



UNIVERSITI
TEKNOLOGI
MARA

ISETC2025

2ND INTERNATIONAL SCIENCE,
ENGINEERING AND TECHNOLOGY
COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A
SUSTAINABLE WORLD

ORGANIZED BY:
FACULTY OF APPLIED SCIENCES
UNIVERSITI TEKNOLOGI MARA
PERAK BRANCH, TAPAH CAMPUS
MALAYSIA

CO-ORGANIZED BY:



**2nd International Science, Engineering and Technology Colloquium
(ISETC 2025)**

Faculty of Applied Sciences,
Universiti Teknologi MARA,
Perak Branch, Tapah Campus,
35400 Tapah Road, Perak, Malaysia.

Colloquium date: 9th July 2025

Publication date: 9th September 2025

Proceedings of Extended Abstracts

EDITORS

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

Ms. Nurul Nazwa Mohammad

Ms. Rozaina Saleh

e-ISBN: 978-629-97630-5-5

Copyright © 2025 ISETC

Published by Faculty of Applied Sciences, Universiti Teknologi MARA,
Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia.

PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

Ms. Nurul Nazwa Mohammad

Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

A PRELIMINARY STUDY OF BIOMASS-DERIVED ACTIVATED CARBON

Nur Syarmila Shazuani Anuar, Siti Aishah Romli, Nurul Nazwa Mohammad*

*Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus,
35400 Tapah Road, Perak, Malaysia*

**Corresponding author: nurul.nazwa@uitm.edu.my*

Abstract: Biomass-derived activated carbon (AC) has emerged as a promising material for sustainable energy storage due to its high surface area, porosity, and low production cost in supercapacitor applications. In this preliminary study, AC was prepared from coconut shells through carbonization at varying temperatures (600 °C, 700 °C, and 800 °C), followed by chemical activation with sodium hydroxide (NaOH). Two qualitative assessments were conducted which are bubble formation test to evaluate pore development and a dye adsorption test to examine adsorption performance. The AC carbonized at 800 °C showed the most visible bubbling and completely decolorized the dye, indicating superior porosity and adsorption capacity. Overall, the study confirms the potential of coconut shell-derived activated carbon as a low-cost and efficient adsorbent while highlighting the importance of temperature in optimizing pore structure.

Keywords: *Biomass-derived carbon, coconut shell, activated carbon, chemical activation, sodium hydroxide*

INTRODUCTION

Activated carbon (AC) refers to a carbon-rich material with high porosity, large specific surface area and excellent adsorption capacity. Due to its unique chemical composition and structure, AC has the ability to adsorb organic molecules and other non-polar chemicals from gas and liquid streams (Balci et al, 1994). These characteristics make AC effectively remove organic pollutants, heavy metals, and harmful gases. It is widely used in water purification, air filtration, and gas separation. In electrochemical systems, it serves as a stable conductive electrode material for storage devices such as supercapacitors and batteries.

Traditionally, AC has been produced from coal or petroleum-based precursors, but these sources are non-renewable and environmentally challenging. In recent years, the use of agricultural waste biomass as precursors has been noticed by many researchers for the production of activated carbon since it offers a renewable, low-cost, and eco-friendly alternative (Ioannidou & Zabaniotou, 2007). Renewable biomass such as agricultural residues, forestry by-products, and food industry waste not only utilizes abundant waste but also supports the circular economy by reducing landfill burdens and creating value-added products (Sevilla & Fuertes, 2009). Agricultural by-products and waste materials such as coconut shell, wood, and rice husk are among the low-cost precursors for activated carbon production.

Production of AC from biomass generally involves carbonization followed by activation. Carbonization is performed under inert atmosphere at elevated temperatures to remove volatile compounds, yielding carbon-rich char. After carbonization, physical or chemical activation process will be conducted to enhance the pore structure of the char. In the physical activation the carbon char will be activated using oxidizing gases such as steam or CO₂ at high temperature (500–1000 °C) (Cecen, 2014), while chemical activation involves impregnation the char with activating agents such as Potassium Hydroxide (KOH), Sodium Hydroxide (NaOH), Phosphoric Acid (H₃PO₄), or Zinc Chloride (ZnCl₂) before heating. Chemical activation often results in higher surface areas and better pore control at lower activation temperatures compared to physical activation (Bansal & Goyal, 2005).

Among biomass sources, coconut shell is selected in this study due to its high lignin content, low ash, and dense structure, resulting in mechanically robust AC with high microporosity. This conversion of biomass-derived carbon into activated carbon would increase its economic value, reducing the disposal cost of the material and provide cheap material for activated carbon preparation since it's inexpensive, even no cost required to obtain the material. The raw biomass-derived carbon (BDC) was first carbonized into the char prior to activation with activation agent NaOH for

activated carbon productions. It suggests that the use of NaOH is very effective for activation of the char of the materials (Prahas et al., 2008).

LITERATURE REVIEW

Biomass-derived carbon (BDC) has gained significant attention as a sustainable alternative to fossil-based carbon materials due to its renewable origin, low cost, and minimal environmental impact. Biomass sources, such as agricultural residues, forestry by-products, and food processing wastes are rich in lignocellulosic components (cellulose, hemicellulose, lignin) that provide an abundant carbon framework for conversion into porous carbon materials (Ioannidou & Zabaniotou, 2007). Utilizing biomass not only addresses waste management challenges but also supports the development of green technologies in line with circular economy principles (Demirbas, 2001).

Various biomass precursors have been investigated for AC production including coconut shells, rice husks, palm shells, and fruit peels. Coconut shell is widely regarded as an ideal precursor due to its high lignin content, high density, low ash content, and naturally rigid structure, which favor the formation of microporous activated carbon with excellent mechanical strength (Fang et al., 2023; Zhao et al., 2021). These properties contribute to the production of mechanically robust AC with predominantly microporous structures and surface areas above 2000 m²/g (Zhao et al., 2021). Coconut shell AC has been successfully applied in removing organic dyes, phenolic compounds, and heavy metals from water. It also been use as well as in capturing volatile organic compounds from air streams. Its high electrical conductivity also makes it suitable for use as electrodes in supercapacitors (Fang et al., 2023).

The activation process is critical in developing the pore structure of AC. Chemical activation using NaOH has been found particularly effective for coconut shell char, producing high micropore volumes and enhanced adsorption capacity. During the activation process, NaOH reacts with the carbon matrix to generate sodium carbonate and metallic sodium, which create and expand pores (Prahas et al., 2008). This method can achieve high surface areas at relatively low temperatures compared to physical activation (Bansal & Goyal, 2005).

The performance of biomass-derived AC is determined by a combination of precursor characteristics, activation method, and processing parameters. In this context, coconut shell when activated chemically with NaOH, not only produces AC with excellent structural and functional properties but also delivers high-value carbon materials with excellent adsorption and electrochemical performance. It is aligning with sustainable material innovation and green technology goals.

MATERIALS AND METHODS

Coconut shell were collected from agriculture waste from local market around Tapah, Perak. The collected coconut shells were washed with deionized (DI) water to remove residual husk and other impurities. They were then dried in the oven overnight to remove the moisture. The dried coconut shells were ground into fine powder. The powdered coconut shells were carbonized in furnace at three difference temperature of 600 °C, 700 °C and 800 °C for 1 hour.

After carbonization, the produced biochar was cooled to room temperature before undergoing chemical activation. The biochar undergoes activation process by using NaOH as an activating agent in a chemical activation procedure. After the activation process, the activated carbon goes through several post-treatment steps to ensure its stability and purity. The activated carbon was repeatedly washed with DI water until the rinse water reached neutral pH, ensuring complete removal of residual NaOH and soluble impurities. The washed product was oven-dried at 100 °C for 24 hours to obtain the final activated carbon.

RESULTS

Bubble Formation Test

A preliminary qualitative test was conducted to evaluate the porosity of AC samples derived from the coconut shells. The AC samples were immersed in distilled water, and the release of air bubbles was observed. The formation of bubbles upon submersion is attributed to the expulsion of trapped air from internal pores, which serves as an indicator of pore development of the carbon (Ioannidou & Zabaniotou, 2007). Figure 1 shows carbon samples carbonized at three different temperatures 600 °C, 700 °C, and 800 °C were submerged in distilled water. The sample carbonized at 600 °C shows no visible bubble formation, suggesting minimal pore development. In contrast, the samples treated at temperature of 700 °C sample displayed tiny visible bubbles, indicating the presence of internal pores that allowed trapped air to escape. The 800 °C sample showed more pronounced bubbling, implying a greater degree of porosity due to the higher activation temperature.

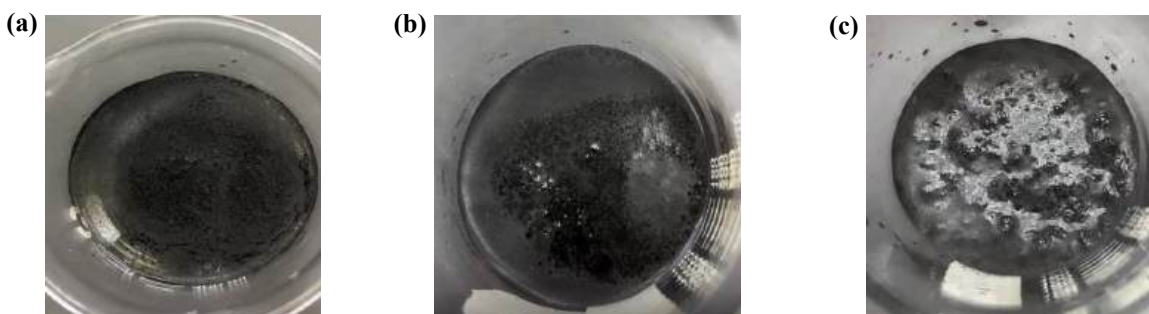


Figure 1. Activated Carbon samples at three different temperatures (a) 600 °C (b) 700 °C and (c) 800 °C

Dye Adsorption Test

Dye adsorption is a widely used method to assess activated carbon (AC) adsorption efficiency. The effectiveness of dye removal is typically determined by the extent of porosity, specific surface area, and surface functional groups on the carbon material (Ioannidou & Zabaniotou, 2007). A dye adsorption test was carried out using red food dye as a simulated contaminant to evaluate the adsorption performance of the activated carbon. Sample was tested by mixing a drop of red dye with 90 mL of distilled water. The solution was then divided into three 30 mL portions. Each portion was treated with a carbon sample activated at 600 °C, 700 °C, or 800 °C. The mixtures were left overnight to allow sufficient contact time for adsorption.

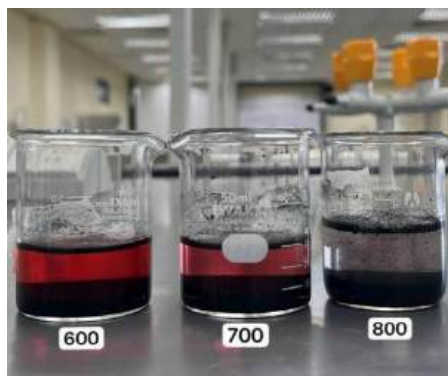


Figure 2. Dye Solution After Treatment with Coconut Shell AC Overnight

Figure 2 show dye solution after treatment with coconut shell AC overnight. The AC produced at 600 °C showed no visible change in the red dye solution color, indicating low adsorption efficiency. At temperature of 700 °C, the solution became noticeably lighter, reflecting moderate adsorption capacity. The sample carbonized at 800 °C achieved the highest adsorption efficiency, as evidenced by the almost complete clear solution. The enhanced adsorption at higher temperatures can be attributed to the increased specific surface area and the development of a well-connected microporous and mesoporous network, which facilitate dye molecule diffusion and binding (Bansal & Goyal, 2005; Zhao et al., 2021). Similar trends have been reported for biomass-derived activated carbons, where both the adsorption rate and capacity improve with higher activation temperatures due to better pore accessibility and surface chemistry (Guo & Lua, 2003).

DISCUSSION

The results of this preliminary study demonstrate that carbonization temperature plays importance role in shaping the pore structure and adsorption performance of coconut shell-derived activated carbon. Stronger bubble formation observed at 800 °C supports the notion that elevated temperatures promote pore development by driving off volatile matter and enhancing carbon structure rearrangement (Daud & Ali, 2004). These findings are consistent with other studies demonstrating that carbonization temperature significantly affects pore formation and adsorption capacity (Karume et al., 2023).

Similarly, enhanced dye adsorption at elevated carbonization temperatures reflects the increased porosity and accessible surface area. Adsorption efficiency is strongly linked to surface properties, with larger surface areas and well-developed pore networks providing more binding sites for dye molecules (Gupta & Suhas, 2009). Specifically, carbonized samples at 800 °C undergo extensive thermal decomposition and structural rearrangement, forming a highly porous matrix that allows efficient dye diffusion and stronger adsorption interactions. These results align with prior studies employing dye molecules, such as methylene blue and Congo red, as probes to evaluate adsorption performance of carbon materials (Foo & Hameed, 2009).

Overall, the findings indicate that carbonization at higher temperatures (700–800 °C) enhances pore development and adsorption efficiency, increasing the likelihood that the resulting material approaches the properties of activated carbon. This is consistent with recent reports emphasizing the influence of carbonization temperature on pore formation and adsorption capacity (Karume et al., 2023). Nevertheless, further characterization such as BET surface area analysis, pore size distribution, and functional group assessment is required to validate the classification of the material as activated carbon according to established standards.

CONCLUSIONS

This preliminary study demonstrated that coconut shell-derived activated carbon prepared via NaOH chemical activation possesses enhanced porosity and adsorption capacity with increasing carbonization temperature. The bubble formation test confirmed the development of pores, with bubble intensity increasing at higher carbonization temperatures. Similarly, the dye adsorption test revealed enhanced removal efficiency with increasing temperature, with the best performance observed at 800 °C. These outcomes agree with prior research showing that higher thermal treatment temperatures facilitate pore expansion, improve surface area, and enhance adsorption potential. Further studies should include surface area characterization, functional group analysis, and kinetic modelling to understand adsorption mechanisms better.

REFERENCES

- Balci, S., Dogu, T., & Dogu, G. (1994). Adsorption of organic compounds on activated carbon. *Carbon*, 32(2), 273–278. [https://doi.org/10.1016/0008-6223\(94\)90078-7](https://doi.org/10.1016/0008-6223(94)90078-7)
- Bansal, R. C., & Goyal, M. (2005). *Activated carbon adsorption*. CRC Press.
- Cecen, F. (2014). *Activated carbon for water and wastewater treatment: Integration of adsorption and biological treatment*. John Wiley & Sons.
- Daud, W. M. A. W., & Ali, W. S. W. (2004). Comparison on pore development of activated carbon produced from palm shell and coconut shell. *Bioresource Technology*, 93(1), 63–69. <https://doi.org/10.1016/j.biortech.2003.09.015>
- Demirbas, A. (2001). Agricultural residues as renewable energy sources. *Energy Sources*, 23(8), 687–699. <https://doi.org/10.1080/009083101300236690>
- Fang, W., Zhang, H., Xu, Y., & Li, J. (2023). Biomass-derived porous carbons for supercapacitors: Recent progress and challenges. *Renewable and Sustainable Energy Reviews*, 174, 113115. <https://doi.org/10.1016/j.rser.2023.113115>
- Foo, K. Y., & Hameed, B. H. (2009). Insights into the modeling of adsorption isotherm systems. *Chemical Engineering Journal*, 156(1), 2–10. <https://doi.org/10.1016/j.cej.2009.09.013>
- Guo, J., & Lua, A. C. (2003). Textural and chemical characterizations of adsorbent prepared from palm shell by potassium hydroxide impregnation at different stages. *Journal of Colloid and Interface Science*, 254(2), 227–233. [https://doi.org/10.1016/S0021-9797\(02\)00064-4](https://doi.org/10.1016/S0021-9797(02)00064-4)
- Gupta, V. K., & Suhas. (2009). Application of low-cost adsorbents for dye removal: A review. *Journal of Environmental Management*, 90(8), 2313–2342. <https://doi.org/10.1016/j.jenvman.2008.11.017>
- Ioannidou, O., & Zabaniotou, A. (2007). Agricultural residues as precursors for activated carbon production—A review. *Renewable and Sustainable Energy Reviews*, 11(9), 1966–2005. <https://doi.org/10.1016/j.rser.2006.03.013>
- Karume, D. G., Dlamini, N. G., & Mamba, B. B. (2023). Influence of carbonization temperature on the textural properties of activated carbon from biomass. *Biomass and Bioenergy*, 171, 106843. <https://doi.org/10.1016/j.biombioe.2023.106843>
- Prahas, D., Kartika, Y., Indraswati, N., & Ismadji, S. (2008). Activated carbon from jackfruit peel waste by H₃PO₄ chemical activation: Pore structure and surface chemistry characterization. *Chemical Engineering Journal*, 140(1–3), 32–42. <https://doi.org/10.1016/j.cej.2007.08.032>
- Sevilla, M., & Fuertes, A. B. (2009). The production of carbon materials by hydrothermal carbonization of cellulose. *Carbon*, 47(9), 2281–2289. <https://doi.org/10.1016/j.carbon.2009.04.026>
- Zhao, Y., Liu, X., Wang, Y., & Zhang, Y. (2021). Porous carbon derived from coconut shell as electrode material for supercapacitors. *Journal of Energy Storage*, 36, 102414. <https://doi.org/10.1016/j.est.2021.102414>



Surat kami : 700-KPK (PRP.UP.1/20/1)
Tarikh : 20 Januari 2023



Prof. Madya Dr. Nur Hisham Ibrahim
Rektor
Universiti Teknologi MARA
Cawangan Perak

Tuan,

**PERMOHONAN KELULUSAN MEMUAT NAIK PENERBITAN UiTM CAWANGAN PERAK
MELALUI REPOSITORI INSTITUSI UiTM (IR)**

Perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pihak kami ingin memohon kelulusan tuan untuk mengimbas (*digitize*) dan memuat naik semua jenis penerbitan di bawah UiTM Cawangan Perak melalui Repositori Institusi UiTM, PTAR.

3. Tujuan permohonan ini adalah bagi membolehkan akses yang lebih meluas oleh pengguna perpustakaan terhadap semua maklumat yang terkandung di dalam penerbitan melalui laman Web PTAR UiTM Cawangan Perak.

Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Setuju.

27.1.2023

SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

PROF. MADYA DR. NUR HISHAM IBRAHIM
REKTOR
UNIVERSITI TEKNOLOGI MARA
CAWANGAN PERAK
KAMPUS SERI ISKANDAR

nar