

Potentials of biomass waste sources for heterogeneous catalyst production

by Hesty Heryani

Submission date: 10-Apr-2023 06:59PM (UTC+0700)

Submission ID: 2060491747

File name: Heryani_2020_IOP_Conf._Ser._Earth_Environ._Sci._472_012035.pdf (944.37K)

Word count: 2858

Character count: 14920

PAPER · OPEN ACCESS

Potentials of biomass waste sources for heterogeneous catalyst production

To cite this article: H Heryani and N R Yanti 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **472** 012035

4
View the [article online](#) for updates and enhancements.

You may also like

- [Effect of Subang Pineapple Leaf Fiber Loading on Flammability and Mechanical Properties of Pineapple Leaf Fiber Reinforced Polypropylene Composites](#)
Toho Dustin Sulomo and Ariadne L Juwono

- [Morphology and fruit quality characters of Pineapple \(*Ananas comosus* L. Merr\) cv. Queen on three sites planting: freshwater peat, brackish peat and alluvial soil](#)
Rosmaina, MA Almaktsur, R Elfanis et al.

- [Experimental investigation on the mechanical properties and water absorption behavior of randomly oriented short pineapple/coir fiber-reinforced hybrid epoxy composites](#)
Mohit Mittal and Rajiv Chaudhary



245th ECS Meeting
San Francisco, CA
May 26–30, 2024

PRiME 2024
Honolulu, Hawaii
October 6–11, 2024

Bringing together industry, researchers, and government across 50 symposia in electrochemistry and solid state science and technology

Learn more about ECS Meetings at
<http://www.electrochem.org/upcoming-meetings>

ECS Save the Dates for future ECS Meetings!

Potentials of biomass waste sources for heterogeneous catalyst production

H Heryani¹ and N R Yanti²

¹ Department of Agro-industrial Technology, University of Lambung Mangkurat, Banjarbaru 70714, Indonesia

² Department of Natural and Environmental Resources Management, University of Lambung Mangkurat, Banjarbaru 70714, Indonesia

e-mail: hheryani@ulm.ac.id

Abstract. 80% of processes in industries in developing countries generally use catalysts, both homogeneous and heterogeneous, derived from biomass. The research aimed to synthesize silica-based heterogeneous catalysts from waste of Sugar palm peel, Pineapple leaf and Orange peel, then carried out characterization of the heterogeneous catalyst used. The method started from the preparation of biomass waste, catalyst characterization including yield of SiO₂ in extract, crystallinity, pore size, surface area and catalyst morphology. The yield of SiO₂ extract from the Sugar palm peel was 12.281% ; Pineapple leaf was 34.131%, and Orange peel was 30.102%. The diffractogram showed that all SiO₂ catalyst synthesis had a crystalline phase; The pore size of the catalyst ranged from 3.918 to 5.6512 nm, and the surface area of the catalyst ranged from 14.2137-247 m² g⁻¹. Morphological test results showed that the catalyst SiO₂ extract of Sugar palm peel was composed of small, regular pores while the catalyst SiO₂ extract of Pineapple leaf was composed of globular blob, and the catalyst SiO₂ extract of Orange peel was composed of very heterogeneous-tight-porous structures. Based on the test results, it is known that the synthesis of heterogeneous catalysts from biomass waste meets the characteristics of standard silica catalysts.

Keyword: Pineapple leaf, Sugar palm peel, Orange peel, Silica (SiO₂), Diffractogram

1. Introduction

The manufacturing industry has recently been introduced to the concept of Industry 4.0 which is supported by very rapid technological advances [1]. In the industry, most processes (above 80%) involve catalysts [2]. The production of a compound generally uses a homogeneous catalyst and heterogeneous catalyst. The disadvantage of homogeneous catalysts is that they are difficult to separate from the resulting solution so that additional processes and costs are needed in the production stage [3]. Homogeneous catalysts can be replaced by heterogeneous catalysts which are more environmentally-friendly, stable at high temperatures, and have large pores [4]. However, the use of commercial heterogeneous catalysts is still dominated by commercial catalysts which has a

¹ Corresponding author's email: hheryani@ulm.ac.id, Tel. +65-11-4772254, Fax. +65-11-4772254

disadvantage, that is, their prices are quite expensive but they remain to be excellent in the industry [5].

In connection with the focus of the development of Science Technology and Innovation towards the Industrial era 4.0, local natural resources from renewable biomass is a search potential which interests researchers to reduce environmental degradation. Concerns about sustainable development have encouraged efforts to improve the efficiency of the utilization of raw resources and reduce the production of waste generated from the agribusiness sector of agriculture and agro-industry due to improper disposal [6, 7]. The source of biomass has the potential as new materials, namely the procurement of basic materials for making heterogeneous catalysts to replace commercial catalysts in meeting industrial needs. One of heterogeneous catalysts which have been developed includes amberlyst-15 [8], amberlyst-35 [9], natural zeolite [10], mesoporous silica, alumina [11], and the use of ion exchange resins [12].

In current developments, the natural potentials which can be considered as raw materials for heterogeneous catalysts are agricultural biomass wastes such as Sugar palm peel, Pineapple leaf and Orange peel whose existence is not utilized due to lack of knowledge and technology especially in rural areas, so they tend to be ignored. In this term, the reuse of waste will cause a significant reduction of the resulting waste so that the environmental impact is reduced. This research aimed to synthesize silica-based heterogeneous catalysts from the waste of Sugar palm peel, Pineapple leaf and Orange peel and tested the characterization of heterogeneous catalysts.

2. Experimental Procedure

2.1. Preparation

In this study, samples of Sugar palm peel waste were from the kolang kaling industry, Pineapple leaf waste in Tamban, Barito Kuala, and Orange peel waste from the market, juice drink sellers, and restaurants. The samples were dried under the sun for 7 days until the water content dropped to around 12-14%. Then the dried samples were mashed with a chopper until it passed the 40 mesh sieve before heated in a furnace for calcination at 800°C for 4 hours. Furthermore, the results of calcination were crushed and sieved to pass 100 mesh.

2.2. Catalyst extraction and synthesis

Each calcined sample was mixed into a 3M NaOH solution in a ratio of 1: 4 (w/v). The leaching process was done for 12 hours at a temperature of 90°C, then the separation between the filtrate and the residue was carried out. The filtrate was then added with 1M HCl little by little until a white precipitate formed and reached a neutral pH (6.5-7). The precipitate was then washed with distilled water and dried at 110°C for 6 hours to form serogel (dry silica gel). The Serogel was then mashed to obtain white silica powder and then calcined at 700°C for 3 hours to obtain silica crystals.

2.3. Characterization of catalyst synthesis

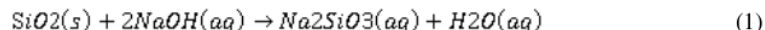
Characterization of heterogeneous catalyst synthesis included analysing the crystallographic structure of the catalyst based on amorphous or crystalline properties with X-ray Diffraction (XRD), analysing pore size of catalysts with Brunauer-Emmett-Teller (BET), and analysing the surface morphology of samples and particle size with Scanning Electron Microscopy-Energy Dispersive X-Ray Spectrometer (SEM-EDX).

3. Results and Discussion

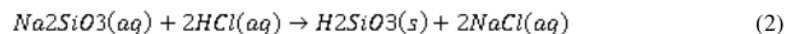
3.1. Silica extract yield

Based on the yield of silica extract (SiO₂), the figure obtained from Sugar palm peel was at 12.281%; Pineapple leaf was at 34.131%, and Orange peel was at 30.102% in Figure 1. This showed that the

extraction process with NaOH was able to penetrate the capillaries in the sample calcination of biomass waste and silica solubility where sodium silicate was formed, as in Equation (1).



Furthermore, the addition of HCl caused the exchange of Na^+ ions with H^+ to produce a gel-shaped solid which would separate silica particles bound to water molecules, namely silicic acid (H_2SiO_3) or silica hydrosol. In this process, the reaction which occurs was as in Equation (2).



This showed that the greater the concentration of NaOH in the extraction process was, the higher hydrogen yield obtained, and the greater the amount of raw material was, the greater the result was [13].

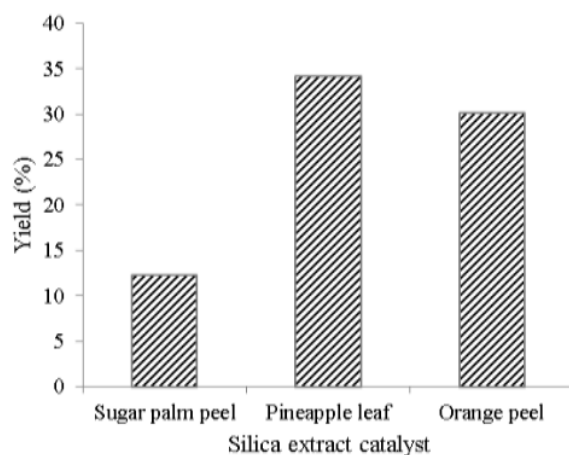


Figure 1. Silica extract yield from calcination results of biomass waste

3.2. Characterization of silica extract catalyst synthesis

Based on the results of diffractograms in the Joint Committee for Powder Diffraction Standards (JCPDS) No. 46-1045 in the International Center for Diffraction Data (ICDD) database, they showed that all silica catalyst synthesis had a crystalline phase having a characteristic peak of silicon oxide (SiO_2), presented in Table 1.

Table 1. The peak diffractogram of the synthesis of silica extract catalysts.

Silica extract source	Phase form	Peak diffractogram			Information
		2θ	2θ	2θ	
SiO_2 standard	Crystal	20.860°	26.640°	45.793°	JCPDS No. 46-2045
SiO_2 sugar palm peel extract	Crystal	20.673°	26.522°	45.250°	research
SiO_2 pineapple leaf extract	Crystal	21.397°	26.532°	45.660°	research
SiO_2 orange peel extract	Crystal	20.883°	25.917°	45.574°	research

Table 1 showed that the peak pattern of diffractogram of Sugar palm peel extract, Pineapple leaf extract and Orange peel extract in crystalline phase with a characteristic peak of silicon oxide (SiO_2) was in accordance with XRD standard silicon oxide structure (SiO_2) JCPDS card No. 46-1045 at $2\theta = 20.860^\circ$, $2\theta = 26.640^\circ$, and $2\theta = 45.793^\circ$. This showed that the synthesis of silica extract catalyst from

calcined biomass waste at 700°C formed the sharp and narrow peak position of diffractogram with a high enough intensity to include the crystalline silicon oxide (SiO_2) phase produced.

Furthermore, the pore size of the catalyst obtained from the adsorption isotherm described the type of adsorption of the solids produced. The pore size results of SiO_2 extract of Sugar palm peel, SiO_2 extract of Pineapple leaf and SiO_2 extract of Orange peel with the Brunauer Emmett Teller (BET) method could be seen in Figure 2.

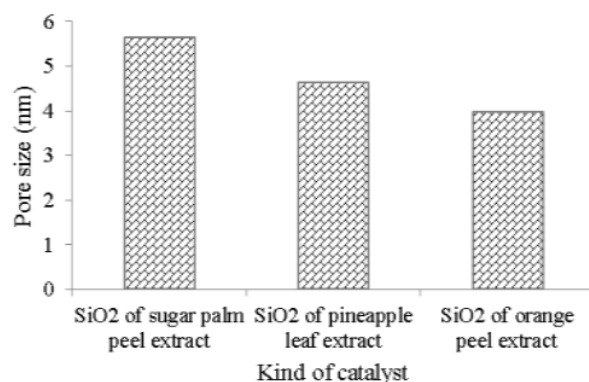


Figure 2. The catalyst pore size of the SiO_2 of Sugar palm peel extract, SiO_2 of Pineapple leaf extract and SiO_2 of Orange peel extract.

Figure 2 showed that the catalyst pore size of the SiO_2 of Sugar palm peel extract, SiO_2 of Pineapple leaf extract and SiO_2 of Orange peel extract ranged around 3.918-5.6512 nm. These results were in line with studies of mesoporous silica nanoparticles (SiO_2) catalysts which produced pore sizes ranging from 2.4 to 6.5 nm [14]. The catalyst pore size produced, including mesoporous, was below 50 nm, because the smaller the pore size, the better the selectivity to the product. This showed that the activation and calcination process at 700°C could change the size of the crystal pore, so there was evaporation of water in the crystalline pore of the catalyst SiO_2 of Sugar palm peel extract, SiO_2 of Pineapple leaf extract and SiO_2 of Orange peel extract.

While the surface area of the catalyst produced from the SiO_2 of Sugar palm peel extract, SiO_2 of Pineapple leaf extract and SiO_2 of Orange peel extract could be seen in Figure 3.

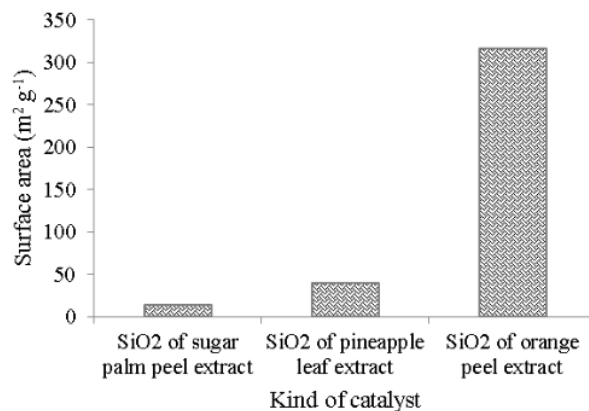


Figure 3. The catalyst surface area of the SiO_2 of Sugar palm peel extract, SiO_2 of Pineapple leaf extract and SiO_2 of Orange peel extract.

Figure 3 showed that the SiO_2 catalyst of Orange peel extract had a surface area of $247 \text{ m}^2 \text{ g}^{-1}$ greater than the surface area of the SiO_2 catalyst of Sugar palm peel extract $14.2137 \text{ m}^2 \text{ g}^{-1}$ and SiO_2 catalyst of Pineapple leaf extract with a surface area of $39.3118 \text{ m}^2 \text{ g}^{-1}$. This showed the catalyst produced from biomass waste had potential as a supporting catalyst in the production process. These results were in line with studies which examined the surface area of silica gel supports, ranging from 14.29 to $299.9 \text{ m}^2 \text{ g}^{-1}$ [15]. From the observations, the surface area of silica obtained in this study was comparable to studies which reported silica, alumina and aluminosilicate with modified conventional depositional treatment resulting in a surface area of $12\text{--}67 \text{ m}^2 \text{ g}^{-1}$ [16].

Furthermore, the morphology of the catalyst solids produced by the analysis of the Scanning Electron Microscopy (SEM) size of $10 \mu\text{m}$ could be seen in Figure 4. It showed that SiO_2 of Sugar palm peel extract which was composed of regular small pores was in line with research related to the characterization of Sugar palm peel [17]. The SiO_2 catalyst of Pineapple leaf extract was composed of globular blob was in line with research examining microporous activated carbon Pineapple leaf fiber [18] and SiO_2 catalyst of Orange peel extract composed of very heterogeneous tightly porous structure was in line with research related to the modification of Orange peel adsorbent [19].

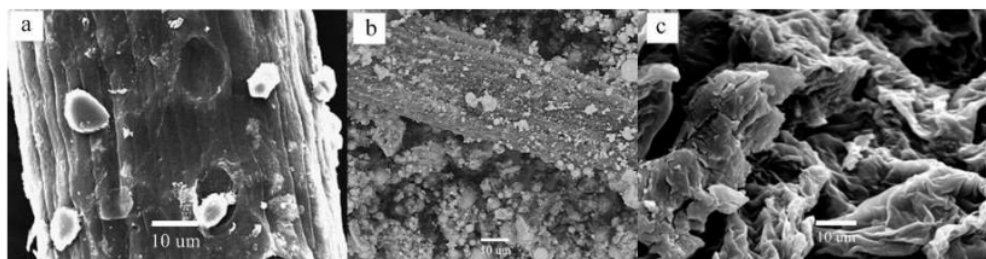


Figure 4. SEM morphology of catalyst solids (a) SiO_2 of Sugar palm peel extract, (b) SiO_2 of Pineapple leaf extract and (c) SiO_2 of Orange peel extract.

The morphological results of the catalyst solids with SEM supported the diffractogram data in the International Centre for Diffraction Data (ICDD) database that the SiO_2 catalyst of Sugar palm peel extract, SiO_2 catalyst of Pineapple leaf extract and SiO_2 catalyst of Orange peel extract had high crystallinity. This showed that the calcination temperature of 700°C for 4 hours created a complete hydrothermal process causing the SiO_2 catalyst of Sugar palm peel extract, the SiO_2 catalyst of Pineapple leaf extract and the SiO_2 catalyst of Orange peel extract to be more crystallized with an open pore shape so that the surface area increased. This was influenced by the fact that calcination temperature determined the characteristics of the peak, based on the diffractogram data and pore size, surface area and the catalyst solids morphology produced during the hydrothermal process [17]. From the catalyst characterization test, it was known that the catalyst extract obtained from Pineapple leaf waste, Sugar palm peel waste and Orange peel waste met commercial silica catalyst standards so that it could be applied to the bio-diesel industry such as fatty matter and crude glycerol in increasing added value.

4. Conclusion

The yield of silica (SiO_2) obtained from each Sugar palm peel is 12.281%; Pineapple leaf is 34.131%, and Orange peel is 30.102%. The diffractogram results show that all silica (SiO_2) catalyst synthesis has a crystalline phase having a characteristic peak of silicon oxide (SiO_2) with catalyst pore size ranging from 3.918 to 5.6512 nm and catalyst surface area ranging from 14.2137 to $247 \text{ m}^2 \text{ g}^{-1}$. The morphological results of the catalyst show that the SiO_2 catalyst of the Sugar palm peel extract is composed of small and regular pores. The SiO_2 catalyst of Pineapple leaf extract is composed of globular blob and the SiO_2 catalyst of Orange peel extract is composed of very heterogeneous tightly

porous structure. Based on the results of the characterization test, it shows that the synthesis of heterogeneous catalysts from biomass waste meets the characteristics of standard silica catalysts.

Reference

- [1] Hermann M T, Pentek and Otto B 2016 *Design Principles for Industrie 4.0 Scenarios* Proc. of the 2016 49th Hawaii international conference on system sciences (HICSS) January, 05-08, 2016 IEEE Computer Society Washintong DC, USA pp 3928-37
- [2] Bravo-Suárez J J, Chaudhari R V and Subramaniam B 2013 Design of heterogeneous catalysts for fuels and chemicals processing: an overview, in novel materials for catalysis and fuels processing *ACS Publication*. **1132** 3-68
- [3] San Kong P, Aroua M K, Daud W M A W, Lee H V, Cognet P and Pères Y 2016 *RSC Adv.* **6** 68885-905
- [4] Ayoub M and Abdullah A Z 2012 *Renew. Sustainable Energy Rev.* **16** 2671-86
- [5] Xie Z, Liu Z, Wang Y, Yang Q, Xu L and Ding W 2010 *Int. J. Mol. Sci.* **11** 2152-87
- [6] Mallesham B, Sudarsanam P and Reddy B M 2014 *Catal. Sci. Technol.* **4** 803-13
- [7] Iranmanesh M and Awang H 2015 *Adv. Environ. Biol.* **9** 117-9
- [8] Zhou L, Nguyen T-H and Adesina A A 2012 *Fuel Processing. Technol.* **104** 310-8
- [9] Liao X, Zhu Y, Wanga S G, Chen H and Li Y 2010 *Appl. Catal. B. Environ.* **94** 64-70.
- [10] Cahyono R B, Mufrodi Z, Hidayat A and Budiman A 2016 *ARPN. J. Eng. Appl. Sci.* **11** 5194-97
- [11] Rane S, Pudi S and Biswas P 2016 *Chem. Biochem. Eng. Quarterly.* **30** 33-45
- [12] Dosuna-Rodríguez I and Gaigneaux E M 2012 *Catal. Today.* **195** 14-21
- [13] Pinna E G, Suarez D.S, Rosales G D and Rodriguez M H 2017 *REM. Int. Eng J.* **70** 451-7
- [14] He Y, Li J, Long M, Liang S and Xu H 2017 *J. Non-Crystalline Solids.* **457** 9-12
- [15] Zhi K, Wang L, Zhang Y, Jiang Y, Zhang L and Yasin A 2018 *Mater.* **11** 1-16
- [16] Faramawy S, El-Naggar A, El-Fadly A, El-Sabagh S and Ibrahim A 2016 *Arabian. J. Chem.* **9** S765-S775
- [17] Ishak M, Sapuan S, Leman Z, Rahman M and Anwar U 2011 *J. Thermal. Anal. Calorimetry.* **109** 981-9
- [18] Mopoung S and Amornsakchai P 2016 *Asian. J. Sci. Res.* **9** 24-33
- [19] Salman T A and Ali M I 2016 *Iraqi. J. Sci.* **57** 1-13

Acknowledgement

The authors would like to thank University of Lambung Mangkurat for supporting the work.

Potentials of biomass waste sources for heterogeneous catalyst production

ORIGINALITY REPORT

15%

SIMILARITY INDEX

13%

INTERNET SOURCES

10%

PUBLICATIONS

9%

STUDENT PAPERS

PRIMARY SOURCES

1	ijtech.eng.ui.ac.id Internet Source	6%
2	Submitted to Udayana University Student Paper	5%
3	eprints.utm.my Internet Source	2%
4	L Musyarofah, D Puspita, E Hidayah, Sujito. "Tensile properties of coir and fleece fibers reinforced poly-lactic acid hybrid green composites", Journal of Physics: Conference Series, 2019 Publication	1%
5	M Al Muttaqii, M Amin, E Prasetyo, R Alviany, L Marlinda. " Production of biodiesel over ZnO-TiO bifunctional oxide catalyst supported on natural zeolite ", IOP Conference Series: Earth and Environmental Science, 2021 Publication	1%

6

Yusof, Yusri, Siti Asia Yahya, and Anbia Adam.
"Novel Technology for Sustainable Pineapple
Leaf Fibers Productions", Procedia CIRP, 2015.

Publication

1 %

Exclude quotes On

Exclude matches < 1%

Exclude bibliography On