



Effect of Addition of Seaweed (*Sargassum* sp.) Charcoal with Pure Graphite on the Microstructure of Graphene Oxide Synthesized by the Modified Hummer's Method

Gebby Wevi Angraini^{1*}, Ramli^{1,2}

¹ Department of Physics, Universitas Negeri Padang, Padang 25131, Indonesia

² Nanoscience and Nanotechnology Research Group, Department of Physics, Universitas Negeri Padang, Padang 25131, Indonesia

Article History

Received : September, 16th 2023

Revised : September, 22nd 2023

Accepted : September, 25th 2023

Published : September, 30th 2023

DOI:

<https://doi.org/10.24036/jeap.v1i2.18>

Corresponding Author

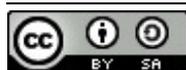
*Author Name: Gebby Wevi

Angraini

Email: gebbywevia@gmail.com

Abstract: Graphite acts as a source of carbon which is used in the synthesis of graphene oxide. Graphite has a fairly high price, so there are limitations to the use of graphite on a large scale. Brown sea grass (*Sargassum* sp.) contains carbon and is not yet well exploited in Indonesia, so experiments can be done by mixing graphite and *Sargassum* sp. to minimize excessive use of graphite. The purpose of this study is to determine the addition of *Sargassum* sp. charcoal could affect the microstructure of graphene oxide synthesized using the modified Hummer method. Where a comparison of 5 variations of the composition of pure graphite and *sargassum* sp. charcoal was carried out, namely (100:0; 70:30; 60:40; 50:50, and 0:100) %. The resulting graphene oxide was characterized by X-Ray Diffraction (XRD), Fourier Transform Infrared (FTIR), and Scanning Electron Microscope (SEM). It can be concluded that the addition of *Sargassum* sp. charcoal to pure graphite influences the microstructure of the graphene oxide. In the XRD test, an average crystal size of 24–33 nm with a cubic crystal structure was obtained; in the FTIR test, there was a bond between carbon (C), hydrogen (H), and oxygen (O); and in the SEM test, the average particle size was 1647–1887 nm. If 30% *Sargassum* sp. charcoal is added to 70% pure graphite, the larger the particle size. This causes the surface pores to become larger so that their properties as supercapacitors are better produced and have structures that tend to be like pieces.

Keywords: Graphene Oxide, Graphite, Microstructure, Modified Hummers Method, Seaweed (*Sargassum* sp.)



Journal of Experimental and Applied Physics is an open access article licensed under a Creative Commons Attribution ShareAlike 4.0 International License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. ©2023 by author.

How to cite:

G. W. Angraini, 2023, Effect of Addition of Seaweed (*Sargassum* sp.) Charcoal with Pure Graphite on the Microstructure of Graphene Oxide Synthesized by the Modified Hummer's Method, *Journal of Experimental and Applied Physics*, Vol.1, No.2, page 74-87. <https://doi.org/10.24036/jeap.v1i2.18>

1. Introduction

Seaweed in Indonesia has promising potential and can be used as a commodity that plays a role in the movement of national economic progress. Indonesia is the second-largest producer of seafood in the world after the Philippines. Seaweed in Indonesia is a fishery product in first position with a percentage of 69% based on data from the Ministry of Marine Affairs and Fisheries (KKP) in 2018. One of the species of seaweed that is quite abundant in Indonesia is *Sargassum* Seaweed [1]. *Sargassum* sp. is an aquatic plant that has a brown color, is relatively large, and grows on a strong base substrate. Generally, seaweed grows wild and still needs to be properly utilized. *Sargassum* sp has a carbon content of around $29.5\% \pm 1.32$, while in the substrate it is $1.98\% \pm 0.90$, and the estimated average value of stored carbon is 4.6 kg C/ m^2 [2]. Carbon was one of the first elements to be recognized and a unique chemical element. Carbon materials are used in many applications due to their structural diversity and unique properties, ranging from chemical bonds between carbon atoms to nanostructures, crystallite alignment, and microstructures [3]. Charcoal is a porous solid containing 85-95% carbon [4]. Activated carbon can be prepared in two steps: carbonization and activation. Carbonization is a process in a room without oxygen and other chemicals. Meanwhile, activation is a carbon processing method that aims to open or enlarge pores by breaking hydrocarbon bonds or oxidizing surface molecules so that carbon changes its physical and chemical properties. That is the surface area increases and affects the adsorption capacity [5]. Carbon is found free in three allotropic forms: amorphous, diamond, and graphite. In allotropes of carbon, diamond is the hardest substance in nature and is transparent in color. Amorphous carbon is the term for impure forms of elemental carbon, such as charcoal, coal, and soot [6]. Diamond and graphite are three-dimensional (3D) crystalline forms of the element carbon. Pure graphite is composed of sp^2 hybridized bonds, whereas pure diamond consists of sp^3 hybridized bonds. Diamond carbon atoms are arranged in a lattice, a variation of the face-centered cubic (fcc) crystal structure. It has excellent physical qualities, most of which come from the strong covalent bonds between its atoms (sp^3 hybridization). Unlike diamond, graphite is specifically described as consisting of a lamellar (layered, planar) structure. In each layer, the carbon atoms are arranged in a hexagonal lattice with a spacing of 0.142 nm (sp^2 hybridization) and the spacing between the planes [3].

Graphite is one of the softest and blackest-gray materials and is a good conductor of electricity [6]. The porous carbon material is commonly used as a supercapacitor because it has a high energy density potential, high electrical conductivity, a wide surface or good porous accessibility, relatively inexpensive production costs, and is easy to obtain. Supercapacitors are attractive in electric energy storage technology because they have a higher energy density compared to conventional capacitors and a higher power density than batteries. Graphene is a material made of graphite in the form of carbon, where each carbon atom has sp^2 bonds with a two-dimensional structure and is tightly packed in a crystal lattice like a honeycomb [7]. Graphene is a material composed of carbon atoms in a hexagonal lattice arrangement with a thickness of one atom. The structure of graphene that is stacked into many layers where one layer with another layer is Van Der Waals bonded is called graphite material [8]. Graphene is a one-atom-thick planar layer of sp^2 hybridized carbon atoms arranged in a hexagonal structure [7]. The unique design of graphene is that the carbon atoms (C) arrangement is very regular and almost perfect [9]. Graphene can be synthesized by processing graphite into single graphene sheets. In simple terms, graphite is oxidized to graphite oxide (GO), then the graphite oxide sheets are exfoliated in water to form graphene oxide [10]. Graphene oxide (GO) is a monolayer form of graphite oxide obtained from exfoliating graphite oxide into sheets by sonication or stirring [11].

Brodie first researched GO in 1859. Brodie researched the structure of graphite by looking at the reactivity of the graphite sheets. Brodie used $KClO_3$ and HNO_3 in the reaction process. Further research was conducted by Staudenmaier using a mixture of H_2SO_4 and HNO_3 , followed by the addition of $KClO_3$ little by little. In 1958, Hummers invented an alternative method for synthesizing GO using $KMnO_4$ and $NaNO_3$ as well as H_2SO_4 . The methods used for GO synthesis include inefficient micromechanical exfoliation methods, epitaxial growth methods, and the Chemical Vapor Decomposition (CVD) method, which involves quite expensive costs, as well as the most effective hummer methods currently used. The advantage of the Hummers method is that the reaction process does not take long and is very safe because it uses $KMnO_4$ does not produce explosives (explosives), such as ClO_2 produced from $KClO_3$, using $NaNO_3$ instead of HNO_3 , which can produce acid fog [12].

In previous research on GO synthesis, many used graphite as a carbon source. Graphite has a fairly high price, so there are limitations to the use of graphite on a large scale. Brown seaweed (*Sargassum* sp.) contains carbon, which can be used to synthesize graphene oxide. *Sargassum* sp. in Indonesia has not been properly utilized, so experiments can be conducted to mix graphite and *sargassum* sp. charcoal to minimize the excessive use of graphite. The purpose of this study is to determine the addition of *sargassum* sp. charcoal could affect the microstructure of graphene oxide. The graphene oxide synthesis method used was the modified Hummer method. Where a comparison of 5 variations of the composition of pure graphite and *sargassum* sp. charcoal was carried out, namely (100:0; 70:30; 60:40; 50:50, and 0:100) %. To determine whether or not graphene oxide is formed, characterization is carried out using X-Ray Diffraction (XRD), Fourier Transform Infrared (FTIR), and Scanning Electron Microscope (SEM).

2. Materials and Method

The sample used was *Sargassum* sp. taken from the shallow sea waters of Kabung Bay, Bungus Bay, Kabung District, Padang City. The experiment uses the Hummer-modified method. The first stage is the preparation of the sample, which can be seen in Figure 1.



Figure 1. Sample Preparation (a) Drying (b) Carbonization (c) Sifting

Figure 1 shows the first stage is the sample preparation stage which includes drying the sample using an oven for 2 hours at 105°C . After the sample is washed and dried in the sun for one day, the carbonization/combustion process uses a furnace for 30 minutes at a predetermined temperature of 300°C . Cooling, grinding, and sifting with a size 170 mesh will produce activated carbon in powder form. The second stage is carbon activation, which can be seen in Figure 2.

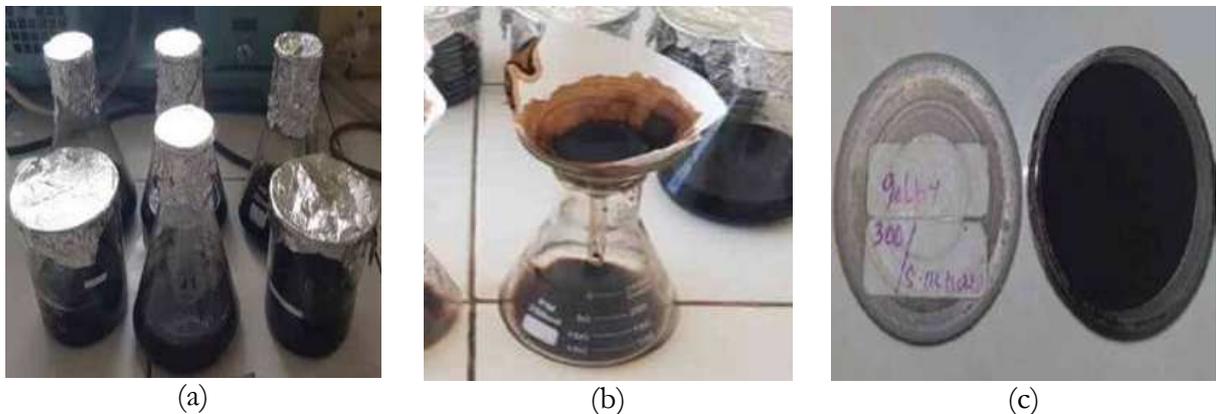


Figure 2. Carbon Activation (a) Sample Deposition (b) Filtrate (c) Carbon Powder

Figure 2 shows the second stage of the carbon activation process using 8 grams of solid potassium hydroxide (KOH) solution with a concentration of 10% in 8 grams of *Sargassum* sp. carbon and 100 ml of aquadest. The sample deposition is carried out for 24 hours. After which the filtration is performed using filtering paper and washed with aquadest until it has a neutral pH (pH 6 to 7) and dried in the oven at 110°C for 3 hours. This process produces carbon powder [13]. The third stage is graphene oxide synthesis, which can be seen in Figure 3.

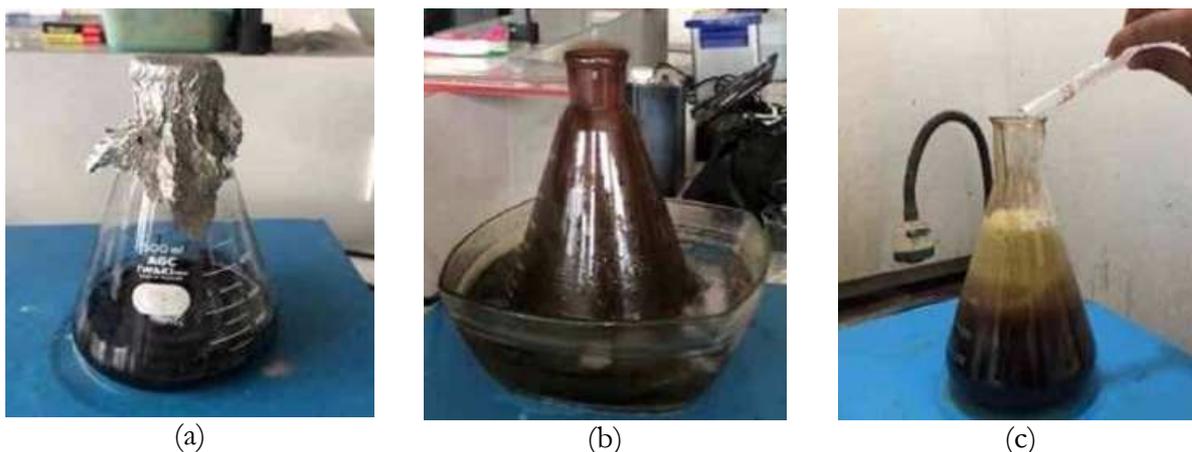


Figure 3. Graphene Oxide Synthesis (a) Stirring Process (b) Added KMnO_4 (c) Added H_2O_2 & Aquadest

Figure 3 shows the third stage is the process of synthesizing graphene oxide using a modified Hummer method, where we vary the composition of pure graphite only and mix pure graphite with sargassum sp. carbon with a ratio of 70:30; 60:40; 50:50. The mass determined is pure graphite as much as 1.5 grams; with a ratio of 70:30 as much as 0.525 grams of pure graphite with 0.225 grams of sargassum sp. carbon; with a ratio of 60:40 as much as 0.45 grams of pure graphite with 0.3 grams of sargassum sp. carbon; with a ratio of 50:50 as much as 0.375 grams of pure graphite and 1.5 grams of sargassum sp. carbon. The first synthesis process is to weigh a predetermined mass and 0.75 grams of NaNO_3 .

Then it is put into an Erlenmeyer which already has a magnetic bar in it. After that, 98% H_2SO_4 sulfuric acid solution was added to as much as 34.5 mL and the Erlenmeyer tip was closed using aluminum foil. Then stir for 20 minutes at a constant speed of 250 rpm until the solution turns black. Place the Erlenmeyer on the ice bath, then continue stirring for 2 hours on the hot plate.

Next, slowly add 4.5 grams of KMnO_4 powder to keep the temperature below 20°C . This process must be carried out carefully so that the mixture does not explode and the synthesized carbon is not reduced. After adding the KMnO_4 to the mix, remove the ice bath from the hot plate and stir the mixture for 30 minutes. This process is carried out for the oxidation process to occur ideally until the solution changes color to dark green. Then 69 mL of aquadest was added slowly using a pipette and stirred for 20 minutes. In this process, the temperature of the solution will rise because when aquadest is added, an endothermic reaction occurs, which causes an increase in the mixture's temperature. Then 100 mL of aquadest was added, followed by 1.5 mL of 30% H_2O_2 . Where this aims as a process to stop the reaction and remove the remaining KMnO_4 . Next, the last 50 ml of aquadest was added to the mixture [14]. The fourth stage is the graphene oxide dispersion process, which can be seen in Figure 4.



Figure 4. GO Dispersion Process (1) Sonication (2) Centrifugation (3) GO Powder

Figure 4 shows the fourth stage the GO dispersion process by sonicating for 2 hours to exfoliate the GO into a thin layer. The sonication process was carried out using an ultrasonic cleaner at a room temperature of 35°C for 2 hours then the solution was precipitated for 24 hours to form a solid and a liquid phase [8]. Furthermore, the centrifugation process was carried out using a centrifuge at a speed of 2500 rpm for 15 minutes. Furthermore, GO neutralization was carried out manually by precipitating the mixture to form solid and liquid phases. Then the liquid phase was replaced with aquadest repeatedly to obtain a neutral pH of 7. After getting a neutral pH, GO was filtered and separated from the liquid phase and dried in an oven at 80°C for 8 hours. This process produces carbon graphene oxide powder [11]. The final stage is the sample Characterization Instrument for graphene oxide, which can be seen in Figure 5.

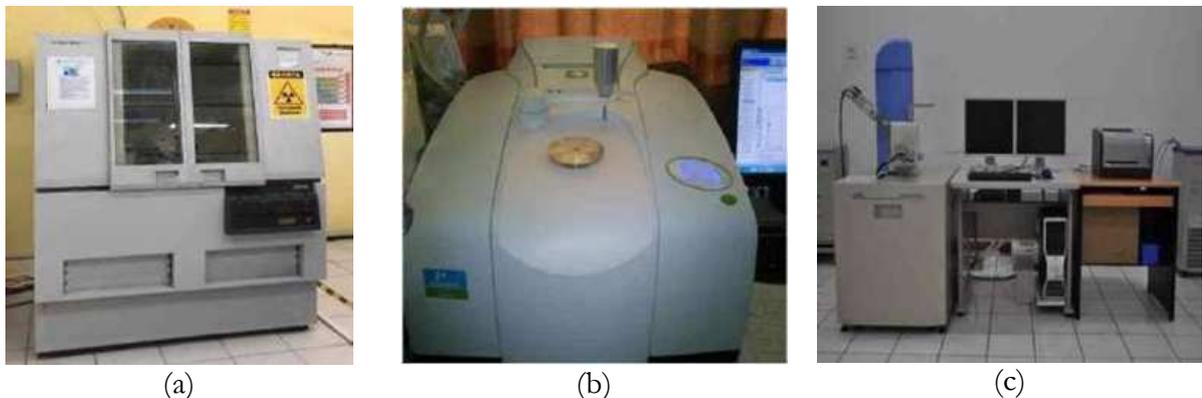


Figure 5. Sample Characterization Instrument (a) XRD (b) FTIR (c) SEM

Figure 5 shows the final stage is the characterization of graphene oxide using X-Ray Diffraction (XRD), Fourier Transform Infrared (FTIR), and Scanning Electron Microscope (SEM). X-Ray Diffraction (XRD) to determine the crystal structure formed. FTIR is used to identify the functional groups of the sample. This FTIR data will later support Scanning Electron Microscope (SEM) data to analyze the microstructural properties of graphene oxide, and SEM is used to observe sample surface morphology and particle size [15]. In this study, composition variations were carried out to determine the effect on the resulting GO and to confirm whether there was still GO or not in the resulting GO variations (through XRD peak results data). The broadening of a diffraction peak from a widening sample can originate from the effects of crystal size and microstrain (lattice strain due to the movement of the unit cell around its normal position). From the XRD characterization data, crystal size can be estimated using the Scherrer formula expressed in the form of equation 1 [16].

$$D = \frac{K\lambda}{\beta \cos(\theta)} \quad (1)$$

Where:

D = the crystal size

K = the form factor of the crystal

λ = the wavelength of the X-rays

β = the value of Full Width at Half Maximum (FWHM)

θ = Angle of diffraction (degree)

The width of the diffraction peak is also affected by microstrain (lattice strain), which is the effect of moving a unit cell around its normal position. This is often produced by several factors, including (1) Non-uniform lattice distortion, which the surface tension of nanocrystals, crystal shape morphology, and interstitial impurities can cause. (2) Dislocations, (3) Boundary domains between phases, which are formed when the arrangement of the material structure is disturbed by the arrangement transformation. Microstrain occurs due to the imperfections of the crystal grid, including emptiness and dislocation. The microstrain contribution to the FWHM widening and Integral Breadth at the diffraction peak is expressed in the form of equation 2 [16].

$$\beta c(2\theta) = C\varepsilon \frac{\sin(\theta)}{\cos(\theta)} \quad (2)$$

Where:

ε = strain (change in size divided by original size)

C = constant.

As well as FTIR testing is carried out to identify the types of molecular chemical bonds by way of infrared passing through the sample then, the sample absorbs some of the incoming infrared, and some of the infrared that is not absorbed passes to the detector. The results will later appear in the computer and confirm whether a GO functional group is still being produced. From the results of SEM testing, the surface morphology of graphene oxide can be obtained, such as the size of the particles making up the resulting graphene oxide. Although determining the exact structure of GO is tricky, it is known that in GO, adjacent aromatic networks in graphene are disrupted by different functional groups. GO has a layered structure similar to graphite. However, the plane of carbon atoms in GO is heavily dotted with oxygen-containing groups, which widens the interlayer spacing and makes the thick atomic layer hydrophilic.

3. Results and Discussion

The results of data analysis of graphene oxide by XRD with five variations of the composition of pure graphite and seaweed charcoal (*Sargassum sp*), namely (100:0; 70:30; 60:40; 50:50 and 0:100) %. This can be seen in Figure 6 below.

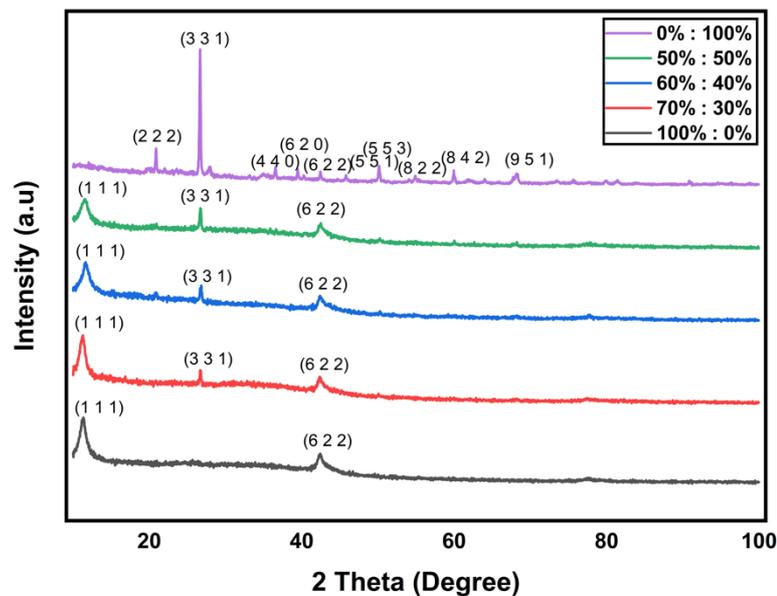


Figure 6. GO XRD Result from Data with Composition Variations

Based on Figure 6, the diffraction patterns of graphene oxide and variations in the composition of graphite and *Sargassum sp.* charcoal, including 100:0, 70:30, 60:40, 50:50, and 0:100, using Origin software. In the 100% graphite composition, it can be seen that the deposition results formed two peaks, namely the angle of 11.0743° with the peak Millers index related to the phase (1 1 1) and the angle of 42.3632° with the peak Millers index related to the phase (6 2 2).

Average lattice parameters on ICDD code 01-082-2261. In the 70:30 composition, it can be seen that the deposition results formed as many as three peaks with angles of 11.2552°, 26.6926° and 42.3316° with the peak Millers index related to the phase (1 1 1), (3 3 1) and (6 2 2). The average lattice parameter on ICDD code 01-082-2261. In the 60:40 composition, it can be seen that the deposition results formed as many as three peaks with angles of 11.1208°, 26.7632° and 42.3739° with the peak Millers index related to the phase (1 1 1), (3 3 1) and (6 2 2). Average lattice parameters on ICDD code 01-082-2261. In the 50:50 composition, it can be seen that the deposition results formed as many as three peaks with angles of 11.0718°, 26.6982° and 42.3924° with the peak Millers index related to phase (1 1 1), (3 3 1) and (6 2 2). Average lattice parameters on ICDD code 01-082-2261. In the composition of 100% sargassum sp, it can be seen that the deposition results formed as many as ten peaks with angles of 22.0592°, 27.9252°, 36.5408°, 39.4921°, 42.5210°, 45.8157°, 50.1790°, 54.8646°, 59.9855° and 68,2482° with the peak Millers index related to the phase (2 2 2), (3 3 1), (4 4 0), (6 2 0), (6 2 2), (5 5 1), (5 5 3), (8 2 2), (8 4 2) and (9 5 1). The composition of Sargassum sp., 100% has many crystal fields, resulting in its peak intensity becoming stronger. Average lattice parameters on ICDD code 01-082-2261. The following is Table 1 of crystal sizes and microstrain.

Table 1 shows the average values of crystal size and microstrain. Based on the results of the diffractogram pattern, it can be used to determine the average crystal size using the Scherrer equation obtained from the peak value of the FWHM. Variations in the composition of graphite and Sargassum sp. charcoal, including (100:0, 70:30, 60:40, 50:50, and 0:100) %. In the 100% graphite composition, the average crystal size value is 32.56138 nm, and the average microstrain value is 3.783×10^{-3} . In the 70% graphite: 30% sargassum sp. composition, the average crystal size value is 21.78806 nm, and the average microstrain value is 8.224×10^{-3} . In the 60% graphite: 40% sargassum sp. composition, the average crystal size value is 28.352 nm, and the average microstrain value is 6.341×10^{-3} . In the 50% graphite: 50% sargassum sp. composition, the average crystal size value is 29.9372 nm, and the average microstrain value is 7.017×10^{-3} . In the 100% sargassum sp. composition, the average crystal size value is 24.6327 nm, and the average microstrain value is 5.628×10^{-3} .

Table 1. Crystal Size and Microstrain

Variation of Composition Graphite: Sargassum sp. Charcoal	Crystal size (nm)	Microstrain (10^{-3})
100:0	32,561	3,783
70:30	21,788	8,224
60:40	28,352	6,341
50:50	29,937	7,017
0:100	24,633	5,628

The characterization results show the crystalline structure of the graphene oxide, which is the cubic structure for all composition variations. Based on XRD (X-Ray Diffraction) data analysis on each sample, it showed that five variations of composition affect the crystal size, and there are crystal fields as well as phases that are lost and emerging. The results of graphene oxide data analysis by FTIR with five composition variations. The data obtained from the characterization will be analyzed based on the technique used. This can be seen in Figure 7 below.

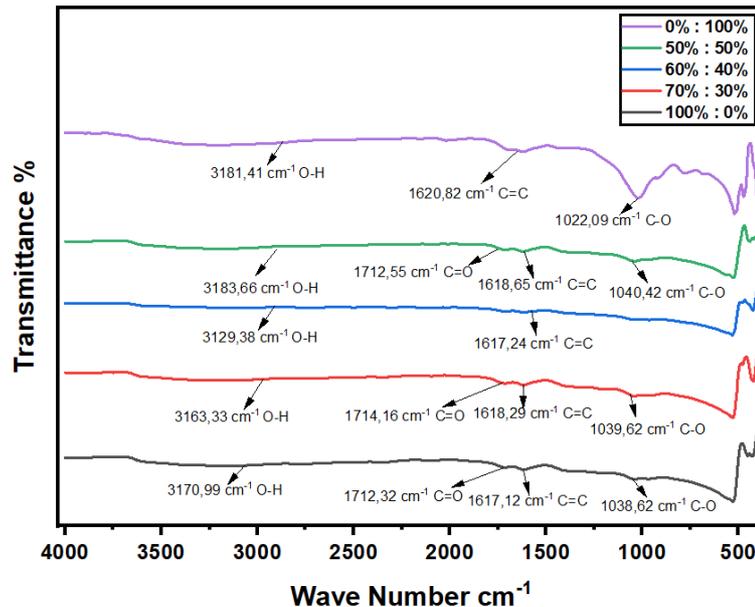


Figure 7. GO FTIR Result from Data with Composition Variations.

Based on Figure 7 FTIR test of graphene oxide from five composition variations, we can see the presence of O- H, C=O, C=C, and C-O bonds. This indicates that graphene oxide has formed in which graphene oxide contains carbon (C), Hydrogen (H) bonds, and Oxygen (O). Where the number of waves 3100–3200 cm^{-1} indicates the presence of an O-H alcohol bond with a weak and wide tip, the wave number 1710–1715 cm^{-1} shows C=O carboxylic acid bonds with a strong tip, the wheel number 1615-1620 cm^{-1} indicates C=C alkene bonding with a medium or medium tip, and the wavelength number 1020-1040 cm^{-1} shows a C-O ether bond with the tip in the area of a fingerprint. The fingerprint area contains a certain number of vibrations that cannot be explored but are specific to each organic compound. According to the results of the FTIR test above, not all GO samples that have been synthesized have the four GO function groups, which means the GO synthesis process on 60% pure graphite samples with 40% Sargassum sp. and 100% Sargassum sp. charcoal samples have not obtained good results. This occurs because there is a detector inside the GO sample that detects the appearance of other functional groups. The main functional groups of GO are the bonds C=C and O - H. The two functional groups are bound together to form the hexagonal structure of the carbon atom, which is a covalent bond. Results of graphene oxide data analysis by SEM with five variations of composition, mixing graphite with sargassum sp. charcoal. This can be seen in Figure 8 below.

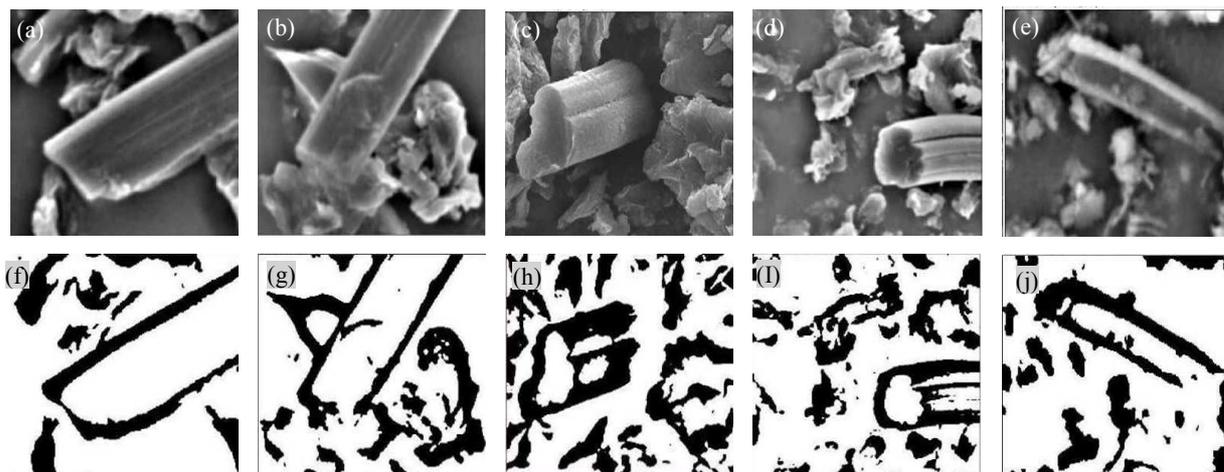


Figure 8. GO SEM Result from Data with Composition Variations, before Threshold: (a) 100:0 (b) 70:30 (c) 60:40 (d) 50:50 (e) 0:100 , after Threshold: (f) 100:0 (g) 70:30 (h) 60:40 (i) 50:50 (j) 0:100

Based on Figure 8, we carried out SEM analysis using Image-J with a magnification of 1000 times. Before the threshold, it is not very clear what the form and morphology of the particle are. After threshold, the form of the morphological structure is formed. The morphology of the size of the particle does not look uniform and shapes the different shapes of each variation of its composition. In every variation of composition, there are cavities in several variations; there is an unequal surface; and there is also an agglomeration, where there is an accumulation of particles or substances into one. The average value of the particle size of each variation of composition, which can be seen in Table 2.

Table 2. Particle Grain Size

Variation of Composition Graphite: Sargassum sp. Charcoal	Particle Grain Size (nm)
100:0	1886.512
70:30	1865.122
60:40	1533.462
50:50	1769.749
0:100	1647.896

Table 2 shows the particle analysis on SEM characterization uses Image-J with data processing using Origin software. Particle analysis using Image-J produced an average particle size for GO Graphite 100% with 1000x magnification of 1886.512 nm, and at Origin, the results obtained COD (Crystallography Open Database) 0.73217. Particle analysis using Image-J resulted in an average particle size at GO 70:30 with 1,000x magnification of 1865.122 nm, and at Origin we obtained COD 0.99276. Particle analysis using Image-J produced an average particle size at GO 60:40 with 1,000x magnification of 1533.462 nm, and at Origin the results obtained COD 0.99106. Particle analysis using Image-J produced an average particle size at GO 50:50 with 1,000x magnification of 1769.749 nm, and at Origin the results obtained COD 0.99795. Particle analysis using Image-J resulted in an average particle size in GO Sargassum sp. with 1,000x magnification of 1647.896 nm, and at Origin the results obtained COD 0.95413.

The XRD results show that the diffraction angle of the GO peak is between 26-28°, which indicates that GO is not entirely bound to the oxygen atom. In addition, there is an increase in d-spacing related to the presence of oxygen and hydroxyl functional groups in the carbon layer structure. The size of the crystal and the microstrain can affect the shape of the peak that results. The crystal size is said to be perfect when the value of the large crystal size is obtained and the microstrain value is small. Microstrain occurs due to the imperfection of the crystal grid, among other forms of emptiness and dislocation. Based on the value of the crystal size obtained, if a 50% addition of Sargassum sp. charcoal is given with a 50% pure graphite, a larger crystal size is produced.

The FTIR results show that the functional groups in GO that can be identified are O-H, C=O, C=C, and C-O bonds. This indicates that graphene oxide has formed in which graphene oxide contains carbon (C), Hydrogen (H) bonds, and Oxygen (O). Based on the value of the number of waves obtained with each variation of the composition, if given an addition of 30% Sargassum sp. charcoal with 70% pure graphite and 50% Sargassum sp. with 50% pure graphite, the wave number value on the four bonds of the resulting function group is large and can be perfectly inferred with the values of the wave count according to its specifications.

The SEM results show that the form of the morphological structure is shaped by the presence of cavities in several variations and their uneven surfaces. The accumulation of some substances causes irregular particle sizes. In each variation of the composition, there is an unequal surface and also an agglomeration, where there is an accumulation of particles or substances into one. Based on the value of particle size obtained, if the addition of 30% Sargassum sp. charcoal with 70% pure graphite is given, the larger the size of the particle produced.

4. Conclusion

Based on research that has been done regarding the effect of adding seaweed charcoal (sargassum sp.) with pure graphite to the microstructure of graphene oxide synthesized using the modified Hummer method. It can be concluded that there is an effect of the addition of sargassum sp. charcoal, as proven by some characteristic properties of graphene oxide: two-theta angles in the XRD test, obtaining average crystal size values of 24-33 nm with cubic crystal structure; the FTIR test found functional groups C-O, C = O, C=C, and O-H; and the SEM test discovered scattering on the sample surface due to the oxidation process. The result of SEM characterization can produce an average particle size of 1647–1887 nm. Solving the problem of reducing the use of pure graphite and being able to produce good graphene oxide if the addition of 30% sargassum sp. charcoal to 70% pure graphite increases the particle size, this causes the surface pores to become larger so that their properties as supercapacitors are better produced and have structures that tend to be like pieces.

Acknowledgments

The author would like to thank the Region X Research Laboratory, Bandung P3GL Laboratory, for analyzing SEM data and the Origin application for making graphics, and the Image J application, for making it easy to process particle size data in SEM.

References

- [1] A. D. Adiguna, B. Krisnamurthi, and E. Erwidodo, "Analisis Daya Saing Ekspor Rumput Laut Olahan Indonesia," *J. Agribisnis Indones.*, vol. 10, no. 1, pp. 31–39, Jun. 2022, doi: 10.29244/jai.2022.10.1.31-39.
- [2] A. Firmansyah, A. M. Riza, and D. Mahreni, "Pemanfaatan Alga Cokelat (Sargassum sp) sebagai Bioadsorben dalam Proses Penyerapan Logam Fe pada Air Sumur UPN 'Veteran' Yogyakarta," *Jur. Tek. Kim.*, 2019.
- [3] Z. Zhen and H. Zhu, "Structure and properties of graphene," in *Graphene: Fabrication, Characterizations, Properties and Applications*, Elsevier, 2017, pp. 1–12. doi: 10.1016/B978-0-12-812651-6.00001-X.
- [4] R. Dewi, Azhari, and I. Nofriadi, "Aktivasi Karbon Dari Kulit Pinang Dengan Menggunakan Aktivator Kimia KOH," 2020. [Online]. Available: www.ft.unimal.ac.id/jurnal_teknik_kimia
- [5] F. Wulandari, Umiatin, and E. Budi, "Pengaruh Konsentrasi Larutan NaOH Pada Karbon Aktif Tempurung Kelapa Untuk Adsorpsi Logam Cu 2+," 2015.
- [6] A. K. Geim and K. S. Novoselov, "The rise of graphene," *Nat. Mater.*, vol. 6, 2007, [Online]. Available: www.nature.com/naturematerials
- [7] V. Loryuenyong, K. Totepvimarn, P. Eimburanaprat, W. Boonchompoo, and A. Buasri, "Preparation and characterization of reduced graphene oxide sheets via water-based exfoliation and reduction methods," *Adv. Mater. Sci. Eng.*, vol. 2013, 2013, doi: 10.1155/2013/923403.
- [8] L. Triprayoga Sutayasa, D. I. Gusti, and M. Sanjaya, "Characterization Of Graphene From Bagasse Charcoal Using XRD And TEM," *J. Chem.*
- [9] M. Terrones *et al.*, "Graphene and graphite nanoribbons: Morphology, properties, synthesis, defects and applications," *Nano Today*, vol. 5, no. 4. Elsevier B.V., pp. 351–372, 2010. doi: 10.1016/j.nantod.2010.06.010.

- [10] M. S. Ekawati Thebora, K. Nastira Ningsih, and M. Irhash Shalihin, "Sintesis Grafena Dari Limbah Pelepah Sawit (*Elaeis Sp.*) Dengan Metode Reduksi Grafit Oksida Menggunakan Pereduksi Zn," *Khazanah Intelekt.*, vol. 3, 2019.
- [11] N. Syakir, R. Nurlina, S. Anam, A. Aprilia, S. Hidayat, and Fitrilawati, "Kajian Pembuatan Oksida Grafit untuk Produksi Oksida Grafena dalam Jumlah Besar Kajian Pembuatan Oksida Grafit untuk Produksi Oksida Grafena dalam Jumlah Besar," *J. Fis. Indones.*, vol. XIX, no. 55, 2015.
- [12] D. R. Dreyer, S. Park, W. Bielawski, and R. S. Ruoff, "The chemistry of graphene oxide," *R. Soc. Chem.*, 2010, doi: 10.1039/b917103g.
- [13] H. Alfiany and S. Bahri, "Kajian Penggunaan Arang Aktif Tongkol Jagung Sebagai Adsorben Logam PB Dengan Beberapa Aktivator Asam," *J. Nat. Sci.*, vol. 2, no. 3, pp. 75–86, 2013.
- [14] M. Hapsari, A. H. Cahyana, S. H. Oktavia, and A. R. Liandi, "Synthesis of Spirooxindole-pyrrolizidine Compounds using Fe₃O₄-GO Catalyst and Their Bioactivity Assays," *Rasayan J. Chem.*, vol. 13, no. December, 2020, doi: 10.31788/RJC.2020.1345583.
- [15] M. B. P. Honorisal, N. Huda, T. Partuti, and A. Sholehah, "Sintesis dan karakterisasi grafena oksida dari tempurung kelapa dengan metode sonikasi dan hidrotermal," *Tek. J. Sains dan Teknol.*, vol. 16, no. 1, p. 1, Jun. 2020, doi: 10.36055/tjst.v16i1.7519.
- [16] M. Sumadiyasa and I. B. S. Manuaba, "Penentuan Ukuran Kristal Menggunakan Formula Scherrer, Williamson-Hull Plot, dan Ukuran Partikel dengan SEM," *Bul. Fis.*, vol. 19, pp. 28–35, 2018.