ISSN 2347 - 3983
Volume 8. No. 6, June 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter44862020.pdf
https://doi.org/10.30534/ijeter/2020/44862020

Utilization of Graphite Bars on Used Batteries Become Coating Material for Steel

Prantasi Harmi Tjahjanti [1 *], Rachmat Firdaus [1], Iswanto [1], Rizky Nurcahyo [1], Sofia Ariyani [2], Andita N.F.Ganda [3]
[1] Department of Mechanical Engineering, Faculty of Science and Technology, Universitas Muhammadiyah Sidoarjo, Sidoarjo, Indonesia
[2] Department of Electrical Engineering, Faculty of Engineering Universitas Muhammadiyah Jember, Jember, Indonesia .
[3] Department of Mechanical Engineering, State University of Surabaya, Surabaya, Indonesia
* Corresponding author: prantasi@gmail.com

ABSTRACT

The purpose of this research is to utilize graphite rods in use batteries to be processed into graphene oxide as a coating on steel to be resistant to corrosion. Liquid exfoliation and surfactant methods used to make Corrosion Penetration Rate (CPR) method for calculating weight loss. Corrosion monitoring by immersing samples of low carbon steel in a solution of 0.1 M NaCl for 2, 4, and 6 hours. Final results showed that low carbon steel samples have CP R values that have the smallest CPR is 0.5 gram graphite bars on using batteries + 25ml aquadest + 25ml H_2SO_4. The value of not exceeding the standard permissible rate (0.5 mm/ yr). Applications for this study showed that CPR of low carbon steel that coated using graphene oxide from graphite bars on using batteries more lower than CPR of steel with a coating in general (galvanized).

Key words: Corrosion, Corrosion penetration rate, Graphite, Coating material

I. INTRODUCTION

The end of 2018, electronic waste collected reached 5.32 tons. The mobile phone's electronic waste alone has collected 1,700 units. Meanwhile, since the beginning of 2018 until now, it is estimated to reach more than 2 tons.

One of the electronic waste uses batteries which are included in hazardous and toxic material waste (B3)), because they contain various heavy metals, such as mercury, manganese, lead, cadmium, nickel and lithium, which are harmful to the environment and our health [1].

There are various types of batteries, but the most commonly used is the type of dry-cell battery. Dry cell batteries are further divided according to fillers, namely alkalin carbon filler material has been utilized ZnC battery carbon powder mixed with acid + detergent and not mixed with detergent. In the results of synthesis that is assisted by detergents, the peaks are detected in the wavelength range of 239 nm to 262 nm which are characteristic of Graphene Oxide (GO) material. Then in the synthesis results without the assistance of detergents, The peaks occur in the wavelength range from 227 nm to 244 nm, which is also a function of GO material. However, the characteristics of GO materials synthesized with the help of detergents give better results than the results of synthesis without the assistance of detergents. [3].

Other research aims to synthesize graphene oxide (GO) from zinc-carbon battery (ZnC) waste materials using a liquid sonication peel (LSE) method using piezoelectric tweeter samples as loudspeakers and to test the optical absorption of GOs produced using a UV-Vis spectrophotometer which varies the mass of graphite materials obtained from ZnC battery residues. The best GO output based on the UV-Vis results is obtained in samples with 0.8 and 1.0 grams of graphite powder which undergo a red shift from 223.5 nm to 227.5 nm [4].

Ferella et al [5] in their research of a recycling process for the recovery of zinc and manganese from Spent Alkaline and zinc-carbon batteries show that the economic viability of this project is shown by spent alkaline and zinc-carbon batteries, assuming a battery price surcharge of 0.5 D kg−1, with an investment return of 34.5 per cent, a gross margin of 35.8 per cent and a payback period of about 3 years. Work to recycle graphite from batteries and other sources, to exfoliate it using surfactants and electrochemical methods, and to study the effects of exfoliated graphene. Local waste collection firms collected batteries based on graphene, and the graphite used was removed from the batteries by hand. Upon washing and cleaning, the graphite stalks collected

are exfoliated to single layers using an electrochemical exfoliation process [6].

Until now, research on graphite rods from using batteries that can be used as graphene oxide, no one has been applied to layers of steel or other metals to protect from corrosion attacks. The purpose of this study is to utilize graphite rods in use batteries into graphene oxide material used to coat steel to be more resistant to corrosion. Some researchers investigated the effect of the ion mechanism and the voltage to the materials [7] – [9]

2. MATERIALS AND METHOD

2.1 Making Graphite Bars into Graphene Oxide

Making Graphene Oxide (GO) from using batteries starts with breaking the contents of the used batteries and taking the graphite rods inside. Then the graphite rod is finely ground and filtered with a fine sieve. (Figure 1).

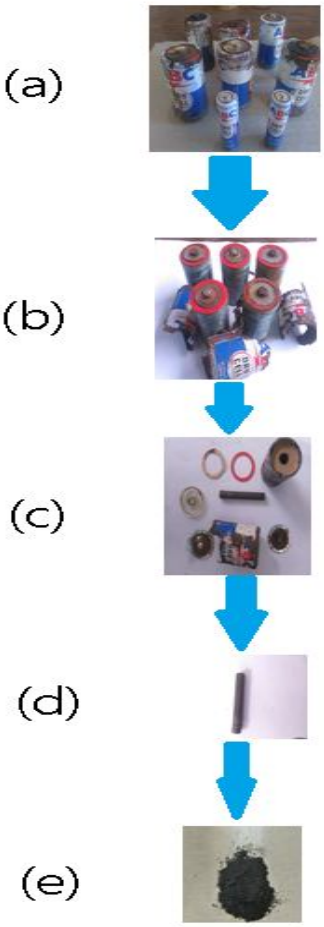

Figure 1: Taking graphite bars from used batteries.(a) Used batteries (b) Apart from the outer layer of the battery (c) Separate all battery component parts (d) Carbon battery rod (e) Carbon battery powder

The next step is finding powder that has been obtained from the carbon battery rod is dissolved in sulfuric acid (H_2SO_4) and distilled water. The composition made is shown in Table 1, while the solution that has been made in Figure 2. The solution made must be tested using UV-Vis Spectrophotometry, which functions to determine the light energy at the wavelength of the solution. Ultraviolet (UV) rays have wavelengths between 200-400 nm, and visible rays have wavelengths of 400-750 nm. The solution in Figure 2, is silenced within 2 days.

Table 1: Composed of carbon battery rod from using batteries, H_2SO_4 and aquades

Sample	Powder of carbon battery rod (gram)	H_2SO_4 (ml)	Aquades (ml)
A	0.5	30	20
B	0.5	25	25
C	0.5	20	30

Figure 2: Solution of carbon battery rod from using batteries, H_2SO_4 and aquades

2.2 Corrosion Test

Prepare a low carbon steel plate (Figure 3), then cut into a beam for a corrosion test, sample 2.95 cm thick, 10 cm long and 3 cm wide (Figure 4), and coated with a 0.01 mm thick coating (Figure 5). Initial weighing (mo) for the specimen was performed.

Figure 3: Low carbon steel plate

Figure 4: Samples plate for corrosion test

Figure 5: Samples plate after coating

Corrosion test in which the sample beam was immersed for 6 hours in a sea water solution (0,1 M NaCl). Immersed in a sea water solution (0.1 M NaCl) for 6 hours. Samples were collected and washed every 2-hour period.

The measuring unit Corrosion Penetration Rate (CPR) is expressed in mile per annum (mpy) or mm/yr. Where parameters are content density (D), test time (T), and weight to be calculated during the test cycle, the equation can be used to measure the CPR:

$$CPR = \frac{KW}{ADT} \quad (1)$$

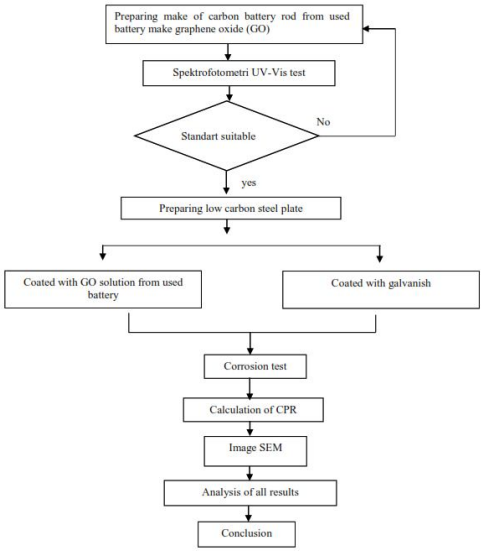

Figure 6: Research Flowchart

Unit: mile (mpy), or mm (mm/yr) per year. W is weight loss (mg) = mo m during processing, m is weight after corroding, the weight before corroding is weekly. K is constant depend on the unit used where K= 534 uses the mpy. When K= 87.6, using mm/yr. D is density (gr/cm3), T is time (hours), A= surface area (cm^2) (the same mpy units of wear as CPR).The value / coefficient was still appropriate when the CPR value was less than 20 mpy (0.5 mm / yr). Figure 6 shows clearly in the flow chart or the research process.

2.3. Result of UV-VIS Test

The results obtained from the UV-VIS test to find out how many layers of graphene by the liquid exfoliation method use wavelengths of 200-800 nm in a variety of different sample composition (Table 2). The graph of UV-VIS test results in Figure 5, shows that the π max analysis results is more higher than the π max of absorbance value.

Table 2: Result of UV-VIS Test

Samples	π Max (nm)	Absorbance
A	300	0.465
B	325	0.335
C	345	0.132

2.4. Result of CPR (immersed in 0.1 M NaCl)

The result for CPR data obtained from time effect in a wet corrosion test when dipped in a 0.1 M NaCl solution as shown in Table 3, respectively. The graphene oxide coated steel has lowest value of corrosion rate when dipped in solution of 0.1 M NaCl for six hours. It showed that corrosion attack is slow, if applied to a coated galvanized sample.

Table 3. CPR (0.1 M NaCl) obtained by wet corrosion test

Sample	Time (hours)	The average of CPR (mm/yr) x 10^{-4}
GO A	2	81.7
	4	55.9
	6	41.2
GO B	2	5.2
	4	4.5
	6	3.9
GO C	2	9.4
	4	11.5
	6	9.7
Galvanized	2	2.8
	4	6.3
	6	9.9

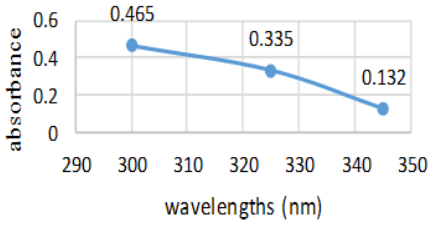

Figure 7: Graph of Analysis Results of UV-VIS

2.5. SEM Image

The microstructure of low carbon steel plate after wet corrosion (dipped in 0.1 NaCl solution) at 6 hours for coated with galvanizing and coated with solution of carbon battery rod from using batteries, H_2SO_4 and aquades was observed using Scanning Electron Microscope (SEM) each is displayed in Figure 8 and Figure 9.

As shown from Figure 8 and 9, after tested for corrosion in 0.1 M NaCl for 6 hours, SEM image coated with galvanizing (8) and coated with carbon battery rod from using batteries + 25ml H_2SO_4+ 25 m aquades (9) that CPR value of coated with carbon battery rod from using batteries + 25ml H_2SO_4+ 25 ml aquades more higher than coated with galvanizing. It is mean that corrosion attack occurs in coated with galvanizing and attack to grain boundary until grain boundaries are broken.

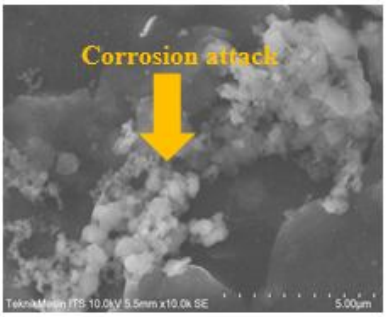

Figure 8: SEM image coated with galvanizing after wet corrosion

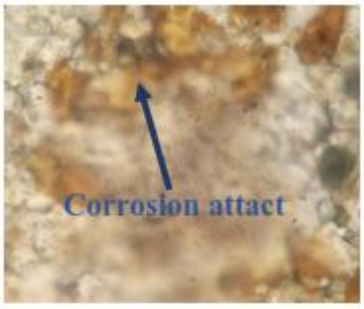

Figure 9: SEM image coated with composed of carbon battery rod from using batteries, 25 ml H_2SO_4 and 25 ml aquades after wet corrosion test

Some of the work relating to the above research involves the positive synthesis of graphene with the Hummers Process. Graphite and graphene efficiency is measured using conductivity check results for graphene, mn / graphene and Cu/graphene with 939 µS cm-1, 551.4 µS cm-1 and 481.1µScm-1 respectively. In primary cell batteries, graphite and graphene may be used as electrodes [10]. Another work was conducted to recycle the carbon rod of the used zinc-carbon battery as a biogas desulfurizer. The carbon rod was coated in $KMnO_4$ solution to improve its performance, and water then tested its performance as a desulfurizer.

Desulfurizer performance is found to increase by putting about 200 grams of carbon bar in $KMnO_4$ solution with a minimum concentration of 20 grams of $KMnO_4$/liter of water [11].

Hutapea et al. [12] showed that one way of exfoliating graphene by Electrochemical Graphite Method Exfoliation (EEG), which is the process of graphene synthesis into graphene sheets using separatin graphite material by electrochemical process. Highest output for solvents $[(NH_4)_2SO_4]$ and (K_2SO_4) respectively accounted for 10.6% and 15.3%. The UV Vis spectrophotometric wave peak resulted in approximately 270 nm indicating the graphene peak. The Raman spectroscopy test results showed that the graphene was nanoplatelet (multilayer) and then the number of layers of graphene was~310 layer. Study of FTIR showed functional groups on graphite after the decline phase. K_2SO_4 solvent 1.5 M was the highest conductivity, being 0.0621-1.cm-1.

The application of this work has improved the current commercially available epoxy grout with the use of graphene nanoplatelets (GNPs) to improve its mechanical properties by 0.1wt percent. The experimental results show a clear improvement in Young's strength and module, by adding GNPs as additives, particularly for tensile, flexural and lap shear tests. GNP involvement has a significant reinforcing effect and was effective in increasing ductility of the grout, reducing its brittle nature. This means that improved epoxy filling output is expected to be reliable and can minimize the sudden breakdown of the pipeline due to bursting [13].

3. CONCLUSION

Based on the results this research the following conclusions can be drawn:
Graphene Oxide material has been successfully obtained from the synthesis of carbon materials ZnC batteries with liquid exfoliation and surfactant methods which are stated by the results of UV-Vis spectrophotometer test there are 3 typical absorption peaks at wavelengths between 300-345 nm.

It was successfully created carbon battery rod that can protect low carbon steel from corrosion attacks when immersed in 0.1 M NaCl solution by using batteries + H_2SO_4 + aquades coating.

The final results showed that CPR values from the use of batteries + H_2SO_4 + aquades coating for low carbon steel samples with all carbon battery rod composition were CPR values which did not exceed the appropriate standard rate (0.5 mm/yr).

ACKNOWLEDGEMENT

Authors thank to Universitas Muhammadiyah Sidoarjo and RISTEK DIKTI (Penelitian Terapan Unggulan Tinggi (PTUPT2019) for supporting research financially.

REFERENCES

1. **Apa yang kita lakukan jika baterai sudah tidak bisa dipakai lagi?**, *BBC News Indonesia*. [Online]. Available: https://www.bbc.com/indonesia/majalah-44920433.
2. **Limbah Baterai Buang Ke Mana Ya?**, *Pokja AMPL : Air Minum dan Penyehatan Lingkungan*. [Online]. Available: http://www.ampl.or.id/digilib/read/limbah-baterai-buang-ke-mana-ya-/21146.
3. S. Rahmawati, **Sintesis dan Karakterisasi Material Graphene Oxide Berbahan Dasar Limbah Karbon Baterai ZnC Menggunakan Kombinasi Metode Liquid-Phase Exfoliation Dan Radiasi Sinar-X Dengan Variasi Waktu Radiasi**, Universitas Negeri Yogyakarta, 2017.
4. R. I. Wisnuwijaya, A. Purwanto, and W. Sunu Brams Dwandaru, "**UV-Visible Optical Absorbance of Graphene Oxide Synthesized from Zinc-Carbon Battery Waste via a Custom-Made Ultrasound Generator based on Liquid Sonication Exfoliation Method**," *Makara J. Sci.*, 2017. https://doi.org/10.7454/mss.v21i4.6752
5. F. Ferella, I. De Michelis, and F. Vegliò, **Process for the recycling of alkaline and zinc-carbon spent batteries**, *J. Power Sources*, 2008.
6. T. M. Ahmed, Z. Ali, M. M. Rahman, and E. Asmatulu, **Advanced recycled materials for economic production of fire resistant fabrics**, in *ASME International Mechanical Engineering Congress and Exposition, Proceedings (IMECE)*, 2018, vol. 12. https://doi.org/10.1115/IMECE2018-88640
7. Chella Santhosh, K. Hari Kishore, G. Pavani Lakshmi, G.Kushwanth, P. Rama Krishna Dharma Teja, R. S. Ernest Ravindran, Sree Vardhan Cheerla, M. Ravi Kumar, **Detection of Heavy Metal Ions using Star-Shaped Microfluidic Channel**, International Journal of Emerging Trends in Engineering Research, 2019, Vol. 7, No.12, pp. 768-771. https://doi.org/10.30534/ijeter/2019/067122019
8. M Siva Kumar, Syed Inthiyaz, M Aditya, P Rupanjani, B Aravind, M Mukesh, Sanath Kumar Tulasi, **Implementation of GDI Logic for Power Efficient SRAM Cell with Dynamic Threshold Voltage Levels**, International Journal of Emerging Trends in Engineering Research, 7(12), December 2019, 902 – 906 https://doi.org/10.30534/ijeter/2019/287122019
9. D. Venkata Ratnam, Rakesh Chowdary Gutta, M. Ravi Kumar, L. Eswara Rao, M. V. Siva Surya Reddy, P. Sai Pavan and Chella Santhosh, **Effect of High-K Dielectric materials on Mobility of Electrons**, International Journal of Emerging Trends in Engineering Research, 8(2), 2020, 314 – 316. https://doi.org/10.30534/ijeter/2020/12822020
10. Siburian, R., Sari, D. R., Gultom, J., Sihotang, H., Raja, S. L., & Supeno, M. (2018, December). **Performance of graphite and graphene as electrodes in primary cell battery**. In Journal of Physics: Conference Series (Vol. 1116, No. 4, p. 042034). IOP Publishing.
11. T. G. T. Nindhia, I. W. Surata, I. K. A. Atmika, D. N. K. P. Negara, and I. P. G. Artana, **Processing Carbon Rod from Waste of Zing-Carbon Battery for Biogas Desulfurizer**, *J. Clean Energy Technol.*, 2015. https://doi.org/10.7763/JOCET.2015.V3.179
12 Michael Hutapea, A. Amri, and R. S. Irianty, **Peluruhan Batang Grafit Baterai Bekas Dengan Metode Electrochemical Exfoliation Menggunakan Pelarut Amonium Sulfat Dan Kalium Sulfat**, *J. Online Mhs. Bid. Tek. dan Sains*, vol. 5, 2018.
13. N. Zainal, H. H. Arifin, L. Zardasti, N. Yahaya, K. S. Lim, and N. Md Noor, **Mechanical Properties of Graphene-Modified Epoxy Grout for Pipeline Composite Repair**, *Int. J. Integr. Eng.*, 2018.