Bibliometric Study of the Production of Scaffold by Polycaprolactone and Graphene Electrospinning

Marco Aurélio Silveira[1*], Jaqueline Leite Vieira[2], Ana Paula Bispo Gonçalves[1], Rodrigo Polkowski[3], Willams Teles Barbosa[1], Milena Botelho Pereira Soares[2], Josiane Dantas Viana Barbosa[1]

[1]SENAI CIMATEC University Center; FIOCRUZ, [2]Fundação Gonçalo Moniz; [3]TRL9 LAB Test and Technical Analysis; Salvador, Bahia, Brazil

This bibliometric study investigated the production of scaffolds using electrospinning with the incorporation of graphene into polycaprolactone (PCL) for biomedical applications. Bibliometric methods were employed to analyze relevant scientific literature and identify trends, publication patterns, key authors and institutions, and primary application areas. Using specific keywords in the Web of Science database, 54 articles published over the past five years were identified. Results indicate a decline in annual publications, potentially due to the impact of the COVID-19 pandemic. Iran emerged as the leading country in research on this topic, while the most cited journals included Materials Science Multidisciplinary, Polymer Science, and Materials Science Biomaterials. These findings provide a comprehensive overview of the current research landscape, highlighting areas of interest and potential future directions.

Keywords: Scaffold. Electrospinning. Graphene. Polycaprolactone (PCL).

Electrospinning is a nanofiber fabrication technique that has gained increasing attention due to its versatility and potential applications in fields such as biomedicine, filtration systems, and advanced composite materials [1]. This technique applies an electric field to a polymer solution, forcing the solution through a needle or nozzle, resulting in ultrafine fibers with nanometer-scale diameters. Recent research has focused on improving the properties of electrospun fibers, with one promising approach being the incorporation of nanomaterials like graphene into polycaprolactone (PCL) solutions [2]. PCL is widely used in tissue engineering due to its flexibility, biocompatibility, biodegradability, and ease of processing into various forms, such as thin films or three-dimensional scaffolds [3].

Graphene, a two-dimensional carbon material, possesses unique properties such as high electrical conductivity, mechanical strength, and surface area, making it a valuable additive for enhancing the characteristics of electrospun fibers [2].

This study explores the current research landscape on electrospun scaffolds with graphene-reinforced PCL by employing bibliometric methods to analyze trends, publication patterns, leading authors and institutions, and critical application areas [4]. The findings aim to provide a comprehensive overview of this emerging field and identify opportunities for further research in regenerative medicine, tissue engineering, and other biomedical applications.

Materials and Methods

Bibliometric analysis measures and describes the evolution of research across various disciplines, enabling the identification of trends, collaboration patterns, and research gaps. This method is widely applied in science, technology, medicine, and social sciences to assess research impact and guide future investigations [5].

This study used the Web of Science database to identify relevant publications. The keywords "scaffold," "electrospinning," "graphene," and "polycaprolactone" were used in the search. Data collected included article records and cited references, exported as tab-delimited files for further

Received on 18 June 2024; revised 21 August 2024.
Address for correspondence: Marco Aurélio Silveira.Av. Orlando Gomes, 1845, Piatã. Zipcode: 41650-010. Salvador, Bahia, Brazil. E-mail: marcos.silveira@aln.senaicimatec.edu.br.

J Bioeng. Tech. Health 2024;7(3):291-293

analysis. The research was conducted on March 10–11, 2024, identifying 54 articles published between 2019 and 2024. The evaluation focused on publication trends, productive countries, and key journals. Table 1 outlines the analyzed elements and their objectives.

Table 1. Data evaluated in the study.

Item	Objective
Articles per year	Assess productivity trends over time
Countries	Identify the most productive and cited nations
Journals	Determine the most influential journals

Results and Discussion

The data revealed the number of articles published annually from 2019 to 2024 (Figure 1). A decline in publication was observed, likely due to the pandemic's impact on research activities. Even with the gradual resumption of laboratory operations, the 2023 publication count had not yet returned to pre-pandemic levels seen in 2019.

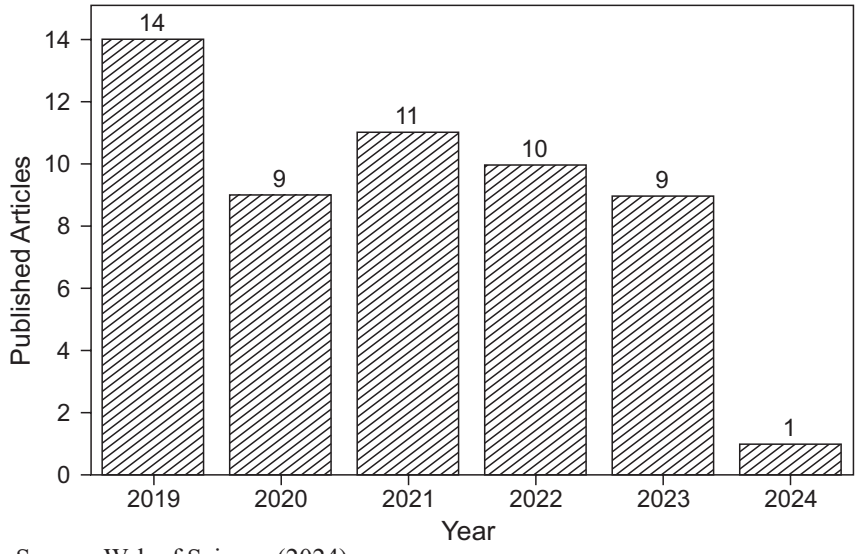
The bibliometric analysis also identified countries with significant research contributions. Iran led with 19 publications (35.18%), followed by China with 9, Canada and India with 4 each, and Brazil with 2 (0.37%). These results highlight Iran's dominant role in this field and suggest that Brazil should increase its scientific contributions to research on PCL-graphene electrospinning for tissue engineering (Table 2).

Table 2. Top 10 countries publishing on the topic.

Country	Number of Publications
Iran	19
China	9
Canada	4
India	4
Italy	3
United States	3
Türkiye	3
South Korea	3
Brazil	2
Colombia	2

Source: Web of Science (2024).

Figure 1. Number of publications per year.



Source: Web of Science (2024).

The analysis of critical journals revealed that Materials Science Multidisciplinary and Polymer Science each accounted for 16 articles (29.63%), followed by Materials Science Biomaterials with 12 articles (22.22%) (Table 3).

Table 3. Journals publishing the most articles.

Journal	Number of Publications
Materials Science Multidisciplinary	16
Polymer Science	16
Materials Science Biomaterials	12
Nanoscience Nanotechnology	8
Applied Physics	8

Source: Web of Science (2024).

These journals' focus on multidisciplinary research aligns with the broad applicability of electrospinning and scaffold technologies in tissue engineering and regenerative medicine.

Conclusion

This bibliometric study highlights a decline in publications, potentially influenced by the pandemic, and identifies Iran as the leading contributor to research on PCL-graphene scaffolds. Brazil's limited output underscores the need for increased scientific efforts. The analysis of critical journals provides valuable insights into the current research landscape, offering guidance for future investigations. These findings are crucial for advancing applications in tissue engineering and regenerative medicine.

Acknowledgments

The authors thank CNPq, CAPES, and FIOCRUZ for funding and SENAI CIMATEC for providing infrastructure support.

References

1. Song J et al. The preparation and characterization of polycaprolactone/graphene oxide biocomposite nanofiber scaffolds and their application for directing cell behaviors. Carbon 2015;95:1039-1050.
2. Rostami F, Tamjid E, Behmanesh M. Drug-eluting PCL/graphene oxide nanocomposite scaffolds for enhanced osteogenic differentiation of mesenchymal stem cells. Materials Science and Engineering: C 2020;115:111102.
3. Basar AO, Sadhu V, Sasmazel HT. Preparation of electrospun PCL-based scaffolds by mono/multi-functionalized GO. Biomedical Materials 2019;14(4):045012.
4. Nasari M et al. Fabrication of novel PCL/PGS fibrous scaffold containing HA and GO through simultaneous electrospinning-electrospray technique. International Journal of Polymeric Materials and Polymeric Biomaterials 2023;72(18):1529-1545.
5. Quevedo-Silva F et al. Estudo bibliométrico: orientações sobre sua aplicação. Revista Brasileira de Marketing 2016;15(2):246-262.