Journal of Scientech Research and Development
Volume 5, Issue 2, December 2023
P-ISSN: 2715-6974 E-ISSN: 2715-5846
Open Access at: http://idm.or.id/JSCR

ANALYSIS OF THE POTENTIAL USE OF GRAPHENE OXIDE NANOPARTICLES IN THE FIELD OF MATERIALS: BIBLIOMETRIC ANALYSIS

Sultan Nazmi Chairul Islam
Chemistry Study Program, Indonesian Education University
E-mail: snazmi25@upi.edu

ARTICLE INFO	*ABSTRACT*

Correspondent:

Sultan Nazmi Chairul Islam
snazmi25@upi.edu

Key words:
Nanoparticles, Graphene Oxide, Materials, Bibliometrics

Website:
https://idm.or.id/JSCR/index.php/JSCR

Page: 672 - 683

This research was carried out to present bibliometric analysis which can be useful for mapping ongoing research topics and trends, especially in the topic of the use of graphene oxide in the materials field, so that it is hoped that it can help further research that will be carried out. The research method used is descriptive qualitative with bibliometric analysis using VOSviewer to visualize related research terms. Data collection was carried out using the publish and publish application using the keywords graphene oxide, nanoparticles, and materials with a time span of 2017 to 2023. The research results showed that there were fluctuations in the number of research conducted each year on the topic of graphene oxide.

INTRODUCTION

Progress in understanding various types of materials is a sign of progress in the field of technology. As an example; use of silicon materials; these materials boost a trillion-dollar industry; aiding communications in all areas, from auxiliary equipment to space telemetry. The problems that occur are not merely technical problems but include various things. Another example, to make an automobile possible, there must be steel or other materials. This shows that human life is always related to material needs such as transportation, housing, clothing, communication and so on (Pandey *et al.*, 2018).

Materials can be defined as raw materials processed by industry and can be obtained from local purchases, imports, or self-processing (Luo *et al.*, 2022). In general, we must understand the difference between materials science and materials engineering. Materials science focuses on research on the relationship between the structure and function of a material as well as synthesizing new materials which can then be used by the discipline of materials engineering. Engineering materials focuses on designing systems using previously discovered materials(callister JR & Rethwisch, 2020).

As technology develops, there is research that introduces the latest technology, using nano particle materials. Nano particles have a very small size with a high surface area. So it is able to make it stronger and more reactive compared to materials that are not nano-sized particles. Nanomaterials have been used for many cases in the oil and gas industry, one of which has succeeded in proving that nanosilica injection can have an impact on increasing oil recovery in low porosity and low permeability reservoirs.(Mursyidah, Adi Novriansyah, Novia Rita, 2015). The latest research introduces two-dimensional Graphene Oxide (GO) nanomaterials made from graphite by introducing CO covalent bonds.(Dimiev & Tour, 2014).

Graphene is a type of nano-sized material that has unique properties and many advantages, so it has been widely used in various applications(Cahyani, 2018)one of which is in the world of oil and gas. Graphene or graphene is the thinnest, strongest and best new material in the world today which is formed from one layer of carbon atoms which has a hexagonal structure resembling a honeycomb.(Aziz & Tjahjono, 2022).

Graphene Oxide can optimize bonds and form composites with cement and is also able to spread into micro pores, this shows great potential to increase the degree of hydration, strength, ductility and durability of cement concrete(Peng *et al.*, 2019).

Graphene Oxide can be obtained from several sources, one of the requirements for a material that can be used as a source of graphene oxide is that it has a high carbon content. Generally, palm oil or graphite in pencils can be used as a source to obtain graphene oxide. The choice of graphite as the basic material for pencils was because when graphene was first discovered it was from the carbon atoms of pencil graphite by Andre Geim and Konstantin Novoselov in 2004 using masking tape, namely the scotch tape method. Pencils contain 65% garphite, 35% clay and high levels of wax, resin and polymer binders(David *et al.*, 2017). Meanwhile, palm oil shells were chosen as the GO production material because they have a large carbon content and low ash content(Mehlin *et al.*, 2006).

Several examples of research on the use of graphene oxide nanomaterials are presented in Table 1.

Table 1 Some Examples in Graphene Oxide Research

No.	Title	Objective	Results	Reference
1	Production of Graphene/Inorganic Matrix Composites through the Sintering of Graphene Oxide Flakes Decorated with CuWO4 ·2H2O Nanoparticles	The aim of this research is to produce composites by decorating flake-shaped graphene oxide with CuWO4 ·2H2O nanoparticles with a diameter of 8 nm and then synthesized to form the final form.	After synthesis, the presence of graphene was found to change grain morphology from elongated needles to polyhedral shapes. It was found that, although the CuWO4 ·2H2O particles used were nanosized, the sintering conditions did not reduce the matrix to a pure matrix. metal; The sintered composite was found to have a mixed phase with copper tungstate and copper oxide. Raman spectroscopy shows that graphene oxide becomes hydrogenated during the sintering process as a result of the reduction of the hydrogen atmosphere used.	(Lin *et al.*, 2023)

No.	Title	Objective	Results	Reference
2	Reduced graphene oxide: biofabrication and environmental applications	The aim of this study is to provide a brief guide for researchers seeking up-to-date information on the properties, production and applications of rGO, with special attention to rGO applications in water purification and biomedical fields	Environmentally friendly preparation of rGO is a new research field in graphene technology that is cost-effective and sustainable in its procedures. Due to the uniform particle size of rGO, this smart nanomaterial has wide applications, including in metal ion and pollutant sensing and adsorption, photocatalysis, optoelectric devices, medical diagnosis, and drug delivery.	(Manikandan & Lee, 2023)
3	Graphene oxide-based nanomaterials for the treatment of pollutants in the aquatic environment: recent trends and perspectives –a review	This study aims to investigate the characteristics, preparation methods, and characterization processes of GO. Removal of contaminants from wastewater has recently become a focus of attention for GO-based materials.	The results showed that GO could be used to immobilize enzymes. It is possible to immobilize enzymes with various characteristics on graphene oxide-based substrates without compromising their functionality, thus developing a new environmental remediation platform that utilizes nanoscale biocatalysts. Doping and co-doping of GO with various heterogeneous semiconductor-based metal oxides are included in a brief strategy to improve the efficiency of GO. Materials with high band gaps are also explored as possible immobilizers, which shift the absorption threshold to the visible range and increase photoactivity. For water treatment applications, graphene-based nanomaterials are used in Fenton reactions, photocatalysis, ozonation, photo electrocatalysis, photo-Fenton, and the combination of photon-Fenton and photocatalysis. Nanoparticles made from GO increase the efficiency of composite materials when used for their intended applications. As a result of the analysis, prospects and improvements become clear, especially in terms of improving GO-based wastewater treatment technology.	(Dayana Priyadharshini *et al.*, 2022)
4	Advances in graphene oxide based nanobiocatalytic technology for wastewater treatment	This article aims to discuss recent advances related to graphene oxide synthesis, enzyme immobilization methods, development of graphene-based carriers for enzyme immobilization, and applications of graphene-based nanobiocatalysts in environmental remediation.	This article concludes the future prospects by focusing on the opportunities associated with multifaceted nanobiocatalysts	(Obayomi *et al.*, 2022)

No.	Title	Objective	Results	Reference
5	Advances of graphene oxide based nanocomposite materials in the treatment of wastewater containing heavy metal ions and dyes	This research aims to remove heavy metal ions and synthetic dyes based on adsorption from aqueous media, as well as photodegradation of dyes using efficient adsorbents or photocatalysts such as graphene-based nanocomposite materials, which have many benefits, including cost effectiveness, application in large-scale operations, efficiency, and utilization. return.	The majority of graphene or reduced graphene oxide nanocomposite materials can remove or degrade more than 90% of heavy metal ions and dye pollutants from wastewater.	(Joshi & Gururani, 2022)

In general, many studies show that graphene oxide has many applications in environmental chemistry, such as research conducted byDayana Priyadharshini *et al.*, 2022; Joshi & Gururani, 2022; Manikandan & Lee, 2023; Obayomi *et al.*, 2022In fact, the use of graphene oxide can also be useful in other fields such as the materials field. One concrete example can be answered with graphene which was discovered by Geim and Novoselov which has good mechanical properties, thermal and electrical resistance.(Singh Chauhan & Mishra, 2011), its good performance as a polymer reinforcing material(Babak *et al.*, 2014), which has a layer thickness of approximately 1.1 ± 0.2 nm(Schniepp *et al.*, 2006)and has a resistivity value of 10-6 Ωcm(Neuberger *et al.*, 2018). Mangadlao, Cao, & Advincula, 2015 also stated that graphene oxide has a function as an additive for drilling cement. Currently graphene is the newest, thinnest, strongest and superior material in the world(Aziz & Tjahjono, 2022), the strength of graphene exceeds that of steel(Syakir *et al.*, 2015), so that it has attracted the attention of many researchers, especially when it can be used for concrete, GO has the potential to also be studied in drilling cement. Apart from that, in the study conducted by(Taha & Lee, 2015)It was found that graphene oxide also has the potential as an additive for fluid loss control and reducing heat from drilling bits. According to his research, GO is able to control the filtration loss of drilling fluid because the morphology of GO has a hexagonal pore shape so that when added to drilling mud, the filtrate will be retained in the GO hexagonal pores.

This research aims to present bibliometric analysis which can be useful for mapping ongoing research topics and trends, especially in the topic of the use of graphene oxide in the materials field, so that it is hoped that it can help further research that will be carried out. Based on several previous studies contained in table 2, it can be seen that the novelty of this article is that there is a more specific in-depth study of the topic regarding the use and application of graphene oxide, especially in the materials field.

Table 2. Previous Research on Bibliometric Analysis

No	Title	Topic Discussion	Ref
1	A bibliometric analysis of graphene in acetaminophen detection: Current status, development, and future directions	In this article, we chose paper containing graphene and acetaminophen. Bibliometrics was used to analyze relationships and trends among these papers. The results show that this topic has developed rapidly since 2009. Among them, the detection of acetaminophen by graphene-based electrochemical sensors is the most important direction.	(Xiang *et al.*, 2022)
2	Nanomaterials for treating emerging contaminants in water by adsorption and photocatalysis: Systematic review and bibliometric analysis	reviews nanomaterials that are reported to remove emerging contaminants via adsorption and/or photocatalysis, and their removal capacities, mechanisms, and influencing factors are discussed. Meanwhile, a large-scale bibliometric analysis was conducted on the emerging trends of contaminants, nanoadsorbents, nanophotocatalysts, and related research topics from the literature during 1998–2017.	(Zhao *et al.*, 2018)
3	Graphene on Dentistry: A Bibliometric and Scientometric Analysis	This bibliometric analysis reveals the progress and trends of graphene research in dentistry and the extensive collaboration between authors, countries, and institutions. The findings of this research may help inspire researchers to plan new research and collaborate in the field of graphene.	(Erdinç, 2023)
4	Bibliometric Analysis of Hydrogels from Graphene Oxide Nanoparticles Using the VOSviewer Application	Aims to examine the development of hydrogel research from graphene oxide nanoparticles published on Google Scholar from 2013 to 2022 (September) through a bibliometric computational analysis approach using the Publish or Perish and VOSviewer applications.	(Indriati & Nandiyanto, 2023)

RESEARCH METHODOLOGY

Data Acquisition

The application used to get the required data is Publish or Perish. This application facilitates the acquisition of literature review data based on selected topics. The VOSviewer application is used to make it easier to map data visually. This application provides three visual data results: network visualization, density visualization, and overlay visualization. In creating bibliometric maps using the VOSviewer application, the frequency of keywords included in the map is mentioned at least three times in one article. If there are words that are not relevant, they will be removed from the map. The desired data can be obtained by the following steps:

1. The process of searching and sorting data using the Publish or Perish application with the Google Scholar database,
2. Bibliometric data processing can be done with Microsoft Excel,
3. The process of mapping bibliometric data can be done with the VOSviewer application,
4. Computational analysis.

The data presented in this article was obtained from journal publications indexed in Google Scholar spanning the years 2017 to 2023. There are two types of data files taken, namely (.ris) and (*.csv) formats. The file format (.ris) is used for visual data processing using the VOSviewer application with mind map results, and the file format (*.csv) is used for statistical data processing using the Microsoft Excel application with statistical graphic results.

Data analysis

The data analysis process is performance analysis and bibliometric analysis. Performance analysis was carried out using Publish or Perish and Microsoft Excel, while bibliometric analysis used the VOSviewer application. Both parts were carried out on the same day and time to reduce error factors in data acquisition and analysis. Analysis of the work was carried out by processing files (*.cvs) in Microsoft Excel, including data on the number of citations, author's name, article title, year of publication, journal name, publisher's name, h-index value, and article number relevant to the theme over a period of years. Use of the Microsoft Excel application to create graphs and tables based on data presented by Publish or Perish (number of publications per year). Bibliometric analysis is assisted by the VOSviewer application which processes data from files (.ris); This application synthesizes data and then creates a bibliometric network that can describe keywords from various relevant articles.

RESULT AND DISCUSSION

Publication Trends

In Figure 1, data is presented regarding the findings of articles that have been published on Google Scholar from 2017 to 2023. There are 200 articles related to the analysis of the potential use of graphene oxide. From Figure 1, it can be concluded that the publication trend regarding graphene oxide has fluctuated or there has been an increase and decrease over the last 6 years. The highest publication was in 2022 with 38 publications (19%). The lowest publication will be in 2023 (until September) with 15 publications. The largest increase in publications occurred from 2021 to 2022 with an increase of 11 publications. The largest decline in publications occurred in 2022 and 2023 with a decline in publications of 23 publications.

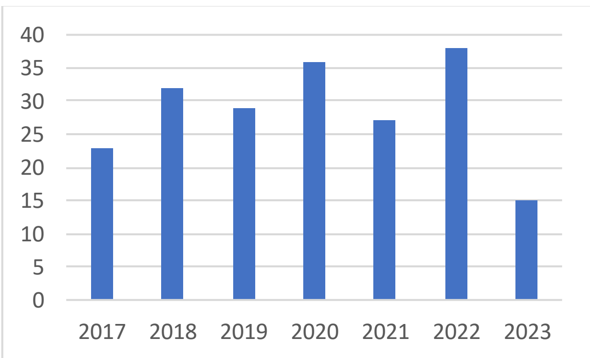

Figure 1. Number Of Documents Published for The Keyword "Graphene Oxide"

Top Articles Documents by Citations

Article documents with more than 100 citations consist of 28 documents. The top 10 documents with the most citations are presented in detail in table 3. The most frequently cited article is "Graphene and Graphene Oxide as Nanomaterials for Medicine and Biology Application" with 396 in 2018 with 396 citations.

Table 4. Top 10 Graphene Oxide quotes and publications

No	Quote	Author	Title	Year	Journal Source	Publisher Source
1	396	Priyadarshini *et al.*	Graphene and graphene oxide as nanomaterials for medicine and biology applications	2018	Journal of Nanostructures	Springer
2	365	Liu *et al.*	Graphene oxide-based materials for efficient removal of heavy metal ions from aqueous solutions: A review	2019	Environmental Pollution	Elsevier
3	351	Ayyaru & Ahn	Application of sulfonic acid group functionalized graphene oxide to improve hydrophilicity, permeability, and antifouling of PVDF nanocomposite ultrafiltration membranes	2017	Journal of Membrane Science	Elsevier
4	309	Velusamy *et al.*	A review on heavy metal ions and containing dyes removal through graphene oxide-based adsorption strategies for textile wastewater treatment	2021	The chemical record	Wiley Online Library
5	308	JY Lim *et al.*	Recent trends in the synthesis of graphene and graphene oxide-based nanomaterials for removal of heavy metals—A review	2018	Journal of Industrial	Elsevier
6	278	Zhang *et al.*	Graphene oxide quantum dots incorporated into a thin film nanocomposite membrane with high flux and antifouling properties for low-pressure nanofiltration	2017	ACS Applied Materials	ACS Publications
7	270	Liu *et al.*	Enhanced X-ray photon response in solution-synthesized CsPbBr3 nanoparticles wrapped by reduced graphene oxide	2018	Solar energy materials	Elsevier
8	252	Yang *et al.*	Long-term antibacterial stable reduced graphene oxide nanocomposites loaded with cuprous oxide nanoparticles	2019	Journal of Colloids	Elsevier
9	235	Pourhashem *et al.*	Investigating the effect of SiO2-graphene oxide hybrid as inorganic nanofiller on corrosion protection properties of epoxy coatings	2017	Surface and coating technology	Elsevier
10	204	Yousufi *et al.*	Anti-bacterial activity of graphene oxide as a new weapon nanomaterial to combat multidrug-resistance bacteria	2017	Materials Science	Elsevier

Vosviewer Visualization Analysis of Authors with Graphene Oxide Research

A visualization of the authors' activity in graphene oxide research is shown in Figure 2. A total of 1400 authors participated in research on graphene oxide. A total of 77 authors are related to research regarding the use and application of graphene oxide in the materials field. The authors who have the most documents are Liu, Zhang, and Wang, represented by a larger circle size than the others. All research is related to each other.

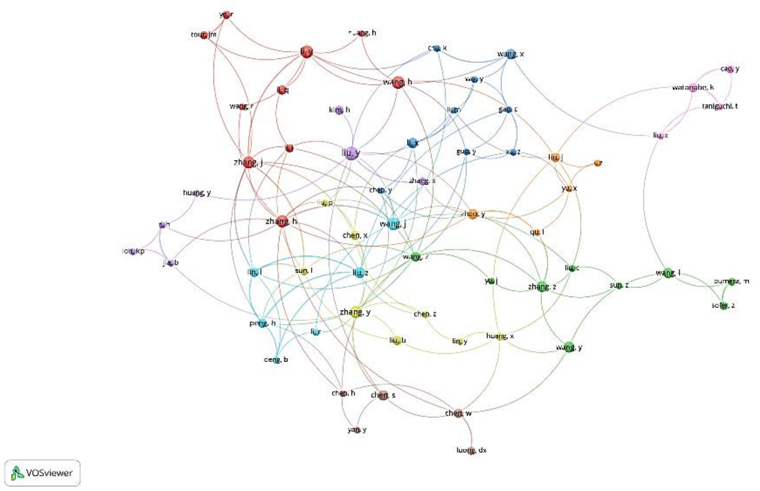

Figure 2. Author's Visualization Analysis with Graphene Oxide Research

Topic Analysis Visualization using Vosviewer

VOSviewer can display bibliometric maps in three different ways: network visualization, overlay visualization, and density visualization (Nandiyanto *et al*., 2023). Each cluster is represented by a colorful circle. The size of the circle is proportional to the number of times the keyword appears in the title and abstract. As a result, the size of letters and circles is determined by the frequency with which they appear. The more frequently a keyword appears, the larger the font and circle size (Donthu *et al*., 2021).

Mapping data obtained using the VOSviewer application resulted in 52 searches divided into 9 clusters, namely:

1. Cluster 1 (red): 3D graphene, characterization, discovery, graphene research, graphene synthesis, high quality graphene, porous graphene, potential application, product, recent development, research
2. Cluster 2 (green): 2D material, advance, conductivity, dimensional material, functionalized graphene, opportunity, prospect, role
3. Cluster 3 (blue): Form, graphene family, graphene nanomaterial, graphene layer, performance, rgo
4. Cluster 4 (yellow): dispersion, graphene layer, layer, mechanical property, paper, short review
5. Cluster 5 (purple): bilayer graphene, electronic property, gnr, graphene nanoribbon, twisted bilayer graphene
6. Cluster 6 (cyan): addition, comprehensive review, gqd, graphene quantum dot
7. Cluster 7 (orange): plasmon graphene, plasmonic graphene, surface graphene, single layer graphene

8. Cluster 8 (Brown): Chemical, graphene oxide, work
9. Cluster 9 (Pink) CVD graphene, researcher, substrate

Size, color, and cluster each provide a different meaning when using VOSviewer. The more prominent a circle is, the more relevant the correlation between keywords, title and abstract of an article. Figure 3 shows the clusters for the research topic areas. From this image, it can be seen that several topics are still rarely discussed so that this could be an opportunity for continuous development for each of these topics.

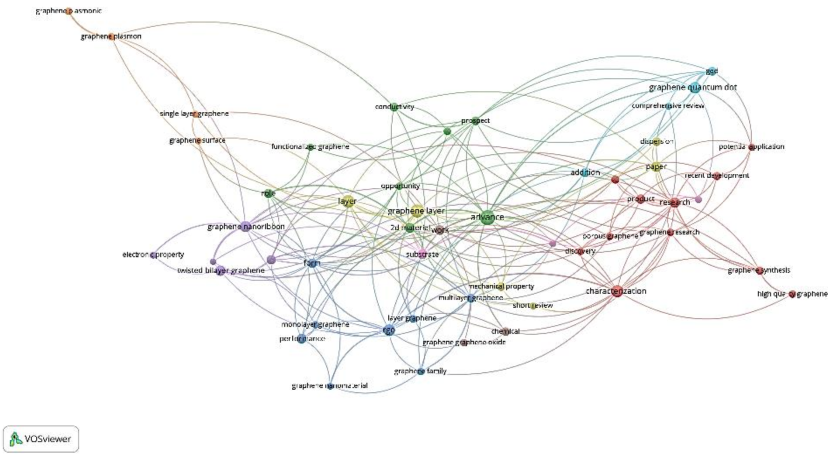

Figure 3. Network Visualization Analysis

Figure 4 shows an overlay visualization between time and related research. The resulting image is more or less the same as network visualization, only different in terms of color. The colors indicate different time periods. In figure 4 the applicable time range is 2017 to 2023. From this figure we can also assess trends on related topics for further research.

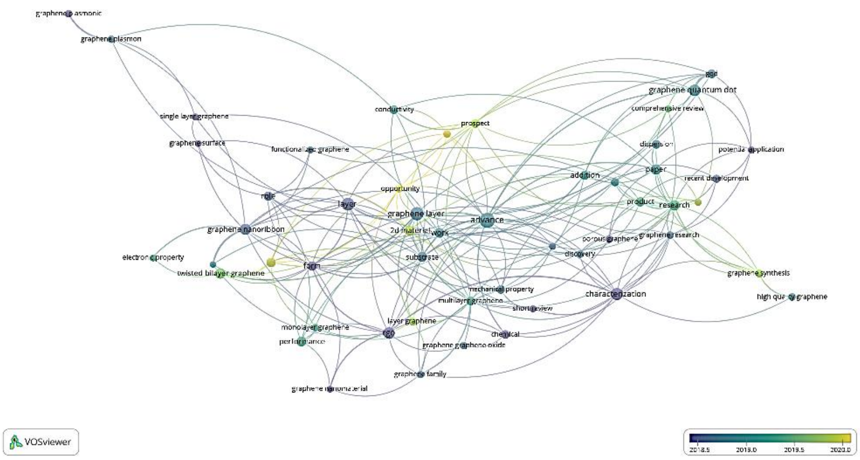

Figure 4. Overlay Visualization Analysis

Figure 5 shows a visualization of the frequency of research. The yellower and larger the visible area, the more often the word appears in research. In Figure 5 you can see the words graphene layer, graphene quantum dot, graphene research, graphene layer, and graphene oxide in bright yellow.

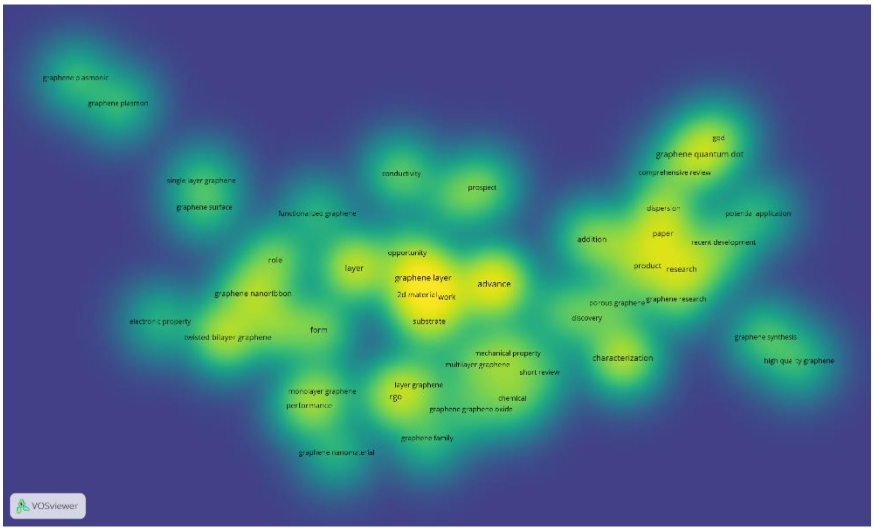

Figure 5. Density Visualization of Graphene Oxide Application for Materials

CONCLUSION

The results of the bibliometric analysis for research trends in the potential and application of graphene oxide in the materials sector experienced fluctuating numbers from year to year during the period 2017 to 2023. Research in 2023 still has the possibility to increase because it only counts until September. Research in the field of graphene oxide is very important to carry out considering that the applications of graphene oxide are very broad and the potential it has is very large.

REFERENCE

Aziz, ZI, & Tjahjono, A. (2022). Synthesis of charcoal-based Graphene Oxide (GO) using the liquid phase exfoliation (LPE) method. Core Journal of Physics, 5(2), 1. https://doi.org/10.20884/1.jtf.2022.5.2.5488

Babak, F., Abolfazl, H., Alimorad, R., & Parviz, G. (2014). Preparation and mechanical properties of graphene oxide: Cement nanocomposites. The Scientific World Journal, 2014. https://doi.org/10.1155/2014/276323

Cahyani, AS (2018). SYNTHESIS OF GRAPHENE OXIDE BASED ON ZINC-CARBON BATTERY WASTE GRAPHITE IN LIQUID PHASE USING AUDIOSONIC AND ULTRASONIC FREQUENCIES. Yogyakarta: UNY, 53(1), 1–8. http://www.tfd.org.tw/opencms/english/about/background.html%0Ahttp://dx.doi.org/10.1016/j.cirp.2016.06.001%0Ahttp://dx.doi.org/10.1016/j.powtec.2016.12.055%0Ahttps://doi.org/10.1016/j.ijfatigue.2019.02.006%0Ahttps://doi.org/10.1016/j.matlet.2019.04.024%0Aht

callister JR, W.D., & Rethwisch, D.G. (2020). Callister's Materials Science and Engineering. John Wiley & Sons.

David, IG, Popa, DE, & Buleandra, M. (2017). Pencil graphite electrodes: A versatile tool in electroanalysis. Journal of Analytical Methods in Chemistry, 2017(Cv). https://doi.org/10.1155/2017/1905968

Dayana Priyadharshini, S., Manikandan, S., Kiruthiga, R., Rednam, U., Babu, P.S., Subbaiya, R., Karmegam, N., Kim, W., & Govarthanan, M. (2022). Graphene oxide-based nanomaterials for the treatment of pollutants in the aquatic environment: Recent trends and perspectives – A review. Environmental Pollution, 306, 119377. https://doi.org/https://doi.org/10.1016/j.envpol.2022.119377

Dimiev, A. M., & Tour, J. M. (2014). Mechanism of graphene oxide formation. ACS Nano, 8(3), 3060–3068.

Donthu, N., Kumar, S., Pandey, N., Pandey, N., & Mishra, A. (2021). Mapping the electronic word-of-mouth (eWOM) research: A systematic review and bibliometric analysis. Journal of Business Research, 135, 758–773. https://doi.org/https://doi.org/10.1016/j.jbusres.2021.07.015

Erdinç, G. (2023). Graphene on Dentistry: A Bibliometric and Scientometric Analysis. Nigerian Journal of Clinical Practice, 26(1), 1070–1077. https://doi.org/10.4103/njcp.njcp

Indriati, D., & Nandiyanto, ABD (2023). Bibliometric Analysis of Hydrogels from Graphene Oxide Nanoparticles Using the VOSviewer Application. Fullerenes Journal of Chemistry, 7(2), 90–100. https://doi.org/10.37033/fjc.v7i1.461

Joshi, N.C., & Gururani, P. (2022). Advances of graphene oxide based nanocomposite materials in the treatment of wastewater containing heavy metal ions and dyes. Current Research in Green and Sustainable Chemistry, 5, 100306. https://doi.org/https://doi.org/10.1016/j.crgsc.2022.100306

Lin, F., Zhou, Y., Xu, R., Zhou, M., Connolly, A.M., Young, R.J., & Kinloch, I.A. (2023). Production of Graphene/Inorganic Matrix Composites through the Sintering of Graphene Oxide Flakes Decorated with CuWO4 2H2O Nanoparticles. ACS Omega, 8(14), 13131–13139. https://doi.org/10.1021/acsomega.3c00063

Luo, 2022). Trimetallic metal–organic frameworks and derived materials for environmental remediation and electrochemical energy storage and conversion. Coordination Chemistry Reviews, 461, 214505. https://doi.org/https://doi.org/10.1016/j.ccr.2022.214505

Manikandan, V., & Lee, N.Y. (2023). Reduced graphene oxide: Biofabrication and environmental applications. Chemosphere, 311, 136934. https://doi.org/https://doi.org/10.1016/j.chemosphere.2022.136934

Mehlin, C., Boni, E., Buckner, F.S., Engel, L., Feist, T., Gelb, M.H., Haji, L., Kim, D., Liu, C., Mueller, N., Myler, P.J., Reddy, J.T., Sampson, J.N., Subramanian, E., Van Voorhis, W.C., Worthey, E., Zucker, F., & Hol, W.G.J. (2006). Heterologous expression of proteins from Plasmodium falciparum: Results from 1000 genes. Molecular and Biochemical Parasitology, 148(2), 144–160. https://doi.org/https://doi.org/10.1016/j.molbiopara.2006.03.011

Mursyidah, Adi Novriansyah, Novia Rita, AH (2015). Effect of Nanosilica Injection to Oil Recovery Factor in Low Porosity and Permeability Reservoir. Journal of Intellect, 9(2), 11–13.

Nandiyanto, ABD, Ragadhita, R., Al Husaeni, DN, & Nugraha, WC (2023). Research trends on the use of mercury in gold mining: Literature review and bibliometric analysis. Moroccan Journal of Chemistry, 11(1), 1–19. https://doi.org/10.48317/IMIST.PRSM/morjchem-v%vi%i.36576

Neuberger, N., Adidharma, H., & Fan, M. (2018). Graphene: A review of applications in the petroleum industry. Journal of Petroleum Science and Engineering, 167, 152–159. https://doi.org/https://doi.org/10.1016/j.petrol.2018.04.016

Obayomi, K.S., Lau, SY, Danquah, M., Chiong, T., & Takeo, M. (2022). Advances in graphene oxide based nanobiocatalytic technology for wastewater treatment. Environmental Nanotechnology, Monitoring & Management, 17, 100647. https://doi.org/https://doi.org/10.1016/j.enmm.2022.100647

Pandey, A. K., Hossain, M. S., Tyagi, V. V, Abd Rahim, N., Selvaraj, J. A. /L., & Sari, A. (2018). Novel approaches and recent developments on potential applications of phase change materials in solar energy. Renewable and Sustainable Energy Reviews, 82, 281–323. https://doi.org/https://doi.org/10.1016/j.rser.2017.09.043

Peng, H., Ge, Y., Cai, C.S., Zhang, Y., & Liu, Z. (2019). Mechanical properties and microstructure of graphene oxide cement-based composites. Construction and Building Materials, 194, 102–109. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2018.10.234

Schniepp, H.C., Li, J.-L., McAllister, MJ, Sai, H., Herrera-Alonso, M., Adamson, D.H., Prud'homme, R.K., Car, R., Saville, D.A., & Aksay, IA (2006). Functionalized Single Graphene Sheets Derived from Splitting Graphite Oxide. The Journal of Physical Chemistry B, 110(17), 8535–8539. https://doi.org/10.1021/jp060936f

Singh Chauhan, S. M., & Mishra, S. (2011). Use of graphite oxide and graphene oxide as catalysts in the synthesis of dipyrromethane and calix[4]pyrrole. Molecules, 16(9), 7256–7266. https://doi.org/10.3390/molecules16097256

Syakir, N., Nurlina, R., Anam, S., Aprilia, A., Hidayat, S., & -, F. (2015). Study on Making Graphite Oxide for Production of Graphene Oxide in Large Quantities (Pages 26 to 29). Indonesian Journal of Physics, 19(56), 26–29. https://doi.org/10.22146/jfi.24354

Taha, N.M., & Lee, S. (2015). Nano Graphene Application Improving Drilling Fluids Performance. In International Petroleum Technology Conference (p. D021S013R005). https://doi.org/10.2523/IPTC-18539-MS

Xiang, S., Mao, S., Chen, F., Zhao, S., Su, W., Fu, L., Zare, N., & Karimi, F. (2022). A bibliometric analysis of graphene in acetaminophen detection: Current status, development, and future directions. Chemosphere, 306, 135517. https://doi.org/https://doi.org/10.1016/j.chemosphere.2022.135517

Zhao, L., Deng, J., Sun, P., Liu, J., Ji, Y., Nakada, N., Qiao, Z., Tanaka, H., & Yang, Y. (2018). Nanomaterials for treating emerging contaminants in water by adsorption and photocatalysis: Systematic review and bibliometric analysis. Science of the Total Environment, 627, 1253–1263. https://doi.org/https://doi.org/10.1016/j.scitotenv.2018.02.006