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Bibliometric Data Analysis of Research on Resin-Based Brake-Pads from 2012 to 2021 using VOSviewer Mapping Analysis Computations

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ABSTRACTS

This study examines the mapping of research bibliometric data analysis related to resin-based brake pads. The research data was collected through the publish or perish reference manager application from the Google Scholar database. The title of the study material and abstract is used as a basis for searching for availability based on the specified keywords, namely "Resin-based Brake Pads". The search results show a total of 398 articles that are relevant and used in the mapping analysis. VOSviewer is used to complete the mapping process. The study period used as the study material was articles published in Google Scholar indexed journals from 2012 to 2021. We examined the number of published articles on resin-based brake pads and their relationship to problem areas using VOSviewer. The results showed that research on resin-based breake pads experienced an increase in research interest from 2017 to 2021. The smallest number of publications occurred in 2015 with 23 publications. There are main terms that are usually discussed and related to the research theme of resin-based brake pads, namely pad material, development and epoxy resin. This review is expected to serve as a starting point for conducting research by taking the field of study of resin-based brake pads.

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1. INTRODUCTION

Brake pad is a braking system which is one of the most important parts of a vehicle, especially land vehicles (Selvaraj *et al*., 2021; Nandiyanto *et al*., 2021a; Nandiyanto *et al*., 2021b; Deni & Nandiyanto, 2022). The brake pad system is classified as a composite material whose components are composed of several components such as reinforcing materials, fillers, and solid lubricants (Kumar & Ghosh, 2020). Based on some of these components, the composition of the binder material and its microstructure affect the brake performance where the brake performance can include mechanical characteristics, wear resistance, durability, and stability of the prepared material (Pérez & Echeberria, 2019; Su *et al*. 2015; Li *et al*. 2019). Brake pad with a constant coefficient of friction and low wear rates are in great demand. It has been mentioned earlier that the performance of brake pad depends on the composition of the binder. The binder can form a matrix at a relatively stable temperature. Composition of the binder consists of various types of resins including phenolic, epoxy, polyester, and rubber. The resin serves to bind various constituent substances in the friction material. Many advances have been made to improve brake pad performance. **Table 1** shows the current study on brake pads.

Table 1. Current Study on Brake Pads.

Sample Type	Filler Material	Binder Material	Results	Reff
Brake pad	Rice Husk	Epoxy Resin	The interpacking distance, interfacial bonding, and thermal softening of the rice husk resin-particle matrix are all affected by the particle size of rice husk. The compressive strength of the brake pads is increased by small particles. Reduced particle size also leads to less pore formation, less mass loss, improved wear rates, a higher coefficient of friction, and a rougher brake pad surface.	Nandiyanto *et ai.* (2021a)
	Banana Peel	Phenolic Resin	Increased banana peel production can be attributed to high compressive strength, high hardness value, high specific gravity, low wear rate, low water absorption, and low water absorption.	Sugözü & Güdük, (2019)
	Sawdust	Epoxy Resin and other supporting materials (i.e., slag waste, silicon carbide, and graphite).	Sawdust had an effect on the wear rate and degradability of the brake pad. Sawdust has a high ash content, a low density, a low compressive strength, and a high degradability/wear rate. Increases in porosity and wear rate are attributed to large sawdust particle size.	Benjamin & Hilary, (2019)
	Palm kernel shell	Epoxy resin and other supporting materials (catalyst and cow bone)	Increases in palm kernel shell particle size results to low density, high impact strength, low hardness value, low water resistance, and low oil resistance.	Afolabi *et al.* (2015)
	Maize Husk	Epoxy resin and other supporting materials (catalyst, silica iron oxide, calcium carbonate, and graphite)	A high concentration of maize husk was associated with a high density, coefficient of friction, water absorption, and oil absorption. A high amount of maize husk, on the other hand, reduced hardness, wear rate, tensile strength, compressive strength, and thermal conductivity.	Ademoh & Olabisi (2015)

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Given the rapid development of brake pad, this research on brake pad is required as a foundation for evaluating quality improvement policies that take trends and research issues into account. The availability and dependability of data from scientific research activities is critical for evaluating research results. To evaluate research results, investigate the interactions between research results, and analyze the mapping of science fields to track the development of new knowledge in certain fields, as well as future indicators in providing competitive advantage and in making strategic plans, thus bibliometric studies should be carried out (Al Husaeni & Nandiyanto, 2022; Nandiyanto & Al Husaeni, 2021).

Therefore, the purpose of this research is to conduct a bibliometric analysis of the resin-based brake pad research field. This bibliometric analysis is being conducted in this research area because there have been no studies discussing research trends in this field, despite the fact that brake pad is a topic whose research is currently developing. The bibliometric analysis was carried out to examine the number of international publications per year and the development map of international research publications in the field of resin-based brake pad based on keywords (co-words).

2. METHOD

This study makes use of information from articles or international publications. This publication's data was gathered from the Google Scholar database using a reference manager application (i.e., Publish or Perish). The keywords **"Resin-Based Brake pads"** were used to search for article data containing research on metal oxides from 2012 to 2021. The data was then analysed using Microsoft Excel in the form of the number of publications per year, authors, origin of authors, and subjects. Meanwhile, the VosViewer software was used to analyse trends in the development of international metal oxide publications. Detailed information for using and installing the software and step-by-step process for obtaining data is explained in our previous studies (Al Husaeni & Nandiyanto, 2022).

3. RESULT AND DISCUSSION

3.1. Publication Data Search Results

The results of the search for publication data regarding resin-based brake pads through the application reference manager Publish or Perish 7 from the Google Scholar database, obtained 398 article data. Each article that is used as data analysis in this study has met the specified criteria. Metadata obtained from this research consists of title, year of publication, author's name, name of the journal that publishes, publisher, article link, number of citations and also the related URL. **Table 2** shows some sample research data regarding resin-based brake pads used in this study. Data samples were taken based on 20 articles with the highest number of citations.

Table 2. Sample of Bibliometric Article Journal.

Cites	Authors	Title	Year	Cites Per Year	Cites Per Author	Ref
488	Odhner *et al*.	A compliant, underactuated hand for robust manipulation	2014	61.00	122	Odhener *et al*. (2014)
447	PJ Kole *et al*.	Wear and tear of tyres: a stealthy source of microplastics in the environment	2017	89.40	112	Kole *et al*. (2017)

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Table 2 (Continue). Sample of Bibliometric Article Journal.

Cites	Authors	Title	Year	Cites Per Year	Cites Per Author	Ref
180	UD Idris *et al*.	Eco-friendly asbestos free brake-pad: Using banana peels	2015	25.71	45	Idris *et al*. (2015)
153	K Ortegon, LF Nies, JW Sutherland	Preparing for end of service life of wind turbines	2013	17.00	51	Ortegon *et al*. (2013)
153	HAC Denier van der Gon *et al*.	The policy relevance of wear emissions from road transport, now and in the future—an international workshop report and consensus statement	2013	17.00	77	Denier van der Gon *et al*. (2013)
143	P Chang *et al*.	3D printed electrochemical energy storage devices	2019	47.67	29	Chang *et al*., (2019)
133	HM Hwang *et al*.	Review of pollutants in urban road dust and stormwater runoff: part 1. Heavy metals released from vehicles	2016	22.17	33	Hwang *et al*. (2016)
132	KK Ikpambese, DT Gundu, LT Tuleun	Evaluation of palm kernel fibers (PKFs) for production of asbestos-free automotive brake pads	2016	22.00	44	Ikpambese *et al*. (2016)
117	DS Yawas, SY Aku, SG Amaren	Morphology and properties of periwinkle shell asbestos-free brake pad	2016	19.50	39	Yawas *et al*. (2016)
108	M Sedlák, D Rak	Large-scale inhomogeneities in solutions of low molar mass compounds and mixtures of liquids: supramolecular structures or nanobubbles?	2013	12.00	54	Sedlák & Rak, (2013).
99	MA Maleque *et al*.	New natural fibre reinforced aluminium composite for automotive brake pad	2012	9.90	25	Maleque *et al*. (2012)
91	RH Behal *et al*.	Subunit interactions and organization of the Chlamydomonas reinhardtii intraflagellar transport complex A proteins	2012	9.10	15	Behal *et al*. (2012)
88	DM Revitt, L Lundy, F Coulon, M Fairley	The sources, impact and management of car park runoff pollution: a review	2014	11.00	22	Revitt *et al*. (2014)
74	DA Harper *et al*.	HAWC, the Far-Infrared Camera and Polarimeter for SOFIA	2018	18.50	19	Harper *et al*. (2018)
61	F Del Pero, M Delogu, M Pierini, D Bonaffini	Life Cycle Assessment of a heavy metro train	2015	8.71	15	Del Pero *et al*. (2015)
59	R Renz, G Seifert, W Krenkel	Integration of CMC brake disks in automotive brake systems	2012	5.90	20	Renz *et al*. (2012)
58	WM Chai *et al.*	Antityrosinase and antimicrobial activities of furfuryl alcohol, furfural and furoic acid	2013	6.44	10	Chai *et al*. (2013)
53	S Manoharan *et al*.	Experimental investigation on the tribo-thermal properties of brake friction materials containing various forms of graphite: a comparative study	2019	17.67	13	Manoharan *et al*. (2019)
53	T Singh, A Patnaik, R Chauhan, A Rishiraj	Assessment of braking performance of lapinus–wollastonite fibre reinforced friction composite materials	2017	10.60	13	Singh *et al*. (2017)
51	M Grujicic *et al*.	Concept-level analysis and design of polyurea for enhanced blast-mitigation performance	2012	5.10	13	Grujicic *et al*. (2012)

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3.2. Research Development in the Field of Resin Based Brake Pads

Table 3 shows the progress of research on research on resin-based brake pads published in the Google Scholar indexed journal. **Table 3** shows a total of 398 publications regarding resin-based brake pads published in journals from 2012 to 2021. The table shows the total number of publications per year, namely in 2012 there were 30 articles, 2013 there were 25 articles, 2014 there were 27 articles, 2015 there were 23 articles, 2016 there are 37 articles, 2017 there are 29 articles, 2018 there are 47 articles, 2019 there are 58 articles, 2020 there are 55 articles, and 2021 there are 67 articles. Most research publications on resin-based brake pads occurred in 2021 and 2015 was the year with the fewest number of research publications on resin-based brake pads. A further description of the development of research on resin-based brake pads is shown in **Figure 1**. Based on **Figure 1**, an increase in research on resin-based brake pads continues to occur in the range of 2017 to 2021. This shows that the existence of research on resin-based brake pads is still high and many researchers are interested in.

Table 3. Development of Resin-Based Brake Pads Research.

Year	Total of Article Publication
2012	30
2013	25
2014	27
2015	23
2016	37
2017	29
2018	47
2019	58
2020	55
2021	67
Total	**398**

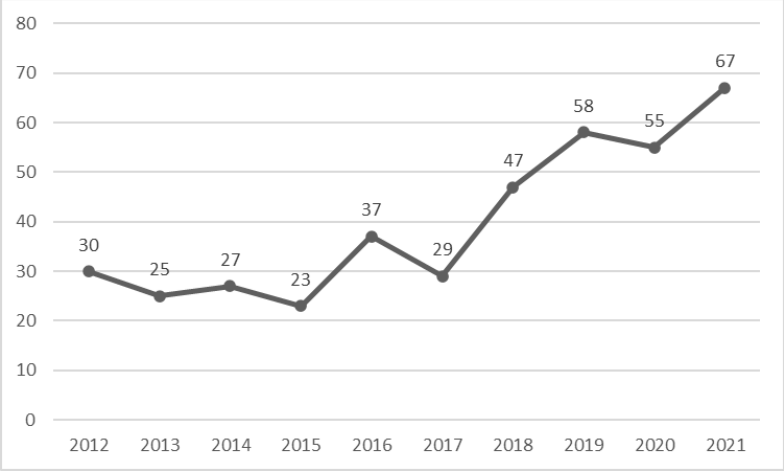

Figure 1. Level of development in resin-based brake pads research.

3.3. Visualization Resin Based Brake Pads Topic Area using VOSviewer

Figure 2 shows the density visualization mapping analysis of research on resin-based brake pads from 2012 to 2021. Based on **Figure 2**, we can find out the terms related to research on resin-based brake pads with the largest number of densities, namely epoxy resin and pad

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material. The density map indicates that the more yellow the color is with the largest circle's diameter, the denser the keyword, the more frequently it appears, and if the color fades, it merges in with the green background, the less frequently it appears (Al Husaeni & Nandiyanto, 2022).

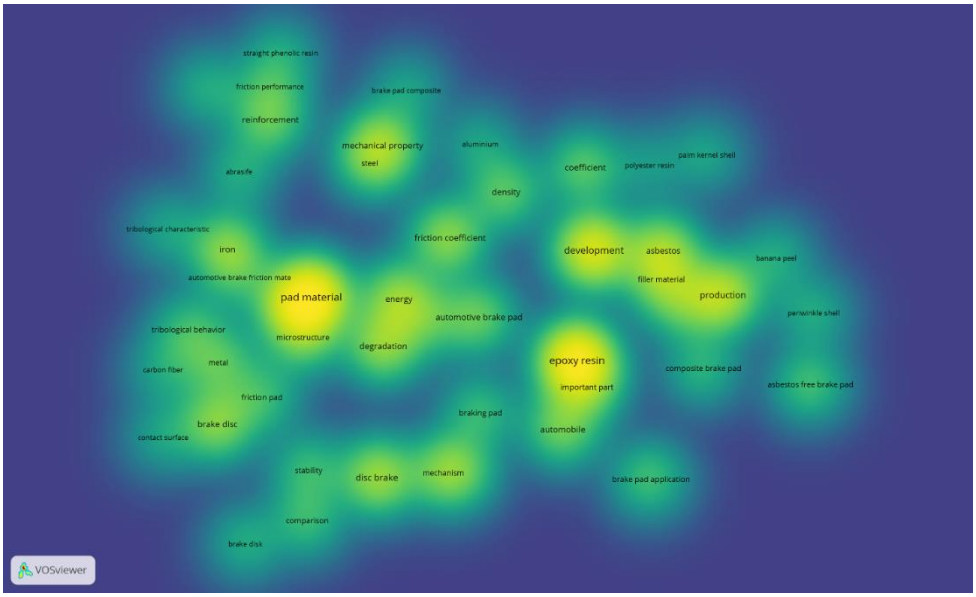

Figure 2. Density visualization of resin-based brake pad research.

In the analysis of the mapping network visualization shown in **Figure 3**, it can be seen that research on resin-based brake pads in the last 10 years has been widely associated with the terms that are the subject of research. Research on resin-based brake pads is mostly associated with research terms regarding the pad material (**Figure 4**), research on its development (**Figure 5**), and epoxy resin as the most widely used material in the manufacture of resin-based brake pads (**Figure 6**). These related terms indicate how resin-based brake pad research is carried out. This allows us to further explore other terms relevant to the research on resin-based brake pads.

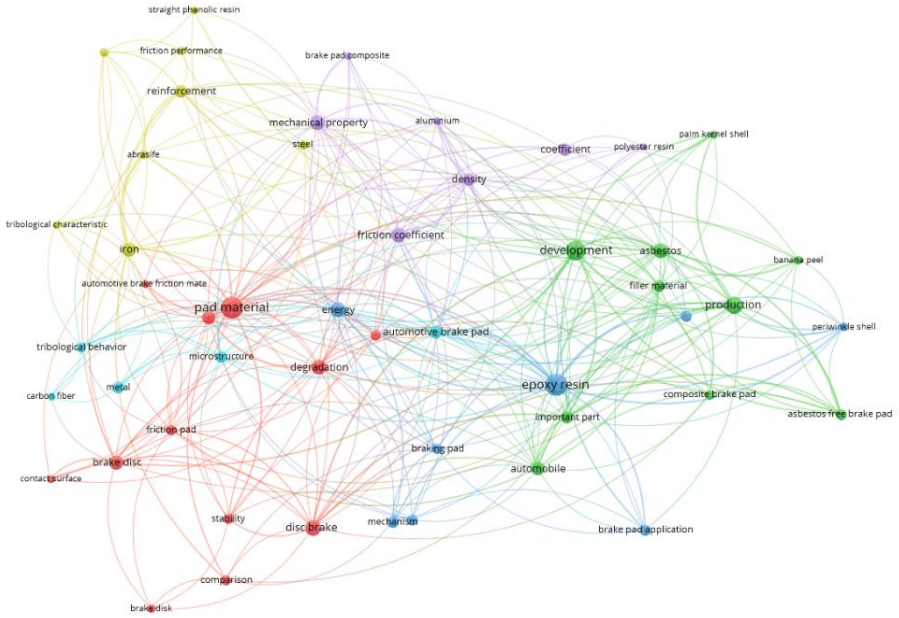

Figure 3. Network visualization of resin-based brake pad research.

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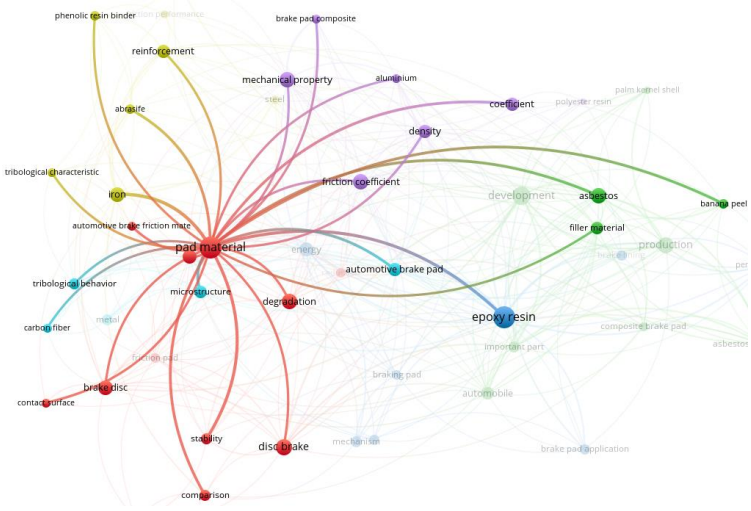

Figure 4. Network visualization of pad materials term.

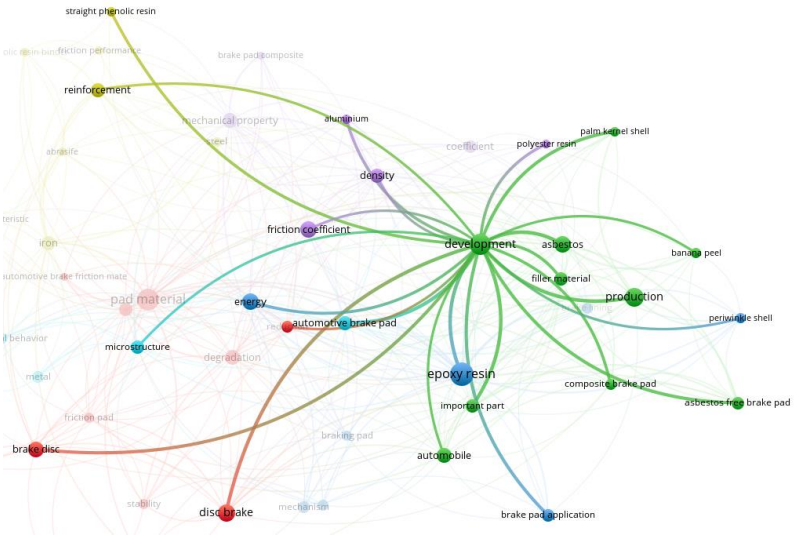

Figure 5. Network visualization of development term.

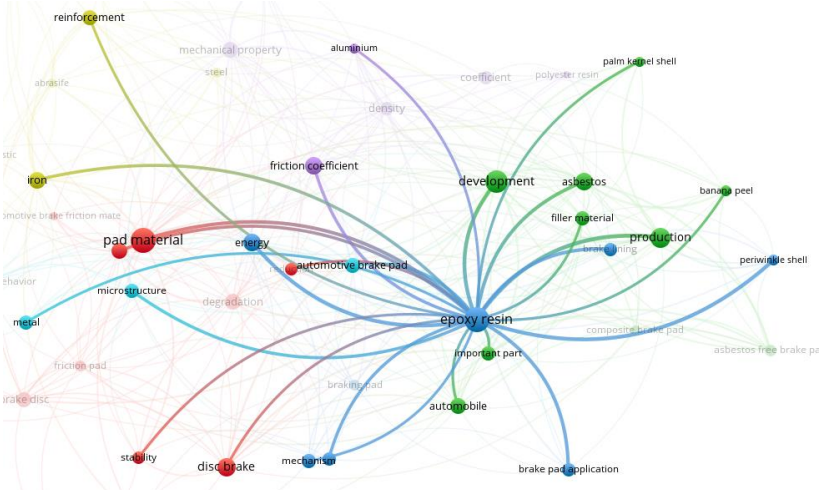

Figure 6. Network visualization of epoxy resin term.

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4. CONCLUSION

The purpose of this study was to perform computational mapping analysis on the bibliometric data of the research article "Resin-Based Brake Pads" Articles obtained through Publish or Perish from the Google Scholar database. The title and abstract of the library were used in this study. Based on the search results, there are 398 relevant articles published between 2012 and 2021. The findings reveal that research on resin-based brake pads fluctuated from 2012 to 2017, and continued to experience increased research from 2017 to 2021. The results showed that researchers usually use epoxy resin as a material for making resin-based brake pads. In addition, the focus of the discussion that is mostly taken is on how to develop resin-based brake pads. Based on these results, it shows that there is still good potential for mechanical engineering education research.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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