CATALYTIC OXIDATIVE HYDROTHERMAL TREATMENT OF PALM OIL MILL EFFLUENT OVER CuO/Al_2O_3 and Ce-CuO/Al_2O_3 CATALYSTS

LEE ZHAN SHENG

DOCTOR OF PHILOSOPHY

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and, in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

(Supervisor's Signature)

Full Name : IR. DR. CHIN SIM YEE

Position : ASSOCIATE PROFESSOR

Date : 29 NOV 2022

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : LEE ZHAN SHENG

ID Number : MKC 18007

Date : 29 NOV 2022

CATALYTIC OXIDATIVE HYDROTHERMAL TREATMENT OF PALM OIL MILL EFFLUENT OVER CuO/Al_2O_3 and $Ce\text{-}CuO/Al_2O_3$ CATALYSTS

LEE ZHAN SHENG

Thesis submitted in fulfilment of the requirements
for the award of the degree of
Doctor of Philosophy

Faculty of Chemical and Process Engineering Technology

UNIVERSITI MALAYSIA PAHANG

November 2022

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my supervisor, Associate Professor Ir. Dr. Chin Sim Yee for her guidance throughout my research. I appreciate the guidance given by Associate Professor Dr. Cheng Chin Kui in making this work a success. I would like to also take this opportunity to thank UMP for the grants (RDU170325, RDU172202, RDU190195) and Doctoral Research Scheme in funding this research.

ABSTRAK

Tesis ini mengkaji kualiti rawatan kumbahan kilang minyak sawit (POME) dengan menggunakan kaedah hidro-haba beroksigen (OHT) dan tanpa oksigen (NOHT). Penyelidikan ini turut melibatkan penggunaan pemangkin dalam proses hidro-haba beroksigen (COHT). Proses hidro-haba sering digunakan dalam rawatan sisa biomas basah, tetapi ia tidak pernah digunakan dalam rawatan POME sebelum kajian ini dijalankan. Objektif kajian ini terdiri daripada kajian proses hidro-haba pada tahap suhu dan masa eksperimen yang berlainan, fungsi pemangkin dalam proses dan cadangan mekanisme proses serta kajian kinetik. 500 mL POME telah digunakan pada tahap suhu 493-533 K dan tempoh eksperimen 2-8 jam. Dalam eksperimen COHT pula, dua jenis pemangkin, iaitu CuO/Al_2O_3 and Ce-CuO/Al_2O_3 telah dikaji pada kapasiti muatan 0.2 mg/ml, 1.0 mg/ml dan 2.0 mg/ml pada tahap suhu 533 K selama 8 jam. Semakin tinggi suhu proses, semakin berkurang sebatian utama dalam POME mentah, iaitu asid heksadekanoik yang ditemui dalam produk cecair NOHT and OHT. Dalam proses NOHT, peningkatan tahap suhu eksperimen menyebabkan sebatian karboksil semakin berkurang manakala sebatian fenolik semakin bertambah. Produk gas yang dihasilkan daripada NOHT mengandungi CO_2, CO, H_2, and hidrokarbon C_3-C_6. Hanya sedikit gas CH_4 yang ditemui dalam produk gas NOHT pada tahap suhu 533 K yang disebabkan proses gasifikasi hidro-haba pada suhu yang rendah. Pada suhu eksperimen 533 K selama 8 jam, penyahwarnaan POME yang dicapai melalui NOHT dan OHT adalah sebanyak 7.02% dan 54.10% masing-masing. Fenomena ini menandakan bahawa keefisienan penyahwarnaan OHT adalah lebih tinggi. Pada tahap suhu dan tempoh eksperimen yang sama, tahap pengurangan permintaan oksigen kimia (COD) dan permintaan oksigen biokimia lima hari (BOD_5) yang dicapai melalui NOHT adalah setinggi 61.4% dan 68.0% masing-masing. Walau bagaimanapun, keefisienan OHT dalam mengurangan COD and BOD_5 adalah lebih tinggi, iaitu 81% dan 87% masing-masing, dengan peningkatan nilai pH produk cecair dari 3.5 ke 6.5. Kualiti rawatan POME melalui COHT adalah lebih tinggi berbanding dengan proses tanpa pemangkin. Dalam COHT, pemangkin Ce-CuO/Al_2O_3 dengan kapasiti muatan sebanyak 2.0 mg/ml telah mengurangkan 86.1% COD dan 94.7% BOD_5 pada suhu 533 K selama 8 jam. Kualiti rawatannya lebih baik daripada CuO/Al_2O_3 yang mencapai pengurangan COD dan BOD_5 sebanyak 79.4% dan 93.8% masing-masing. Sumbangan pemangkin dalam menurunkan COD dan BOD_5 POME tidak lagi ketara dengan kapasiti muatan pemangkin melebihi 1.0 mg/ml, Jadi 1.0 mg/ml menjadi kapasiti muatan optimum dari segi teknikal dan ekonomi. Kajian kebolehgunaan semula pemangkin Ce-CuO/Al_2O_3 menunjukkan bahawa perlakuan larut lesap elemen Cu dan Al adalah tidak ketara. Tambahan pula, pengurangan COD (75.4%) dan BOD_5 (85.2%) selepas tiga kali penggunaan semula menandakan tiada penyahaktifan pemangkin yang ketara. Tindak balas tertib kedua ialah hukum kadar kinetik COHT yang sesuai kerana pekali korelasi model ini dengan data eksperimen adalah melebihi 0.90 serta sisihan piawai yang kurang daripada 0.1%. Dalam aspek mekanisme kimia NOHT, POME mereput menjadi sebatian larut air lalu mengalami proses penyahoksigenan (dehidrasi dan dekarboksilasi) untuk menghasilkan hidrochar yang mengandungi oksigen yang rendah serta produk cecair yang mengandungi sebatian aromatik yang tinggi. Mekanisme kimia bagi COHT pula ialah proses radikal bebas. Hasil kajian ini membuktikan bahawa rawatan POME berpotensi menggantikan proses rawatan kumbahan yang sedia ada. Hasil kajian ini boleh dijadikan sebagai bahan asas bagi mengkomersialkan dan menaiktarafkan proses hidro-haba dalam rawatan POME pada masa akan datang.

ABSTRACT

This study aspires to investigate the performance of novel non-oxidative and oxidative subcritical hydrothermal treatments (NOHT and OHT, respectively), followed by catalytic oxidative hydrothermal treatment (COHT) of palm oil mill effluent (POME). Hydrothermal reaction is commonly used in wet biomass treatment, but it had never been used in POME treatment before this research was conducted. The high reaction temperature and time of hydrothermal process and catalyst activity in an aqueous environment are problems to be addressed. Hence, the objectives of this research are to investigate the performance of hydrothermal reactions and catalytic reactions as well as to propose the reaction mechanisms. The experiments of OHT and NOHT were conducted using 500 mL POME of initial COD and BOD_5 at 52200 mg/L and 18020 mg/L, respectively, at different temperatures (493-533 K) and reaction times (2-8 h). Meanwhile, the experiments of COHT were performed using a similar working volume of POME over two types of catalysts, i.e., CuO/Al_2O_3 and $Ce\text{-}CuO/Al_2O_3$, at loadings of 0.2, 1.0, and 2.0 mg/ml at 533 K for 8 h. The dominant component of fresh POME, i.e., n-hexadecanoic acid, gradually reduced in the liquid products of NOHT and OHT in reactions with elevated temperatures. Carboxyl compounds reduced while phenolic components increased as reaction temperature increased over NOHT. The gaseous products of NOHT contained carbon dioxide (CO_2), carbon monoxide (CO), hydrogen gas (H_2), and C_3-C_6 hydrocarbons. Traces of methane gas (CH_4) were only found at 533 K due to subcritical hydrothermal gasification at low temperatures. The decolourisations of POME in NOHT and OHT were 7.02% and 54.10% respectively at 533 K and 8 h, indicating the notable performance of OHT in decolourising POME. At 533 K and 8 h, NOHT achieved the highest reductions of chemical oxygen demand (COD) and five-day biochemical oxygen demand (BOD_5) at 61.4% and 68.0%. However, the OHT reaction resulted in better removals of COD and BOD_5, recording 81% and 87% respectively, with the pH of the liquid product approaching 6.5 from the initial value of 3.5 at the same reaction temperature and time. Notwithstanding, COHT of POME achieved more remarkable performance than the non-catalytic reactions. At a loading of 2.0 mg/ml catalyst in COHT, $Ce\text{-}CuO/Al_2O_3$ recorded 86.1% COD and 94.7% BOD_5 removals at 533 K and 8 h, where its performance was slightly better than CuO/Al_2O_3 (79.4% COD and 93.8% BOD_5 removals). The increase of catalysts loading after 1.0 mg/ml did not contribute any significant difference in degrading the pollutants of POME, suggesting the adequacy of using 1.0 mg/ml catalysts viewing from the technical and economic aspects. The reusability test of spent $Ce\text{-}CuO/Al_2O_3$ catalysts showed insignificant leaching of Cu and Al elements, and the reductions of COD and BOD_5 were as high as 75.4% and 85.2% respectively, indicating no significant deactivation of catalysts up to three reaction cycles. In the derivation of kinetic rate law, a second-order kinetic conformed well to experimental data of COHT with correlation coefficients greater than 0.90 and an error of less than 5% between the estimated and experimental findings. For the mechanism studies, POME in NOHT decomposed into water-soluble compounds, followed by deoxygenation (dehydration and decarboxylation) in producing hydrochar with lower oxygen content and higher aromatic compounds in the liquid product. On the other hand, the reaction mechanism was dominated by the free radicals' reaction in COHT. The experimental findings have successfully revealed the potential of this novel POME treatment method in substituting the conventional treatment process. This novel study could act as a foundation for the scalability and commercialisation of hydrothermal processes in POME treatment in the future.

TABLE OF CONTENTS

REFERENCES

Abbasi, A., Najafi, M., Janczak, J., & Van Hecke, K. (2019). Mo(VI) and W(VI) complexes as heterogeneous catalysts for degradation of azo dyes. *Journal of Environmental Chemical Engineering, 7*(1), 102865. doi:https://doi.org/10.1016/j.jece.2018.102865

Abdullah, N., & Sulaiman, F. (2013). The Oil Palm Wastes in Malaysia. In M. D. Matovic (Ed.), *Biomass Now - Sustainable Growth and Use* (pp. Ch. 03). Rijeka: InTech.

Abdullah, N., Sulaiman, F., & Aliasak, Z. (2013). A case study of pyrolysis of oil palm wastes in Malaysia. *AIP Conference Proceedings, 1528*(1), 331-336. doi:10.1063/1.4803619

Abe, N., Tang, Y.-Q., Iwamura, M., Morimura, S., & Kida, K. (2013). Pretreatment followed by anaerobic digestion of secondary sludge for reduction of sewage sludge volume. *Water Science and Technology, 67*(11), 2527-2533. doi:10.2166/wst.2013.154

Abe, N., Tang, Y.-Q., Iwamura, M., Ohta, H., Morimura, S., & Kida, K. (2011). Development of an efficient process for the treatment of residual sludge discharged from an anaerobic digester in a sewage treatment plant. *Bioresource Technology, 102*(17), 7641-7644. doi:10.1016/j.biortech.2011.05.030

Adeleke, O. A., Latiff, A. A. A., Saphira, M. R., Daud, Z., Ismail, N., Ahsan, A., Ab Aziz, N. A., Al-Gheethi, A., Kumar, V., Fadilat, A., & Apandi, N. (2019). 1 - Principles and Mechanism of Adsorption for the Effective Treatment of Palm Oil Mill Effluent for Water Reuse. In A. Ahsan & A. F. Ismail (Eds.), *Nanotechnology in Water and Wastewater Treatment* (pp. 1-33): Elsevier.

Adhikari, S., Fernando, S. D., & Haryanto, A. (2009). Hydrogen production from glycerol: An update. *Energy Conversion and Management, 50*(10), 2600-2604. doi:https://doi.org/10.1016/j.enconman.2009.06.011

Ahmad, A., & Ghufran, R. (2014). Evaluation of the bio-kinetics of cement kiln dust in an upflow anaerobic sludge blanket reactor for treatment of palm oil mill effluent as a function of hydraulic retention time. *Separation and Purification Technology, 133*(Supplement C), 129-137. doi:10.1016/j.seppur.2014.06.047

Ahmad, A., & Ghufran, R. (2018). Review on industrial wastewater energy sources and carbon emission reduction: towards a clean production. *International Journal of Sustainable Engineering*, 1-11. doi:10.1080/19397038.2018.1423647

Ahmad, A. L., Chong, M. F., Bhatia, S., & Ismail, S. (2006). Drinking water reclamation from palm oil mill effluent (POME) using membrane technology. *Desalination, 191*(1), 35-44. doi:https://doi.org/10.1016/j.desal.2005.06.033

Ahmad Shahrifun, N. S. (2015). *CHARACTERIZATION OF PALM OIL MILL SECONDARY EFFLUENT (POMSE)* (Vol. 27).

Akhtar, J., Kuang, S. K., & Amin, N. S. (2010). Liquefaction of empty palm fruit bunch (EPFB) in alkaline hot compressed water. *Renewable Energy, 35*(6), 1220-1227. doi:https://doi.org/10.1016/j.renene.2009.10.003

Alam, M., Jamal, P., & Mohd Nadzir, M. (2007). *Bioconversion of palm oil mill effluent for citric acid production: Statistical optimization of fermentation media and time by central composite design* (Vol. 24).

Alejandre, A., Medina, F., Salagre, P., Fabregat, A., & Sueiras, J. E. (1998). Characterization and activity of copper and nickel catalysts for the oxidation of phenol aqueous solutions. *Applied Catalysis B: Environmental, 18*(3), 307-315. doi:https://doi.org/10.1016/S0926-3373(98)00050-2

Alhaji, M. H., Sanaullah, K., Salleh, S. F., Baini, R., Lim, S. F., Rigit, A. R. H., Said, K. A. M., & Khan, A. (2018). Photo-oxidation of pre-treated palm oil mill Effluent using cylindrical column immobilized photoreactor. *Process Safety and Environmental Protection*. doi:https://doi.org/10.1016/j.psep.2018.04.012

Álvarez, P. M., McLurgh, D., & Plucinski. (2002a). Copper Oxide Mounted on Activated Carbon as Catalyst for Wet Air Oxidation of Aqueous Phenol. 1. Kinetic and Mechanistic Approaches. *Industrial & Engineering Chemistry Research, 41*(9), 2147-2152. doi:10.1021/ie0104464

Álvarez, P. M., McLurgh, D., & Plucinski, P. (2002b). Copper Oxide Mounted on Activated Carbon as Catalyst for Wet Air Oxidation of Aqueous Phenol. 2. Catalyst Stability. *Industrial & Engineering Chemistry Research, 41*(9), 2153-2158. doi:10.1021/ie010447w

Amalraj, S., & Michael, P. A. (2019). Synthesis and characterization of Al2O3 and CuO nanoparticles into nanofluids for solar panel applications. *Results in Physics, 15*, 102797. doi:https://doi.org/10.1016/j.rinp.2019.102797

An, N., Yuan, X., Pan, B., Li, Q., Li, S., & Zhang, W. (2014). Design of a highly active Pt/Al2O3 catalyst for low-temperature CO oxidation. *RSC Advances, 4*(72), 38250-38257. doi:10.1039/C4RA05646A

Appell H, R. (1971). Converting Organic Wasters to Oil. *Bureau of Mines Report of Investigations, 7560*.

Appell, H. R., Fu, Y. C., Illig, E. G., Steffgen, F. W., & Miller, R. D. (1975). *Conversion of cellulosic wastes to oil*. Retrieved from https://ui.adsabs.harvard.edu/abs/1975STIN...7527572A

Arena, F., Giovenco, R., Torre, T., Venuto, A., & Parmaliana, A. (2003). Activity and resistance to leaching of Cu-based catalysts in the wet oxidation of phenol. *Applied Catalysis B: Environmental, 45*(1), 51-62. doi:https://doi.org/10.1016/S0926-3373(03)00163-2

Aris, N. S. M., Ibrahim, S., Arifin, B., & Hawari, Y. (2017). Effect of Operating Parameters on Decolourisation of Palm Oil Mill Effluent (POME) using Electrocoagulation Process. *PERTANIKA JOURNAL OF SCIENCE AND TECHNOLOGY, 25*, 197-206.

Ates, M., Demir, V., Arslan, Z., Daniels, J., Farah, I. O., & Bogatu, C. (2015). Evaluation of alpha and gamma aluminum oxide nanoparticle accumulation, toxicity, and depuration in Artemia salina larvae. *Environmental toxicology, 30*(1), 109-118. doi:10.1002/tox.21917

Awalludin, M. F., Sulaiman, O., Hashim, R., & Nadhari, W. N. A. W. (2015). An overview of the oil palm industry in Malaysia and its waste utilization through thermochemical conversion, specifically via liquefaction. *Renewable and Sustainable Energy Reviews, 50*, 1469-1484. doi:https://doi.org/10.1016/j.rser.2015.05.085

Ayusheev, A. B., Taran, O. P., Seryak, I. A., Podyacheva, O. Y., Descorme, C., Besson, M., Kibis, L. S., Boronin, A. I., Romanenko, A. I., Ismagilov, Z. R., & Parmon, V. (2014). Ruthenium nanoparticles supported on nitrogen-doped carbon nanofibers for the catalytic wet air oxidation of phenol. *Applied Catalysis B: Environmental, 146*, 177-185. doi:https://doi.org/10.1016/j.apcatb.2013.03.017

Azadi, P., & Farnood, R. (2011). Review of heterogeneous catalysts for sub- and supercritical water gasification of biomass and wastes. *International Journal of Hydrogen Energy, 36*(16), 9529-9541. doi:https://doi.org/10.1016/j.ijhydene.2011.05.081

Azmi, N. S., & Khairul, Y. (2014). *Wastewater Treatment of Palm Oil Mill Effluent (POME) by Ultrafiltration Membrane Separation Technique Coupled with Adsorption Treatment as Pre-treatment* (Vol. 2).

Azmi, N. S., & Yunos, K. F. M. (2014). Wastewater Treatment of Palm Oil Mill Effluent (POME) by Ultrafiltration Membrane Separation Technique Coupled with Adsorption Treatment as Pre-treatment. *Agriculture and Agricultural Science Procedia, 2*, 257-264. doi:https://doi.org/10.1016/j.aaspro.2014.11.037

Baker, T. J., Tyler, C. R., & Galloway, T. S. (2014). Impacts of metal and metal oxide nanoparticles on marine organisms. *Environmental Pollution, 186*, 257-271. doi:https://doi.org/10.1016/j.envpol.2013.11.014

Baranitharan, E., Khan, M. R., Prasad, D., & Salihon, J. B. (2013). Bioelectricity generation from palm oil mill effluent in microbial fuel cell using polacrylonitrile carbon felt as electrode. *Water, Air, & Soil Pollution, 224*(5), 1533.

Barbier, J., Oliviero, L., Renard, B., & Duprez, D. (2005). Role of ceria-supported noble metal catalysts (Ru, Pd, Pt) in wet air oxidation of nitrogen and oxygen containing compounds. *Topics in Catalysis, 33*(1), 77-86. doi:10.1007/s11244-005-2509-1

Barmo, C., Ciacci, C., Canonico, B., Fabbri, R., Cortese, K., Balbi, T., Marcomini, A., Pojana, G., Gallo, G., & Canesi, L. (2013). In vivo effects of n-TiO2 on digestive gland and immune function of the marine bivalve Mytilus galloprovincialis. *Aquatic Toxicology, 132-133*, 9-18. doi:https://doi.org/10.1016/j.aquatox.2013.01.014

Bashir, M. J. K., Tham, M. H., Lim, J. W., Ng, C. A., & Abu Amr, S. S. (2016). Polishing of treated palm oil mill effluent (POME) from ponding system by electrocoagulation process. *Water Science and Technology, 73*(11), 2704-2712. doi:10.2166/wst.2016.123

Bautista, P., Mohedano, A. F., Casas, J. A., Zazo, J. A., & Rodriguez, J. J. (2011). Highly stable Fe/γ-Al2O3 catalyst for catalytic wet peroxide oxidation. *Journal of Chemical Technology & Biotechnology, 86*(4), 497-504. doi:10.1002/jctb.2538

Bayat, H., Dehghanizadeh, M., Jarvis, J. M., Brewer, C. E., & Jena, U. (2021). Hydrothermal Liquefaction of Food Waste: Effect of Process Parameters on Product Yields and Chemistry. *Frontiers in Sustainable Food Systems, 5*(160). doi:10.3389/fsufs.2021.658592

Berge, N. D., Ro, K. S., Mao, J., Flora, J. R. V., Chappell, M. A., & Bae, S. (2011). Hydrothermal Carbonization of Municipal Waste Streams. *Environmental Science & Technology, 45*(13), 5696-5703. doi:10.1021/es2004528

Bhargava, S. K., Tardio, J., Prasad, J., Föger, K., Akolekar, D. B., & Grocott, S. C. (2006). Wet Oxidation and Catalytic Wet Oxidation. *Industrial & Engineering Chemistry Research, 45*(4), 1221-1258. doi:10.1021/ie051059n

Bobleter, O. (1994). Hydrothermal degradation of polymers derived from plants. *Progress in Polymer Science, 19*(5), 797-841. doi:https://doi.org/10.1016/0079-6700(94)90033-7

Boikanyo, D., Mishra, A. K., Mishra, S. B., & Mhlanga, S. D. (2018). Biopolymers: A Natural Support for Photocatalysts Applied to Pollution Remediation. *Nanotechnology in Environmental Science*.

Boucher, V., Beaudon, M., Ramirez, P., Lemoine, P., Volk, K., Yargeau, V., & Segura, P. A. (2021). Comprehensive evaluation of non-catalytic wet air oxidation as a pretreatment to remove pharmaceuticals from hospital effluents. *Environmental Science: Water Research & Technology, 7*(7), 1301-1314. doi:10.1039/D1EW00203A

Buchanan, J. R., & Seabloom, R. W. (2004). Aerobic Treatment of Wastewater and Aerobic Treatment Units. http://onsite.tennessee.edu/Aerobic%20Treatment%20&%20ATUs.pdf

Bukhari, N. A., Ngatiman, M., Loh, S. K., & Choo, Y. M. (2013). *Characteristics of palm oil mill effluent (Pome) in an anaerobic biogas digester* (Vol. 16).

Busca, G., Berardinelli, S., Resini, C., & Arrighi, L. (2008). Technologies for the removal of phenol from fluid streams: A short review of recent developments. *Journal of Hazardous Materials, 160*(2), 265-288. doi:https://doi.org/10.1016/j.jhazmat.2008.03.045

Byrappa, K., & Yoshimura, M. (2001). History of Hydrothermal Technology. In (pp. 53-81).

Casademont, P., García-Jarana, M., Chen, X., Carreño, O. C., Sánchez-Oneto, J., Portela, J. R., & Enrique, M. d. l. O. (2016). *Energy Production by Hydrothermal Treatment of Liquid and Solid Waste from Industrial Olive Oil Production* (Vol. 5).

Chaiprapat, S., & Laklam, T. (2011). Enhancing digestion efficiency of POME in anaerobic sequencing batch reactor with ozonation pretreatment and cycle time reduction. *Bioresource Technology, 102*(5), 4061-4068. doi:https://doi.org/10.1016/j.biortech.2010.12.033

Chan, Y., & Chong, M. F. (2019). Palm Oil Mill Effluent (POME) Treatment—Current Technologies, Biogas Capture and Challenges. In (pp. 71-92).

Chan, Y. J., Chong, M. F., & Law, C. L. (2010). Effects of Temperature on Aerobic Treatment of Anaerobically Digested Palm Oil Mill Effluent (POME). *Industrial & Engineering Chemistry Research, 49*(15), 7093-7101. doi:10.1021/ie901952m

Chan, Y. J., Tan, W. J. R., How, B. S., Lee, J. J., & Lau, V. Y. (2015). Fuzzy optimisation approach on the treatment of palm oil mill effluent (POME) via up-flow anaerobic sludge blanket–hollow centered packed bed (UASB–HCPB) reactor. *Journal of Water Process Engineering, 5*, 112-117. doi:https://doi.org/10.1016/j.jwpe.2015.01.005

Chang, D.-J., Lin, S.-S., Chen, C.-L., Wang, S.-P., & Ho, W.-L. (2002). Catalytic wet air oxidation of phenol using CeO2 as the catalyst. Kinetic study and mechanism development. *Journal of Environmental Science and Health, Part A, 37*(7), 1241-1252. doi:10.1081/ESE-120005983

Channiwala, S. A., & Parikh, P. P. (2002). A unified correlation for estimating HHV of solid, liquid and gaseous fuels. *Fuel, 81*(8), 1051-1063. doi:https://doi.org/10.1016/S0016-2361(01)00131-4

Chen, G., Xu, N., Li, X., Liu, Q., Yang, H., & Li, W. (2015). Hydrogen production by aqueous-phase reforming of ethylene glycol over a Ni/Zn/Al derived hydrotalcite catalyst. *RSC Advances, 5*(74), 60128-60134.

Chen, I. P., Lin, S.-S., Wang, C.-H., Chang, L., & Chang, J.-S. (2004). Preparing and characterizing an optimal supported ceria catalyst for the catalytic wet air oxidation of phenol. *Applied Catalysis B: Environmental, 50*(1), 49-58. doi:https://doi.org/10.1016/j.apcatb.2003.12.019

Chen, I. P., Lin, S.-S., Wang, C.-H., & Chang, S.-H. (2007). CWAO of phenol using CeO2/γ-Al2O3 with promoter—Effectiveness of promoter addition and catalyst regeneration. *Chemosphere, 66*(1), 172-178. doi:https://doi.org/10.1016/j.chemosphere.2006.05.023

Cheng, C. K., Deraman, M. R., & Khan, M. R. (2014). *Evaluation of The Photocatalytic Degradation of Pre-Treated Palm Oil Mill Effluent (POME) over Pt-loaded Titania* (Vol. 3).

Cheng, C. K., Deraman, M. R., Ng, K. H., & Khan, M. R. (2016). Preparation of titania doped argentum photocatalyst and its photoactivity towards palm oil mill effluent degradation. *Journal of Cleaner Production, 112*, 1128-1135. doi:https://doi.org/10.1016/j.jclepro.2015.06.104

Cheng, J., Zhu, X., Ni, J., & Borthwick, A. (2010). Palm oil mill effluent treatment using a two-stage microbial fuel cells system integrated with immobilized biological aerated filters. *Bioresource Technology, 101*(8), 2729-2734. doi:https://doi.org/10.1016/j.biortech.2009.12.017

Cheng, L., Ye, X. P., He, R., & Liu, S. (2009). Investigation of rapid conversion of switchgrass in subcritical water. *Fuel Processing Technology, 90*(2), 301-311. doi:https://doi.org/10.1016/j.fuproc.2008.09.009

Cheng, Y. W., Khan, M. R., Ng, K. H., Wongsakulphasatch, S., & Cheng, C. K. (2019a). Harnessing renewable hydrogen-rich syngas from valorization of palm oil mill effluent (POME) using steam reforming technique. *Renewable Energy, 138*, 1114-1126. doi:https://doi.org/10.1016/j.renene.2019.02.040

Cheng, Y. W., Ng, K. H., Lam, S. S., Lim, J. W., Wongsakulphasatch, S., Witoon, T., & Cheng, C. K. (2019b). Syngas from catalytic steam reforming of palm oil mill effluent: An optimization study. *International Journal of Hydrogen Energy, 44*(18), 9220-9236. doi:https://doi.org/10.1016/j.ijhydene.2019.02.061

Chew, C. M., Aroua, M. K., Hussain, M. A., & Ismail, W. M. Z. W. (2016). Evaluation of ultrafiltration and conventional water treatment systems for sustainable development: an industrial scale case study. *Journal of Cleaner Production, 112*, 3152-3163. doi:https://doi.org/10.1016/j.jclepro.2015.10.037

Chin, M. J., Poh, P. E., Tey, B. T., Chan, E. S., & Chin, K. L. (2013). Biogas from palm oil mill effluent (POME): Opportunities and challenges from Malaysia's perspective. *Renewable and Sustainable Energy Reviews, 26*, 717-726. doi:https://doi.org/10.1016/j.rser.2013.06.008

Choi, W.-H., Shin, C.-H., Son, S.-M., Ghorpade, P. A., Kim, J.-J., & Park, J.-Y. (2013). Anaerobic treatment of palm oil mill effluent using combined high-rate anaerobic reactors. *Bioresource Technology, 141*(Supplement C), 138-144. doi:10.1016/j.biortech.2013.02.055

Chong, M. N., Jin, B., Chow, C. W. K., & Saint, C. (2010). Recent developments in photocatalytic water treatment technology: A review. *Water Research, 44*(10), 2997-3027. doi:https://doi.org/10.1016/j.watres.2010.02.039

Christoskova, S. G., Stoyanova, M., & Georgieva, M. (2001). Low-temperature iron-modified cobalt oxide system: Part 2. Catalytic oxidation of phenol in aqueous phase. *Applied Catalysis A: General, 208*(1), 243-249. doi:https://doi.org/10.1016/S0926-860X(00)00710-9

Cortright, R. D., Davda, R. R., & Dumesic, J. A. (2002). Hydrogen from catalytic reforming of biomass-derived hydrocarbons in liquid water. *Nature, 418*, 964. doi:10.1038/nature01009

Cybulski, A. (2007). Catalytic Wet Air Oxidation: Are Monolithic Catalysts and Reactors Feasible? *Industrial & Engineering Chemistry Research, 46*(12), 4007-4033. doi:10.1021/ie060906z

Cybulski, A., & Trawczyński, J. (2004). Catalytic wet air oxidation of phenol over platinum and ruthenium catalysts. *Applied Catalysis B: Environmental, 47*(1), 1-13. doi:https://doi.org/10.1016/S0926-3373(03)00327-8

Danso-Boateng, E., Holdich, R., Shama, G., Wheatley, A. D., Sohail, M., & Martin, S. (2013). Kinetics of faecal biomass hydrothermal carbonisation for hydrochar production. *Applied energy, 111*, 351-357.

Danso-Boateng, E., Shama, G., Wheatley, A. D., Martin, S. J., & Holdich, R. G. (2015). Hydrothermal carbonisation of sewage sludge: Effect of process conditions on product characteristics and methane production. *Bioresource Technology, 177*, 318-327. doi:https://doi.org/10.1016/j.biortech.2014.11.096

Daud, N. S., Ghazi, T. I. M., & Ahamad, I. S. (2014). Wheat Germ as Natural Coagulant for Treatment of Palm Oil Mill Effluent (POME). *International Journal, 5*(2).

Davda, R. R., & Dumesic, J. A. (2004). Renewable hydrogen by aqueous-phase reforming of glucose. *Chemical Communications*(1), 36-37. doi:10.1039/B310152E

Davda, R. R., Shabaker, J. W., Huber, G. W., Cortright, R. D., & Dumesic, J. A. (2003). Aqueous-phase reforming of ethylene glycol on silica-supported metal catalysts. *Applied Catalysis B: Environmental, 43*(1), 13-26. doi:https://doi.org/10.1016/S0926-3373(02)00277-1

Davda, R. R., Shabaker, J. W., Huber, G. W., Cortright, R. D., & Dumesic, J. A. (2005). A review of catalytic issues and process conditions for renewable hydrogen and alkanes by aqueous-phase reforming of oxygenated hydrocarbons over supported metal catalysts. *Applied Catalysis B: Environmental, 56*(1), 171-186. doi:https://doi.org/10.1016/j.apcatb.2004.04.027

Debellefontaine, H., & Foussard, J. N. (2000). Wet air oxidation for the treatment of industrial wastes. Chemical aspects, reactor design and industrial applications in Europe. *Waste Management, 20*(1), 15-25. doi:https://doi.org/10.1016/S0956-053X(99)00306-2

Deniz, I., Vardar-Sukan, F., Yüksel, M., Saglam, M., Ballice, L., & Yesil-Celiktas, O. (2015). Hydrogen production from marine biomass by hydrothermal gasification. *Energy Conversion and Management, 96*, 124-130. doi:https://doi.org/10.1016/j.enconman.2015.02.048

Dimitriadis, A., & Bezergianni, S. (2017). Hydrothermal liquefaction of various biomass and waste feedstocks for biocrude production: A state of the art review. *Renewable and Sustainable Energy Reviews, 68*, 113-125. doi:https://doi.org/10.1016/j.rser.2016.09.120

Doukkali, M. E., Iriondo, A., Arias, P. L., Requies, J., Gandarías, I., Jalowiecki-Duhamel, L., & Dumeignil, F. (2012). A comparison of sol–gel and impregnated Pt or/and Ni based γ-alumina catalysts for bioglycerol aqueous phase reforming. *Applied Catalysis B: Environmental, 125*, 516-529. doi:https://doi.org/10.1016/j.apcatb.2012.06.024

Doukkali, M. E., Iriondo, A., Cambra, J. F., & Arias, P. L. (2014). Recent improvement on H 2 production by liquid phase reforming of glycerol: catalytic properties and performance, and deactivation studies. *Topics in Catalysis, 57*(10-13), 1066-1077.

Edgar, G., Lutz, M., & Liselotte, S. (2003). Using Life-Cycle Assessment in Process Design. *Journal of Industrial Ecology, 7*(3 ‐ 4), 75-91. doi:doi:10.1162/108819803323059415

Eibisch, N., Helfrich, M., Don, A., Mikutta, R., Kruse, A., Ellerbrock, R., & Flessa, H. (2013). *Properties and Degradability of Hydrothermal Carbonization Products* (Vol. 42).

El-Shobaky, G. A., Radwan, F. M., Turky, A. E.-M. M., & El-Moemen, A. A. (2001). Surface and Catalytic Properties of the CuO/Al2O3 System as Influenced by Doping with CeO2 or ZrO2 and by γ-Irradiation. *Adsorption Science & Technology*, *19*(10), 779-793. doi:10.1260/0263617011494583

El Doukkali, M., Iriondo, A., Miletic, N., Cambra, J. F., & Arias, P. L. (2017). Hydrothermal stability improvement of NiPt-containing γ-Al2O3 catalysts tested in aqueous phase reforming of glycerol/water mixture for H2 production. *International Journal of Hydrogen Energy*, *42*(37), 23617-23630. doi:https://doi.org/10.1016/j.ijhydene.2017.04.218

Elaigwu, S. E., & Greenway, G. M. (2016). Chemical, structural and energy properties of hydrochars from microwave-assisted hydrothermal carbonization of glucose. *International Journal of Industrial Chemistry*, *7*(4), 449-456. doi:10.1007/s40090-016-0081-0

Emerson, S. C., Zhu, T., Davis, T. D., Peles, A., She, Y., Willigan, R. R., Vanderspurt, T. H., Swanson, M., & Laudal, D. A. (2014). Liquid phase reforming of woody biomass to hydrogen. *International Journal of Hydrogen Energy*, *39*(1), 137-149. doi:https://doi.org/10.1016/j.ijhydene.2013.09.041

Fogler, H. S. (2010). *Elements of Chemical Reaction Engineering* (4^{th} ed.): Pearson Education International

Fortuny, A., Bengoa, C., Font, J., & Fabregat, A. (1999). Bimetallic catalysts for continuous catalytic wet air oxidation of phenol. *Journal of Hazardous Materials*, *64*(2), 181-193. doi:https://doi.org/10.1016/S0304-3894(98)00245-3

Funke, A., & Ziegler, F. (2010). Hydrothermal carbonization of biomass: A summary and discussion of chemical mechanisms for process engineering. *Biofuels, Bioproducts and Biorefining*, *4*(2), 160-177. doi:doi:10.1002/bbb.198

Gao, Y., Wang, X.-H., Yang, H.-P., & Chen, H.-P. (2012). Characterization of products from hydrothermal treatments of cellulose. *Energy*, *42*(1), 457-465. doi:https://doi.org/10.1016/j.energy.2012.03.023

Genç, N., Yonsel, Ş., Dağaşan, L., & Onar, A. N. (2002). Wet oxidation: a pre-treatment procedure for sludge. *Waste Management*, *22*(6), 611-616. doi:https://doi.org/10.1016/S0956-053X(02)00040-5

Gnansounou, E., & Pandey, A. (2017). Chapter 1 - Classification of Biorefineries Taking into Account Sustainability Potentials and Flexibility. In E. Gnansounou & A.

Pandey (Eds.), *Life-Cycle Assessment of Biorefineries* (pp. 1-39). Amsterdam: Elsevier.

Gupta, P., & Verma, N. (2021). Evaluation of degradation and mineralization of glyphosate pollutant in wastewater using catalytic wet air oxidation over Fe-dispersed carbon nanofibrous beads. *Chemical Engineering Journal, 417*, 128029. doi:https://doi.org/10.1016/j.cej.2020.128029

Habib, M. A. B., Yusoff, F. M., Phang, S. M., Ang, K. J., & Mohamed, S. (1997). Nutritional values of chironomid larvae grown in palm oil mill effluent and algal culture. *Aquaculture, 158*(1), 95-105. doi:https://doi.org/10.1016/S0044-8486(97)00176-2

Hall, M., Bansal, P., Lee, J. H., Realff, M. J., & Bommarius, A. S. (2010). Cellulose crystallinity – a key predictor of the enzymatic hydrolysis rate. *The FEBS Journal, 277*(6), 1571-1582. doi:doi:10.1111/j.1742-4658.2010.07585.x

Hall, S. (2012). 27 - Properties. In S. Hall (Ed.), *Branan's Rules of Thumb for Chemical Engineers (Fifth Edition)* (pp. 401-421). Oxford: Butterworth-Heinemann.

Harsono, S. S., Grundmann, P., & Soebronto, S. (2014). Anaerobic treatment of palm oil mill effluents: potential contribution to net energy yield and reduction of greenhouse gas emissions from biodiesel production. *Journal of Cleaner Production, 64*, 619-627. doi:https://doi.org/10.1016/j.jclepro.2013.07.056

Hassan, M. A., Nawata, O., Shirai, Y., Rahman, N. A. A., Yee, P. L., Ariff, A. B., & Karim, M. I. A. (2002). A Proposal for Zero Emission from Palm Oil Industry Incorporating the Production of Polyhydroxyalkanoates from Palm Oil Mill Effluent. *JOURNAL OF CHEMICAL ENGINEERING OF JAPAN, 35*(1), 9-14. doi:10.1252/jcej.35.9

Hii, K., Baroutian, S., Parthasarathy, R., Gapes, D. J., & Eshtiaghi, N. (2014). A review of wet air oxidation and Thermal Hydrolysis technologies in sludge treatment. *Bioresource Technology, 155*, 289-299. doi:https://doi.org/10.1016/j.biortech.2013.12.066

Hii, K. L., Yeap, S. P., & Mat Don, M. (2012). *Cellulase production from palm oil mill effluent in Malaysia: Economical and technical perspectives* (Vol. 12).

Hoekman, S. K., Broch, A., & Robbins, C. (2011). Hydrothermal Carbonization (HTC) of Lignocellulosic Biomass. *Energy & Fuels, 25*(4), 1802-1810. doi:10.1021/ef101745n

Holladay, J. D., Hu, J., King, D. L., & Wang, Y. (2009). An overview of hydrogen production technologies. *Catalysis Today, 139*(4), 244-260. doi:https://doi.org/10.1016/j.cattod.2008.08.039

Hosseini, S. E., & Wahid, M. A. (2015). Pollutant in palm oil production process. *Journal of the Air & Waste Management Association, 65*(7), 773-781. doi:10.1080/10962247.2013.873092

Hrnčič, M. K., Kravanja, G., & Knez, Ž. (2016). Hydrothermal treatment of biomass for energy and chemicals. *Energy, 116*, 1312-1322. doi:https://doi.org/10.1016/j.energy.2016.06.148

Huber, G. W., Shabaker, J. W., & Dumesic, J. A. (2003). Raney Ni-Sn Catalyst for H₂ Production from Biomass-Derived Hydrocarbons. *Science, 300*(5628), 2075-2077. doi:10.1126/science.1085597

Hwang, I.-H., Aoyama, H., Matsuto, T., Nakagishi, T., & Matsuo, T. (2012). Recovery of solid fuel from municipal solid waste by hydrothermal treatment using subcritical water. *Waste Management, 32*(3), 410-416. doi:https://doi.org/10.1016/j.wasman.2011.10.006

Ibbett, R., Gaddipati, S., Davies, S., Hill, S., & Tucker, G. (2011). The mechanisms of hydrothermal deconstruction of lignocellulose: New insights from thermal–analytical and complementary studies. *Bioresource Technology, 102*(19), 9272-9278. doi:10.1016/j.biortech.2011.06.044

Imamura, S. (1999). Catalytic and Noncatalytic Wet Oxidation. *Industrial & Engineering Chemistry Research, 38*(5), 1743-1753. doi:10.1021/ie980576l

Inchaurrondo, N. S., Massa, P., Fenoglio, R., Font, J., & Haure, P. (2012). Efficient catalytic wet peroxide oxidation of phenol at moderate temperature using a high-load supported copper catalyst. *Chemical Engineering Journal, 198-199*, 426-434. doi:https://doi.org/10.1016/j.cej.2012.05.103

Isa, M. H., Wong, L.-P., Bashir, M. J. K., Shafiq, N., Kutty, S. R. M., Farooqi, I. H., & Lee, H. C. (2020). Improved anaerobic digestion of palm oil mill effluent and biogas production by ultrasonication pretreatment. *Science of The Total Environment, 722*, 137833. doi:https://doi.org/10.1016/j.scitotenv.2020.137833

Islam, M. A., Rahman, M., Yousuf, A., Cheng, C. K., & Wai, W. C. (2016). Performance of Klebsiella oxytoca to generate electricity from POME in microbial fuel cell. *MATEC Web of Conferences, 38*, 03004.

Ismail, S., Idris, I., Ng, Y. T., & Ahmad, A. L. (2014). Coagulation of Palm Oil Mill Effluent (POME) at High Temperature. *Journal of Applied Sciences, 14*, 1351-1354. doi:10.3923/jas.2014.1351.1354

Jamal, P., Alam, M. Z., & Mohamad, A. B. (2007, 2007//). *Microbial Bioconversion of Palm Oil Mill Effluent to Citric Acid with Optimum Process Conditions.* Paper presented at the 3rd Kuala Lumpur International Conference on Biomedical Engineering 2006, Berlin, Heidelberg.

Jin, F. (2014). *Application of hydrothermal reactions to biomass conversion*: Springer.

Jong, B., Liew, P., Juri, M. L., Kim, B., Mohd. Dzomir, A., Leo, K., & Awang, M. (2011). Performance and microbial diversity of palm oil mill effluent microbial fuel cell. *Letters in applied microbiology, 53*(6), 660-667.

Kalderis, D., Kotti, M. S., Méndez, A., & Gascó, G. (2014). Characterization of hydrochars produced by hydrothermal carbonization of rice husk. *Solid Earth, 5*(1), 477-483. doi:10.5194/se-5-477-2014

Kandiah, S., & Batumalai, R. (2013). *Palm oil clarification using evaporation* (Vol. 25).

Kang, S., Li, X., Fan, J., & Chang, J. (2013). Hydrothermal conversion of lignin: A review. *Renewable and Sustainable Energy Reviews, 27*, 546-558. doi:https://doi.org/10.1016/j.rser.2013.07.013

Karagöz, S., Bhaskar, T., Muto, A., Sakata, Y., & Uddin, M. A. (2004). Low-Temperature Hydrothermal Treatment of Biomass: Effect of Reaction Parameters on Products and Boiling Point Distributions. *Energy & Fuels, 18*(1), 234-241. doi:10.1021/ef030133g

Keav, S., Barbier, J., & Duprez, D. (2011). Deactivation and regeneration of wet air oxidation catalysts. *Catalysis Science & Technology, 1*(3), 342-353. doi:10.1039/C0CY00085J

Keav, S., de los Monteros, A. E., Barbier, J., & Duprez, D. (2014). Wet Air Oxidation of phenol over Pt and Ru catalysts supported on cerium-based oxides: Resistance to fouling and kinetic modelling. *Applied Catalysis B: Environmental, 150-151*, 402-410. doi:https://doi.org/10.1016/j.apcatb.2013.12.028

Keav, S., Martin, A., Barbier, J., & Duprez, D. (2010). Deactivation and reactivation of noble metal catalysts tested in the Catalytic Wet Air Oxidation of phenol. *Catalysis Today, 151*(1), 143-147. doi:https://doi.org/10.1016/j.cattod.2010.01.025

Khalid, A. R., & Mustafa, W. A. W. (1992). *External benefits of environmental regulation: Resource recovery and the utilisation of effluents* (Vol. 12).

Khan, A. A., de Jong, W., Jansens, P. J., & Spliethoff, H. (2009). Biomass combustion in fluidized bed boilers: Potential problems and remedies. *Fuel Processing Technology, 90*(1), 21-50. doi:https://doi.org/10.1016/j.fuproc.2008.07.012

Khatamian, M., Hashemian, S., Yavari, A., & Saket, M. (2012). Preparation of metal ion (Fe3+ and Ni2+) doped TiO2 nanoparticles supported on ZSM-5 zeolite and investigation of its photocatalytic activity. *Materials Science and Engineering: B, 177*(18), 1623-1627. doi:https://doi.org/10.1016/j.mseb.2012.08.015

Kim, D., Lee, K., & Park, K. Y. (2014). Hydrothermal carbonization of anaerobically digested sludge for solid fuel production and energy recovery. *Fuel*, *130*, 120-125. doi:https://doi.org/10.1016/j.fuel.2014.04.030

Kim, K.-H., & Ihm, S.-K. (2007). Characteristics of titania supported copper oxide catalysts for wet air oxidation of phenol. *Journal of Hazardous Materials, 146*(3), 610-616. doi:https://doi.org/10.1016/j.jhazmat.2007.04.063

Kim, K.-H., & Ihm, S.-K. (2011). Heterogeneous catalytic wet air oxidation of refractory organic pollutants in industrial wastewaters: A review. *Journal of Hazardous Materials, 186*(1), 16-34. doi:https://doi.org/10.1016/j.jhazmat.2010.11.011

Kim, S.-K., Kim, K.-H., & Ihm, S.-K. (2007). The characteristics of wet air oxidation of phenol over CuOx/Al2O3 catalysts: Effect of copper loading. *Chemosphere, 68*(2), 287-292. doi:https://doi.org/10.1016/j.chemosphere.2006.12.080

Kim, W. R., Ahn, H. G., Shin, J. S., Kim, Y. C., Moon, D. J., & Park, N. C. (2013). Effect of Ceria on Hydrogen Production by Auto-Thermal Reforming of Propane Over Supported Nickel Catalysts. *Journal of Nanoscience and Nanotechnology, 13*(1), 649-652. doi:10.1166/jnn.2013.6955

Kim, Y. K., Walters, H. K., & Hatfield, J. D. (1983). Oxidation kinetics of the carbon compounds in concentrated wet-process phosphoric acid. *Industrial & Engineering Chemistry Product Research and Development, 22*(2), 376-379. doi:10.1021/i300010a040

Kıpçak, E., Söğüt, O. Ö., & Akgün, M. (2011). Hydrothermal gasification of olive mill wastewater as a biomass source in supercritical water. *The Journal of Supercritical Fluids, 57*(1), 50-57. doi:https://doi.org/10.1016/j.supflu.2011.02.006

Kong, L., Li, G., Zhang, B., He, W., & Wang, H. (2008). Hydrogen Production from Biomass Wastes by Hydrothermal Gasification. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 30*(13), 1166-1178. doi:10.1080/15567030701258246

Konovalova, E. Y., Stom, D. I., Zhdanova, G. O., Yuriev, D. A., Li, Y., Barbora, L., & Goswami, P. (2018). The microorganisms used for working in microbial fuel cells. *AIP Conference Proceedings, 1952*(1), 020017. doi:10.1063/1.5031979

Kouraichi, R., Delgado, J. J., López-Castro, J. D., M.Stitou, Rodríguez-Izquierdo, J. M., & Cauqui, M. A. (2010). Deactivation of Pt/MnOx–CeO2 catalysts for the catalytic wet oxidation of phenol: Formation of carbonaceous deposits and leaching of manganese. *Catalysis Today, 154*(3), 195-201. doi:https://doi.org/10.1016/j.cattod.2010.04.020

Krammer, P., & Vogel, H. (2000). Hydrolysis of esters in subcritical and supercritical water. *The Journal of Supercritical Fluids, 16*(3), 189-206. doi:https://doi.org/10.1016/S0896-8446(99)00032-7

Krishnan, S., Singh, L., Mishra, P., Nasrullah, M., Sakinah, M., Thakur, S., Siddique, N. I., & Wahid, Z. A. (2017a). Comparison of process stability in methane generation from palm oil mill effluent using dairy manure as inoculum. *Environmental Technology & Innovation, 8*(Supplement C), 360-365. doi:10.1016/j.eti.2017.08.005

Krishnan, Y., Bong, C. P. C., Azman, N. F., Zakaria, Z., Othman, N. A., Abdullah, N., Ho, C. S., Lee, C. T., Hansen, S. B., & Hara, H. (2017b). Co-composting of palm empty fruit bunch and palm oil mill effluent: Microbial diversity and potential mitigation of greenhouse gas emission. *Journal of Cleaner Production, 146*, 94-100. doi:https://doi.org/10.1016/j.jclepro.2016.08.118

Kritzer, P. (2004). Corrosion in high-temperature and supercritical water and aqueous solutions: a review. *The Journal of Supercritical Fluids, 29*(1), 1-29. doi:https://doi.org/10.1016/S0896-8446(03)00031-7

Kruse, A. (2009). Hydrothermal biomass gasification. *The Journal of Supercritical Fluids, 47*(3), 391-399. doi:https://doi.org/10.1016/j.supflu.2008.10.009

Kruse, A., Funke, A., & Titirici, M.-M. (2013). Hydrothermal conversion of biomass to fuels and energetic materials. *Current Opinion in Chemical Biology, 17*(3), 515-521. doi:https://doi.org/10.1016/j.cbpa.2013.05.004

Kumabe, K., Itoh, N., Matsumoto, K., & Hasegawa, T. (2017). Hydrothermal gasification of glucose and starch in a batch and continuous reactor. *Energy Reports, 3*, 70-75. doi:https://doi.org/10.1016/j.egyr.2017.04.001

Kumar, A., & Verma, N. (2018). Wet air oxidation of aqueous dichlorvos pesticide over catalytic copper-carbon nanofiberous beads. *Chemical Engineering Journal, 351*, 428-440. doi:https://doi.org/10.1016/j.cej.2018.06.058

Kumar, M., Oyedun, A., & Kumar, A. (2018). *A review on the current status of various hydrothermal technologies on biomass feedstock* (Vol. 81, Part 2).

Kuppusamy, P., Ilavenil, S., Srigopalram, S., Maniam, G. P., Yusoff, M. M., Govindan, N., & Choi, K. C. (2017). Treating of palm oil mill effluent using Commelina nudiflora mediated copper nanoparticles as a novel bio-control agent. *Journal of Cleaner Production, 141*, 1023-1029. doi:https://doi.org/10.1016/j.jclepro.2016.09.176

Kushairi, A., Loh, K. S., Azman, I., Hishamuddin, E., Ong-Abdullah, M., Zanal, B. M. N. I., Razmah, G., Sundram, S., & Parveez, G. K. A. (2018). *OIL PALM*

ECONOMIC PERFORMANCE IN MALAYSIA AND R&D PROGRESS IN 2017 – Review Article (Vol. 30).

Lam, M. K., & Lee, K. T. (2011). Renewable and sustainable bioenergies production from palm oil mill effluent (POME): Win–win strategies toward better environmental protection. *Biotechnology Advances, 29*(1), 124-141. doi:https://doi.org/10.1016/j.biotechadv.2010.10.001

Larimi, A., & Khorasheh, F. (2018). Renewable hydrogen production by ethylene glycol steam reforming over Al_2O_3 supported Ni-Pt bimetallic nano-catalysts. *Renewable Energy, 128*, 188-199. doi:https://doi.org/10.1016/j.renene.2018.05.070

Lee, D.-K., Kim, D.-S., Kim, T.-H., Lee, Y.-K., Jeong, S.-E., Le, N. T., Cho, M.-J., & Henam, S. D. (2010). Deactivation of Pt catalysts during wet oxidation of phenol. *Catalysis Today, 154*(3), 244-249. doi:https://doi.org/10.1016/j.cattod.2010.03.052

Leng, L., Huang, H., Li, H., Li, J., & Zhou, W. (2019). Biochar stability assessment methods: A review. *Science of The Total Environment, 647*, 210-222. doi:https://doi.org/10.1016/j.scitotenv.2018.07.402

Leng, L., & Zhou, W. (2018). Chemical compositions and wastewater properties of aqueous phase (wastewater) produced from the hydrothermal treatment of wet biomass: A review. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 40*(22), 2648-2659. doi:10.1080/15567036.2018.1495780

Li, D., Zheng, H., Wang, Q., Wang, X., Jiang, W., Zhang, Z., & Yang, Y. (2014). A novel double-cylindrical-shell photoreactor immobilized with monolayer TiO2-coated silica gel beads for photocatalytic degradation of Rhodamine B and Methyl Orange in aqueous solution. *Separation and Purification Technology, 123*, 130-138. doi:https://doi.org/10.1016/j.seppur.2013.12.029

Li, M., Czymmek, K. J., & Huang, C. P. (2011). Responses of Ceriodaphnia dubia to TiO2 and Al2O3 nanoparticles: A dynamic nano-toxicity assessment of energy budget distribution. *Journal of Hazardous Materials, 187*(1), 502-508. doi:https://doi.org/10.1016/j.jhazmat.2011.01.061

Libra, J. A., Ro, K. S., Kammann, C., Funke, A., Berge, N. D., Neubauer, Y., Titirici, M. M., Führer, C., Bens, O., Kern, J., & Emmerich, K. H. (2011). Hydrothermal carbonization of biomass residuals: a comparative review of the chemistry, process, and applications of wet and dry pyrolysis. *Biofuels, 2*(1), 89-124.

Liew, J., Chan, Y., Pau Loke, S., Manickam, S., & Fong Chong, M. (2015). *Enzymatic Pre-treatment of Palm Oil Mill Effluent (POME) For Enhanced Anaerobic Digestion*.

Lin, S. H., Ho, S. J., & Wu, C. L. (1996). Kinetic and Performance Characteristics of Wet Air Oxidation of High-Concentration Wastewater. *Industrial & Engineering Chemistry Research, 35*(1), 307-314. doi:10.1021/ie950251u

Lin, S. S., Chen, C. L., Chang, D. J., & Chen, C. C. (2002). Catalytic wet air oxidation of phenol by various CeO2 catalysts. *Water Research*, *36*(12), 3009-3014. doi:https://doi.org/10.1016/S0043-1354(01)00539-5

Lippits, M. J., & Nieuwenhuys, B. E. (2010). Direct conversion of ethanol into ethylene oxide on gold-based catalysts: Effect of CeOx and Li2O addition on the selectivity. *Journal of Catalysis*, *274*(2), 142-149. doi:https://doi.org/10.1016/j.jcat.2010.06.011

Lokman, N. A., Ithnin, A. M., Yahya, W. J., & Yuzir, M. A. (2021). A brief review on biochemical oxygen demand (BOD) treatment methods for palm oil mill effluents (POME). *Environmental Technology & Innovation, 21*, 101258. doi:https://doi.org/10.1016/j.eti.2020.101258

Luck, F. (1999). Wet air oxidation: past, present and future. *Catalysis Today, 53*(1), 81-91. doi:https://doi.org/10.1016/S0920-5861(99)00112-1

Luo, M.-F., Zhong, Y.-J., Yuan, X.-X., & Zheng, X.-M. (1997). TPR and TPD studies of CuOCeO2 catalysts for low temperature CO oxidation. *Applied Catalysis A: General, 162*(1), 121-131. doi:https://doi.org/10.1016/S0926-860X(97)00089-6

Luterbacher, J. S., Fröling, M., Vogel, F., Maréchal, F., & Tester, J. W. (2009). Hydrothermal Gasification of Waste Biomass: Process Design and Life Cycle Asessment. *Environmental Science & Technology*, *43*(5), 1578-1583. doi:10.1021/es801532f

Ma, C., Wen, Y., Yue, Q., Li, A., Fu, J., Zhang, N., Gai, H., Zheng, J., & Chen, B. H. (2017). Oxygen-vacancy-promoted catalytic wet air oxidation of phenol from MnOx–CeO2. *RSC Advances*, *7*(43), 27079-27088. doi:10.1039/C7RA04037G

Ma, X., Zhou, B., Budai, A., Jeng, A., Hao, X., Wei, D., Zhang, Y., & Rasse, D. (2016). Study of Biochar Properties by Scanning Electron Microscope – Energy Dispersive X-Ray Spectroscopy (SEM-EDX). *Communications in Soil Science and Plant Analysis, 47*(5), 593-601. doi:10.1080/00103624.2016.1146742

Mäkelä, M., Forsberg, J., Söderberg, C., Larsson, S. H., & Dahl, O. (2018). Process water properties from hydrothermal carbonization of chemical sludge from a pulp and board mill. *Bioresource Technology, 263,* 654-659. doi:https://doi.org/10.1016/j.biortech.2018.05.044

Mäkelä, M., & Yoshikawa, K. (2016). *Ash behavior during hydrothermal treatment for solid fuel applications. Part 2: Effects of treatment conditions on industrial waste biomass* (Vol. 121).

Malakahmad, A., Chuan, S. Y., & Eisakhani, M. (2014). Post-treatment of Anaerobically Digested Palm Oil Mill Effluent by Polymeric Flocculant-Assisted Coagulation. *Applied Mechanics & Materials*(567).

Martínez-Arias, A., Fernández-García, M., Soria, J., & Conesa, J. C. (1999). Spectroscopic Study of a Cu/CeO2Catalyst Subjected to Redox Treatments in Carbon Monoxide and Oxygen. *Journal of Catalysis, 182*(2), 367-377. doi:https://doi.org/10.1006/jcat.1998.2361

Massa, P., Ivorra, F., Haure, P., & Fenoglio, R. (2005). Preparation and characterization of wet-proofed CuO/Al2O3 catalysts for the oxidation of phenol solutions. *Catalysis Letters, 101*(3), 201-209. doi:10.1007/s10562-005-4892-4

Massa, P., Ivorra, F., Haure, P., & Fenoglio, R. (2009). Optimized wet-proofed CuO/Al2O3 catalysts for the oxidation of phenol solutions: Enhancing catalytic stability. *Catalysis Communications, 10*(13), 1706-1710. doi:https://doi.org/10.1016/j.catcom.2009.05.014

Menezes, A. O., Rodrigues, M. T., Zimmaro, A., Borges, L. E. P., & Fraga, M. A. (2011). Production of renewable hydrogen from aqueous-phase reforming of glycerol over Pt catalysts supported on different oxides. *Renewable Energy, 36*(2), 595-599. doi:https://doi.org/10.1016/j.renene.2010.08.004

Milne, T. A., Elam, C. C., & Evans, R. J. (2002). *Hydrogen from biomass: state of the art and research challenges*. Retrieved from

Mishra, V. S., Mahajani, V. V., & Joshi, J. B. (1995). Wet Air Oxidation. *Industrial & Engineering Chemistry Research, 34*(1), 2-48. doi:10.1021/ie00040a001

Mohammed, A., Hasfalina, C. M., Aida, I. I., Khairul, F. Y., & Zurina, Z. A. (2018). Treatment of Palm Oil Mill Effluent Using Membrane Bioreactor: Novel Processes and Their Major Drawbacks. *10*(9), 1165.

Montoya, C., Cochard, B., Flori, A., Cros, D., Lopes, R., Cuellar, T., Espeout, S., Syaputra, I., Villeneuve, P., Pina, M., Ritter, E., Leroy, T., & Billotte, N. (2014). Genetic Architecture of Palm Oil Fatty Acid Composition in Cultivated Oil Palm (Elaeis guineensis Jacq.) Compared to Its Wild Relative E. oleifera (H.B.K) Cortés. *PLOS ONE, 9*(5), e95412. doi:10.1371/journal.pone.0095412

Mootabadi, H., Salamatinia, B., Bhatia, S., & Abdullah, A. Z. (2010). Ultrasonic-assisted biodiesel production process from palm oil using alkaline earth metal oxides as the heterogeneous catalysts. *Fuel, 89*(8), 1818-1825. doi:https://doi.org/10.1016/j.fuel.2009.12.023

MPOB. (2020, January 2020). Overview of The Malaysian Oil Palm Industry 2019. Retrieved from http://bepi.mpob.gov.my/images/overview/Overview_of_Industry_2019.pdf

Mumtaz, T., Yahaya, N. A., Abd-Aziz, S., Abdul Rahman, N. A., Yee, P. L., Shirai, Y., & Hassan, M. A. (2010). Turning waste to wealth-biodegradable plastics polyhydroxyalkanoates from palm oil mill effluent – a Malaysian perspective. *Journal of Cleaner Production, 18*(14), 1393-1402. doi:https://doi.org/10.1016/j.jclepro.2010.05.016

Najafpour, G. D., Zinatizadeh, A. A. L., Mohamed, A. R., Hasnain Isa, M., & Nasrollahzadeh, H. (2006). High-rate anaerobic digestion of palm oil mill effluent in an upflow anaerobic sludge-fixed film bioreactor. *Process Biochemistry, 41*(2), 370-379. doi:https://doi.org/10.1016/j.procbio.2005.06.031

Nasrullah, M., Singh, L., Mohamad, Z., Norsita, S., Krishnan, S., Wahida, N., & Zularisam, A. W. (2017). Treatment of palm oil mill effluent by electrocoagulation with presence of hydrogen peroxide as oxidizing agent and polialuminum chloride as coagulant-aid. *Water Resources and Industry, 17*, 7-10. doi:https://doi.org/10.1016/j.wri.2016.11.001

Neri, G., Pistone, A., Milone, C., & Galvagno, S. (2002). Wet air oxidation of p-coumaric acid over promoted ceria catalysts. *Applied Catalysis B: Environmental, 38*(4), 321-329. doi:https://doi.org/10.1016/S0926-3373(02)00061-9

Ng, K. H., & Cheng, C. K. (2015). A novel photomineralization of POME over UV-responsive TiO2 photocatalyst: kinetics of POME degradation and gaseous product formations. *RSC Advances, 5*(65), 53100-53110. doi:10.1039/C5RA06922J

Ng, K. H., Deraman, M. R., Ang, C. H., Chong, S. K., Kong, Z. Y., Khan, M. R., & Cheng, C. K. (2014). Phototreatment of Palm Oil Mill Effluent (POME) over Cu/TiO2 Photocatalyst. *Bulletin of Chemical Reaction Engineering & Catalysis; 2014: BCREC Volume 9 Issue 2 Year 2014 (SCOPUS Indexed, August 2014)*. doi:10.9767/bcrec.9.2.6011.121-127

Novianti, S., Nurdiawati, A., Zaini, I. N., Sumida, H., & Yoshikawa, K. (2016). Hydrothermal treatment of palm oil empty fruit bunches: an investigation of the solid fuel and liquid organic fertilizer applications. *Biofuels, 7*(6), 627-636. doi:10.1080/17597269.2016.1174019

Nunotani, N., Supandi, A. R., Choi, P.-G., & Imanaka, N. (2018). Catalytic Liquid-Phase Oxidation of Phenolic Compounds Using Ceria-Zirconia Based Catalysts. *Frontiers in chemistry, 6*, 553-553. doi:10.3389/fchem.2018.00553

Nwuche, C. O., Aoyagi, H., & Ogbonna, J. C. (2013). Citric acid production from cellulase-digested palm oil mill effluent. *Asian Journal of Biotechnology, 5*(2), 51-60.

O-Thong, S., Boe, K., & Angelidaki, I. (2012). Thermophilic anaerobic co-digestion of oil palm empty fruit bunches with palm oil mill effluent for efficient biogas production. *Applied energy, 93*, 648-654. doi:https://doi.org/10.1016/j.apenergy.2011.12.092

Oktaviananda, C., Rahmawati, R. F., Prasetya, A., Purnomo, C. W., Yuliansyah, A. T., & Cahyono, R. B. (2017). Effect of temperature and biomass-water ratio to yield and product characteristics of hydrothermal treatment of biomass. *AIP Conference Proceedings, 1823*(1), 020029. doi:10.1063/1.4978102

Oliveira, A. S., Cordero-Lanzac, T., Baeza, J. A., Calvo, L., Heras, F., Rodriguez, J. J., & Gilarranz, M. A. (2021). Continuous aqueous phase reforming of a synthetic brewery wastewater with Pt/C and PtRe/C catalysts for biohydrogen production. *Chemosphere, 281*, 130885. doi:https://doi.org/10.1016/j.chemosphere.2021.130885

Osada, M., Sato, T., Watanabe, M., Shirai, M., & Arai, K. (2006). CATALYTIC GASIFICATION OF WOOD BIOMASS IN SUBCRITICAL AND SUPERCRITICAL WATER. *Combustion Science and Technology, 178*(1-3), 537-552. doi:10.1080/00102200500290807

Othman, M. R., Hassan, M. A., Shirai, Y., Baharuddin, A. S., Ali, A. A. M., & Idris, J. (2014). Treatment of effluents from palm oil mill process to achieve river water quality for reuse as recycled water in a zero emission system. *Journal of Cleaner Production, 67*, 58-61. doi:https://doi.org/10.1016/j.jclepro.2013.12.004

Ovejero, G., Sotelo, J. L., Rodríguez, A., Vallet, A., & García, J. (2011). Wet air oxidation and catalytic wet air oxidation for dyes degradation. *Environmental Science and Pollution Research, 18*(9), 1518. doi:10.1007/s11356-011-0504-6

Park, S., Baker, J. O., Himmel, M. E., Parilla, P. A., & Johnson, D. K. (2010). Cellulose crystallinity index: measurement techniques and their impact on interpreting cellulase performance. *Biotechnology for biofuels, 3*(1), 10.

Parshetti, G. K., Hoekman, K. S., & Balasubramanian, R. (2013). Chemical, structural and combustion characteristics of carbonaceous products obtained by hydrothermal carbonization of palm empty fruit bunches. *Bioresource Technology, 135*, 683-689. doi:https://doi.org/10.1016/j.biortech.2012.09.042

Parthasarathy, S., Mohammed, R. R., Fong, C. M., Gomes, R. L., & Manickam, S. (2016). A novel hybrid approach of activated carbon and ultrasound cavitation for the intensification of palm oil mill effluent (POME) polishing. *Journal of Cleaner Production, 112*, 1218-1226. doi:https://doi.org/10.1016/j.jclepro.2015.05.125

Patience, G. S. (2013). *Experimental Methods And Instrumentation For Chemical Engineers*. USA: Elsevier.

Pavlovič, I., Knez, Ž., & Škerget, M. (2013). Hydrothermal Reactions of Agricultural and Food Processing Wastes in Sub- and Supercritical Water: A Review of

Fundamentals, Mechanisms, and State of Research. *Journal of Agricultural and Food Chemistry, 61*(34), 8003-8025. doi:10.1021/jf401008a

Peng, C., Zhai, Y., Zhu, Y., Xu, B., Wang, T., Li, C., & Zeng, G. (2016). Production of char from sewage sludge employing hydrothermal carbonization: Char properties, combustion behavior and thermal characteristics. *Fuel, 176*, 110-118. doi:https://doi.org/10.1016/j.fuel.2016.02.068

Pham, T. H., Rabaey, K., Aelterman, P., Clauwaert, P., De Schamphelaire, L., Boon, N., & Verstraete, W. (2006). Microbial Fuel Cells in Relation to Conventional Anaerobic Digestion Technology. *Engineering in Life Sciences, 6*(3), 285-292. doi:doi:10.1002/elsc.200620121

Pires, C. A., Santos, A. C. C. d., & JordÃ£o, E. (2015). OXIDATION OF PHENOL IN AQUEOUS SOLUTION WITH COPPER OXIDE CATALYSTS SUPPORTED ON ³-Al2O3, PILLARED CLAY AND TiO2: COMPARISON OF THE PERFORMANCE AND COSTS ASSOCIATED WITH EACH CATALYST. *Brazilian Journal of Chemical Engineering, 32*, 837-848.

Pleşa Chicinaş, R., Coteţ, L. C., Măicăneanu, A., Vasilescu, M., & Vulpoi, A. (2016). Preparation, characterization, and testing of metal-doped carbon xerogels as catalyst for phenol CWAO. *Environ. Sci. Pollut. Res.*, 1-7.

Poerschmann, J., Weiner, B., Koehler, R., & Kopinke, F.-D. (2017). Hydrothermal Carbonization of Glucose, Fructose, and Xylose—Identification of Organic Products with Medium Molecular Masses. *ACS Sustainable Chemistry & Engineering, 5*(8), 6420-6428. doi:10.1021/acssuschemeng.7b00276

Poh, P. E., & Chong, M. F. (2009). Development of anaerobic digestion methods for palm oil mill effluent (POME) treatment. *Bioresource Technology, 100*(1), 1-9. doi:https://doi.org/10.1016/j.biortech.2008.06.022

Poh, P. E., & Chong, M. F. (2014). Upflow anaerobic sludge blanket-hollow centered packed bed (UASB-HCPB) reactor for thermophilic palm oil mill effluent (POME) treatment. *Biomass and Bioenergy, 67*, 231-242. doi:https://doi.org/10.1016/j.biombioe.2014.05.007

Prasannamedha, G., Kumar, P. S., Mehala, R., Sharumitha, T. J., & Surendhar, D. (2021). Enhanced adsorptive removal of sulfamethoxazole from water using biochar derived from hydrothermal carbonization of sugarcane bagasse. *Journal of Hazardous Materials, 407*, 124825. doi:https://doi.org/10.1016/j.jhazmat.2020.124825

Promdej, C., & Matsumura, Y. (2011). Temperature Effect on Hydrothermal Decomposition of Glucose in Sub- And Supercritical Water. *Industrial & Engineering Chemistry Research, 50*(14), 8492-8497. doi:10.1021/ie200298c

Quan, C., Xu, S., & Zhou, C. (2017). Steam reforming of bio-oil from coconut shell pyrolysis over Fe/olivine catalyst. *Energy Conversion and Management, 141*(Supplement C), 40-47. doi:10.1016/j.enconman.2016.04.024

Quintanilla, A., Casas, J. A., & Rodriguez, J. J. (2010). Hydrogen peroxide-promoted-CWAO of phenol with activated carbon. *Applied Catalysis B: Environmental, 93*(3-4), 339-345. doi:10.1016/j.apcatb.2009.10.007

Quitain, A. T., Herng, C. Y., Yusup, S., Sasaki, M., & Uemura, Y. (2015). Conversion of Biomass to Bio-Oil in Sub- and Supercritical Water. In K. Biernat (Ed.), *Biofuels - Status and Perspective* (pp. Ch. 21). Rijeka: InTech.

Radwan, N. R. E., Fagal, G. A., & El-Shobaky, G. A. (2001). Effects of CeO2-doping on surface and catalytic properties of CuO/Al2O3 solids. *Colloids and Surfaces A: Physicochemical and Engineering Aspects, 178*(1), 277-286. doi:https://doi.org/10.1016/S0927-7757(00)00709-3

Rahim, S. H. A., Rahim, A., Milone, C., Piperopoulos, E., & Santangelo, S. (2018). *Enhanced Catalytic Activity of Platinum Carbonaceous Materials in Catalytic Wet Air Oxidation of Poly Phenolic Substrate-p-coumaric Acid* (Vol. 13).

Rahman, Z. A., Hadi, N. A., Hawari, Y., Hashim, Z., & Tan, D. (2013). *Zero Waste Technology for Palm Oil Mills (POMEDfree).*

Remón, J., García, L., & Arauzo, J. (2016). Cheese whey management by catalytic steam reforming and aqueous phase reforming. *Fuel Processing Technology, 154*, 66-81. doi:10.1016/j.fuproc.2016.08.012

Reza, M. T., Andert, J., Wirth, B., Busch, D., Pielert, J., Lynam, J., & Mumme, J. (2014). *Review Article: Hydrothermal Carbonization of Biomass for Energy and Crop Production* (Vol. 1).

Reza, M. T., Yan, W., Uddin, M. H., Lynam, J. G., Hoekman, S. K., Coronella, C. J., & Vásquez, V. R. (2013). Reaction kinetics of hydrothermal carbonization of loblolly pine. *Bioresource Technology, 139*, 161-169. doi:https://doi.org/10.1016/j.biortech.2013.04.028

Rivas, F. J., Beltrán, F. J., Gimeno, O., & Acedo, B. (2001). Wet Air Oxidation Of Wastewater From Olive Oil Mills. *Chemical Engineering & Technology*, *24*(4), 415-421. doi:10.1002/1521-4125(200104)24:4<415::aid-ceat415>3.0.co;2-c

Sakaki, T., Shibata, M., Miki, T., Hirosue, H., & Hayashi, N. (1996). Decomposition of Cellulose in Near-Critical Water and Fermentability of the Products. *Energy & Fuels, 10*(3), 684-688. doi:10.1021/ef950160+

Salimi, M., Safari, F., Tavasoli, A., & Shakeri, A. (2016). Hydrothermal gasification of different agricultural wastes in supercritical water media for hydrogen production:

a comparative study. *International Journal of Industrial Chemistry, 7*(3), 277-285. doi:10.1007/s40090-016-0091-y

Sánchez-Oneto, J., Portela, J. R., Nebot, E., & Martínez-de-la-Ossa, E. J. (2006). Kinetics and Mechanism of Wet Air Oxidation of Butyric Acid. *Industrial & Engineering Chemistry Research, 45*(12), 4117-4122. doi:10.1021/ie060103b

Santiago, A. F. J., Sousa, J. F., Guedes, R. C., Jerônimo, C. E. M., & Benachour, M. (2006). Kinetic and wet oxidation of phenol catalyzed by non-promoted and potassium-promoted manganese/cerium oxide. *Journal of Hazardous Materials, 138*(2), 325-330. doi:https://doi.org/10.1016/j.jhazmat.2006.05.118

Santos, A., Yustos, P., Quintanilla, A., Ruiz, G., & Garcia-Ochoa, F. (2005). Study of the copper leaching in the wet oxidation of phenol with CuO-based catalysts: Causes and effects. *Applied Catalysis B: Environmental, 61*(3), 323-333. doi:https://doi.org/10.1016/j.apcatb.2005.06.006

Schuchardt, F., Wulfert, K., & Herawan, T. (2008). EFFECT OF NEW PALM OIL MILL PROCESSES ON THE EFB AND POME UTILIZATION. *Journal of Oil Palm Research*(Special Issue), 21-31.

Sevilla, M., & Fuertes, A. B. (2009a). Chemical and Structural Properties of Carbonaceous Products Obtained by Hydrothermal Carbonization of Saccharides. *Chemistry – A European Journal, 15*(16), 4195-4203. doi:10.1002/chem.200802097

Sevilla, M., & Fuertes, A. B. (2009b). The production of carbon materials by hydrothermal carbonization of cellulose. *Carbon, 47*(9), 2281-2289. doi:https://doi.org/10.1016/j.carbon.2009.04.026

Shabaker, J. W., Huber, G. W., Davda, R. R., Cortright, R. D., & Dumesic, J. A. (2003). Aqueous-Phase Reforming of Ethylene Glycol Over Supported Platinum Catalysts. *Catalysis Letters, 88*(1), 1-8. doi:10.1023/a:1023538917186

Shabaker, J. W., Huber, G. W., & Dumesic, J. A. (2004). Aqueous-phase reforming of oxygenated hydrocarbons over Sn-modified Ni catalysts. *Journal of Catalysis, 222*(1), 180-191. doi:https://doi.org/10.1016/j.jcat.2003.10.022

Shah, S. N. A., Shah, Z., Hussain, M., & Khan, M. (2017). Hazardous Effects of Titanium Dioxide Nanoparticles in Ecosystem. *Bioinorganic Chemistry and Applications, 2017*, 4101735. doi:10.1155/2017/4101735

Shanableh, A. (2000). Production of useful organic matter from sludge using hydrothermal treatment. *Water Research, 34*(3), 945-951. doi:https://doi.org/10.1016/S0043-1354(99)00222-5

Shanableh, A., & Shimizu, Y. (2000). Treatment of sewage sludge using hydrothermal oxidation – technology application challenges. *Water Science and Technology, 41*(8), 85-92. doi:10.2166/wst.2000.0146

Sharma, A., Nakagawa, H., & Miura, K. (2006). A novel nickel/carbon catalyst for CH4 and H2 production from organic compounds dissolved in wastewater by catalytic hydrothermal gasification. *Fuel, 85*(2), 179-184. doi:https://doi.org/10.1016/j.fuel.2005.04.035

Shih, C.-C., & Chang, J.-R. (2006). Pt/C stabilization for catalytic wet-air oxidation: Use of grafted TiO2. *Journal of Catalysis, 240*(2), 137-150. doi:https://doi.org/10.1016/j.jcat.2006.03.019

Silva, F., Lansarin, M., & Moro, C. (2012). A Comparison of slurry and inmobilized TiO2 in the photocatalytic degradation of phenol. *Latin American applied research, 42*(3), 275-280.

Soler-Cabezas, J. L., Torà-Grau, M., Vincent-Vela, M. C., Mendoza-Roca, J. A., & Martínez-Francisco, F. J. (2015). Ultrafiltration of municipal wastewater: study on fouling models and fouling mechanisms. *Desalination and Water Treatment, 56*(13), 3427-3437. doi:10.1080/19443994.2014.969320

Sonenshine, J. (2021). Copper Just Hit a Near-Decade High. Here Are 3 Reasons Why It Can Keep Soaring. Retrieved from https://www.barrons.com/articles/copper-just-hit-a-near-decade-high-here-are-3-reasons-why-it-can-keep-soaring-51614016831

Spivey, J. J. (1987). Complete catalytic oxidation of volatile organics. *Industrial & Engineering Chemistry Research, 26*(11), 2165-2180. doi:10.1021/ie00071a001

Stirling, R. J., Snape, C. E., & Meredith, W. (2018). The impact of hydrothermal carbonisation on the char reactivity of biomass. *Fuel Processing Technology, 177*, 152-158. doi:https://doi.org/10.1016/j.fuproc.2018.04.023

Stoyanova, M., Christoskova, S., & Georgieva, M. (2003). Mixed Ni-Mn-oxide systems as catalysts for complete oxidation: Part II. Kinetic study of liquid-phase oxidation of phenol. *Applied Catalysis A: General, 249*(2), 295-302. doi:https://doi.org/10.1016/S0926-860X(03)00229-1

Stüber, F., Font, J., Fortuny, A., Bengoa, C., Eftaxias, A., & Fabregat, A. (2005). Carbon materials and catalytic wet air oxidation of organic pollutants in wastewater. *Topics in Catalysis, 33*(1), 3-50. doi:10.1007/s11244-005-2497-1

Subramanian, N. D., Callison, J., Catlow, C. R. A., Wells, P. P., & Dimitratos, N. (2016). Optimised hydrogen production by aqueous phase reforming of glycerol on Pt/Al2O3. *International Journal of Hydrogen Energy, 41*(41), 18441-18450. doi:https://doi.org/10.1016/j.ijhydene.2016.08.081

Sun, P., Heng, M., Sun, S., & Chen, J. (2010). Direct liquefaction of paulownia in hot compressed water: Influence of catalysts. *Energy, 35*(12), 5421-5429. doi:https://doi.org/10.1016/j.energy.2010.07.005

Tadza, M. Y. M., Ghani, N. A. F., & Sobani, H. H. M. (2016). Evaluation Of Sludge From Coagulation Of Palm Oil Mill Effluent With Chitosan Based Coagulant. *Jurnal Teknologi, 78*(5-4), 19-22.

Tamrin, K. F., & Zahrim, A. Y. (2017). Determination of optimum polymeric coagulant in palm oil mill effluent coagulation using multiple-objective optimisation on the basis of ratio analysis (MOORA). *Environmental Science and Pollution Research, 24*(19), 15863-15869. doi:10.1007/s11356-016-8235-3

Tanksale, A., Beltramini, J. N., & Lu, G. M. (2010). A review of catalytic hydrogen production processes from biomass. *Renewable and Sustainable Energy Reviews, 14*(1), 166-182. doi:https://doi.org/10.1016/j.rser.2009.08.010

Tarka, A., Zybert, M., Ronduda, H., Patkowski, W., Mierzwa, B., Kępiński, L., & Raróg-Pilecka, W. (2022). On Optimal Barium Promoter Content in a Cobalt Catalyst for Ammonia Synthesis. *Catalysts, 12*(2). doi:10.3390/catal12020199

Taylor, A. D., DiLeo, G. J., & Sun, K. (2009). Hydrogen production and performance of nickel based catalysts synthesized using supercritical fluids for the gasification of biomass. *Applied Catalysis B: Environmental, 93*(1), 126-133. doi:https://doi.org/10.1016/j.apcatb.2009.09.021

Teh, C. Y., Budiman, P. M., Shak, K. P. Y., & Wu, T. Y. (2016). Recent Advancement of Coagulation–Flocculation and Its Application in Wastewater Treatment. *Industrial & Engineering Chemistry Research, 55*(16), 4363-4389. doi:10.1021/acs.iecr.5b04703

Tekin, K., Karagöz, S., & Bektaş, S. (2014). A review of hydrothermal biomass processing. *Renewable and Sustainable Energy Reviews, 40*, 673-687. doi:https://doi.org/10.1016/j.rser.2014.07.216

Teng, T. T., Wong, Y.-S., Ong, S.-A., Norhashimah, M., & Rafatullah, M. (2013). Start-up Operation of Anaerobic Degradation Process for Palm Oil Mill Effluent in Anaerobic Bench Scale Reactor (ABSR). *Procedia Environmental Sciences, 18*, 442-450. doi:https://doi.org/10.1016/j.proenv.2013.04.059

Toor, S. S., Rosendahl, L., & Rudolf, A. (2011). Hydrothermal liquefaction of biomass: A review of subcritical water technologies. *Energy, 36*(5), 2328-2342. doi:https://doi.org/10.1016/j.energy.2011.03.013

Torkian, A., Eqbali, A., & Hashemian, S. J. (2003). *The effect of organic loading rate on the performance of UASB reactor treating slaughterhouse effluent* (Vol. 40).

Tunç, S., Duman, O., & Gürkan, T. (2013). Monitoring the Decolorization of Acid Orange 8 and Acid Red 44 from Aqueous Solution Using Fenton's Reagents by Online Spectrophotometric Method: Effect of Operation Parameters and Kinetic Study. *Industrial & Engineering Chemistry Research, 52*(4), 1414-1425. doi:10.1021/ie302126c

Valenzuela, M. B., Jones, C. W., & Agrawal, P. K. (2006). Batch aqueous-phase reforming of woody biomass. *Energy & Fuels, 20*(4), 1744-1752.

Vijayaraghavan, K., Ahmad, D., & Ezan, M. A. A. (2007). Aerobic treatment of palm oil mill effluent. *Journal of Environmental Management, 82*(1), 24-31. doi:https://doi.org/10.1016/j.jenvman.2005.11.016

Wang, J., Fu, W., He, X., Yang, S., & Zhu, W. (2014a). Catalytic wet air oxidation of phenol with functionalized carbon materials as catalysts: Reaction mechanism and pathway. *Journal of Environmental Sciences, 26*(8), 1741-1749. doi:https://doi.org/10.1016/j.jes.2014.06.015

Wang, L., Zhang, L., & Li, A. (2014b). Hydrothermal treatment coupled with mechanical expression at increased temperature for excess sludge dewatering: Influence of operating conditions and the process energetics. *Water Research, 65*, 85-97. doi:https://doi.org/10.1016/j.watres.2014.07.020

Wang, T., Zhai, Y., Zhu, Y., Li, C., & Zeng, G. (2018). A review of the hydrothermal carbonization of biomass waste for hydrochar formation: Process conditions, fundamentals, and physicochemical properties. *Renewable and Sustainable Energy Reviews, 90*, 223-247. doi:https://doi.org/10.1016/j.rser.2018.03.071

Wang, X., Shi, F., Huang, W., & Fan, C. (2012). Synthesis of high quality TiO2 membranes on alumina supports and their photocatalytic activity. *Thin Solid Films, 520*(7), 2488-2492. doi:https://doi.org/10.1016/j.tsf.2011.10.023

Wei, Y., Lei, H., Liu, Y., Wang, L., Zhu, L., Zhang, X., Yadavalli, G., Ahring, B., & Chen, S. (2014). Renewable Hydrogen Produced from Different Renewable Feedstock by Aqueous-Phase Reforming Process. *Journal of Sustainable Bioenergy Systems, Vol.04No.02*, 15. doi:10.4236/jsbs.2014.42011

Weller, S. (1956). Analysis of kinetic data for heterogeneous reactions. *AIChE Journal, 2*(1), 59-62. doi:doi:10.1002/aic.690020112

Williams, P. T., & Onwudili, J. (2006). Subcritical and Supercritical Water Gasification of Cellulose, Starch, Glucose, and Biomass Waste. *Energy & Fuels, 20*(3), 1259-1265. doi:10.1021/ef0503055

Wong, K. M., Nor'aini, A. R., Suraini, A., Vikineswary, S., & Hassan, M. A. (2008). Enzymatic Hydrolysis of Palm Oil Mill Effluent Solid Using Mixed Cellulases from Locally Isolated Fungi. *Research Journal of Microbiology, 3*, 474-481. doi:10.3923/jm.2008.474.481

Wu, T. Y., Mohammad, A. W., Jahim, J. M., & Anuar, N. (2010). Pollution control technologies for the treatment of palm oil mill effluent (POME) through end-of-pipe processes. *Journal of Environmental Management, 91*(7), 1467-1490. doi:https://doi.org/10.1016/j.jenvman.2010.02.008

Wu, T. Y., Mohammad, A. W., Md. Jahim, J., & Anuar, N. (2007). Palm oil mill effluent (POME) treatment and bioresources recovery using ultrafiltration membrane: Effect of pressure on membrane fouling. *Biochemical Engineering Journal, 35*(3), 309-317. doi:https://doi.org/10.1016/j.bej.2007.01.029

Xie, F., Chu, X., Hu, H., Qiao, M., Yan, S., Zhu, Y., He, H., Fan, K., Li, H., Zong, B., & Zhang, X. (2006). Characterization and catalytic properties of Sn-modified rapidly quenched skeletal Ni catalysts in aqueous-phase reforming of ethylene glycol. *Journal of Catalysis, 241*(1), 211-220. doi:https://doi.org/10.1016/j.jcat.2006.05.001

Xu, C., & Etcheverry, T. (2008). Hydro-liquefaction of woody biomass in sub- and super-critical ethanol with iron-based catalysts. *Fuel, 87*(3), 335-345. doi:https://doi.org/10.1016/j.fuel.2007.05.013

Xu, C., & Lancaster, J. (2008). Conversion of secondary pulp/paper sludge powder to liquid oil products for energy recovery by direct liquefaction in hot-compressed water. *Water Research, 42*(6), 1571-1582. doi:https://doi.org/10.1016/j.watres.2007.11.007

Yacob, S., Hassan, M. A., Shirai, Y., Wakisaka, M., & Subash, S. (2005). Baseline study of methane emission from open digesting tanks of palm oil mill effluent treatment. *Chemosphere, 59*(11), 1575-1581. doi:https://doi.org/10.1016/j.chemosphere.2004.11.040

Yan, Q., Guo, L., & Lu, Y. (2006). Thermodynamic analysis of hydrogen production from biomass gasification in supercritical water. *Energy Conversion and Management, 47*(11), 1515-1528. doi:https://doi.org/10.1016/j.enconman.2005.08.004

Yang, L. (2008). *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*. Singapore: John Wiley & Sons (Asia) Pte Ltd

Yaser, A., Mansa, R., Menaka, S., Su, S. Y., Melvin, F., & Chan, E. S. (2009). *Decolorisation of anaerobic palm oil mill effluent via activated sludge-granular activated carbon* (Vol. 5).

Yeh, T. M., Dickinson, J. G., Franck, A., Linic, S., Thompson Jr, L. T., & Savage, P. E. (2013). Hydrothermal catalytic production of fuels and chemicals from aquatic biomass. *Journal of Chemical Technology & Biotechnology, 88*(1), 13-24. doi:10.1002/jctb.3933

Yin, J., Cheng, Z., Guo, L., Li, S., & Jin, H. (2017). Products distribution and influence of nickel catalyst on glucose hydrothermal decomposition. *International Journal of Hydrogen Energy, 42*(7), 4642-4650. doi:https://doi.org/10.1016/j.ijhydene.2016.07.065

Younis, S. A., & Kim, K.-H. (2020). Heterogeneous Photocatalysis Scalability for Environmental Remediation: Opportunities and Challenges. *Catalysts*, *10*(10), 1109.

Yousefifar, A., Baroutian, S., Farid, M. M., Gapes, D. J., & Young, B. R. (2017). Hydrothermal processing of cellulose: A comparison between oxidative and non-oxidative processes. *Bioresource Technology, 226*, 229-237. doi:https://doi.org/10.1016/j.biortech.2016.12.010

Yuliansyah, A. T., & Hirajima, T. (2012). Efficacy of Hydrothermal Treatment for Production of Solid Fuel from Oil Palm Wastes. In V. Abrol & P. Sharma (Eds.), *Resource Management for Sustainable Agriculture* (pp. Ch. 01). Rijeka: InTech.

Zahrim, A. Y., Dexter, Z. D., Joseph, C. G., & Hilal, N. (2017). Effective coagulation-flocculation treatment of highly polluted palm oil mill biogas plant wastewater using dual coagulants: Decolourisation, kinetics and phytotoxicity studies. *Journal of Water Process Engineering, 16*, 258-269. doi:https://doi.org/10.1016/j.jwpe.2017.02.005

Zahrim, A. Y., Nasimah, A., & Hilal, N. (2014). *Pollutants analysis during conventional palm oil mill effluent (POME) ponding system and decolourisation of anaerobically treated POME via calcium lactate-polyacrylamide* (Vol. 4).

Zangeneh, H., Zinatizadeh, A. A. L., Habibi, M., Akia, M., & Hasnain Isa, M. (2015). Photocatalytic oxidation of organic dyes and pollutants in wastewater using different modified titanium dioxides: A comparative review. *Journal of Industrial and Engineering Chemistry, 26*, 1-36. doi:https://doi.org/10.1016/j.jiec.2014.10.043

Zapico, R. R., Marín, P., Díez, F. V., & Ordóñez, S. (2017). Assessment of phenol wet oxidation on CuO/γ-Al2O3 catalysts: Competition between heterogeneous and leached-copper homogeneous reaction paths. *Journal of Environmental Chemical Engineering, 5*(3), 2570-2578. doi:https://doi.org/10.1016/j.jece.2017.04.050

Žerjav, G., Kaplan, R., & Pintar, A. (2018). Catalytic wet air oxidation of bisphenol A aqueous solution in trickle-bed reactor over single TiO2 polymorphs and their mixtures. *Journal of Environmental Chemical Engineering*, *6*(2), 2148-2158. doi:https://doi.org/10.1016/j.jece.2018.03.024

Zhang, B., Heidari, M., Regmi, B., Salaudeen, S., Arku, P., Thimmannagari, M., & Dutta, A. (2018a). *Hydrothermal Carbonization of Fruit Wastes: A Promising Technique for Generating Hydrochar* (Vol. 11).

Zhang, B., von Keitz, M., & Valentas, K. (2009). Thermochemical liquefaction of high-diversity grassland perennials. *Journal of Analytical and Applied Pyrolysis, 84*(1), 18-24. doi:https://doi.org/10.1016/j.jaap.2008.09.005

Zhang, L., Champagne, P., & Xu, C. (2011). Bio-crude production from secondary pulp/paper-mill sludge and waste newspaper via co-liquefaction in hot-compressed water. *Energy, 36*(4), 2142-2150. doi:https://doi.org/10.1016/j.energy.2010.05.029

Zhang, L., Wang, Q., Wang, B., Yang, G., Lucia, L. A., & Chen, J. (2015). Hydrothermal Carbonization of Corncob Residues for Hydrochar Production. *Energy & Fuels, 29*(2), 872-876. doi:10.1021/ef502462p

Zhang, Z., Borhani, T. N. G., & El-Naas, M. H. (2018b). Chapter 4.5 - Carbon Capture. In I. Dincer, C. O. Colpan, & O. Kizilkan (Eds.), *Exergetic, Energetic and Environmental Dimensions* (pp. 997-1016): Academic Press.

Zhao, M., Li, B., Cai, J.-X., Liu, C., McAdam, K. G., & Zhang, K. (2016). Thermal & chemical analyses of hydrothermally derived carbon materials from corn starch. *Fuel Processing Technology, 153*, 43-49. doi:https://doi.org/10.1016/j.fuproc.2016.08.002

Zheng, X., Shen, Z.-P., Shi, L., Cheng, R., & Yuan, D.-H. (2017). *Photocatalytic Membrane Reactors (PMRs) in Water Treatment: Configurations and Influencing Factors* (Vol. 7).

Zhong, C., & Wei, X. (2004). A comparative experimental study on the liquefaction of wood. *Energy, 29*(11), 1731-1741. doi:https://doi.org/10.1016/j.energy.2004.03.096

Zhu, X., Liu, Y., Qian, F., Zhou, C., Zhang, S., & Chen, J. (2015). Role of Hydrochar Properties on the Porosity of Hydrochar-based Porous Carbon for Their Sustainable Application. *ACS Sustainable Chemistry & Engineering, 3*(5), 833-840. doi:10.1021/acssuschemeng.5b00153

Zinatizadeh, A. A., Ibrahim, S., Aghamohammadi, N., Mohamed, A. R., Zangeneh, H., & Mohammadi, P. (2017). Polyacrylamide-induced coagulation process removing suspended solids from palm oil mill effluent. *Separation Science and Technology, 52*(3), 520-527. doi:10.1080/01496395.2016.1260589

Zou, L. Y., Li, Y., & Hung, Y.-T. (2007). Wet Air Oxidation for Waste Treatment. In L. K. Wang, Y.-T. Hung, & N. K. Shammas (Eds.), *Advanced Physicochemical Treatment Technologies* (pp. 575-610). Totowa, NJ: Humana Press.