JPSE (Journal of Physical Science and Engineering), Vol. 7, No. 2, 2022, Page 142–146.
DOI: 10.17977/um024v7i22022p142

JPSE
(Journal of Physical Science and Engineering)

http://journal2.um.ac.id/index.php/jpse
EISSN: 2541-2485

Analysis of Phase and Energy Band Gap Width of Corncob Carbon-PEG 4000

Received
03 August 2022

Revised
24 September 2022

Accepted for Publication
30 November 2022

Published
31 December 2022

K W Mas'udah[1*] and Darminto[2]

[1] Department of Physics, Faculty of Engineering, University of Pembangunan Nasional Veteran East Java, Jl. Raya Rungkut Madya Gunung Anyar, Surabaya, 60294, Indonesia.
[2] Department of Physics, Faculty of Science and Data Analytics, Sepuluh Nopember Institute of Technology, Jl. Teknik Kimia, Surabaya, 60111, Indonesia.

***E-mail:** kusuma.w.fisika@upnjatim.ac.id

Abstract
This study aims to identify and analyze the band gap width of the carbon phase produced from corncobs mixed with PEG-4000 to see the surface area of the corncob carbon phase. First, the characterization test was carried out using Scanning Electron Microscope Energy-Dispersive X-ray (SEM-EDX) spectroscopy to determine the morphology and Ultraviolet–Visible (UV-Vis) spectroscopy to determine the band gap width of corncob carbon. Then, adding Polyethylene Glycol (PEG) 4000 at a specific concentration to develop the potential of corncob carbon. Finally, the corncob-PEG 4000 carbon reduction process was sifted through and tested by UV-Vis spectroscopy, and the energy gap value was 0.954 eV.
Keywords: Corncobs, UV-Vis, SEM-EDX, absorbance, energy gap.

1. Introduction

Corncobs are one of the agricultural waste biomass that can be used as an adsorbent to remove pollutants. This agricultural waste can bind heavy metals by adsorption, chelation (chelating), and ion exchange [1]. In addition, corncobs contain chemical components such as cellulose, hemicellulose, and lignin. The high percentage of cellulose makes corncobs that can be used as an alternative carbon material [2].

Carbon is one of the materials that have the potential to be used for various purposes, including in the fields of the utilization of electronic components [3], optics [4], mechanics [5], as an absorbent (adsorbent) [6], aircraft brakes, batteries, fuel cell electrodes [7], and supercapacitors. Carbon has three main structures or allotropes of carbon: graphite, fullerenes, and diamond [8]. Carbon can be produced from pyrolysis combustion and the carbonization process of organic materials. The carbonization process is carried out through the decomposition of organic compounds by heating in the absence of oxygen so that the carbon element can be retained and its volatile components can be removed. At the same time, pyrolysis is incomplete combustion [9].

On the other hand, Indonesia, an archipelagic country with a tropical climate, has abundant natural resources in the form of raw materials for corncobs [10]. However, the utilization of corncob raw materials still needs to be improved, and there is still huge potential, so there needs to be a solution to utilize and increase the economic value of corncobs. Previous research on corncobs is widely used as activated charcoal [11], and it is still necessary to develop characterization tests on corncobs. This study aims to identify and analyze the band gap width of the carbon phase produced from corncobs mixed with Polyethylene Glycol (PEG) 4000 to see the surface area of the corncob carbon phase. The characterization test was carried out using Scanning Electron Microscope Energy-Dispersive X-ray (SEM-EDX) spectroscopy to determine the morphology and Ultraviolet–Visible (UV-Vis) spectroscopy to determine the band gap width of corncob carbon.

2. Method

2.1. *Corncob Sample Preparation*

Sample preparation was carried out by drying the corncobs and then cleaning the corn kernels until only the corncobs were left. Corncobs are powdered so that the heat distribution when the carbonization process starts is more even or homogeneous. The dried corncob charcoal powder was tested for X-ray Diffraction (XRD), SEM-EDX, and Fourier-Transform Infrared (FTIR). Corncobs material is dried first at a temperature of 100 °C. The drying process uses an oven. After drying, the material is carbonized at a temperature of 400 °C with a holding time of 5 hours. Through this process, the content of the carbon phase formed in it can be seen.

Corncob material is dried first at a temperature of 100 °C. The drying process uses an oven. After drying, the material is carbonized at a temperature of 400 °C with a holding time of 5 hours. Through this process, the content of the carbon phase formed in it can be seen [12], [13].

The washing steps using the acid-base method were 10 grams of corncob powder added to 80 mL of HCl solution stirred on a magnetic stirrer at a speed of 750 rpm at room temperature for 20 minutes. Then the titration was carried out using 80 mL of NH_4OH solution into the mixture with a stirring process at a speed of 720 rpm at room temperature for 30 minutes. After that, it was washed using distilled water to pH seven, and the precipitate was taken. Finally, the precipitate is heated in an oven at a temperature of 100 °C until it becomes a powder [14], [15].

The stages of mixing corncob carbon samples use PEG-4000. PEG-4000 was weighed as much as 1 gram, mixed with 40 ml of distilled water, and heated at a temperature of 90 C at 700 rpm. The process of stirring the solution was carried out for 30 minutes. After that. 20 ml of PEG-4000 solution was mixed with 3 grams of corncob carbon sample and stirred for 1 hour at 750 rpm. The precipitate from the filtering process was dried at 100 °C for 5 hours to become powder [16], [17].

2.2. Characterization of Test Material

In this study, the test material was characterized through SEM-EDX and UV-Vis. Measurement with UV-Vis Spectrophototrometry equipment aims to determine the energy band gap width. Measurements were made in the wavelength range of 190–1100 nm.

3. Result and Discussion

The energy band gap width (Eg) can be calculated using the absorbance edge method based on the graph of the absorbance relationship with the wavelength resulting from testing using a UV-Vis spectrophotometer. The optical properties of corncob carbon powder that had been synthesized and mixed with PEG-4000 were obtained from absorbance testing. The absorbance was scanned spectrophotometrically in the 190–500 nm wavelength range. It can be seen in the graph between absorbance and wavelength that there are three absorbance peaks at wavelength 205, 240, 265, 325, and 365 nm with each absorbance value of 14023.97, 226.24, 576.23, 1431370.67, and 1476501.63, respectively (Figure 1). The absorbance value obtained shows that there is the absorption of UV radiation by particles. The wavelength this sample absorbs is influenced by the crystal structure formed in the phase [2]. The results show the behavior of adding PEG to the sample of this corncob. A large number of absorbance peaks is probably because the oxidized sample has a high absorption of UV radiation [18]. Based on the plotting results, the energy gap value is 0.954 eV (Figure 2). Therefore, carbon, a constituent of graphite, is a material that can conduct electric current quite well [14].

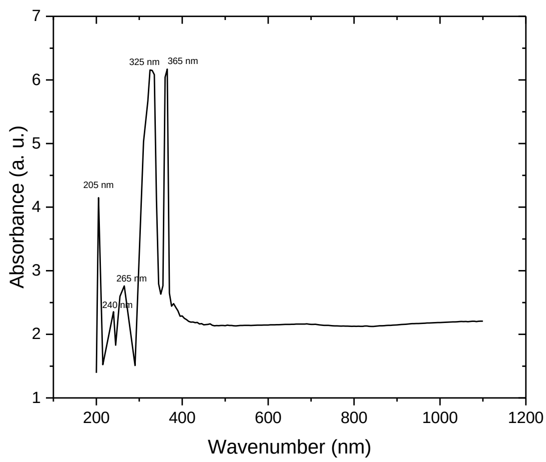

Figure 1. UV-Vis spectra on corncob powder-PEG 4000 between absorbance and wavelength.

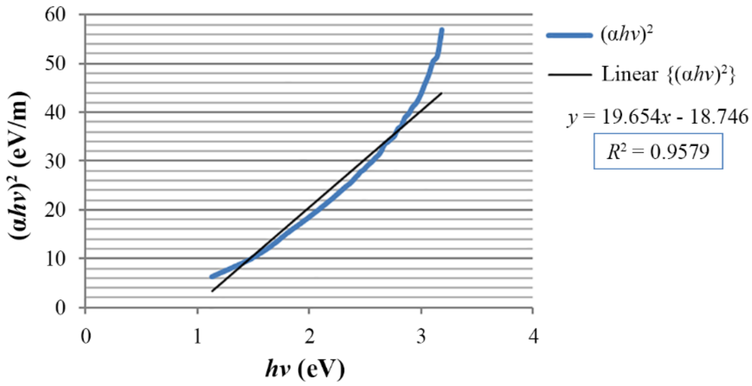

Figure 2. Energy gap sample value.

SEM for corncob powder-PEG 4000 is shown in Figure 3. Corncob structure was revealed by SEM investigation. SEM micrographs of corncob powder have a flat surface structure. It is possible that corncob carbon has a flat structure attached to the PEG, and there is a layer that encloses the pores indicating that the PEG completely covers the supporting material [6]. The average size of cob carbon attached to the PEG's surface is 422.5 nm, and the average pore size is 1.101 µm. Analysis of chemical element composition in corncob powder can be done by testing Energy Dispersive X-Ray (EDX). The existence of testing on the composition of these chemical elements is used to determine what elements are contained in corncob powder, an organic material—the percentage of carbon atoms (C) with a value of 61.38%. Meanwhile, the percentage of Oxygen (O) with a value of 38.62% is shown in Table 1. It indicates that the carbon synthesis results from the corncobs we produce have succeeded [19], [20].

4. Conclusion

We show that the study of corncobs has tremendous potential to produce carbon, as evidenced by the presence of element C from the EDX test, which is 61.38%. The main advantages of corncobs are that they are abundant in nature, cost-effective, and product isolation can be done because they can be extracted from plant waste or inedible plant products. The energy gap value is 0.954 eV, which indicates that corncob-PEG 4000 powder can be categorized as a semiconductor material. This approach opens up a new way to synthesize corncob carbon into environmentally friendly semiconductor materials.

Figure 3. SEM of corncob powder-PEG 4000.

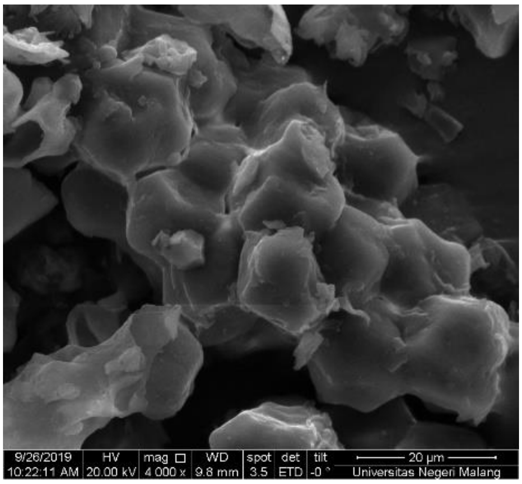

Table 1. Atomic composition of the sample.

Element	Wt %	At %
C	54.41	61.38
O	45.59	38.62

Acknowledgment
We thank the LPPM of the National Development University “Veterans” East Java for supporting and funding this research through the Basic Research Grant for the 2022 Fiscal Year under the Basic Research scheme with the Sepuluh Nopember Institute of Technology.

References

[1] Sunaryono *et al.*, “Effect of polyethylene glycol (PEG) on particle distribution of Mn0.25Fe2.75O4-PEG 6000 nanoparticles,” *J. Phys. Conf. Ser.*, vol. 1093, no. 1, 2018, doi: 10.1088/1742-6596/1093/1/012005.

[2] P. E. Yuwita, K. W. Mas’udah, Sunaryono, and A. Taufiq, “Structural, morphological, and functional group analysis of corncob powder,” *AIP Conf. Proc.*, vol. 2251, no. 1, p. 040012, Aug. 2020, doi: 10.1063/5.0015676.

[3] B. Priyanto *et al.*, “Hydrogenated amorphous carbon films from palmyra sugar,” *J. Renew. Mater.*, vol. 9, no. 6, pp. 1087–1098, Jun. 2021, doi: 10.32604/jrm.2021.014466.

[4] W. Islamiyah, L. Nashirudin, M. A. Baqiya, Y. Cahyono, and Darminto, “Sulfuric acid intercalated-mechanical exfoliation of reduced graphene oxide from old coconut shell,” *AIP Conf. Proc.*, vol. 1945, no. 1, p. 020054, Apr. 2018, doi: 10.1063/1.5030276.

[5] I. Khambali *et al.*, “Synthesis of n-doped reduced graphene oxide from coconut shell as supercapacitors,” *Mater. Sci. Forum*, vol. 966, pp. 437–443, Aug. 2019, doi: 10.4028/www.scientific.net/MSF.966.437.

[6] K. W. Mas’udah, A. Taufiq, and Sunaryono, “The potential of corncobs in producing reduced graphene oxide as a semiconductor material,” *J. Eng. Technol. Sci.*, vol. 54, no. 2, pp. 223–240, Mar. 2022, doi: 10.5614/j.eng.technol.sci.2022.54.2.1.

[7] G. B. Putra, H. Y. Pradana, D. E. Soenaryo, M. A. Baqiya, and Darminto, “Synthesis of green Fe3+/glucose/rGO electrode for supercapacitor application assisted by chemical exfoliation process from burning coconut shell,” *AIP Conf. Proc.*, vol. 1945, no. 1, p. 020040, Apr. 2018, doi: 10.1063/1.5030262.

[8] R. Asih *et al.*, “Physical properties comparison of rGO-like phase prepared from coconut Shell and the commercial product,” *J. Fis. Apl.*, vol. 16, no. 2, pp. 82–86, Jun. 2020, doi: 10.12962/j24604682.v16i2.6712.

[9] A. Ananthi, D. Geetha, and P. S. Ramesh, “Preparation and characterization of silica material from rice husk ash–an economically viable method,” *Chem. Mater. Res*, vol. 8, no. 6, pp. 1–7, 2016.

[10] K. W. Mas’udah, P. E. Yuwita, A. Taufiq, and Sunaryono, “Fabrication of nanocrystalline carbon based on corncobs charcoal,” *AIP Conf. Proc.*, vol. 2231, no. 1, Apr. 2020, doi: 10.1063/5.0002468.

[11] K. W. Mas’udah, M. Diantoro, and A. Fuad, “Synthesis and structural analysis of silicon carbide from silica rice husk and activated carbon using solid-state reaction,” *J. Phys. Conf. Ser.*, vol. 1093, no. 1, Sep. 2018, doi: 10.1088/1742-6596/1093/1/012033.

[12] K. W. Masudah, F. Astuti, and D. Darminto, “Study on physical properties of reduced graphene oxide from heating coconut shell,” *JPSE (J. Phys. Sci. Eng.)*, vol. 1, no. 1, pp. 1–6, Dec. 2016, doi: 10.17977/um024v1i12016p001.

[13] S. Prayogi, Y. Cahyono, and D. Darminto, “Hydrogenated amorphous silicon density of state analyzed by dielectric function model derived from ellipsometric spectroscopy,” *JPSE (J. Phys. Sci. Eng.)*, vol. 7, no. 2, pp. 68–74, Oct. 2022, doi: 10.17977/um024v7i22022p068.

[14] A. Taufiq *et al.*, “Structural, magnetic, optical and antibacterial properties of magnetite ferrofluids with PEG-20000 template,” *Mater. Today Proc.*, vol. 17, pp. 1728–1735, 2019, doi: 10.1016/j.matpr.2019.06.204.

[15] A. Wojciechowska, A. M. Szczupak, and Z. L. Bieluń, “TiO2-modified magnetic nanoparticles (Fe3O4) with antibacterial properties,” *Mater.*, vol. 15, no. 5, p. 1863, Mar. 2022, doi: 10.3390/ma15051863.

[16] A. S. Dewanto, “Structure analysis of Fe3O4@ SiO2 core shells prepared from amorphous and crystalline SiO2 particles,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 367, no. 1, p. 012010, May 2018, doi: 10.1088/1757-899X/367/1/012010.

[17] E. H. Alosaimi, I. H. Alsohaimi, T. E. Dahan, Q. Chen, and S. Melhi, “Adsorptive performance of tetracarboxylic acid-modified magnetic silica nanocomposite for recoverable efficient removal of toxic Cd (II) from aqueous environment: Equilibrium, isotherm, and reusability studies,” *J. Mol. Liq.*, vol. 334, p. 116069, Jul. 2021, doi: 10.1016/j.molliq.2021.116069.
[18] K. W. Mas’udah, Hendy, and A. Taufiq, “Characteristics of crystal structure and microwave absorption of silica particles as the effect of sintering temperature,” *AIP Conf. Proc.*, vol. 2231, no. 1, p. 040072, Apr. 2020, doi: 10.1063/5.0002477.
[19] K. W. Mas’udah *et al.*, “Solution of reduced graphene oxide synthesized from coconut shells and its optical properties,” *AIP Conf. Proc.*, vol. 1725, no. 1, p. 020045, Apr. 2016, doi: 10.1063/1.4945499.
[20] R. Kumar, E. Joanni, R. K. Singh, D. P. Singh, and S. A. Moshkalev, “Recent advances in the synthesis and modification of carbon-based 2D materials for application in energy conversion and storage,” *Prog. Energy Combust. Sci.*, vol. 67, pp.115–157, Jul. 2018, doi: 10.1016/j.pecs.2018.03.001.