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#6323 Review

[SUMMARY](#) [REVIEW](#) [EDITING](#)

Submission

Authors Siti Jamilatun, Yeni Elisthatiana, Siti Nurhalizatul Aini, Ilham Mufandi, Arief Budiman

Title Effect of Temperature on Yield Product and Characteristics of Bio-oil From Pyrolysis of Spirulina platensis Residue

Section Articles

Editor Muhammad Ridwan Harahap

Peer Review

Round 1

Review Version 6323-14429-2-RV.DOCX 2020-02-17

Initiated 2020-02-17

Last modified 2020-07-07

Uploaded file Reviewer B 6323-15610-1-RV.DOCX 2020-04-02

Editor Decision

Decision Accept Submission 2020-04-20

Notify Editor Editor/Author Email Record 2020-04-16

Editor Version 6323-14684-1-ED.DOCX 2020-02-17
6323-14684-2-ED.DOCX 2020-04-16

Author Version 6323-15656-1-ED.DOCX 2020-04-04 [DELETE](#)
6323-15656-2-ED.DOCX 2020-04-20 [DELETE](#)
6323-15656-3-ED.DOCX 2020-06-23 [DELETE](#)

Upload Author Version No file chosen

P-ISSN : 2460-8912
E-ISSN : 2460-8920

ELKAWNIE



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sitiJamilatun

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AUTHOR

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- ▶Active (0)
- ▶Archive (3)
- ▶New Submission



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LAMPIRAN 1. SUBMIT

The screenshot shows a web browser window displaying the ELKAWNIE journal submission review interface. The browser's address bar shows the URL: jurnal.ar-raniry.ac.id/index.php/elkawnie/author/submissionReview/6323. The page header includes the journal logo, ISSN numbers (P-ISSN: 2460-8912, E-ISSN: 2460-8920), and accreditation information from Kemenristek - DIKTI.

The navigation menu includes: HOME, ABOUT, USER HOME, SEARCH, CURRENT, ARCHIVES, ANNOUNCEMENTS, EDITORIAL TEAM, and EDITORIAL POLICIES. A left sidebar contains various links such as REGISTER, PUBLICATION ETHICS, OPEN ACCESS POLICY, PEER-REVIEW, REVIEWERS, FORM OF STATEMENT, JOURNAL STATISTICS, MANUSCRIPT STATISTICS, and AUTHOR FEE.

The main content area displays the submission details for article #6323. The breadcrumb trail is: Home > User > Author > Submissions > #6323 > Review. The article title is "Effect of Temperature on Yield Product and Characteristics of Bio-oil From Pyrolysis of Spirulina platensis Residue". The authors listed are Siti Jamilaton, Yeni Elisthatiana, Siti Nurhalizatul Aini, Ilham Mufandi, and Arief Budiman. The editor is Muhammad Ridwan Harahap.

The "Peer Review" section shows a "Round 1" review process with the following details:

Review Version	6323-14420-2-RV.DOCX	2020-02-17
Initiated	2020-02-17	
Last modified	2020-07-07	
Uploaded file	Reviewer B 6323-15610-1-RV.DOCX	2020-04-02

The "Editor Decision" section shows the following actions:

Action	Date
Accept Submission	2020-04-20
Notify Editor	Editor/Author Email Record 2020-04-16
Editor Version	6323-14684-1-ED.DOCX 2020-02-17 6323-14684-2-ED.DOCX 2020-04-16
Author Version	6323-15656-1-ED.DOCX 2020-04-04 6323-15656-2-ED.DOCX 2020-04-20 6323-15656-3-ED.DOCX 2020-06-23

The "Upload Author Version" section includes a "Choose File" button, the text "No file chosen", and an "Upload" button.

The right sidebar contains a "USER" section with login information for "sitijamilaton" and links for "My Journals", "My Profile", and "Log Out". Below this is an "AUTHOR" section with links for "Submissions", "Active (0)", "Archive (3)", and "New Submission". The sidebar also features logos for Scopus, Mendeley, Turnitin, Grammarly, Sinta, EBSCO, and Google.

The bottom of the page shows a Windows taskbar with several open applications, including "LapDetailRealisasiA...xls", "LapRekapProgram (...xls)", "LapRekapAnggaran...xls", and "LapRekapUsulanPr...xls". The system tray displays the date and time as 10:38 on 06/07/2022, along with weather information (30°C Hujan ringan).

LAMPIRAN 2. REGISTRASI

The screenshot displays a Gmail interface with the following elements:

- Browser Tabs:** [EKW] Journal Registration - sitiji, (280) WhatsApp, Sistem Informasi Manajemen PA, ASEAN Journal of Chemical Engin, Edit item: Non-catalytic and Cata, #6323 Review.
- Address Bar:** mail.google.com/mail/u/0/#search/elkawnie/FMfcgwxGDDmJIHGdVQpVfMFZxncvXvbX
- Gmail Header:** Search for 'elkawnie', 'Aktif' status, and user profile 'UNIVERSITAS AHMAD DAHLAN'.
- Left Sidebar:** Navigation menu including 'Email' (Kotak Masuk: 9,569, Berbintang, Ditunda, Penting, Terkirim, Draf: 198, Kategori, Unwanted) and 'Chat' (Rachma Tia Evitasari, maryudi maryudi, Melia Dian, Heni Anggorowati, Shinta Amelia, Aous Aktawan).
- Right Sidebar:** 'Ruang' (Meeting Prodi Teknik Ki...) and 'Rapat'.
- Selected Email 1:**
 - From:** Hendri Ahmadian <jurnal@ar-raniry.ac.id>
 - To:** Siti Jamilatun
 - Date:** 2 Feb 2020 17.49
 - Subject:** [EKW] Journal Registration
 - Body:** You have now been registered as a user with Elkawnie. We have included your username and password in this email, which are needed for all work with this journal through its website. At any point, you can ask to be removed from the journal's list of users by contacting me.
Username: sitijamilatun
Password: 60960133
Thank you,
Hendri Ahmadian
<http://jurnal.ar-raniry.ac.id/index.php/elkawnie>
- Selected Email 2:**
 - From:** Siti Jamilatun <sitijamilatun@che.uad.ac.id>
 - To:** Hendri
 - Date:** 5 Feb 2020 11.42
 - Subject:** EDITOR IN CHIEF
 - Body:** Please give me information, I did not find the facility to submit online ELKAWNIE Journl.
Thankyou
Regard
Siti Jamilatun

The Windows taskbar at the bottom shows the search bar, taskbar icons for various applications (including Excel, Word, and a browser), and system tray information: 30°C Hujan ringan, 10:45, 06/07/2022.

LAMPIRAN 3. SUBMISSION ACKNOLEGMENT

The screenshot shows a Gmail interface on a Windows desktop. The browser tabs include '[EKW] Submission Acknowledgement', '(280) WhatsApp', 'Sistem Informasi Manajemen PA...', 'ASEAN Journal of Chemical Engin...', 'Edit item: Non-catalytic and Cata...', and '#6323 Review'. The Gmail search bar contains 'elkawnie'. The email list on the left shows 'Email' with categories like 'Kotak Masuk' (9,569), 'Ditunda', 'Penting', 'Terkirim', 'Draf' (198), and 'Kategori'. Under 'Chat', several contacts are listed, including Rachma Tia Evitasari, maryudi maryudi, Melia Dian, Heni Anggorowati, Shinta Amelia, and Aous Aktawan. Under 'Ruang', there is a meeting titled 'Meeting Prodi Teknik Ki...'. The main email is from 'Hendri Ahmadian <jurnal@ar-raniry.ac.id>' to 'siti.jamilatun' on 'Kam, 6 Feb 2020 20.38'. The subject is '[EKW] Submission Acknowledgement (do not reply to this email)'. The body text reads: 'Thank you for submitting the manuscript, "PENGARUH SUHU TERHADAP YIELD PRODUK DAN KARAKTERISTIK BIO-OIL PADA PIROLISIS spirulina platensis RESIDUE" to Elkawnie. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site: Manuscript URL: <https://jurnal.ar-raniry.ac.id/index.php/elkawnie/author/submission/6323> Username: sitijamilatun If you have any questions, please contact me. Thank you for considering this journal as a venue for your work. Hendri Ahmadian Elkawnie This is an automated message. Please do not reply to this email. Elkawnie <http://jurnal.ar-raniry.ac.id/index.php/elkawnie>'. At the bottom of the email, there are three buttons: 'Noted with thanks.', 'Thank you for your response.', and 'Received with thanks.'. The Windows taskbar at the bottom shows several open Excel files ('LapDetailRealisasiA...xls', 'LapRekapProgram (...).xls'), 'LapRekapAnggaran...xls', and 'LapRekapUsulanPr...xls'. The system tray shows '30°C Hujan ringan', '10:47', and '06/07/2022'.

LAMPIRAN 4. EDITOR DECISION

The screenshot shows a Gmail interface on a Windows desktop. The browser tabs include '[EKW] Editor Decision (do not reply to this email)', '(280) WhatsApp', 'Sistem Informasi Manajemen PAI', 'ASEAN Journal of Chemical Engi...', 'Edit item: Non-catalytic and Cata...', and '#6323 Review'. The Gmail search bar contains 'elkawnie'. The left sidebar shows the 'Email' section with folders like 'Kotak Masuk' (9,569), 'Berbintang', 'Ditunda', 'Penting', 'Terkirim', 'Draf' (198), 'Kategori', and 'Unwanted'. The 'Chat' section lists contacts like Rachma Tia Evitasari, maryudi maryudi, Melia Dian, Heni Anggorowati, Shinta Amelia, and Aous Aktawan. The 'Ruang' section shows a meeting titled 'Meeting Prodi Teknik Ki...'. The main email content is from Muhammad Ridwan Harahap (journal@ar-raniry.ac.id) to 'saya, Yeni, Siti, Ilham, Arief'. The subject is '[EKW] Editor Decision (do not reply to this email)'. The body text states: 'We have reached a decision regarding your submission to Elkawnie, "PENGARUH SUHU TERHADAP YIELD PRODUK DAN KARAKTERISTIK BIO-OIL PADA PIROLISIS spirulina platensis RESIDUE". Our decision is to: Revision Required. Muhammad Ridwan Harahap, Department of Chemistry, Faculty of Science and Technology, State Islamic University of Ar-Raniry, Banda Aceh, Indonesia. This is an automated message. Please do not reply to this email.' A link to the journal website is provided: <http://jurnal.ar-raniry.ac.id/index.php/elkawnie>. The bottom of the screen shows the Windows taskbar with several open Excel files and a system tray displaying '30°C Hujan ringan' and the date '06/07/2022'.

LAMPIRAN 5. COPYEDITING REVIEW REQUEST

The screenshot displays a Gmail inbox on a desktop browser. The email being viewed is titled "[EKW] Copyediting Review Request (do not reply to this email)" and is from Muhammad Ridwan Harahap (journal@ar-raniry.ac.id), sent on April 20, 2020, at 22:01. The email content includes a list of instructions for the reviewer, a submission URL, and a note about the proofreading stage.

[EKW] Copyediting Review Request (do not reply to this email) Kotak Masuk

Muhammad Ridwan Harahap <jurnal@ar-raniry.ac.id>
kepada saya

Siti JAMILATUN:

Your submission "PENGARUH SUHU TERHADAP YIELD PRODUK DAN KARAKTERISTIK BIO-OIL PADA PIROLISISIS spirulina platensis RESIDUE" for **Elkawnie** has been through the first step of copyediting, and is available for you to review by following these steps.

1. Click on the Submission URL below.
2. Log into the journal and click on the File that appears in Step 1.
3. Open the downloaded submission.
4. Review the text, including copyediting proposals and Author Queries.
5. Make any copyediting changes that would further improve the text.
6. When completed, upload the file in Step 2.
7. Click on METADATA to check indexing information for completeness and accuracy.
8. Send the COMPLETE email to the editor and copyeditor.

Submission URL:
<https://jurnal.ar-raniry.ac.id/index.php/elkawnie/author/submissionEditing/6323>
Username: sitijamilatun

This is the last opportunity to make substantial copyediting changes to the submission. The proofreading stage, that follows the preparation of the galleys, is restricted to correcting typographical and layout errors.

If you are unable to undertake this work at this time or have any questions, please contact me. Thank you for your contribution to this journal.

Muhammad Ridwan Harahap
Department of Chemistry, Faculty of Science and Technology, State Islamic University of Ar-Raniry, Banda Aceh, Indonesia

The interface also shows a sidebar with folders like "Kotak Masuk" (9,569), "Draf" (198), and "Chat". The Windows taskbar at the bottom shows the date as 06/07/2022 and the time as 10:52.

LAMPIRAN 6. BIAYA PUBLIKASI

The screenshot shows a Gmail interface with a search bar containing 'elkawnie'. The left sidebar lists folders like 'Kotak Masuk' (9,569), 'Berbintang', 'Ditunda', 'Penting', 'Ter kirim', 'Draf' (198), 'Kategori', 'Unwanted' (1), 'Chat', 'Ruang', and 'Rapat'. The main content area displays an email from Hendri Ahmadian (journal@ar-raniry.ac.id) to Siti Jamilatun (sitijamilatun@che.uad.ac.id) dated Saturday, June 9, 2020, at 11:17. The email subject is '[EKW] Biaya Publikasi' and is marked as 'Kotak Masuk'. The body of the email reads: 'Assalamualaikum Wr.Wb Bapak/Ibu penulis yang terhormat, berhubung akan terbitnya Jurnal **Elkawnie** Edisi Vol. 6 No. 1 Juni 2020 pada 30 Juni 2020 maka kami mengingatkan kembali kepada Ibu untuk melakukan konfirmasi biaya publikasi yang dibebankan kepada penulis. Dengan biaya publikasi bahasa Inggris Rp. 1.000.000,- dan bahasa Indonesia Rp. 1.500.000,- Semua artikel dipublikasikan dalam bahasa Inggris. Biaya publikasi dapat dibayarkan melalui No. Rek: 2019100115 Bank BNI Syariah atas nama Hendri Ahmadian (WA : 082370742500) Atas kerjasama yang baik, kami ucapkan terima kasih. Ttd Redaksi **Elkawnie** : Journal Islamic Science and Technology' followed by a link to the journal's website. A second email from Siti Jamilatun is partially visible below, dated Saturday, June 9, 2020, at 12:01, with the text: 'Waalikumsalam wr.wb. Berikut saya kirimkan bukti transfer sebesar Rp. 1.000.000,- untuk paper bahasa Inggris. Atas kerjasamanya saya ucapkan terimakasih. Salam Siti Jamilatun'. The Windows taskbar at the bottom shows the system tray with a temperature of 30°C, weather 'Hujan ringan', and date '06/07/2022'. The taskbar also displays several open Excel files related to 'LapRekapProgram' and 'LapRekapAnggaran'.

LAMPIRAN 6. COPYEDITING

The screenshot shows a Gmail interface on a Windows desktop. The browser tabs include '[EKW] Copyediting Review Ackn...', '(280) WhatsApp', 'Sistem Informasi Manajemen PA...', 'ASEAN Journal of Chemical Engi...', 'Edit item: Non-catalytic and Cat...', and '#6323 Review'. The Gmail search bar contains 'elkawnie'. The left sidebar shows folders: Email (9,569), Chat (+), and Ruang (+). The main content area displays an email from Muhammad Ridwan Harahap (journal@ar-raniry.ac.id) dated 'Sel, 23 Jun 2020 13.39'. The email subject is '[EKW] Copyediting Review Acknowledgement (do not reply to this email)'. The body text reads: 'Siti Jاملاتون: Thank you for reviewing the copyediting of your manuscript, "PENGARUH SUHU TERHADAP YIELD PRODUK DAN KARAKTERISTIK BIO-OIL PADA PIROLISIS spirulina platensis RESIDUE," for [Elkawnie](#). We look forward to publishing this work. Muhammad Ridwan Harahap, Department of Chemistry, Faculty of Science and Technology, State Islamic University of Ar-Raniry, Banda Aceh, Indonesia. ridwankimia@ar-raniry.ac.id. This is an automated message. Please do not reply to this email. <http://jurnal.ar-raniry.ac.id/index.php/elkawnie>'. Below the email are 'Balas' and 'Teruskan' buttons. The taskbar at the bottom shows several open Excel files and a search bar.

LAMPIRAN 8. PROOFREADING

The screenshot shows a Gmail interface with a search bar containing "elkawnie". The email list on the left includes "Kotak Masuk" (9,569), "Berbintang", "Ditunda", "Penting", "Terkirim", "Draf" (198), "Kategori", "Unwanted" (1), "Chat" (+), "Ruang" (+), and "Rapat". The selected email is titled "[EKW] Proofreading Request (Author) (do not reply to this email)".

[EKW] Proofreading Request (Author) (do not reply to this email) Kotak Masuk

Muhammad Ridwan Harahap <jurnal@ar-raniry.ac.id> Kam, 25 Jun 2020 22.24

kepada saya

Siti Jamilatun:

Your submission "PENGARUH SUHU TERHADAP YIELD PRODUK DAN KARAKTERISTIK BIO-OIL PADA PIROLISIS spirulina platensis RESIDUE" to **Elkawnie** now needs to be proofread by following these steps.

1. Click on the Submission URL below.
2. Log into the journal and view PROOFING INSTRUCTIONS
3. Click on VIEW PROOF in Layout and proof the galley in the one or more formats used.
4. Enter corrections (typographical and format) in Proofreading Corrections.
5. Save and email corrections to Layout Editor and Proofreader.
6. Send the COMPLETE email to the editor.

Submission URL:
<https://jurnal.ar-raniry.ac.id/index.php/elkawnie/author/submissionEditing/6323>
Username: sitijamilatun

Muhammad Ridwan Harahap
Department of Chemistry, Faculty of Science and Technology, State Islamic University of Ar-Raniry, Banda Aceh, Indonesia
ridwankimia@ar-raniry.ac.id

This is an automated message. Please do not reply to this email.

Elkawnie
<http://jurnal.ar-raniry.ac.id/index.php/elkawnie>

Received, thank you. Done. Noted with thanks.

Taskbar: 6323-15656-2-ED.docx, LapDetailRealisasiA..., LapRekapProgram (...).xls, LapRekapProgram (...).xls, LapRekapProgram (...).xls, LapRekapAnggaran(...).xls, LapRekapAnggaran(...).xls, Show all

System tray: 30°C Hujan ringan, 10:58, 06/07/2022

LAMPIRAN 9. PROOFREADING ACKNOLEDMENT

The screenshot shows a Gmail interface with a search bar containing 'elkawnie'. The email list on the left includes 'Kotak Masuk' (9,569), 'Berbintang', 'Ditunda', 'Penting', 'Terkirim', 'Draf' (198), 'Kategori', 'Unwanted' (1), 'Chat', and 'Ruang'. The selected email is from Muhammad Ridwan Harahap (journal@ar-raniry.ac.id) dated June 26, 2020, at 14:28. The email content is as follows:

[EKW] Proofreading Acknowledgement (Author) (do not reply to this email) Kotak Masuk

Muhammad Ridwan Harahap <journal@ar-raniry.ac.id> kepada saya

Siti Jamlatun:

Thank you for proofreading the galley for your manuscript, "PENGARUH SUHU TERHADAP YIELD PRODUK DAN KARAKTERISTIK BIO-OIL PADA PIROLISIS spirulina platensis RESIDUE," in **Elkawnie**. We are looking forward to publishing your work shortly.

If you subscribe to our notification service, you will receive an email of the Table of Contents as soon as it is published. If you have any questions, please contact me.

Muhammad Ridwan Harahap
Department of Chemistry, Faculty of Science and Technology, State Islamic University of Ar-Raniry, Banda Aceh, Indonesia
ridwankimia@ar-raniry.ac.id

This is an automated message. Please do not reply to this email.

Elkawnie
<http://jurnal.ar-raniry.ac.id/index.php/elkawnie>

At the bottom of the screenshot, the Windows taskbar is visible, showing the search bar, taskbar icons, and system tray with a temperature of 31°C and date 06/07/2022.

**EFFECT OF TEMPERATURE ON YIELD PRODUCT
AND CHARACTERISTICS OF BIO-OIL FROM PYROLYSIS OF
Spirulina platensis RESIDUE**

Siti Jamilatun*, **Yeni Elisthatiana****, **Siti Nurhalizatul Aini*****, **Ilham Mufandi******,
Arif Budiman*****

**Departement of Chemical Engineering, Universitas Ahmad Dahlan, Yogyakarta, Indonesia,*
sitijamilatun@che.uad.ac.id

***Departement of Chemical Engineering, Universitas Ahmad Dahlan, Yogyakarta, Indonesia,*
e832yeniel@gmail.com

****Departement of Chemical Engineering, Universitas Ahmad Dahlan, Yogyakarta, Indonesia,*
halizatulaini12@gmail.com

*****Department of Mechanical Engineering, Faculty of Engineering, Khon Kaen University, Thailand,*
ilhammufandi@kkumail.com

******Department of Chemical Engineering, Gadjah Mada University, Yogyakarta, Indonesia,*
abudiman@ugm.ac.id

Email Correspondence: sitijamilatun@che.uad.ac.id

Received: February 6, 2020 Accepted: April 20, 2020 Published: June 30, 2020

Abstract : Dependence on the use of fossil fuels in Indonesia is still quite high, especially crude oil; if no new energy reserves found, it will disrupt long-term energy availability. Biofuel is a renewable energy source derived from biomass, such as the type of microalgae *spirulina platensis* (SP). Solid residues from SP extraction still contained high levels of protein and carbohydrates. This solid residue can be processed by pyrolysis to produce bio-oil, water phase, charcoal, and gas. Bio-oil and gas products can use as fuel, charcoal can use for pharmaceutical needs, and the water phase as a chemical can use in food and health. The pyrolysis process carried out in a fixed-bed reactor with temperature ranging from 300-600°C. Heating was carried out by electricity through a nickel wire wrapped outside the reactor. Pyrolysis product in the form of gas condensed in the condenser, the condensate formed measured by weight. Char weight measured after the pyrolysis process completed. At the same time, non-condensable gas calculated by gravity from the initial weight difference of SPR minus liquid weight (bio-oil and water phase) and char. SPR samples were analyzed proximate and ultimate, while bio-oil products examined by the GC-MS method. The experimental results showed that the optimum pyrolysis temperature at 500°C produced by 18.45% of bio-oil, 20% of the water phase, 32.02 of charcoal, and 29.54% of gas by weight. GC-MS results from bio-oil consisted of ketones, aliphatics, nitrogen, alcohol, acids, while PAHs, phenols, and aromatics not found.

Keywords : Bio-oil, Pyrolysis, *Spirulina platensis*

Abstrak : Ketergantungan penggunaan bahan bakar fosil di Indonesia masih cukup tinggi terutama minyak mentah, jika tidak ditemukan cadangan energi baru maka akan mengganggu ketersediaan energi jangka panjang. Biofuel adalah salah satu sumber energi terbarukan yang berasal dari biomassa seperti jenis mikroalga *spirulina platensis* (SP). Residu padat dari ekstraksi SP masih mengandung protein dan karbohidrat yang cukup tinggi. Residu padat ini dapat diproses dengan pirolisis untuk menghasilkan bio-minyak, fase air, arang, dan gas. Produk bio-minyak dan gas dapat digunakan untuk

bahan bakar, arang dapat digunakan untuk kebutuhan farmasi, dan fase air sebagai bahan kimia dapat digunakan di bidang makanan dan kesehatan. Proses pirolisis dilakukan dalam reaktor fixed-bed dengan suhu 300-600°C. Pemanasan dilakukan dengan listrik melalui kawat nikel yang dibungkus di luar reaktor. Produk pirolisis berupa gas dikondensasi dalam kondensor, kondensat yang terbentuk diukur beratnya. Berat char diukur setelah proses pirolisis selesai, sementara gas yang tidak dapat dikondensasi dihitung beratnya dari perbedaan bobot awal SPR dikurangi bobot cair (bio-oil dan fase air) dan char. Sampel SPR dianalisis proksimat dan ultimat, sedangkan produk bio-minyak dianalisis dengan metode GC-MS. Hasil percobaan menunjukkan bahwa suhu optimum pirolisis adalah 500°C yang menghasilkan bio-oil, *water phase*, arang, dan gas berturut-turut adalah 18,45; 20; 32,02 dan 29,54 % berat. Hasil GC-MS dari bio-oil terdiri dari keton, alifatik, nitrogen, alkohol dan asam, sedangkan PAH, fenol dan tidak ditemukan.

Kata kunci : Bio-oil, Pirolisis, *Spirulina platensis*

Introduction

Indonesia is the most significant energy consumption in Southeast Asia and ranks fifth in Pacific Asia after China, India, Japan, and South Korea. The final energy consumption in Indonesia in 2016 was dominated by fuel oil (BBM) around 47%. Based on the sector area, the transportation sector has the most significant consumption of around 42%. It was more than that the industrial sector around 36%. The energy consumption of the transportation sector almost entirely fulfilled by fossil fuel (BPPT-OEI, 2018).

The Increasing fossil energy needs will disrupt energy source, so it is necessary to get renewable energy in the form of biofuel from biomass (BPPT-OEI, 2018). Biomass is a renewable energy source abundant throughout the world that can produce heat and power as planned and can neutralize CO₂ (Bridgwater *et al.*, 1999). The types of biomass consist of wood, herbal plant, agricultural waste, aquatic, animal waste, and household waste (Jamilatun and Salamah, 2014; Vassilev *et al.*, 2010).

The advantages of biofuel from biomass are (i) available abundant and stables raw material from biomass, low sulfur, potential green energy source (Choi *et al.*, 2020; Jamilatun *et al.*, 2017). Biomass processing can be done in two ways: Biochemical (anaerobic digestion and fermentation) and Thermochemical (direct combustion, gasification, pyrolysis, and liquefaction). In general, the thermochemical conversion is faster than biological methods, and the process is relatively more straightforward (Basu, 2010). Pyrolysis is the Thermochemical conversion to convert biomass into non-condensable gas (CO₂, CO, H₂, and CH₄), condensable-gas (*water phase* dan bio-oil), and char product at a temperature around 300-600°C in the absence of oxygen. (Jamilatun *et al.*, 2010; Jamilatun *et al.*, 2014). According (Gronli, 1996) bio-oil has dark brown and has a heating value about half of the conventional fuel oil.

Currently, the conversion of renewable energy from biomass with the pyrolysis method is highly unusual to develop into bio-fuel. (Suttibak, 2012) has

reported that the biomass from cassava waster into bio-fuel. The development of renewable energy from sugarcane has investigated by (Treedet and Suntivarakorn, 2011; Mufandi *et al.*, 2020). Biomass from Napier grass also has experimented with (Treedet and Suntivarakorn, 2018; Mufandi *et al.*, 2019). However, there is one type of biomass that needs to be developed by researchers, namely biomass from microalgae as one of the alternative fuel oil sources in the future. The development of microalgae as a renewable energy source is urgent to research because microalgae have many advantages compared to other energy sources such as high growth rate, not competing with a food source, and without requiring large areas to grow (Gultom *et al.*, 2014).

One of the benefits of microalgae is to produce more oil about 136.900 L/hectare for microalgae of 70% in biomass. Its value is equivalent to 74 times more than *Jatropha* oil and 23 times more than palm oil. Besides, microalgae planting land not require extensive area. In America, around 50% of all transportation fuel required 2 Ha of microalgae land, 140 Ha of *jatropha* land, and 45 Ha of palm oil land (Scheck *et al.*, 2008). The comparison of oil yield and area needed in each type of biomass that can see in table 1.

Table 1. The comparison of oil yield and area for each kind of biomass (Scheck *et al.*, 2008).

Plant	Oil Yield (L/Ha)	Area needed (Ha) ^a	%Area of land harvest in AS
Corn	172	1540	846
Soybean	446	594	326
Canola	1190	223	122
<i>Jatropha</i>	1892	140	77
Coconut	2689	99	54
Plam	5950	45	24
Microalgae	136.900	2	1.1
Microalgae	58.700	4.5	2.5

To fulfill 50% for all transportation fuel in AS.

^b70% oil (by wt) in biomass.

^c30% oil (by wt) in biomass.

According to (Chen *et al.*, 2018; Miao *et al.*, 2004), the bio-oil from microalgae has high heat about 1.4 times of biomass from wood, low viscosity, and low density. The biomass from microalgae is more satisfying as fuel than lignocellulosic material.

The composition of the bio-oil varies according to process conditions and raw material. The bio-oil content consists of water of 15-35 wt.% and hundreds of compounds. The bio-oil compounds as follows nitrogen (amides, amines, pyrroles, indole, pyridine, and its derivatives), oxygenated compounds (acid, alcohol, ketone, aldehyde, phenol, ether, ester, sugar, furan) and hydrocarbons (alkenes, benzene, toluene dan xylene) and solid particles (Hu *and* Gholizadeh, 2019; Yang

et al., 2019). Water content in bio-oil depends on the water content in the raw material of biomass.

Bio-oil from the pyrolysis of microalgae and biomass with high protein content is generally more stable, higher High Heating Value (HHV), and lower Oxygen content (O) than bio-oil from lignocellulose. Hydrocarbon linear in the bio-oil content has produced from pyrolysis lipid, aromatic hydrocarbon obtained from protein pyrolysis, and glucose obtained from carbohydrate pyrolysis (Hu *et al.*, 2013; Kan *et al.*, 2016). The composition of bio-oil included carbohydrate derivatives, protein, and lipids. Every type of microalgae has different structures, two kinds of compounds, and weight percent. The application of the use of bio-oil consists of fuel, electric generation for the factory, chemical material for various chemical industry needs (Jamilatun and Salamah, 2015; Jamilatun *et al.*, 2016; Jamilatun and Salamah, 2017; Jamilatun *et al.*, 2019).

From the above explanation, the biomass from microalgae is highly potential to convert into renewable fuels. In this experiment, the biomass from microalgae was conducted in the pyrolysis process in a fixed-bed reactor with temperature ranging from 300 to 600°C. The pyrolysis process in this experiment has produced gas, liquid (water phase and bio-oil), and char. The bio-oil product was tested by GC-MS to identify the bio-oil compound such as oxygenated, nitrogenated, aliphatic, aromatic, monocyclic aromatic hydrocarbon (MAH), and polycyclic aromatic hydrocarbon (PAH).

Experimental Materials, Devices, and Methods

Materials

Dry *Spirulina platensis* residue (SPR) used in this experiment, it was obtained from *Spirulina platensis* (SP) solid residue extraction. SPR was dried under the sun to reduce the water content. SPR samples were analyzed to obtain ultimate, proximate, and High Heating Value (HHV) that can see in table 2. The analysis of SPR samples conducted at the Food and Agriculture Product Laboratory, Department of Agriculture Technology, UGM.

Devices

Dry *Spirulina platensis* residue (SPR) was pyrolyzed in the fixed bed reactor with an inner diameter of 40 mm, an outer diameter of 44 mm, and a height of 600 mm. The reactor made from stainless steel equipped with heater in the around of reactor (Jamilatun *et al.*, 2017; Jamilatun *et al.*, 2019). The detail of the pyrolysis system shown in figure 1.

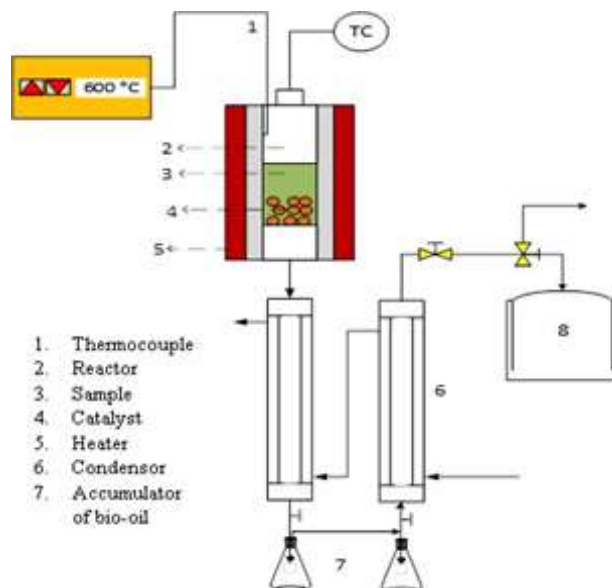


Figure 1. The SPR pyrolysis equipment (Jamilatun *et al.*, 2019)

Methods

Fifty grams of SPR was fed, tightly closed, and heated. SPR samples heated in the fixed bed reactor with a constant heating rate from room temperature to the desired temperature (300, 400, 500, 550, 600 °C). Then the temperature was held constant. The temperature-controlled by the thermocouple placed inside of the reactor. The hot gas was condensed. The liquid product comes out and collected in the accumulator. The gas product obtained in the storage gas. After the experiment finished, the solid product/char was taken and weighed. The yield of bio-oil, gas, and char calculated by equation (Jamilatun *et al.*, 2017):

$$Y_L = (W_L/W_M) \times 100 \% ; Y_{Ai} = (W_{Ai}/W_M) \times 100 \% \dots (1)$$

$$Y_A = (W_A/W_M) \times 100 \% = Y_L - Y_{Ai} \dots (2)$$

$$Y_C = (W_C/W_M) \times 100 \% ; Y_G = 1 - (Y_L + Y_C) \dots (3)$$

In this case, Y_L is liquid product yield; W_L is the weight of the liquid product, W_M is sample weight, Y_A is water phase yield, W_A is the weight of the water phase, Y_{Ai} is bio-oil yield, W_{Ai} is the weight of bio-oil, Y_C is char yield, Y_G is gas product yield. GC-MS analyzed Bio-oil properties.

Results and Discussions

Spirulina Platensis Residue (SPR) Characteristic

Proximate analysis, ultimate analysis, HHV were used to know the SPR characteristic. It can display in table 2.

Table 2. *Spirulina platensis* residue (SPR) characteristic (Jamilatun *et al.*, 2017)

Component	SPR
<i>Composition analysis (wt.%)</i>	
<i>Lipid</i>	0,09
<i>Carbohydrate</i>	38,51
<i>Protein</i>	49,60
<i>Ultimate analysis (wt.%)</i>	
<i>Sulfur</i>	0,55
<i>Carbon</i>	41,36
<i>Hydrogen</i>	6,60
<i>Nitrogen</i>	7,17
<i>Oxygen</i>	35,33
<i>Higher heating value (MJ/kg)</i>	18,21

From table 2 it shows the proximate and ultimate analysis, the results have shown that the SPR properties were 49.6 wt.% of protein, 38.51 wt.% of carbohydrate, and 0.09 wt.% of lipid. In the utilization of microalgae residue, this analysis conducted to measure that the SPR samples have shallow lipid content. (Jamilatun *et al.*, 2017; Jamilatun *et al.*, 2019).

The Influence of Temperature on Bio-oil Yield

The impact of temperature on bio-oil yield shown in figure 2. From these figures, and it shows that the maximum of bio-oil yield at an optimum temperature of 500°C was 18.45 wt.%. This experiment found that the bio-oil yield was increased from 4.61 wt.% to 18.45 wt.% when the temperature is ranging from 300 to 500°C. While the temperature was decreased from 18.45 wt.% to 16.14 wt.% at the temperature under 500°C. The decrease of bio-oil yield was affected by secondary cracking occurs in tar (bio-oil and water phase). Secondary cracking is tar decomposition into gas and char. So it can be said that based on the highest amount of bio-oil, the temperature of 500°C is the optimum temperature for pyrolysis without a catalyst. The influence of temperature on SPR decomposition was very significant. Other forces are biomass type, heating rate, the residence time in the reactor, and reactor type (Yang *et al.*, 2019).

On the pyrolysis process occurs the cracking reaction, namely the breaking of the C-C bonding from a long carbon chain (polymer) and massive molecular weight into a short carbon chain (monomer) with a small molecular weight. This case can affect increasing pyrolysis temperature; the more bonds (hydrocarbon chains) broken, so yield increased. High temperature also affects the reduction of liquid products and consistent with its top gas products. It occurs the secondary cracking process, which breaks long chains of organic compounds and hydrocarbons into shorter chains so that they cannot be condensed again (Jamilatun *et al.*, 2019).

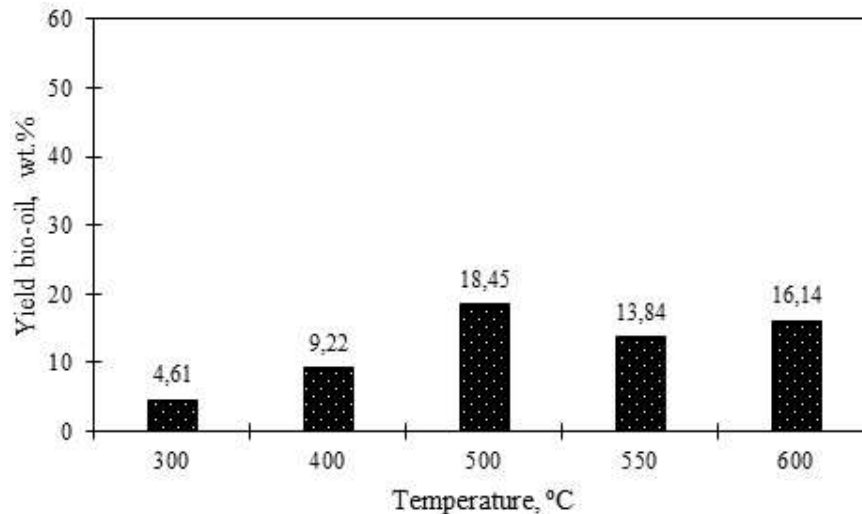


Figure 2. The effect temperature on yield bio-oil

The Influence of Temperature on Water Phase Yield

Figure 3 shows the influence of temperature on the water phase. From these experiments, the water phase yield has increased, which is affected by the temperature increase from 300-400 °C. Then the water phase yield was relatively constant at 400-550°C and dropped slightly at a temperature of 550°C. At a temperature of 600, the water phase yield has decreased. The water phase yield influenced by the water content of SPR (9.99 wt.% of dry based) and the reactions of water formation during pyrolysis proses (dehydration). Based on (Basu, 2010), the average water content of tar in biomass is above 20 wt.%.

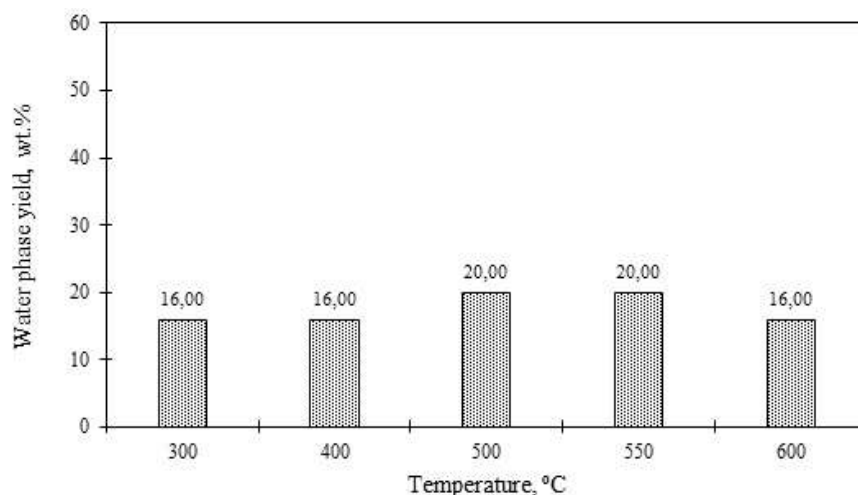


Figure 3. The influence of pyrolysis temperature on water phase yield

The Influence of Temperature on Char Yield

Figure 4 shows the influence of temperature on char yield from SPR pyrolysis. Form these experiments; the char yield obtained from the temperature of 300°C, 400 °C, 500 °C, 550 °C and 600 °C with the percentage of 49.02 wt.%,

39.96 wt.%, 32,02 wt.%, 30.11 wt.%, and 28.39 wt.%, respectively. These results indicated that the char yield has significantly decreased. Based on the literature review (Dickerson T, 2013) shown that the pyrolysis at low temperatures less than 400 ° C or relatively low heating will produce relatively high char products. A lower heating rate and a longer the residence time causing a secondary cracking reaction will affect the bio-oil properties. The higher of the pyrolysis temperature used so that the char content will be lower because the SPR complier content will decompose, and the volatile matter content will decrease with the increase of the pyrolysis temperature.

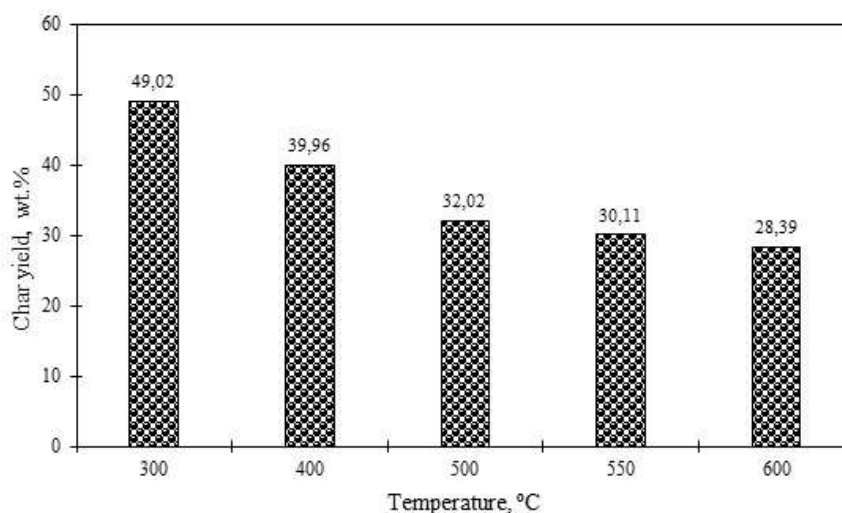


Figure 4. The influence of temperature on char yield

The Influence of Temperature on Gas Yield

Figure 5 shows the influence of temperature on gas yield. From these experiments, the gas yield obtained from the temperature of 300 °C, 400 °C, 500 °C, 550 °C, and 600 °C with the percentage of 30.37 wt.%, 34.82 wt.%, 29.54 wt.%, 36.06 wt.%, and 39.47 wt.%, respectively. The experiment found that the temperature of 500 °C obtained the lowest yield among others because the SPR conversion at 500 °C of temperature was more bio-oil than converted to gas. The gas yield at a temperature of 550 °C and 600 °C has increased with the percentage of 36.06 wt.%, and 39.47 wt.%, respectively. So it can be seen that gas products are growing with increasing pyrolysis temperature.

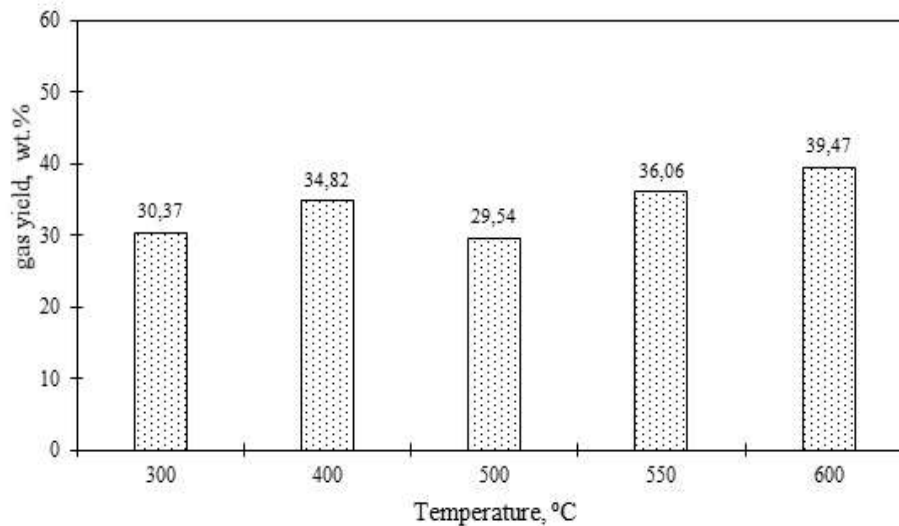


Figure 5. The influence of temperature on gas yield

The Influence of Temperature on Bio-oil Composition

The bio-oil tested by GCMS that can see in figure 6. From the testing, it found that the forms of bio-oil consist of nitrogen, alcohol, ketone, aldehyde, carbonyl, poly-aromatic, aliphatic, acid, phenol, aromatic—the bio-oil compositions displayed in figure 7.

In this experiment, the hydrocarbon compounds in bio-oil are aromatic and aliphatic hydrocarbon. The aromatic hydrocarbon can increase the octane value of the fuel, while high aliphatic hydrocarbons can apply as transportation fuels (Li G *et al.*, 2013). The aliphatic hydrocarbon includes alkane (single bond), alkene (double bond), cycloalkane, and cycloalkene that resulted from lipid pyrolysis at SPR. Aromatic hydrocarbon consists of monocyclic aromatic hydrocarbon (MAH) and polycyclic aromatic hydrocarbon (PAH). PAH compound in the bio-oil is quite high at 500°C (Zhou H *et al.*, 2015). PAH can form when products such as coal, oil, gas, and organic matter not burned out completely. Aromatic compounds not identified in this study.

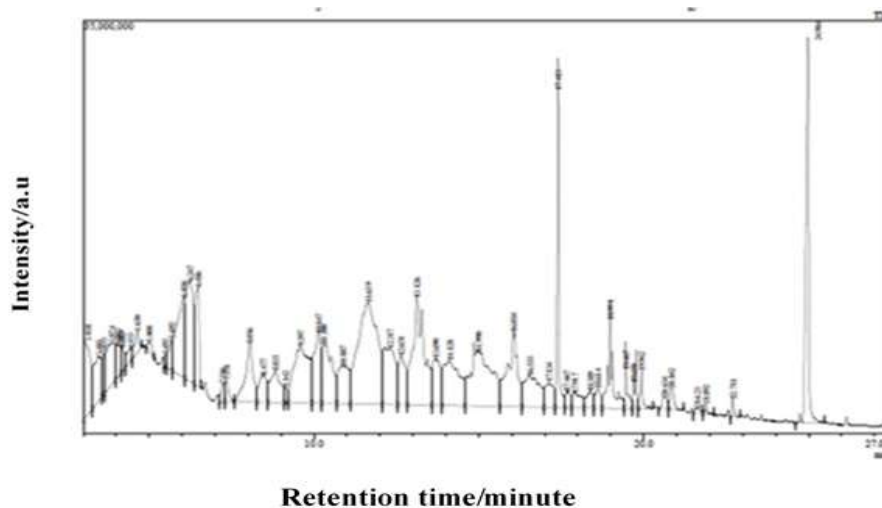


Figure 6. Spectra GC-MS bio-oil from SPR pyrolysis

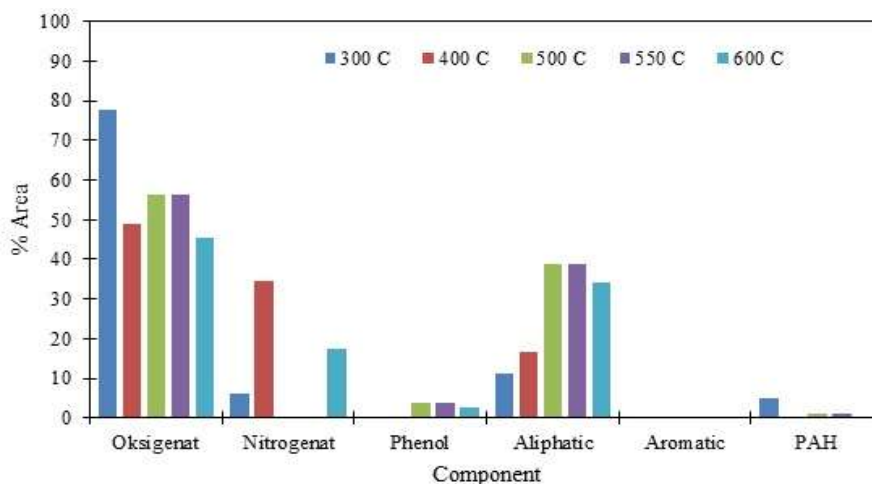


Figure 7. The influence of temperature on bio-oil compositions

Conclusions

Biofuel is one of the renewable energy sources that obtained from biomass. *Spirulina platensis residue* (SPR) obtained from *Spirulina platensis* (SP) solid residue extraction. It heated in the fixed-bed reactor with temperature ranging from 300-600°C to produce three products, such as gas, char, and liquid (water phase and bio-oil). This experiment found that the maximum bio-oil yield was 18.45 wt.% at a pyrolysis temperature of 500°C. The maximum water phase yield obtained about 20 wt.% at the pyrolysis temperature from 500-550°C. The maximum char yield obtained at temperature 300°C about 49.02 wt.%. The gas yield was obtained 35.47 wt.% at a temperature of 600°C. However, the pyrolysis temperature had effected the pyrolysis product. GC-MS tested the bio-oil yield. From the analysis result, the compositions of the bio-oil consist of nitrogen, alcohol, ketone, aldehyde, carbonyl, poly-aromatic, aliphatic, acid, phenol, and aromatic.

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