Computational and Experimental Research in Materials and Renewable Energy (CERiMRE)
Volume 7, Issue 1, page 1-8
eISSN : 2747-173X

Submitted : April 24, 2024
Accepted : May 21, 2024
Online : May 31, 2024
DOI : 10.19184/cerimre.v7i1.47636

Synthesis of C-Dots Based on Bitter Melon Peel using the Bottom UP Method

Rahmat Firman Septiyanto1[,a], Qothrunnada[1], Asep Saefullah[1], and Isriyanti Affifah[2]

[1] Department of Physics Education, Universitas Sultan Ageng Tirtayasa, Serang, Indonesia

[2] Department of Chemistry Education, Universitas Sultan Ageng Tirtayasa, Serang, Indonesia

[a]rahmat_firman99@untirta.ac.id

Abstract. *There is an increasing demand for creative ways to turn garbage into useful resources as environmental sustainability becomes more and more of a global concern. Carbon dots can be synthesized using organic materials, one of which is bitter melon skin. The goal of this research is to create an economical and environmentally friendly process for creating carbon dots from organic waste. The bitter melon peel synthesis process uses a bottom-up method with microwave techniques. Furthermore, c-dots were characterized using a UV-Vis spectrophotometer to determine the absorbance value and wavelength and FTIR (Fourier Transform Infra-Red) to determine the functional groups contained in the sample. The UV-Vis spectrophotometer characterization results obtained an absorbance value of 3.311 and a wavelength of 206 nm. FTIR results show the presence of O-H and C=C functional group bonds indicating that this synthesis process has been successfully carried out.*

Keywords: Carbon Dots, Bitter Melon Peel, Bottom-up

Introduction

Carbon dots (C-dots) are a type of nanomaterial that has a size of less than 10 nm [1]. C-dots have an amorphous, spherical structure, and are also water-soluble and non-toxic [2]. C-dots also have good resistance to light (photo) and chemical degradation, tunable fluorescence emission, and excitation, high quantum yield, and large Stokes shift [3]. Synthesis of C-dots can be done with organic materials such as C-dots made from shallot peel [2], mango leaves [4], corn, mustard greens, potatoes [5], bamboo leaves [6], seeds, dried coriander pods [7] and binohang leaves [8]. In this research, bitter melon peel was used as the basic ingredient for making C-dots.

C-dots have efficient emission in the visible light range, indicating good carbon emitters' development [5]. One of the distinctive properties of C-dots is that they can fluoresce. The luminescence in C-dots comes from electrons moving from one state to the ground state in the form of photons.

C-dots have several advantages, namely having strong photoluminescence, being inert or easily soluble in water, non-toxic, and not easily photobleaching so that carbon dots can be developed in a wide range of applications, examples of C-dots that have been developed to date are as a substitute for optoelectronics such as LEDs, displays, sensors, and solar cells [9]. C-dots have been widely used as fluorescent sensors that not only have good optical properties but C-dots are also more environmentally friendly. In addition, the manufacturing process of C-dots is not too complicated and can be made from organic materials so it is environmentally friendly. Especially in Indonesia, renewable biomass is a major component of the global energy supply [10]. Although

Computational and Experimental Research
in Materials and Renewable Energy (CERiMRE)
Volume 7, Issue 1, page 1-8
eISSN : 2747-173X

Submitted : April 24, 2024
Accepted : May 21, 2024
Online : May 31, 2024
DOI : 10.19184/cerimre.v7i1.47636

there is a lot of biodiversity in Indonesia, it hasn't been completely utilized [11]. One of the biodiversity that is easily found is waste of melon peel. It is used to fabricate c-dots

C-dots can be synthesized in two ways, namely top-down and bottom-up. The "top-down" method determines the preparation of CDs by fragmentation of large carbon precursor molecules into nano-scale particles, while the "bottom-up" method determines the transformation of CDs from suitable molecular precursors under specific conditions [12]. Top-down methods include arc discharge, laser ablation, electrochemical oxidation, chemical oxidation, and ultrasonic synthesis. Bottom-up methods include microwave synthesis, thermal decomposition, hydrothermal processing, template routing, and plasma processing [6]. C-dots have optical, electrical, and hydropholic properties that are affected by the use of precursors, reaction conditions such as temperature, time, solvents, and different separation processes. Therefore, C-dots synthesized with different methods and conditions will have different properties [13].

Research [12] carbon dots produced from activated and non-activated pyrolytic carbon black obtained from waste tires chemically oxidized with HNO_3 showed the effect on the properties of carbon dots analyzed using FTIR which showed the presence of O-H functional groups at a wavelength of 3361 cm^{-1}, C=C at a wavelength of 2100 cm^{-1}, -COOH at a wavelength of 1377 cm^{-1}, and NO_2 at wavelengths of 1639 cm^{-1} and 600 cm^{-1}, UV-Vis spectrophotometer showed an absorbance peak at 255 nm, and TEM. The next research [1] the synthesis of Cdots has been successfully carried out with the basic ingredients of tea grounds using presto and microwave heating, while the results of his research show absorbance peaks at wavelengths of 272 nm, 271 nm, 215.5 nm, and 270 nm and FTIR results show the sample has N-H and C=C bond functional groups. As for the novelty in this research, namely using bitter melon peel which is household waste which is made into C-dots by microwave techniques. bitter melon contains saponin compounds [13] which make it possible to be used as a basic material for making C-dots. saponin compounds are composed of 15 carbon atoms with a C6-C3-C6 configuration [14].

Theoretical Background

Bottom-up method

C-dots can be synthesized by two methods, namely top-down and bottom-up. In this study, the bottom-up method was used to synthesize C-dots. The bottom-up method is a synthesis method for the formation of C-dots derived from precursor molecules [9]. The bottom-up method uses atoms or molecules to create the desired nanometer-sized particles. In this study, the bottom-up method was used with microwave techniques to synthesize C-dots. Frequently used bottom-up methods are hydrothermal and microwave irradiation methods. While the top-down method that is often used is the laser ablation method. Of the two methods, the bottom-up method is easier and more practical than the top-down method, which is more expensive.

Spectrofotometer UV-Vis

The synthesized C-dots were then characterized using a UV-Vis spectrophotometer. UV-Vis spectrophotometer has a working principle based on the correlation of electromagnetic radiation with matter. The advantage of this method is that it does not require a long time and is relatively cheap when compared to other methods [8]. UV-Vis spectrometer is a technical part of spectroscopic analysis using electromagnetic radiation sources of near-ultraviolet (190 - 380 nm)

Computational and Experimental Research in Materials and Renewable Energy (CERiMRE)
Volume 7, Issue 1, page 1-8
eISSN : 2747-173X

Submitted : April 24, 2024
Accepted : May 21, 2024
Online : May 31, 2024
DOI : 10.19184/cerimre.v7i1.47636

and visible light (380 - 780 nm) using spectrophotometer instruments (trivariate). The results of UV-Vis spectrophotometer characterization are in the form of wave peaks and absorbance values. A spectrophotometer is a quantitative measurement method based on the measurement of absorbance (absorption) of electromagnetic wave radiation [2]. C-dots created through diverse techniques typically exhibit potent ultraviolet absorption, yet they yield varying absorption peaks. The operation of a UV-Vis spectrophotometer hinges on the principle that chemical compounds absorb ultraviolet or visible light, leading to the generation of distinct spectra.

FTIR (Fourier Transform Infra-Red)

The next characterization is by using FTIR. This characterization will produce functional groups contained in the C-dots sample. C-dots are a material that consists mostly of carbon, hydrogen, and oxygen. Partial oxidation of the C-dots source, namely carbon precursors, carboxyl groups, carboxylic acids, hydroxyls, and ethers produces a C-dots surface rich in functional groups. The determination of functional groups on C-dots determines the interaction of C-dots with metals or materials to be detected. Absorption of C-dots can increase if there is surface passivation along with the addition of functional groups. According to Geo in [13] Functional groups on the surface of C-dots will affect optical absorption because different functional groups will have different absorption areas.

Materials and Methods

This research aims to synthesize C-dots from the bitter melon peel. Bitter melon peel was synthesized by a bottom-up method using microwave technique. The top-down method is used to synthesize nanoparticles by breaking large particles into nanometer-sized pieces [9]. C-dots were characterized with a Spectrophotometer to determine the wavelength and absorbance value and tested with FTIR to determine the functional groups. This research was conducted at Untirta Physics Laboratory, Untirta Integrated Laboratory, Serang, Banten, and at BRIN (National Innovation Research Agency), Tangerang, Banten. The data was collected by mass variation of 5 grams of bitter melon peel and 75 ml of distilled water with heating time in the microwave for 15 minutes, then tested using UV-Vis spectrophotometer and FTIR.

Computational and Experimental Research
in Materials and Renewable Energy (CERiMRE)
Volume 7, Issue 1, page 1-8
eISSN : 2747-173X

Submitted : April 24, 2024
Accepted : May 21, 2024
Online : May 31, 2024
DOI : 10.19184/cerimre.v7i1.47636

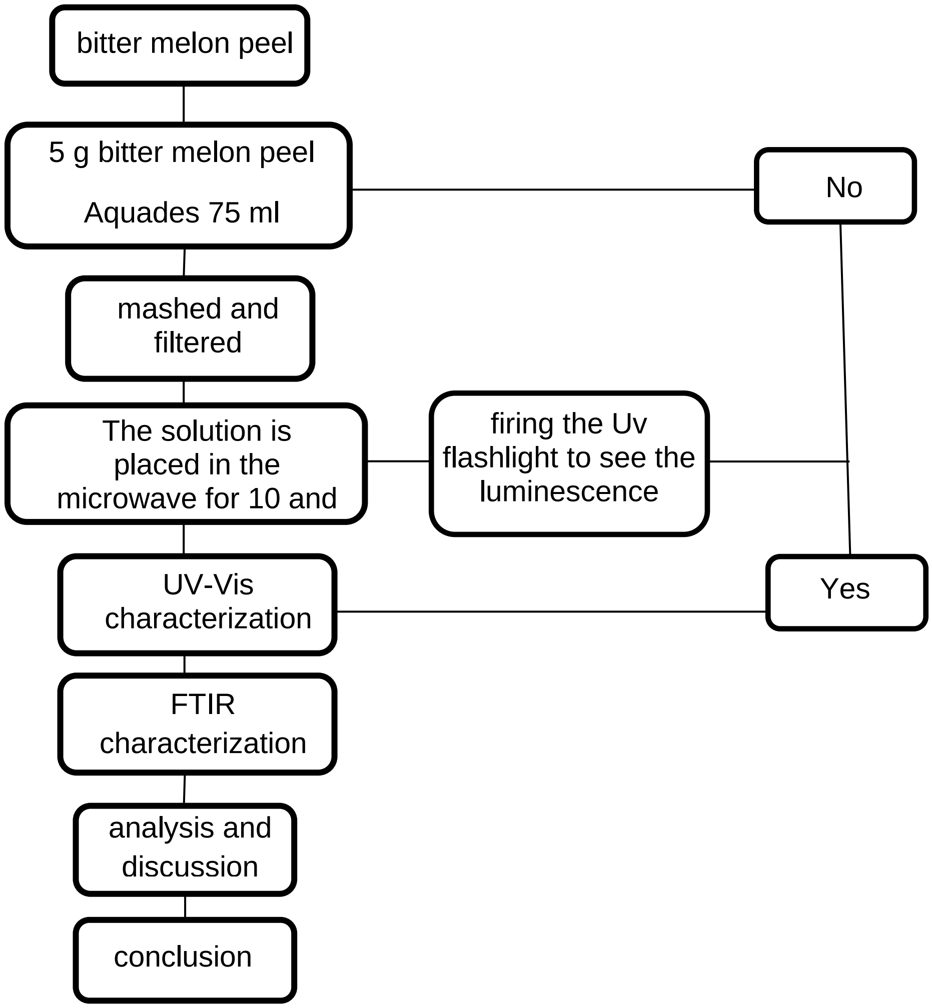

Figure 1. Research flow diagram

Results and Discussion

Characterization in this study used a UV-Vis spectrophotometer UH5300. This UV-Vis characterization is to determine the absorbance value and wavelength. UV-Vis spectrometer is a technical part of spectroscopic analysis using electromagnetic radiation sources of near-ultraviolet (190 - 380 nm) and visible light (380 - 780 nm) using spectrophotometer instruments [2]. The success of C-dot synthesis can be confirmed by analyzing the the absorption pattern of the sample using a UV-Vis spectrophotometer. C-dots was measured using a UV-Vis spectrophotometer at a wavelength range of wavelength range of 200 to 800 nm using a UV-Vis spectrophotometer [7].

The following are the results of the UV-Vis spectrophotometer test:

Computational and Experimental Research
in Materials and Renewable Energy (CERiMRE)
Volume 7, Issue 1, page 1-8
eISSN : 2747-173X

Submitted : April 24, 2024
Accepted : May 21, 2024
Online : May 31, 2024
DOI : 10.19184/cerimre.v7i1.47636

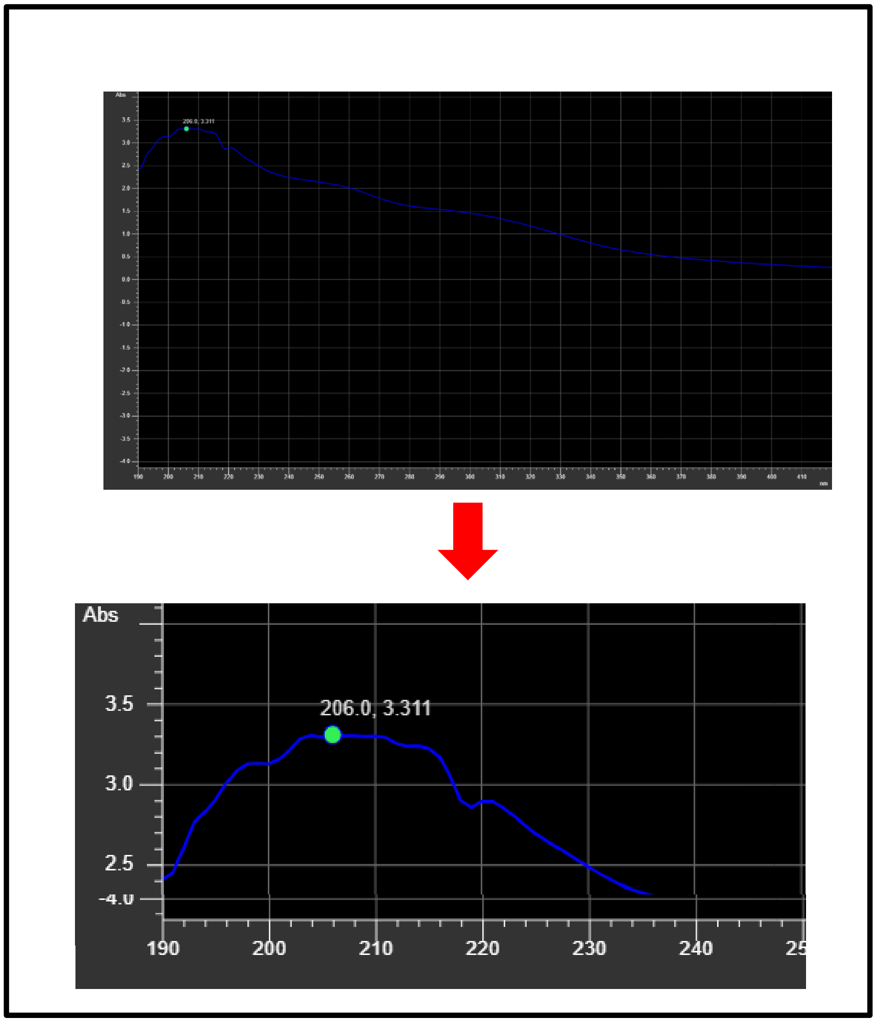

Figure 2. Uv-vis spectrophotometer test results

Figure 2 is the result of UV-vis spectrophotometer analysis which shows that the absorbance of C-dots with a concentration of 5 grams of bitter melon peel and 75 ml of distilled water with a variation of sample time in the microwave for 15 minutes has one peak, which is at wavelength 206 with an absorbance peak of 3.311. These results are by research [14] Synthesis of C-dots from coffee waste base material has an absorbance peak in the length range of 203 nm for a mass variation of 5 g, 204.5 nm for a mass variation of 10 g, 208 nm for mass variation of 15 g, 209 nm for mass variation of 20 gr, and 231 nm for mass variation of 25 gr mass variation. research [7] on the preparation of C-dots from seed pods and kesumba keling (*Bixa Orellana)* seeds showed the UV-Vis absorption spectra of C-dot featuring eight samples with absorption peaks at wavelengths of 260-280 nm and 320-340 nm.

The absorbance readings on the UVVis graph show that all samples underwent electronic transitions (excitation) as a result of absorbing energy from UV wavelengths. The absorption occurs because the energy of UV light at a certain wavelength is equal to the excitation energy of the sample electrons. The electronic transition that occurs is the excitation of electrons in the

Computational and Experimental Research
in Materials and Renewable Energy (CERiMRE)
Volume 7, Issue 1, page 1-8
eISSN : 2747-173X

Submitted : April 24, 2024
Accepted : May 21, 2024
Online : May 31, 2024
DOI : 10.19184/cerimre.v7i1.47636

Highest Occupied Molecular Orbital (HOMO) to the level of the energy level of the Lowest Unoccupied Molecular Orbital (LUMO) [15].

The next test uses FTIR, the sample used is a concentration of 5 grams of bitter melon peel and 75 ml of distilled water with a variation of sample time in the microwave for 15 minutes as in the **Figure 3**.

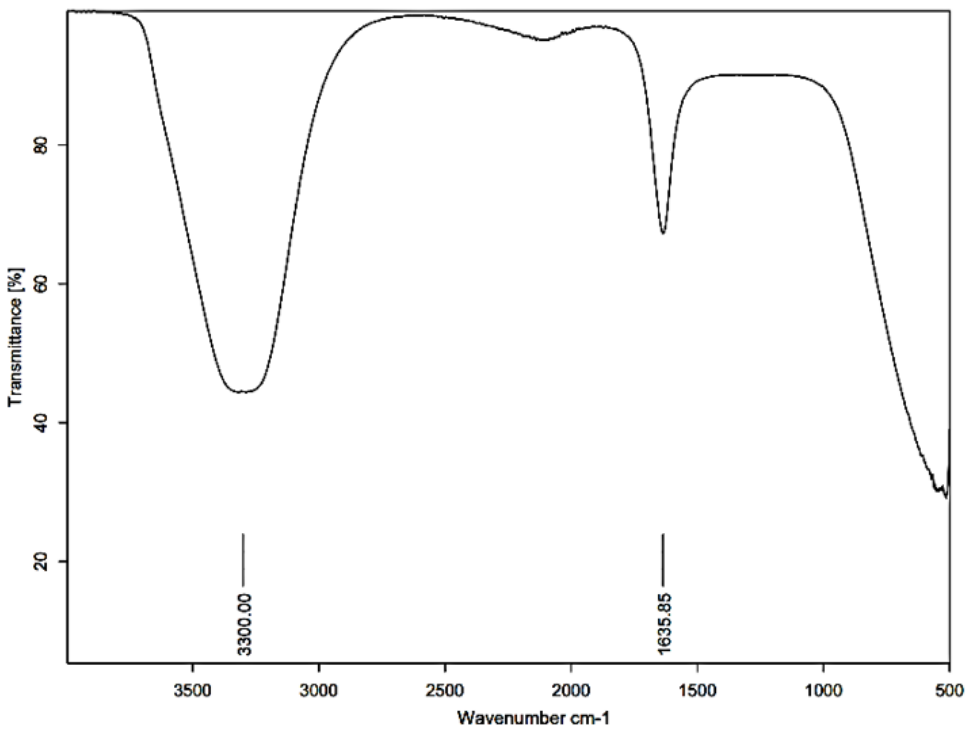

Figure 3. FTIR (Fourier Transform Infra-Red) testing

Figure 3 is the result of FTIR testing with a concentration of 5 grams of bitter melon peel and 75 ml of distilled water with a variation of sample time in the microwave for 15 minutes showing that the characteristic absorption peak in the form of O-H bonds at wave number 3299.84 cm-1 and there are C=C bonds with absorption at wave number 1635.34 cm^{-1}. These results are by research [1] in which there are O-H, C-H, and C=C bond functional groups, research [16] also successfully synthesized C-dots from *moringa oleifera* as a potentiometric sensor with FTIR results showing at 1593 cm^{-1} and also at 1433 cm^{-1} which indicates the presence of C-C bands. A small C-O stretching vibrational mode was also observed at 1049 cm^{-1}.

Conclusions

Based on the results of this study, it can be concluded that the synthesis of C-dots from bitter melon peel base material has been successfully carried out using the bottom-up method of microwave irradiation technique with a mass variation of 5 grams of bitter melon peel and 75 ml of distilled water with a heating time of 15 minutes. UV-Vis spectrophotometer test results showed

Submitted : April 24, 2024
Accepted : May 21, 2024
Online : May 31, 2024
DOI : 10.19184/cerimre.v7i1.47636

a peak wavelength of 206 nm and absorbance of 3.311. FTIR test results show the presence of O-H and C=C functional group bonds indicating that this synthesis process has been successfully carried out.

ACKNOWLEDGMENTS
The author would like to thank all parties involved who cannot be mentioned one by one in this research, and to the BRIN (National Innovation Research Agency) who have helped in the sample testing process as well.

References

[1] A. Qurrata A'yun and W. S. B. Dwandaru, "Sintesis Dan Karakterisasi Nanomaterial Carbon Dots Berbahan Dasar Ampas Teh Menggunakan Pemanasan Presto Synthesis and Characterization of Nanomaterial Carbon Dots Based on Tea Dress Using Pressure Cooker," no. 3, pp. 26–32, 2021.

[2] D. Triwardiati and I. R. Ermawati, "Analisis Bandgap Karbon Nanodots (C-Dots) Kulit Bawang Merah Menggunakan Teknik Microwave," *Prosiding Seminar Nasional Teknoka*, vol. 3, no. 2502, pp. 25, 2018, doi: 10.22236/teknoka.v3i0.2810.

[3] P. A. Putro and A. Maddu, "Sifat Optik Carbon Dots (C-Dots) dari Daun Bambu Hasil," *Wahana Fisika*, vol. 4, no. 1, pp. 47–55, 2019.

[4] A. Qurrata, Isnaeni, D. Tahir, N. M. Ramlan, and R. H. Putri, "Perbandingan Sifat Optik Karbon Dots (C-Dots) dari Daun Mangga Kering dan Segar," *Prosiding Seminar Nasional Quantum*, vol. 25, pp. 626–631, 2018.

[5] S. Fatimah, I. Isnaeni, and D. Tahir, "Sintesis dan Karakterisasi Fotoluminisens Carbon Dots Berbahan Dasar Organik dan Limbah Organik," *Positron*, vol. 7, no. 2, pp. 37, 2018, doi: 10.26418/positron.v7i2.22660.

[6] P. A. Putro and A. Maddu, "Sifat Optik Carbon Dots (C-Dots) Dari Daun Bambu Hasil Sintesis Hijau Berbantukan Gelombang Mikro," *Wahana Fisika*, vol. 4, no. 1, pp. 47, 2019, doi: 10.17509/wafi.v4i1.15569.

[7] A. Rosyada, S. Sugiarti, and I. H. Suparto, "Synthesis of Carbon Dot Nanoparticles (C-Dot) from Seeds and Seedpods of Kesumba Keling (Bixa orellana) using Hydrothermal and Solvothermal Methods," *Jurnal Kimia Sains dan Aplikasi*, vol. 26, no. 6, pp. 204–210, 2023.

[8] Y. S. Asmara, A. R. Maharani, L. S. Aulia, and I. A. Dwi Astuti, "Perbandingan Sifat Optik Cdots Berbahan Daun Binahong (Anredera Scandes L.) Segar Dan Kering Menggunakan Metode Bottom Up," *Jurnal Inovasi Penelitian dan Pembelajaran Fisika*, vol. 3, no. 2, pp. 51, 2022, doi: 10.26418/jippf.v3i2.56837.

[9] A. R. C. Dewi, M. P. Aji, and S. Sulhadi, "Absorbance Spectrum Carbon Nanodots (C-Dots) Daun Tembakau," p, 2016, doi: 10.21009/0305020225.

Submitted : April 24, 2024
Accepted : May 21, 2024
Online : May 31, 2024
DOI : 10.19184/cerimre.v7i1.47636

[10] R. Kusumaningtyas, W. Maulina, and S. Supriyadi, “Characterization of Carbon Derived from Water Hyacinth as a Renewable Energy Sources,” *Computational And Experimental Research In Materials And Renewable Energy*, vol. 1, no. 1, pp. 6, Nov. 2018, doi: 10.19184/cerimre.v1i1.19543.

[11] M. Ghiffari, W. Maulina, and A. T. Nugroho, “Study of Dielectric and Adsorption Properties of Activated Carbon Prepared from Water Hyacinth using KOH as an Activating Agent,” *Computational And Experimental Research In Materials And Renewable Energy*, vol. 3, no. 1, pp. 38, May 2020, doi: 10.19184/cerimre.v3i1.26417.

[12] H. H. Jing, F. Bardakci, S. Akgöl, K. Kusat, M. Adnan, and S. Sasidharan, “Quantium Dot 5.Pdf,” 2023.

[13] C. N. Rahmi, S. Sugiarti, and A. D. Yuliani, “Karbon dots (C-dots) dari Bahan Hayati untuk Deteksi Logam Berat,” *ALCHEMY Jurnal Penelitian Kimia*, vol. 19, no. 2, pp. 234, 2023, doi: 10.20961/alchemy.19.2.61881.234-246.

[14] J. Elfino and W. S. B. Dwandaru, “Sintesis dan Karakterisasi Carbon Nanodots Berbahan Dasar Limbah Biji Kopi Menggunakan Metode Pemanasan Oven,” *Jurnal Ilmu Fisika dan Terapannya*, vol. 9, no. 1, pp. 1–7, 2022.

[15] D. Novita and A. Astuti, “Sintesis dan Karakterisasi Sifat Optik Nanokomposit Fe3O4@CQD (Carbon Quantum Dots),” *Jurnal Fisika Unand*, vol. 12, no. 2, pp. 310–315, 2023, doi: 10.25077/jfu.12.2.310-315.2023.

[16] M. Muthukumaran, G. Dhinagaran, V. Narayanan, T. Raju, and K. Venkatachalam, “A green synthesis, characterization of highly luminescent carbon dots from Moringa oleifera gum application as an efficient potentiometric sensor for Hg2+ toxic metal ions,” *Journal of the Indian Chemical Society*, vol. 96, no. International Conference on Advances in New Materials (ICAN), pp. 78–80, 2019.