia*, *65*, 116–120. https://doi.org/10.1016/j.egypro.2015.01.042

Ho, S. M. (2022). Journal of Chemistry and Research A Review of Chemical Activating Agent on the Properties of Activated Carbon. *International Journal of Chemistry and Research*, *s1*(1), 1–13. https://doi.org/10.18689/ijcr-s1-001

Hone, J. J. W. C. and G. A. (1992). *Eucalyptus oils : a review of production and markets (NRI Bulletin)* (No. 56).

Husien, S., El-taweel, R. M., Salim, A. I., Samy, I., Said, L. A., & Radwan, A. G. (2022). Review of activated carbon adsorbent material for textile dyes removal : Preparation , and modelling. *Current Research in Green and Sustainable Chemistry*, *5*(February), 100325. https://doi.org/10.1016/j.crgsc.2022.100325

Hussain, K., Hoque, R. R., & Balachandran, S. (2018). *Monitoring and Risk Analysis of PAHs in the Environment Monitoring and Risk Analysis of PAHs in the Environment* (Issue January). https://doi.org/10.1007/978-3-319-58538-3

Imandiani, S., Indira, C., Johan, A., & Budiyono. (2018). Utilization of Natural Zeolite from Ponorogo and Purworejo for Naphthol Substance Adsorption. *E3S Web of Conferences*, *31*, 4–7. https://doi.org/10.1051/e3sconf/20183105002

Indira, T. I., Hadi, K., Manurung, R., & Widiana, A. (2021). Enhancement of Essential Oil Yield from Melaleuca Leucadendra L . Leaves by Lignocellulose Degradation Pre-Treatment Using Filamentous Fungi. *Journal of Bioresources and Bioproducts*, *6*(4), 379–386. https://doi.org/10.1016/j.jobab.2021.02.010

Islam, M. N., Khatton, A., Sarker, ahid, Sikder, H. A., & Chowdhury, A. M. S. (2022). Preparation and Characterization of Activated Carbon from Jute Stick by Chemical Activation: Comparison of Different Activating Agents. *Saudi Journal of Engineering and Technology*, *7*(2), 112–117. https://doi.org/10.36348/sjet.2022.v07i02.008

Jamilatun, S., & Salamah, S. (2015). Peningkatan Kualitas Asap Cair Dengan Menggunakan Arang Aktif Sntt Fgdt 2015. *Simposium Nasional Teknologi Terapan (SNTT)*, *3*, 1–6.

Janairo, J. I. B., & Amalin, D. M. (2018). Volatile chemical profile of cacao liquid smoke. *International Food Research Journal*, *25*(1), 213–216.

Javier-Astete, R., Jimenez-Davalos, J., & Zolla, G. (2021). Determination of hemicellulose, cellulose, holocellulose and lignin content using FTIR in Calycophyllum spruceanum (Benth.) K. Schum. And Guazuma crinita Lam. *PLoS ONE*, *16*(10 October), 1–12. https://doi.org/10.1371/journal.pone.0256559

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Jawad, A. H., Ezzuldin, S., Saber, M., Saud, A., Reghioua, A., Alothman, Z. A., & Wilson, L. D. (2022). Diamond & Related Materials Mesoporous activated carbon from mangosteen (Garcinia mangostana) peels by H3PO4 assisted microwave : Optimization , characterization , and adsorption mechanism for methylene blue dye removal. *Diamond & Related Materials*, *129*(September), 109389. https://doi.org/10.1016/j.diamond.2022.109389

Jayanudin, J., & Suhendi, E. (2012). Identifikasi komponen kimia asap cair tempurung kelapa dari wilayah Anyer Banten. *Jurnal Agroekoteknologi*, *4*(1), 39–46.

Jira, W. (2004). A GC/MS method for the determination of carcinogenic polycyclic aromatic hydrocarbons (PAH) in smoked meat products and liquid smokes. *European Food Research and Technology*, *218*(2), 208–212. https://doi.org/10.1007/s00217-003-0827-8

Jozefaciuk, G., & Bowanko, G. (2002). Effect of acid and alkali treatments on surface areas and adsorption energies of selected minerals. *Clays and Clay Minerals*, *50*(6), 771–783. https://doi.org/10.1346/000986002762090308

Kadir, S., Darmadji, P., & Hidayat, C. (2014). Sifat Sensoris Asap Cair Tempurung Kelapa Hasil Adsorpsi Pada Zeolit. *Jurnal Agroland*, *21*(2), 69–76.

Kalyani, P., & Anitha, A. (2013). Refuse derived energy - tea derived boric acid activated carbon as an electrode material for electrochemical capacitors. *Portugaliae Electrochimica Acta*, *31*(3), 165–174. https://doi.org/10.4152/pea.201303165

Karimi, M., & Shirzad, M. (2022). *Biomass / Biochar carbon materials for CO 2 capture and sequestration by cyclic adsorption processes : A review and prospects for future directions*. *57*(January). https://doi.org/10.1016/j.jcou.2022.101890

Kartikawati, N. K., Rimbawanto, A., Susanto, M., Baskorowati, L., & Prastyono. (2014). *Budidaya Dan Prospek Pengembangan Kayuputih (Melaleuca cajuputi)* (1st ed.). IPB Press.

Katja, D. G., Suryanto, E., & Momuat, L. I. (2008). *Pengaruh Adsorben Terhadap Aktivitas Antioksidan Dari Asap Cair Kayu Cempaka (Michelia champaka Linn)*. *1*(1), 54–59.

Kembar Sari, R. (2016). Potensi Mineral Batuan Tambang Bukit 12 Dengan Metode Xrd, Xrf Dan Aas. *Jurnal Eksakta*, *2*(17), 13–23.

Kesuma, R. F., & Sitorus, B. (2013). *Karakterisasi Pori Adsorben Berbahan Baku Kaolin Capkala dan Zeolit Dealuminasi*.

Klingstedt, F., Kalantar Neyestanaki, A., Lindfors, L. E., Salmi, T., Heikkilä, T., & Laine, E. (2003). An investigation of the activity and stability of Pd and Pd-Zr modified Y-zeolite catalysts for the removal of PAH, CO, CH4 and NOx emissions. *Applied Catalysis A:*

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

General, *239*(1–2), 229–240. https://doi.org/10.1016/S0926-860X(02)00386-1

Komarayati, S., Wibowo, S., & Alat, A. B. (2015). *(Characteristics of Liquid Smoke from Three Bamboo Species)*. *33*(2), 167–174.

Kumar, A., & Jena, H. M. (2016). Preparation and characterization of high surface area activated carbon from Fox nut (Euryale ferox) shell by chemical activation with H3PO4. *Results in Physics*, *6*, 651–658. https://doi.org/10.1016/j.rinp.2016.09.012

Kurniasari, L., Djaeni, M., & Purbasari, A. (2011). Aktivasi zeolit alam sebagai adsorben pada alat pengering bersuhu rendah. *Reaktor*, *13*(3), 178–184.

Kurniatia, F. D., Pardoyoa, & Suhartana. (2011). Sintesis Arang Aktif dari Tempurung Kelapa dan Aplikasinya Untuk Adsorpsi Asap Cair. *Jurnal Kimia Sains Dan Aplikasi*, *14*(3), 72–76.

Kusdarto. (2008). Potensi zeolit di indonesia. *JURNAL ZEOLIT INDONESIA*, *7*(2), 78–87.

Lamichhane, S., Bal Krishna, K. C., & Sarukkalige, R. (2016). Polycyclic aromatic hydrocarbons (PAHs) removal by sorption: A review. *Chemosphere*, *148*(March 2019), 336–353. https://doi.org/10.1016/j.chemosphere.2016.01.036

Langi, B. G., Rampe, M. J., & Tengker, S. M. T. (2020). Ekstraksi dan Identifikasi Komponen Utama Pasir Putih dari Desa Marinsow Kabupaten Minahasa Utara dengan Pengujian XRF dan XRD. *Fullerene Journal of Chemistry*, *5*(2), 78. https://doi.org/10.37033/fjc.v5i2.186

Lee, S. M., Lee, S. H., & Roh, J. S. (2021). Analysis of activation process of carbon black based on structural parameters obtained by XRD analysis. *Crystals*, *11*(2), 1–11. https://doi.org/10.3390/cryst11020153

Lemić, J., Tomašević-Čanović, M., Adamović, M., Kovačević, D., & Milićević, S. (2007). Competitive adsorption of polycyclic aromatic hydrocarbons on organo-zeolites. *Microporous and Mesoporous Materials*, *105*(3), 317–323. https://doi.org/10.1016/j.micromeso.2007.04.014

Lestari, Y. I., Idiawati, N., & Harlia. (2015). Aktivitas Antibakteri Asap Cair Tandan Kosong Sawit Grade 2 Yang Sebelumnya Diadsorpsi Zeolit Teraktivasi. *Jurnal Kimia Khatulistiwa*, *4*(4), 45–42.

Lewandowski, W. M., Ryms, M., & Kosakowski, W. (2020). Thermal Biomass Conversion : A Review. *Processes*, *8*(516), 1–48. https://doi.org/10.3390/pr8050516

Li, F., Chen, J., Hu, X., He, F., Bean, E., Tsang, D. C. W., Ok, Y. S., & Gao, B. (2020). Applications of carbonaceous adsorbents in the remediation of polycyclic aromatic hydrocarbon-contaminated sediments: A review. *Journal of Cleaner Production*, *255*,

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

120263. https://doi.org/10.1016/j.jclepro.2020.120263

Li, Z., Zhang, L., Chen, G., Wu, L., Liu, B., Li, Y., Sun, S., Zhang, H., Zhang, Z., & Wang, Z. (2018). A new method for comprehensive utilization of wood vinegar by distillation and liquid−liquid extraction. *Process Biochemistry*, *75*, 194–201. https://doi.org/10.1016/j.procbio.2018.08.012

Liang, W., Huang, J., Xiao, P., Singh, R., Guo, J., Dehdari, L., & Li, G. K. (2022). Amine-immobilized HY zeolite for CO2 capture from hot flue gas. *Chinese Journal of Chemical Engineering*, *43*, 335–342. https://doi.org/10.1016/j.cjche.2022.02.004

Lingbeck, J. M., Cordero, P., O'Bryan, C. A., Johnson, M. G., Ricke, S. C., & Crandall, P. G. (2014). Functionality of liquid smoke as an all-natural antimicrobial in food preservation. *Meat Science*, *97*(2), 197–206. https://doi.org/10.1016/j.meatsci.2014.02.003

Liu, K. (2019). Effects of sample size, dry ashing temperature and duration on determination of ash content in algae and other biomass. *Algal Research*, *40*(November 2018), 101486. https://doi.org/10.1016/j.algal.2019.101486

Liu, Z.-S. (2006). Control of PAHs from Incineration by Activated Carbon Fibers. *Journal of Environmental Engineering*, *132*(5), 463–469. https://doi.org/10.1061/(asce)0733-9372(2006)132:5(463)

Ma, C., Song, K., Yu, J., Yang, L., Zhao, C., Wang, W., Zu, G., & Zu, Y. (2013). Pyrolysis process and antioxidant activity of pyroligneous acid from Rosmarinus officinalis leaves. *Journal of Analytical and Applied Pyrolysis*, *104*, 38–47. https://doi.org/10.1016/j.jaap.2013.09.011

Madejová, J. (2003). FTIR techniques in clay mineral studies. *Vibrational Spectroscopy*, *31*(1), 1–10. https://doi.org/10.1016/S0924-2031(02)00065-6

Maga, J. A. (2009). *The flavor chemistry of wood smoke*. *May 2015*, 37–41. https://doi.org/10.1080/87559128709540810

Manni, A., Saviano, G., De Casa, G., Rotatori, M., Guarnieri, A., & Guerriero, E. (2007). Natural zeolites for PAH removal from liquid effluents. *Organohalogen Compounds*, *69*(February 2015), 2938–2941.

Mansouri, N., Rikhtegar, N., Ahmad Panahi, H., Atabi, F., & Shahraki, B. K. (2013). Porosity, characterization and structural properties of natural zeolite - Clinoptilolite - As a sorbent. *Environment Protection Engineering*, *39*(1), 139–152. https://doi.org/10.5277/EPE130111

Mansur, D., Sugiwati, S., Rizal, W. A., Suryani, R., & Maryana, R. (2021). Pyrolysis of cajuput (Melaleuca leucadendron) twigs and rice (Oryza sativa) husks to produce liquid smoke-

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

containing fine chemicals for antibacterial agent application. *Biomass Conversion and Biorefinery*, *0123456789*. https://doi.org/10.1007/s13399-021-01896-x

Marsyahyo, E. (2009). Analisis Brunnaeur Emmet Teller (Bet) Topografi Permukaan Serat Rami (Boehmeria nivea). *Jurnal Flywheel*, *2*, 33–41.

Mateen, F., Javed, I., Rafique, U., Tabassum, N., Sarfraz, M., Safi, S. Z., Yusoff, I., & Ashraf, M. A. (2015). New method for the adsorption of organic pollutants using natural zeolite incinerator ash (ZIA) and its application as an environmentally friendly and cost-effective adsorbent. *Desalination and Water Treatment*, *57*(14), 6230–6238. https://doi.org/10.1080/19443994.2015.1005146

Maulina, S., & Amalia, R. (2020). Quality improvement of liquid smoke from oil palm frond pyrolysis through the adsorption-distillation process using activated carbon as adsorbent. *IOP Conference Series: Materials Science and Engineering*, *801*(1). https://doi.org/10.1088/1757-899X/801/1/012064

Maulina, Seri, Kamny, E. R., & Amalia, R. (2021). Comparison of activated zeolite and activated carbon as adsorbent on liquid smoke purification. *IOP Conference Series: Materials Science and Engineering*, *1122*(1), 012102. https://doi.org/10.1088/1757-899x/1122/1/012102

Maulina, Seri, & Karo, E. O. br. (2021). Improving the quality of liquid smoke from pyrolysis of oil palm fronds with the adsorption–distillation purification process. *IOP Conference Series: Materials Science and Engineering*, *1122*(1), 012101. https://doi.org/10.1088/1757-899x/1122/1/012101

Maulina, Seri, & Mentari, V. A. (2019). Comparison of Functional Group and Morphological Surface of Activated Carbon from Oil Palm Fronds Using Phosphoric Acid (H3PO4) and Nitric Acid (HNO3) as an Activator. *IOP Conference Series: Materials Science and Engineering*, *505*(1). https://doi.org/10.1088/1757-899X/505/1/012023

Meng, J., Moore, A., Tilotta, D. C., Kelley, S. S., Adhikari, S., & Park, S. (2015). Thermal and Storage Stability of Bio-Oil from Pyrolysis of Torrefied Wood. *Energy and Fuels*, *29*(8), 5117–5126. https://doi.org/10.1021/acs.energyfuels.5b00929

Menon, V., & Rao, M. (2012). Trends in bioconversion of lignocellulose : Biofuels , platform chemicals & biore fi nery concept. *Progress in Energy and Combustion Science*, *38*(4), 522–550. https://doi.org/10.1016/j.pecs.2012.02.002

Menya, E., Olupot, P. W., Storz, H., Lubwama, M., & Kiros, Y. (2018). Characterization and alkaline pretreatment of rice husk varieties in Uganda for potential utilization as precursors in the production of activated carbon and other value-added products. *Waste Management*,

UNIVERSITAS GADJAH MADA
Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

81, 104–116. https://doi.org/10.1016/j.wasman.2018.09.050

Milly, P. J., Toledo, R. T., & Ramakrishnan, S. (2005). Determination of minimum inhibitory concentration of liquid smoke fractions. *Journal of Food Science*, *70*(1), 12–17. https://doi.org/10.1111/j.1365-2621.2005.tb09040.x

Mirzaee, E., & Sartaj, M. (2022). Activated carbon-based magnetic composite as an adsorbent for removal of polycyclic aromatic hydrocarbons from aqueous phase: Characterization, adsorption kinetics and isotherm studies. *Journal of Hazardous Materials Advances*, *6*(February), 100083. https://doi.org/10.1016/j.hazadv.2022.100083

Mitchual, S. J., Frimpong-Mensah, K., & Darkwa, N. A. (2014). Evaluation of Fuel Properties of Six Tropical Hardwood Timber Species for Briquettes. *Journal of Sustainable Bioenergy Systems*, *04*(01), 1–9. https://doi.org/10.4236/jsbs.2014.41001

Mkungunugwa, T., Manhokwe, S., Chawafambira, A., & Shumba, M. (2021). Synthesis and Characterisation of Activated Carbon Obtained from Marula (Sclerocarya birrea) Nutshell. *Journal of Chemistry*, *2021*. https://doi.org/10.1155/2021/5552224

Mokrzycki, W., & Tatol, M. (2011). Color difference Delta E - A survey Colour difference Δ E - A survey Faculty of Mathematics and Informatics. *Machine Graphics and Vision*, *20*(4), 383–411.

Montazeri, N., Oliveira, A. C. M., Himelbloom, B. H., Leigh, M. B., & Crapo, C. A. (2013). Chemical characterization of commercial liquid smoke products. *Food Science & Nutrition*, *1*(1), 102–115. https://doi.org/10.1002/fsn3.9

Moria, K. M., Khurshid, H., Mustafa, M. R. U., Alhothali, A., & Bamasag, O. O. (2022). Application of the Response Surface Methodology (RSM) in the Optimization of Acenaphthene (ACN) Removal from Wastewater by Activated Carbon. *Sustainability (Switzerland)*, *14*(14). https://doi.org/10.3390/su14148581

Mozgawa, W., Król, M., & Barczyk, K. (2011). FT-IR studies of zeolites from different structural groups. *Chemik*, *65*(7), 671–674.

Muharyani, N., & Abdillah, E. (2020). POTENSI PENANGANAN LIMBAH DAUN KAYU PUTIH SISA PENYULINGAN DI PMKP KRAI-GUNDIH. *Risalah Kebijakan PErtanian Dan Lingkungan*, *7*(1), 28–36.

Mukherjee, A., Okolie, J. A., Niu, C., & Dalai, A. K. (2022). Experimental and Modeling Studies of Torrefaction of Spent Coffee Grounds and Coffee Husk: Effects on Surface Chemistry and Carbon Dioxide Capture Performance. *ACS Omega*, *7*(1), 638–653. https://doi.org/10.1021/acsomega.1c05270

Muliyanti, K., Hidayat, C., & Supriyadi, S. (2023). Identification and Composition of Volatile

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Compounds in Liquid Smoke Derived from Betara Variety of Areca catechu Husk. *Agritech*, *43*(2), 187–198.

Mulyana, B., Wahyuni, S., Siallagan, S., Yuwono, T., & Purwanto, H. (2019). Daur Optimum Pemangkasan Daun Kayu Putih Di KPH Yogyakarta. *Jurnal Penelitian Kehutanan Wallacea*, *8*(1), 71–79.

Mumtazy, M. R., Amelia, S. T. W., & Wiguno, A. (2020). Pra Desain Pabrik Minyak Kayu Putih dari Daun Kayu Putih. *Jurnal Teknik ITS*, *9*(2), F355–F361.

Munasir, M., Triwikantoro, T., Zainuri, M., & Darminto, D. (2012). Uji Xrd Dan Xrf Pada Bahan Meneral (Batuan Dan Pasir) Sebagai Sumber Material Cerdas (Caco3 Dan Sio2). *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*, *2*(1), 20. https://doi.org/10.26740/jpfa.v2n1.p20-29

Muttaqii, M. Al, Birawidha, D. C., Isnugroho, K., Amin, M., Hendronursito, Y., Istiqomah, A. D., & Dewangga, D. P. (2019). Pengaruh aktivasi secara kimia menggunakan larutan asam dan basa terhadap karakteristik zeolit alam. *Jurnal Riset Teknologi Industri*, *13*(2), 266–271.

Nagham Mahmood Aljamali, Radhiyah Abdul Baqi Aldujaili, & Intisar Obaid Alfatlawi. (2021). Physical and Chemical Adsorption and its Applications. *International Journal of Thermodynamics and Chemical Kinetics*, *7*(2), 1–9. https://doi.org/10.37628/IJTCK

Naikoo, R. A., Bhat, S. U., Mir, M. A., Tomar, R., Khanday, W. A., Dipak, P., & Tiwari, D. C. (2016). Polypyrrole and its composites with various cation exchanged forms of zeolite X and their role in sensitive detection of carbon monoxide. *RSC Advances*, *6*(101), 99202–99210. https://doi.org/10.1039/c6ra19708f

Nandiyanto, A. B. D., Oktiani, R., & Ragadhita, R. (2019). How to read and interpret ftir spectroscope of organic material. *Indonesian Journal of Science and Technology*, *4*(1), 97–118. https://doi.org/10.17509/ijost.v4i1.15806

Nendissa, D. . N. (2007). EFEK METODA PEMURNIAN REDESTILASI DAN ADSORBSI DENGAN ZEOLIT AKTIF TERHADAP KOMPONEN ASAP CAIR TEMPURUNG KELAPA. *Seminar Nasional"Akselerasi Inovasi Teknologi Pertanian Spesifik Lokasi Mendukung Ketahanan Pangan DiWilayah Kepulauan,"* 722–727.

Ngatijo, Farid, F., & Dika, D. S. P. (2021). Zeolite Coating with Phenantroline for Adsorption of Ion Fe (III). *Proceedings of the 3rd Green Development International Conference (GDIC 2020)*, *205*(Gdic 2020), 31–35. https://doi.org/10.2991/aer.k.210825.007

Nguyen, H., Hai, T., Rimbawanto, A., Kartikawati, N. K., & Wu, H. (2019). Genetic improvement for essential oil yield and quality in Melaleuca cajuputi. *Industrial Crops &*

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Products, *137*(June), 681–686. https://doi.org/10.1016/j.indcrop.2019.05.061

Ningrum, shinta silir yunia, & Anggraini, sinar perbawani abrina. (2018). Pemurnian Asap Cair Terhadap Kinerja Reaktor Pirolisis Melalui Proses Filtrasi Zeolit Aktif. *Prosiding Seminar Nasional Teknologi Industri, Lingkungan Dan Infrastruktur*, *1*(September), 1–6.

Nizami, A. S., Rehan, M., Waqas, M., Naqvi, M., Ouda, O. K. M., Shahzad, K., Miandad, R., Khan, M. Z., Syamsiro, M., Ismail, I. M. I., & Pant, D. (2017). Waste biorefineries: Enabling circular economies in developing countries. *Bioresource Technology*, *241*, 1101–1117. https://doi.org/10.1016/j.biortech.2017.05.097

Nurhasni, N., Firdiyono, F., & Sya'ban, Q. (2012). Penyerapan Ion Aluminium dan Besi dalam Larutan Sodium Silikat Menggunakan Karbon aktif. *Jurnal Kimia VALENSI*, *2*(4). https://doi.org/10.15408/jkv.v2i4.269

Nurhayati, T., Pasaribu, R. A., & Mulyadi, D. (2006). Produksi Dan Pemanfaatan Arang Dan Cuka Kayu Dari Serbuk Gergaji Kayu Campuran. *Jurnal Penelitian Hasil Hutan*, *24*(5), 395–411. https://doi.org/10.20886/jphh.2006.24.5.395-411

Nyankson, E., Efavi, J. K., Yaya, A., Manu, G., Asare, K., Daafuor, J., & Abrokwah, R. Y. (2018). Synthesis and characterisation of zeolite-A and Zn-exchanged zeolite-A based on natural aluminosilicates and their potential applications. *Cogent Engineering*, *5*(1), 1–23. https://doi.org/10.1080/23311916.2018.1440480

Oktafany, E., Idiawati, N., & Harlia. (2016a). Pengaruh Destilasi Berulang dan Pemurnian menggunakan Zeolit Teraktivasi H2SO4 terhadap Komposisi Asap Cair Tandan Kosong Kelapa Sawit (TKKS). *Jurnal Kimia Dan Kemasan (JKK)*, *5*(2), 62–67.

Oktafany, E., Idiawati, N., & Harlia. (2016b). Pengaruh Destilasi Berulang Dan Pemurnian Menggunakan Zeolit Teraktivasi H2so4 Terhadap Komposisi Asap Cair Tandan Kosong Kelapa Sawit (TKKS). *Jurnal Kimia Khatulistiwa*, *5*(4), 62–67.

Oleszczuk, P., Hale, S. E., Lehmann, J., & Cornelissen, G. (2012). Activated carbon and biochar amendments decrease pore-water concentrations of polycyclic aromatic hydrocarbons (PAHs) in sewage sludge. *Bioresource Technology*, *111*, 84–91. https://doi.org/10.1016/j.biortech.2012.02.030

Omri Abdessalem, B. M. (2012). Characterization of Activated Carbon Prepared From a New Raw Lignocellulosic Material: Ziziphus Spina-Christi Seeds. *Journal de La Société Chimique de Tunisie*, *14*, 175–183.

Ong, H. C., Yu, K. L., Chen, W. H., Pillejera, M. K., Bi, X., Tran, K. Q., Pétrissans, A., & Pétrissans, M. (2021). Variation of lignocellulosic biomass structure from torrefaction: A critical review. In *Renewable and Sustainable Energy Reviews* (Vol. 152).

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

https://doi.org/10.1016/j.rser.2021.111698

Padalia, R. C., Verma, R. S., Chauhan, A., Goswami, P., Verma, S. K., & Darokar, M. P. (2015). Chemical composition of Melaleuca linarrifolia Sm . from India : a potential source of 1 , 8-cineole. *Industrial Crops & Products*, *63*, 264–268. https://doi.org/10.1016/j.indcrop.2014.09.039

Pálinkó, I., Kónya, Z., Kukovecz, Á., & Kiricsi, I. (2013). Zeolites. In *Springer Handbook of Nanomaterials* (pp. 822–850).

Parker, J. K., Lignou, S., Shankland, K., Kurwie, P., Gri, H. D., & Baines, D. A. (2018). *Development of a Zeolite Filter for Removing Polycyclic Aromatic Hydrocarbons (PAHs) from Smoke and Smoked Ingredients while Retaining the Smoky Flavor*. https://doi.org/10.1021/acs.jafc.6b05399

Pathak, S., Sakhiya, A. K., Anand, A., Pant, K. K., & Kaushal, P. (2022a). A state-of-the-art review of various adsorption media employed for the removal of toxic Polycyclic aromatic hydrocarbons (PAHs): An approach towards a cleaner environment. *Journal of Water Process Engineering*, *47*(November 2021), 102674. https://doi.org/10.1016/j.jwpe.2022.102674

Patramurti, C., Amin, R., Nastiti, C. M. R. R., & Hariono, M. (2020). A Review on the Potency of Melaleuca leucadendron Leaves Solid Waste in Wood Preservation and Its In Silico Prediction upon Biological Activities. *International Journal of Forestry Research*, *2020*. https://doi.org/https://doi.org/10.1155/2020/8885259

Peak, D. (2013). Fourier Transform Infrared Spectroscopic Methods of Soil Analysis. In *Reference Module in Earth Systems and Environmental Sciences* (Issue July). Elsevier Inc. https://doi.org/10.1016/b978-0-12-409548-9.05170-8

Peng, P., Lang, Y., & Wang, X. (2016). Adsorption behavior and mechanism of pentachlorophenol on reed biochars : pH effect , pyrolysis temperature , hydrochloric acid treatment and isotherms. *Ecological Engineering*, *90*, 225–233. https://doi.org/10.1016/j.ecoleng.2016.01.039

Perhutani. (2020). *laporan tahunan 2020 perum perhutani*.

Phuphuakrat, T., Namioka, T., & Yoshikawa, K. (2011). Absorptive removal of biomass tar using water and oily materials. *Bioresource Technology*, *102*(2), 543–549. https://doi.org/10.1016/j.biortech.2010.07.073

Pimenidou, P., & Dupont, V. (2012). Characterisation of palm empty fruit bunch (PEFB) and pinewood bio-oils and kinetics of their thermal degradation. *Bioresource Technology*, *109*, 198–205. https://doi.org/10.1016/j.biortech.2012.01.020

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Pino, J. A. (2014). Characterisation of volatile compounds in a smoke flavouring from rice husk. *Food Chemistry*, *153*, 81–86. https://doi.org/10.1016/j.foodchem.2013.12.041

Potnuri, R., Suriapparao, D. V., Rao, C. S., & Kumar, T. H. (2022). Understanding the role of modeling and simulation in pyrolysis of biomass and waste plastics: A review. *Bioresource Technology Reports*, *20*, 101221. https://doi.org/10.1016/j.biteb.2022.101221

Pourhakkak, P., Taghizadeh, A., Taghizadeh, M., Ghaedi, M., & Haghdoust, S. (2021a). Fundamentals of adsorption technology. In M. Ghaed (Ed.), *Adsorption : Fundamental Process and Applications* (pp. 1–70). elsevier science.

Prasetyo, D. J., Budhijanto, W., Kurnianto, R. W., & Wahono, S. K. (2021). Peruraian Anaerobik Termofilik Limbah Vinasse : Pengaruh Zeolit Alam Teraktivasi Asam dan Basa Terhadap Performa Proses. *Jurnal Riset Teknologi Industri*, *15*(2), 257. https://doi.org/10.26578/jrti.v15i2.7005

Pratita, A. T. K., Aisy, N. R., Wardani, G. A., & Fathurohman, M. (2022). Isolasi dan aktivitas antioksidan dengan menggunakan metode ABTS (2,2 Azinobis (3-Ethylbenzotiazolin) 6 Sulfonat) senyawa superoksida dismutase pada mikroalga (Chlorrela vulgaris). *Prosiding Seminar Nasional Diseminasi Hasil Penelitian Program Studi S1 Farmasi*, *2*(1), 177–184.

Prayitno, T. A., Pramana, J., & Sutapa, G. (2014). *Kualitas Asap Cair Batang Gelam (Melaleuca sp .) (Quality of Wood Vinegar Stem Gelam (Melaleuca sp .))*. *32*(2), 83–92.

Putri, R. E., Kasim, A., Emriadi, & Asben, A. (2019). Pyrolysis and Characterization of Liquid Smoke from Cacao Pod Husks. *IOP Conference Series: Earth and Environmental Science*, *327*(1). https://doi.org/10.1088/1755-1315/327/1/012011

Qiu, B., Shao, Q., Shi, J., Yang, C., & Chu, H. (2022). Application of biochar for the adsorption of organic pollutants from wastewater : Modification strategies , mechanisms and challenges. *Separation and Purification Technology*, *300*(June), 121925. https://doi.org/10.1016/j.seppur.2022.121925

Qiu, B., Yang, C., Shao, Q., Liu, Y., & Chu, H. (2022). Recent advances on industrial solid waste catalysts for improving the quality of bio-oil from biomass catalytic cracking: A review. *Fuel*, *315*(November 2021), 123218. https://doi.org/10.1016/j.fuel.2022.123218

R.E. Wrolstad, D. E. S. (2021). Color Analysis. In S. S. Nielsen (Ed.), *Food Analysis* (fifth edit, pp. 545–554). Springer. https://doi.org/10.1007/978-3-319-45776-5

Rad, L. R., & Anbia, M. (2021). Zeolite-based composites for the adsorption of toxic matters from water: A review. *Journal of Environmental Chemical Engineering*, *9*(5), 106088. https://doi.org/10.1016/j.jece.2021.106088

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GADJAH MADA
**Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Ramesh, K., & Reddy, D. D. (2011). Zeolites and Their Potential Uses in Agriculture. In *Advances in Agronomy* (Vol. 113, pp. 219–235). https://doi.org/10.1016/B978-0-12-386473-4.00004-X

Rampe, M. J., Santoso, I. R. S., Rampe, H. L., Tiwow, V. A., & Apita, A. (2021). Infrared Spectra Patterns of Coconut Shell Charcoal as Result of Pyrolysis and Acid Activation Origin of Sulawesi, Indonesia. *E3S Web of Conferences*, *328*, 3–6. https://doi.org/10.1051/e3sconf/202132808008

Rampe, M. J., & Tiwow, V. A. (2018). Fabrication and Characterization of Activated Carbon from Charcoal Coconut Shell Minahasa, Indonesia. *Journal of Physics: Conference Series*, *1028*(1). https://doi.org/10.1088/1742-6596/1028/1/012033

Ratnawati, & Singgih, H. (2010). Terhadap Kuantitas Dan Kualitas Asap Cair Pembuatan dan Karakterisasi Asap Cair. *Jurnal Sains Materi Indonesia*, *12*(1), 7–11.

Reilly, T., Mierczynski, P., Suwanto, A., Wahono, S. K., Maniukiewicz, W., Vasilev, K., Bindon, K., & Mierczynska-vasilev, A. (2023). *Using Zeolites to Cold Stabilize White Wines*. *2023*.

Rhofita, E. I., Rachmat, R., Meyer, M., & Montastruc, L. (2022). Mapping analysis of biomass residue valorization as the future green energy generation in Indonesia. *Journal of Cleaner Production*, *354*(March), 131667. https://doi.org/10.1016/j.jclepro.2022.131667

Ria Suryani, Wahyu Anggo Rizal, Diah Pratiwi, D. J. P. (2020). Characteristics and Antibacterial Activity of Liquid Smoke From White Wood (Melaleuca leucadendra) and Teak Wood (Tectona grandis) Biomass. *Jurnal Teknologi Pertanian*, *21*(2), 106–117.

Ridhuan, K., Irawan, D., & Inthifawzi, R. (2019). Proses Pembakaran Pirolisis dengan Jenis Biomassa dan Karakteristik Asap Cair yang Dihasilkan. *Turbo : Jurnal Program Studi Teknik Mesin*, *8*(1), 69–78. https://doi.org/10.24127/trb.v8i1.924

RImbawanto, A., Kartikawati, N., & Latumahina, F. (2021). Conservation and utilization of Melaleuca cajuputi sub sp cajuputi, an indigenous species in Moluccas Island, Indonesia. *IOP Conf. Series: Earth and Environmental Science 800*, 800. https://doi.org/10.1088/1755-1315/800/1/012040

Rinaldi, A., Alimuddin, & Panggabean, A. S. (2015). Pemurnian Asap Cair Dari Kulit Durian Dengan Menggunakan Arang Aktif. *Molekul*, *10*(2), 112–120.

Rinawati, Hidayat, D., Supriyanto, R., Permana, D. F., & Yunita. (2019). Adsorption of Polycyclic Aromatic Hydrocarbons using Low- Cost Activated Carbon Derived from Rice Husk. *IOP Conf. Series: Journal of Physics*. https://doi.org/10.1088/1742-6596/1338/1/012005

UNIVERSITAS
GADJAH MADA
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Rizal, W. A., Maryana, R., Prasetyo, D. J., Suwanto, A., & Wahono, S. K. (2020). Alkaline pretreatment of sugarcane bagasse on pilot scale reactor. *IOP Conference Series: Earth and Environmental Science*, *462*(1). https://doi.org/10.1088/1755-1315/462/1/012056

Rizal, Wahyu Anggo, Suryani, R., Anwar, M., Prasetyo, D. J., Wahono, S. K., Apriyanaa, W., Jatmikoa, T. H., Suwantoa, A., Maryana, R., & Hernawan. (2022). Efektivitas Pemurnian Asap Cair Biomassa Serbuk Gergaji dengan Distilasi, Adsorpsi Zeolite dan Karbon Aktif. *Jurnal Selulosa*, *12*(1), 11–22.

Rizal, Wahyu Anggo, Suryani, R., Wahono, S. K., Anwar, M., Prasetyo, D. J., Amdani, R. Z., Suwanto, A., & Februanata, N. (2020). Pirolisis limbah biomassa serbuk gergaji kayu campuran: parameter proses dan analisis produk asap cair. *Jurnal Riset Teknologi Industri*, *14*(2), 353–364.

Ruíz-Baltazar, A., Esparza, R., Gonzalez, M., Rosas, G., & Pérez, R. (2015). Preparation and characterization of natural zeolite modified with iron nanoparticles. *Journal of Nanomaterials*, *2015*, 1–9. https://doi.org/10.1155/2015/364763

Saab, R., Polychronopoulou, K., Zheng, L., Kumar, S., & Schiffer, A. (2020). Synthesis and performance evaluation of hydrocracking catalysts: A review. *Journal of Industrial and Engineering Chemistry*, *89*, 83–103. https://doi.org/10.1016/j.jiec.2020.06.022

Sait, H. H., Hussain, A., Salema, A. A., & Ani, F. N. (2012). Pyrolysis and combustion kinetics of date palm biomass using thermogravimetric analysis. *Bioresource Technology*, *118*, 382–389. https://doi.org/10.1016/j.biortech.2012.04.081

Salamah, S., & Jamilatun, S. (2017). *Pemanfaatan Asap Cair Food Grade yang Dimurnikan dengan Arang Aktif sebagai Pengawet Ikan Nila The Utilization of Food Grade Liquid Smoke Purified by Activated Charcoal as Tilapia Fish Preservative*. *14*(2), 29–34.

Salami, A., Raninen, K., Heikkinen, J., Tomppo, L., & Vilppo, T. (2020). Industrial Crops & Products Complementary chemical characterization of distillates obtained from industrial hemp hurds by thermal processing. *Industrial Crops & Products*, *155*(November 2019), 112760. https://doi.org/10.1016/j.indcrop.2020.112760

Sari, R. M., Gea, S., Wirjosentono, B., Hendrana, S., & Torres, F. G. (2021). The effectiveness of coconut coir as tar adsorbent in liquid smoke integrated into the pyrolysis reactor. *Case Studies in Thermal Engineering*, *25*(December 2020), 0–5. https://doi.org/10.1016/j.csite.2021.100907

Sari, R. M., Wahono, S. K., Anwar, M., Rizal, W. A., Suryani, R., & Suwanto, A. (2023). Reduction of Tar Generated During Liquid Smoke Pyrolysis Integrated Water Scrubber. *SSRN Electronic Journal*, *0123456789*. https://doi.org/10.2139/ssrn.4387986

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Sari, W. P., Sumantri, D., Noviyanti, D., & Imam, A. (2014). Pemeriksaan Komposisi Glass Fiber Komersial Dengan Teknik X-Ray Fluorescence Spectrometer (XRF). *Jurnal B-Dent*, *1*(2), 155–160.

Satouh, S., Mart, J., Orta, M., Medina-carrasco, S., Messikh, N., Bougdah, N., Santos, J. L., Aparicio, I., & Alonso, E. (2021). Adsorption of Polycyclic Aromatic Hydrocarbons by Natural , Synthetic and Modified Clays. *Environments*, *8*(124), 1–16.

Schlanges, I., Meyer, D., Palm, W. U., & Ruck, W. (2008). Identification, quantification and distribution of PAC-metabolites, heterocyclic PAC and substituted PAC in groundwater samples of tar-contaminated sites from Germany. *Polycyclic Aromatic Compounds*, *28*(4–5), 320–338. https://doi.org/10.1080/10406630802377807

Sentosa, L., Subagio, B. S., Rahman, H., & Yamin, R. A. (2018). Aktivasi Zeolit Alam Asal Bayah dengan Asam dan Basa sebagai Aditif Campuran Beraspal Hangat (Warm Mixed Asphalt). *Jurnal Teoritis Dan Terapan Bidang Rekayasa Sipil*, *25*(3), 203–212. https://doi.org/10.5614/jts.2018.25.3.5

Septian, F. D., & Nur, M. M. (2020). Kajian Pengaruh Pemurnian Asap Cair dengan Metode Distilasi dan Adsorpsi Menggunakan Zeolit Alam. *Jurnal Inovasi Ramah Lingkungan*, *1*(2), 2–5.

Seri Maulina, & Feni Sari Putri. (2017). Pengaruh Suhu, Waktu, Dan Kadar Air Bahan Baku Terhadap Pirolisis Serbuk Pelepah Kelapa Sawit. *Jurnal Teknik Kimia USU*, *6*(2), 35–40. https://doi.org/10.32734/jtk.v6i2.1581

Shamsuddin, M. S., Yusoff, N. R. N., & Sulaiman, M. A. (2016). Synthesis and Characterization of Activated Carbon Produced from Kenaf Core Fiber Using H3PO4 Activation. *Procedia Chemistry*, *19*, 558–565. https://doi.org/10.1016/j.proche.2016.03.053

Shen, Y., Zhou, Y., Fu, Y., & Zhang, N. (2020). Activated carbons synthesized from unaltered and pelletized biomass wastes for bio-tar adsorption in different phases. *Renewable Energy*, *146*, 1700–1709. https://doi.org/10.1016/j.renene.2019.07.167

Sherman, J. D. (1999). Synthetic zeolites and other microporous oxide molecular sieves. *Proc. Natl. Acad. Sci. USA*, *96*(March), 3471–3478. https://doi.org/10.1073/pnas.96.7.3471

Shi, C., Li, L., & Li, Y. (2020). *High-throughput screening of hypothetical aluminosilicate zeolites for CO 2 capture from flue gas*. *42*(October). https://doi.org/10.1016/j.jcou.2020.101346

Shrestha, D., Gyawali, G., & Nyachhyon, A. R. (2018). Preparation and characterization of activated carbon from FROM WASTE SAWDUST FROM SAW MILL. *Journal of*

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Institute of Science and Technology, *22*(2), 103–108.

Simko, P. (2005). Factors affecting elimination of polycyclic aromatic hydrocarbons from smoked meat foods and liquid smoke flavorings. *Mol. Nutr. Food Res*, *49*, 637–647. https://doi.org/10.1002/mnfr.200400091

Singh, S., Kumar Bhaumik, S., Dong, L., & Vuthaluru, H. (2022). Enhanced tar removal in syngas cleaning through integrated steam catalytic tar reforming and adsorption using biochar. *Fuel*, *331*(July 2021). https://doi.org/10.1016/j.fuel.2022.125912

Sirait, M., Bukit, N., & Simarmata, U. (2014). Sintesis Nanozeolit Alam menggunakan Metode Ball Milling. *Jurnal Sains Materi Indonesia*, *16*(1), 7–11.

Siruru, H.-, & Riupassa, P. (2021). Analisis Bilangan Gelombang Arang Aktif Kayu Makila (Litsea Angulata B.L). *Makila*, *15*(2), 110–119. https://doi.org/10.30598/makila.v15i2.4560

Soares, J. M., da Silva, P. F., Puton, B. M. S., Brustolin, A. P., Cansian, R. L., Dallago, R. M., & Valduga, E. (2016). Antimicrobial and antioxidant activity of liquid smoke and its potential application to bacon. *Innovative Food Science and Emerging Technologies*, *38*, 189–197. https://doi.org/10.1016/j.ifset.2016.10.007

Soazo, M., Pérez, L. M., Piccirilli, G. N., Delorenzi, N. J., & Verdini, R. A. (2016). Antimicrobial and physicochemical characterization of whey protein concentrate edible films incorporated with liquid smoke. *Lwt*, *72*, 285–291. https://doi.org/10.1016/j.lwt.2016.04.027

Sokamte tegang, A., Mbougueng, P. D., Sachindra, N. M., Douanla Nodem, N. F., & Tatsadjieu Ngoune, L. (2020a). Characterization of volatile compounds of liquid smoke flavourings from some tropical hardwoods. *Scientific African*, *8*, e00443. https://doi.org/10.1016/j.sciaf.2020.e00443

Solinska, A., & Bajda, T. (2022). Modified zeolite as a sorbent for removal of contaminants from wet flue gas desulphurization wastewater. *Chemosphere*, *286*(March 2021), 1–10. https://doi.org/10.1016/j.chemosphere.2021.131772

Song, L., Du, X., Chen, Y., Yang, Z., Ran, J., & Yang, G. (2021). Microporous and Mesoporous Materials Screening of zeolites for H 2 S adsorption in mixed gases : GCMC and DFT simulations. *Microporous and Mesoporous Materials*, *328*(March), 111495. https://doi.org/10.1016/j.micromeso.2021.111495

Suaib, nur fajriani, Yermia, & Agustina. (2019). PEMBUATAN DAN ANALISIS KOMPONEN KIMIA ASAP CAIR KAYU GAMAL (Gliricidia sepium) HASIL PEMURNIAN DENGAN METODE DESTILASI BERTINGKAT. *Jurnal Sains Dan*

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Teknologi Pangan, *4*(1), 1868–1878.

Sugiwati, S., Mansur, D., Rizal, W. A., Suryani, R., & Maryana, R. (2022). Antioxidant activity of liquid smoke fractions from cajuput (Melaleuca leucadendron) twigs and rice (Oryza sativa) husks. *AIP Conference Proceedings, 7th International Symposium on Applied Chemistry*, *070026*(December). https://doi.org/https://doi.org/10.1063/5.0115927

Suhartana, & Pardoyo. (2020). Activation of Natural Zeolite and Its Application for Adsorbents in Domestic Wastewater Treatment in Tembalang District, Semarang City. *Jurnal Kimia Sains Dan Aplikasi*, *23*(1), 28–33. https://doi.org/https://doi.0rg/10.14710/jksa.23.1.28-33

Sullivan, G. L., Prigmore, R. M., Knight, P., & Godfrey, A. R. (2019). Activated carbon biochar from municipal waste as a sorptive agent for the removal of polyaromatic hydrocarbons (PAHs), phenols and petroleum based compounds in contaminated liquids. *Journal of Environmental Management*, *251*(September), 109551. https://doi.org/10.1016/j.jenvman.2019.109551

Sultana, M., Hasan, M., Sabrin, M., Rahaman, H., & Alam, N. (2022). A review on experimental chemically modified activated carbon to enhance dye and heavy metals adsorption. *Cleaner Engineering and Technology*, *6*, 100382. https://doi.org/10.1016/j.clet.2021.100382

Suryani, R., Daradwinta, R., Syifa, S. A., Rahmah, A., Anggo, W., Tri, R., Jatmiko, H., Apriyana, W., & Asih, Y. (2022). *Antioxidant Activity , Total Phenolic Content , and Chemical Composition of Liquid Smoke Derived from Wood Sawdust*. *22*, 634–639.

Suryani, R., Rizal, W. A., Prasetyo, D. J., Apriyana, W., Anwar, M., & Wahono, S. K. (2023). Physicochemical Characteristics , Antioxidant and Antibacterial Activities of Liquid Smoke Derived from Mixed Sawdust and Cocoa Pod Husks Biomass. *TRENDS IN SCIENCES*, *20*(6). https://doi.org/https://doi.org/10.48048/tis.2023.4985

Suryanto, E., Taroreh, M. R. ., & Taomuat, L. I. (2020). Purification and Characterization of Phenolic Antioxidant from Corncob Liquid Smoke. *Asian Journal of Chemistry*, *32*(12), 2985–2990. https://doi.org/https://doi.org/10.14233/ajchem.2020.22486

Sutapa, J. P. G., & Hidayat, A. N. (2009). pemanfaatan limbah daun dan ranting penyulingan minyak kayu putih (melaleuca cajuputi powell) untuk pembuatan arang aktif. *Prosiding Seminar Nasional Masyarakat Peneliti Kayu Indonesia XIV*, 379–385.

T A B Prasetyo, B. S. (2018). Characterization of sonicated natural zeolite/ferric chloride hexahydrate by infrared spectroscopy. *3rd International Symposium on Frontier of Applied Physics*. https://doi.org/doi :10.1088/1742-6596/985/1/012022

Tan, I. A. W., Abdullah, M. O., Lim, L. L. P., & Yeo, T. H. . (2017). Surface Modification and

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Characterization of Coconut Shell-Based Activated Carbon Subjected to Acidic and Alkaline Treatments. *Journal of Applied Science & Process Engineering*, *4*(2), 186–194.

Tan, Z. (2020). Air Pollution and Greenhouse Gases, From Basic Concepts to Engineering Applications for Air Emission Control. In *Commercial Energy Auditing*. Springer. https://doi.org/10.1201/9781003151999-22

Thaipong, K., Boonprakob, U., Crosby, K., Cisneros-Zevallos, L., & Hawkins Byrne, D. (2006). Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts. *Journal of Food Composition and Analysis*, *19*(6–7), 669–675. https://doi.org/10.1016/j.jfca.2006.01.003

Thapa, S., Bhoi, P. R., Kumar, A., & Huhnke, R. L. (2017). *Effects of Syngas Cooling and Biomass Filter Medium on Tar Removal*. *Ic*, 1–12. https://doi.org/10.3390/en10030349

Thengane, S. K., Kung, K. S., Gomez-barea, A., & Ghoniem, A. F. (2022). Advances in biomass torrefaction : Parameters , models , reactors , applications , deployment , and market. *Progress in Energy and Combustion Science*, *93*(November 2021), 101040. https://doi.org/10.1016/j.pecs.2022.101040

Thomas, B. N., George, S. C., & Shell, C. O. (2015). Production of Activated Carbon from Natural Sources. *Trends in Green Chemistry*, *1*(1), 1–5.

Thommes, M., Kaneko, K., Neimark, A. V, Olivier, J. P., Rodriguez-reinoso, F., Rouquerol, J., & Sing, K. S. W. (2015). Physisorption of gases , with special reference to the evaluation of surface area and pore size distribution (IUPAC Technical Report). *Pure Appl. Chem*. https://doi.org/10.1515/pac-2014-1117

Tkachenko, Y., & Niedzielski, P. (2022). FTIR as a Method for Qualitative Assessment of Solid Samples in Geochemical Research: A Review. *Molecules*, *27*(24). https://doi.org/10.3390/molecules27248846

Tsai, W. T., Chang, C. Y., & Lee, S. L. (1997). Preparation and characterization of activated carbons from corn cob. *Carbon*, *35*(8), 1198–1200.

Uddin, M. N., Techato, K., Taweekun, J., Rahman, M. M., Rasul, M. G., Mahlia, T. M. I., & 7, S. M. A. (2018). An Overview of Recent Developments in Biomass Pyrolysis Technologies. *Energies*, *11*(3115), 1–24. https://doi.org/10.3390/en11113115

Upamali, A., Chen, S. S., Tsang, D. C. W., Zhang, M., Vithanage, M., Mandal, S., Gao, B., Bolan, N. S., & Sik, Y. (2016). Chemosphere Engineered / designer biochar for contaminant removal / immobilization from soil and water : Potential and implication of biochar modi fi cation. *Chemosphere*, *148*, 276–291. https://doi.org/10.1016/j.chemosphere.2016.01.043

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**Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Verma, M, Godbout, S., Brar, S. K., Solomatnikova, O., Lemay, S. P., & Larouche, J. P. (2012). Biofuels Production from Biomass by Thermochemical Conversion Technologies. *International Journal of Chemical Engineering*, *2012*, 18. https://doi.org/10.1155/2012/542426

Verma, Mamta, & Kaur, G. (2021). Materials Today : Proceedings A mini review on zeolite. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2021.04.271

Vieira, F. R., Luna, C. M. R., A, G. L. A. F. A., & Avila, I. (2020). Biomass and Bioenergy Optimization of slow pyrolysis process parameters using a fixed bed reactor for biochar yield from rice husk. *Biomass and Bioenergy*, *132*. https://doi.org/10.1016/j.biombioe.2019.105412

Villa, C. C., Valencia, G. A., L´opez, A. C., Ortega-Toro, R., Ahmed, S., & Guti´errez, T. J. (2022). Zeolites for food applications: A review. *Contents Lists Available at ScienceDirect F*, *46*(November 2021). https://doi.org/10.1016/j.fbio.2022.101577

Wada, A., Kono, M., Kawauchi, S., Takagi, Y., Morikawa, T., & Funakoshi, K. (2012). Rapid Discrimination of Gram-Positive and Gram-Negative Bacteria in Liquid Samples by Using NaOH-Sodium Dodecyl Sulfate Solution and Flow Cytometry. *PLoS ONE*, *7*(10). https://doi.org/10.1371/journal.pone.0047093

Wahono, S. K., Maryana, R., Kismurtono, M., Nisa, K., & Poeloengasih, C. D. (2010). *Pembangkit Listrik Modification As an Effort Local Zeolite – Gunungkidul Performance Improvement for Biogas*. 1–6.

Wahono, S. K., Prasetyo, D. J., Jatmiko, T. H., Pratiwi, D., Suwanto, A., Hernawan, & Vasilev, K. (2019). Multi-stage dealumination for characteristic engineering of mordenite-clinoptilolite natural zeolite. *AIP Conference Proceedings*, *2085*(March). https://doi.org/10.1063/1.5095022

Wahono, S. K., & Rizal, W. A. (2014). Biogas Filter Based on Local Natural Zeolite Materials. *International Jurnal of Renewable Energy Development*, *3*(February), 1–5. https://doi.org/10.14710/ijred.3.1.1-5

Wahono, S. K., Stalin, J., Addai-Mensah, J., Skinner, W., Vinu, A., & Vasilev, K. (2020). Physico-chemical modification of natural mordenite-clinoptilolite zeolites and their enhanced CO2 adsorption capacity. *Microporous and Mesoporous Materials*, *294*(June 2019), 109871. https://doi.org/10.1016/j.micromeso.2019.109871

Wahono, S. K., Suwanto, A., Prasetyo, D. J., Hernawan, Jatmiko, T. H., & Vasilev, K. (2019). Plasma activation on natural mordenite-clinoptilolite zeolite for water vapor adsorption enhancement. *Applied Surface Science*, *483*(February), 940–946.

UNIVERSITAS GADJAH MADA
Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi Fase Gas Pada Proses Pirolisis
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https://doi.org/10.1016/j.apsusc.2019.04.033

wahyu anggo rizal. khoirun nisa, roni maryana, diah pratiwi, dwi joko prasetyo, tri hadi jatmiko, dini ariani, andri suwanto. (2020). Chemical composition of liquid smoke from coconut shell waste produced by SME in Rongkop Gunungkidul. *Iop Confrence Series: Earth and Environmental Science*. https://doi.org/10.1088/1755-1315/462/1/012057

Wahyu Anggo Rizal , Ria Suryani , Muslih Anwar , Dwi Joko Prasetyo , Satriyo Krido Wahono , Wuri Apriyana, Tri Hadi Jatmiko, Andri Suwanto, Roni Maryana , Hernawan, S. H. (2022). Efektivitas Pemurnian Asap Cair Biomassa Serbuk Gergaji dengan Distilasi, Adsorpsi Zeolite dan Karbon Aktif. *JURNAL SELULOSA*, *12*(1), 11–22. https://doi.org/http://dx.doi.org/10.25269/jsel.v12i01.353 11

Wang, C., Leng, S., Guo, H., Cao, L., & Huang, J. (2019). Acid and alkali treatments for regulation of hydrophilicity / hydrophobicity of natural zeolite. *Applied Surface Science*, *478*(January), 319–326. https://doi.org/10.1016/j.apsusc.2019.01.263

Wang, Jiajun, Deng, S., Zhao, R., Zhao, J., Xue, J., Wu, Z., & Bai, Y. (2022). Performance comparison of three adsorption cycles for CF 4 recovery from waste gas using 13X zeolite. *Journal of Cleaner Production*, *337*(September 2021), 130546. https://doi.org/10.1016/j.jclepro.2022.130546

Wang, Jianlong, & Wang, S. (2019). Preparation , modi fi cation and environmental application of biochar : A review. *Journal of Cleaner Production*, *227*, 1002–1022. https://doi.org/10.1016/j.jclepro.2019.04.282

Wang, X., Ozdemir, O., Hampton, M. A., Nguyen, A. V, & Do, D. D. (2012). The effect of zeolite treatment by acids on sodium adsorption ratio of coal seam gas water. *Water Research*, *46*(16), 5247–5254. https://doi.org/10.1016/j.watres.2012.07.006

Wawrzy, D., Majchrzak-kuc, I., Srokosz, K., Kozak, M., Nowak, W., Zdeb, J., Smó, W., & Zajchowski, A. (2019). *Separation and Puri fi cation Technology The pilot dual-re fl ux vacuum pressure swing adsorption unit for CO 2 capture from fl ue gas*. *209*(March 2018), 560–570. https://doi.org/10.1016/j.seppur.2018.07.079

Wei, R., Li, H., Lin, Y., Yang, L., Long, H., Xu, C. C., & Li, J. (2020). Reduction Characteristics of Iron Oxide by the Hemicellulose, Cellulose, and Lignin Components of Biomass. *Energy and Fuels*, *34*(7), 8332–8339. https://doi.org/10.1021/acs.energyfuels.0c00377

Wijaya Kasrun, A., Anggono, W., & Sutrisno, T. (2016). Karakteristik Pembakaran Briket Dari Limbah Daun Pohon Bintaro. *Jurnal Teknik Mesin*, *16*(2), 64–70. https://doi.org/10.9744/jtm.16.2.64-70

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
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Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

Wu, L., Xue, X., Yu, H., Zhang, C., Wei, X., Liang, J., & Sun, Y. (2020). Catalytic pyrolysis of poplar sawdust: Excellent hydrocarbon selectivity and activity of hollow zeolites. *Bioresource Technology*, *317*(May), 123954. https://doi.org/10.1016/j.biortech.2020.123954

Xin, X., Dell, K., Udugama, I. A., Young, B. R., & Baroutian, S. (2020). Transforming biomass pyrolysis technologies to produce liquid smoke food flavouring. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2020.125368

Xin, X., Essien, S., Dell, K., Woo, M. W., & Baroutian, S. (2022). Effects of Spray-Drying and Freeze-Drying on Bioactive and Volatile Compounds of Smoke Powder Food Flavouring. *Food and Bioprocess Technology*, *15*(4), 785–794. https://doi.org/10.1007/s11947-022-02779-3

Xin, X., Zhao, W., Essien, S., Dell, K., & Baroutian, S. (2022). The effects of ageing treatment on bioactive contents and chemical composition of liquid smoke food flavourings. *European Food Research and Technology*, *248*(5), 1311–1319. https://doi.org/10.1007/s00217-022-03976-2

Xu, H., Zhan, M., Cai, P., Ji, L., Chen, T., & Li, X. (2019). *Adsorption Characteristics of Polycyclic Aromatic Hydrocarbons by Biomass-Activated Carbon in Flue Gas*. https://doi.org/10.1021/acs.energyfuels.9b02723

Xu, Z., Zhang, D., Yuan, Z., Chen, W., Zhang, T., Tian, D., & Deng, H. (2017). Physicochemical and adsorptive characteristics of activated carbons from waste polyester textiles utilizing MgO template method. *Environmental Science and Pollution Research*, *24*(28), 22602–22612. https://doi.org/10.1007/s11356-017-9939-8

Yang, H., Yan, R., Chen, H., Lee, D. H., & Zheng, C. (2007). Characteristics of hemicellulose, cellulose and lignin pyrolysis. *Fuel*, *86*(12–13), 1781–1788. https://doi.org/10.1016/j.fuel.2006.12.013

Yanti, R. N., Hambali, E., Pari, G., Suryani, A., Kuning, U. L., Sarjana, S. P.,. (2021). The Functional Characteristics of Active Natural Zeolite as a Catalyst after. *Jurnal Penelitian Hasil Hutan*, *39*(3), 138–147. https://doi.org/10.20886/jphh.2021.39.3.138-147

Yao, Q., Li, Y., Tang, X., Gao, J., Wang, R., & Zhang, Y. (2019). Separation of petroleum ether extracted residue of low temperature coal tar by chromatography column and structural feature of fractions by TG-FTIR and PY-GC / MS. *Fuel*, *245*(February), 122–130. https://doi.org/10.1016/j.fuel.2019.02.074

Yao, X., Li, L., & Li, H. (2014). *A new method for preparing hydrophilic-activated carbon through ester hydrolysis in an alkaline environment*. 4807–4815.

Peningkatan Kualitas Asap Cair Berbahan Baku Limbah Biomassa Ranting Kayu Putih Melalui Adsorpsi
Fase Gas Pada Proses Pirolisis
Wahyu Anggo Rizal, Ahmad Tawfiequrrahman Yuliansyah, S.T., M.T., D.Eng. ; Satriyo Krido Wahono, S.T., Ph.D.
Universitas Gadjah Mada, 2024 | Diunduh dari http://etd.repository.ugm.ac.id/

https://doi.org/10.1007/s10853-014-8180-9

Yogaswara, D. (2017). Adsorpsi Senyawa Polisiklik Aromatik Hidrokarbon (Pah) Oleh Karbon Aktif. *Oseana*, *42*(1), 1–8. https://doi.org/10.14203/oseana.2017.vol.42no.1.33

Yousef, S., Eimontas, J., Striūgas, N., & Abdelnaby, M. A. (2021). Pyrolysis kinetic behaviour and TG-FTIR-GC–MS analysis of Coronavirus Face Masks. *Journal of Analytical and Applied Pyrolysis*, *156*(February). https://doi.org/10.1016/j.jaap.2021.105118

Yunita, A. I., Sulistyaningsih, T., & Widiarti, N. (2019). Karakterisasi dan Uji Sifat Fisik Material Zeolit Modifikasi Magnetit sebagai Adsorben Ion Klorida dalam Larutan Berair. *Indonesian Journal of Chemical Science*, *8*(2), 87–92.

Zefri Azharman, Delia Meldra, Y. M. (2019). Pengujian Rancangan Reaktor Konversi Plastik Menjadi Minyak Sebagai Inovasi Penangangan Sampah Plastik Rumah Tangga. *Jurnal Teknik Ibnu Sina*, *4*(2), 99–104. https://doi.org/10.3652/jt-ibsi.v4i2.38

Zhang, H., Zhang, X., Wang, Y., Bai, P., Hayakawa, K., Zhang, L., & Tang, N. (2022). Characteristics and Influencing Factors of Polycyclic Aromatic Hydrocarbons Emitted from Open Burning and Stove Burning of Biomass: A Brief Review. *International Journal of Environmental Research and Public Health*, *19*(7). https://doi.org/10.3390/ijerph19073944

Zhang, L., Yang, L., Zhou, Q., Zhang, X., Xing, W., Wei, Y., Hu, M., Zhao, L., Toriba, A., Hayakawa, K., & Tang, N. (2019). ScienceDirect Size distribution of particulate polycyclic aromatic hydrocarbons in fresh combustion smoke and ambient air : A review. *Journal of Environmental Sciences*, *88*, 370–384. https://doi.org/10.1016/j.jes.2019.09.007

Zhou, M., & Tian, X. (2022). International Journal of Biological Macromolecules Development of different pretreatments and related technologies for efficient biomass conversion of lignocellulose. *International Journal of Biological Macromolecules*, *202*(November 2021), 256–268. https://doi.org/10.1016/j.ijbiomac.2022.01.036

Zilfa, Septiani, U., & Mirawati. (2020). Pengaruh HCl terhadap Aktifasi Zeolit Alam Clipnotilolit-Ca pada Penyerapan Pb (II). *Jurnal Riset Kimia*, *11*(2), 80–88. https://doi.org/DOI: https://doi.org/10.25077/jrk.v11i2.355

Zou, W., Bai, H., & Zhao, L. (2011). *Characterization and properties of zeolite as adsorbent for removal of uranium (VI) from solution in fixed bed column*. 779–788. https://doi.org/10.1007/s10967-011-1026-x