

## LIPASE IMMOBILIZATION APPLIED IN BIOTECHNOLOGY: BIBLIOMETRIC ANALYSIS IN TWO DATABASES

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### ABSTRACT

Advancements in lipase immobilization techniques pave the way for more sustainable and efficient biocatalytic processes in various industrial sectors. In order to identify what is being published in the area in the two main global databases (Web of Science – WoS and Scopus - Scp), a bibliometric analysis was carried out. Data analysis utilized VOSviewer 1.6.20 to assess keyword citations and international academic collaborations, with Microsoft Office 2016®, particularly Microsoft Excel® 2021, employed for result compilation and visualization via tables and graphs. More documents were obtained from WoS (724), with a significant peak in publications from 2010 onwards. In the case of Scopus (313), after the peak between 2010 and 2013, there was a period of decline. China, Brazil, Spain, United States and India, as along with the institutions affiliated with these nations, stand out as the academically most productive in the field of lipase immobilization applied in biotechnology. More than 90% were articles or reviews published in the fields of microbiology, biochemistry, and molecular biology applied to biotechnology. The difference in information and documents found in the two databases highlights the significant impact of database selection and the importance of more studies that utilize multiple databases in their analyses.

**Keywords:** Bibliometric. VOSviewer. Databases. Lipase Immobilization. Biotechnology.

### 1 INTRODUCTION

Enzymatic biocatalysts have gained prominence due to their remarkable efficiency compared to chemical catalysts, enhancing the significance of industrial biotechnology utilizing enzymes. Lipases are a widely studied and applied example, frequently used in hydrolysis and capable of catalyzing various reactions, such as acidolysis and interesterification<sup>1</sup>. The use of lipase is attributed to its versatility and tolerance to organic solvents<sup>2</sup>.

Due to the nature of enzymes and their solubility, separating them from the reaction medium when used in free form is challenging. Common methods of enzyme immobilization include physical adsorption to a constructed support, cross-linking on an insoluble support, and encapsulation in polymeric matrices<sup>3</sup>. Immobilized enzymes offer numerous advantages, including enhanced stability, protection against degradation, increased surface area, and improved reusability. These properties make them more resilient to harsh conditions and suitable for large-scale industrial applications in biotechnology, such as pharmaceuticals, food, and textiles<sup>4,5</sup>.

This immobilization technique reduces costs, simplifies downstream processing, and enhances operational stability, leading to higher catalytic efficiency and productivity, allow for easy recovery and reuse, facilitating flexible bioreactor design and process optimization. Research in lipase immobilization and its applications presents several gaps in biotechnology. While immobilization enhances stability and reusability, challenges such as high cost, lower activity compared to free lipase and chemical catalysts, and the need for optimization of reaction conditions persist. Current industrial applications of immobilized lipases focus on strategies to minimize mass transfer limitations and eliminate the need for organic solvents, indicating future research directions<sup>3,6</sup>.

Bibliometric analysis has been applied in various fields, including research on immobilized lipases in biotechnology, to understand scientific developments, map research directions, and identify trends. This study employed bibliometric analysis using two databases to examine the global panorama of the topic. The aim was to demonstrate differences in information between the two databases, the annual evolution of publications, keyword networks, types of publications, countries and collaborative networks, and main authors.

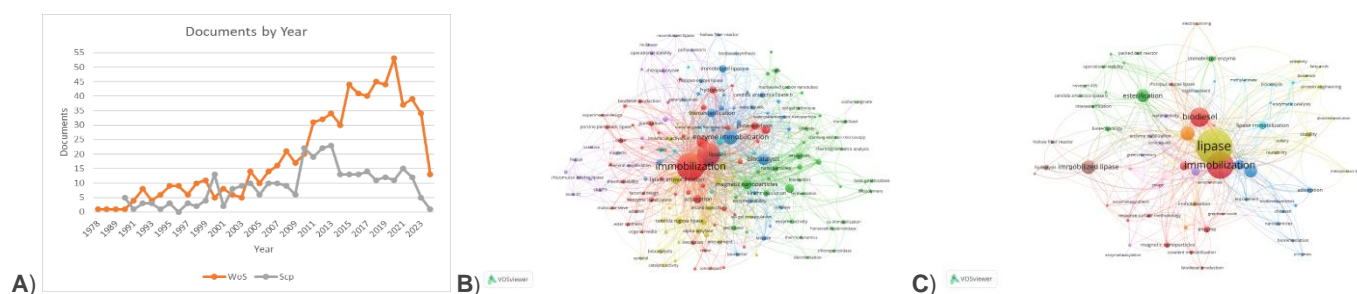
### 2 MATERIAL & METHODS

The Web of Science (WoS) and Scopus (Scp) databases were used to investigate the worldwide literature on lipase immobilization applied in biotechnology. The search terms included "immobilized," "immobilized lipase," "lipase enzyme," "immobilization," and "biotechnology," and covered titles, abstracts, and keywords of articles indexed in the databases until 2024. The search was conducted in May 2024. Data analysis was performed using VOSviewer software version 1.6.20 to evaluate keyword citations and academic collaborations among countries. Microsoft Office 2016®, specifically Microsoft Excel® version 2021, was used to compile the results and produce tables and graphs. The analysis focused on the top 10 occurrences in each category: type of publication, annual evolution, field, major journals, and authors.

### 3 RESULTS & DISCUSSION

In this study, two major global databases, Scopus and Web of Science (WoS), were used. These databases are essential tools for academic research, offering vast repositories of journal articles, conference papers, books, and other scientific materials. The Web of Science database yielded 724 documents, while the Scopus database found only 313 documents using the selected keywords. This difference arises because Web of Science, created in 1964 by Clarivate Analytics, is one of the oldest and most prestigious citation databases, with more than 74 million records, including over 21,100 active series titles and more than 230,000 books. It features a Core Collection that selects the most influential and rigorous journals in each field, along with other collections covering regional, emerging, and specialized sources. Conversely, Scopus, launched in 2004 by Elsevier, has over 91 million records, including more than 27,950 active series titles and over 292,000 books <sup>7</sup>.

When comparing the annual evolution of publications, the first indexed work in Web of Science (WoS) appeared in 1978. Scopus began indexing related works in 1990 with five publications. WoS achieved a steady increase, reaching close to ten articles annually since 1992, with notable milestones of 14 documents in 2004 and 21 in 2008. From 2010 onwards, the number of documents in WoS increased considerably, peaking at 53 articles in 2018. In contrast, Scopus experienced its initial peak in 2000 and a significant rise in publications between 2010 and 2013, reaching its highest count of approximately 30 documents during this period. By 2021, Scopus had indexed 15 documents. These trends illustrate the dynamic growth and shifts in research activities related to lipase immobilization across these two major databases (Figure 1A). The objective of the keyword co-occurrence analysis is to identify emerging trends and monitor scientific progress (Figure 1B and C).

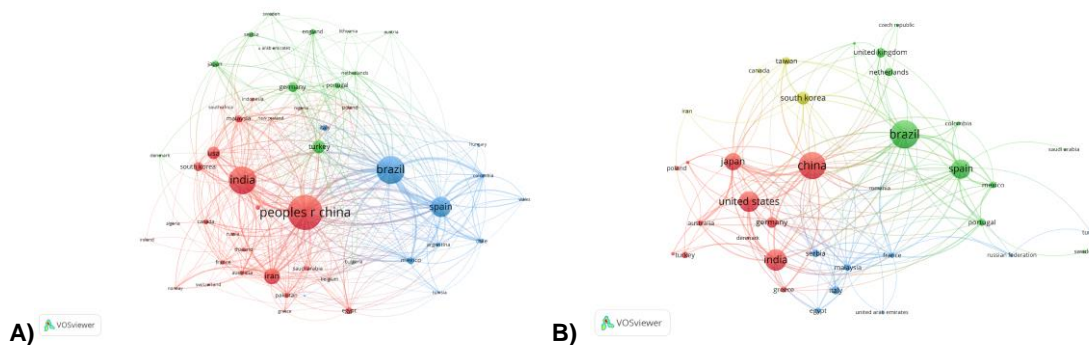


**Figure 1** Annual scientific production (A), keyword trend analysis of scientific publications in the WoS (B) and Scp (C).

Figures 1b and 1c represent the bibliometric analysis networks using the articles obtained from WoS and Scopus, respectively. The results revealed a strong tendency towards keywords such as lipase, immobilization, biocatalysis, and biodiesel, forming the main interconnected clusters in the network. One prominent cluster is enzyme immobilization, which includes works related to fixing enzymes onto solid supports, enhancing their reuse and stability. This cluster contains terms such as “enzyme immobilization” and “enzyme carriers.” Another cluster focuses on immobilizing materials, with terms like “support materials,” “matrix,” and “carrier materials” used to immobilize enzymes. Additionally, clusters of specific applications include keywords such as “biosensors,” “biocatalysis,” and “drug delivery,” highlighting the diverse applications of immobilized enzymes in various fields of industrial biotechnology. While both databases highlight core areas such as enzyme immobilization and biocatalysis, WoS exhibits a broader and more interconnected research landscape, whereas Scopus shows a stronger focus on specific applications and advanced materials.

In WoS, 656 documents consist of articles, 57 review articles, 19 proceeding papers, 10 early access articles, 3 notes, 2 book chapters, 1 correction, and 1 retraction, all written in English. In Scopus, there were 243 articles, 46 reviews, 11 book chapters, 8 conference papers, 3 short surveys, 1 erratum, and 1 editorial, all in English, and additionally including two works in Chinese. It is evident that the two databases offer significant coverage but differ in the number and types of journals indexed. Regarding publication areas, microbiology, biochemistry, and molecular biology applied to biotechnology represent the major areas, accounting for over 80%, followed by engineering, chemistry, and food science.

An analysis of publications by country revealed that Brazil, China, India, Spain, the United States, Turkey, Japan, and Germany are among the leading contributors to the field (Figure 4). According to the Web of Science (WoS) data, China leads with 142 articles, followed by Brazil with 107, India with 103, and Spain with 65 articles. In the network created by Scopus, Brazil ranks first with 44 articles, followed by China with 42, India with 31, the United States with 29, and Spain with 27 articles. Both figures illustrate the extensive and intricate networks of collaboration among countries, with China consistently at the center of these networks. In both the Web of Science (WoS) and Scopus network analyses, China is central, demonstrating strong international collaborations. In WoS, China, India, the United States, and France form the red cluster, while Brazil, with strong ties to Spain and Portugal, is prominent in the green cluster. Additional contributions come from Iran, South Korea, and Germany. In Scopus, China and Brazil are central, with extensive connections. The red cluster includes China, India, the United States, Germany, and Japan, indicating broader collaborations. Brazil's prominence, green cluster, reflects its active engagement and strong research ties with Spain and Portugal. Other active participants include the United Kingdom, Netherlands, and South Korea, highlighting global interest and collaboration.



**Figure 2** Collaborative networks between in the field according to a bibliometric analysis of the WoS (A) and Scp (B) Scopus database.

Collaboration between countries is reinforced when analyzing the 10 most relevant authors in the research according to the two databases. This data highlights the significant overlap in leading authors between the two databases, with Fernandez-Lafuente, R. (Spain) emerging as a prominent figure in both, indicating his influential role in the research of lipase immobilization. In the WoS, followed closely by Sheldon, R.A. (United Kingdom), and Raghava Rao, K.S.M.S. (India), each with 15 publications. In the Scopus database, Hill, C.G. (United States), and De Castro, H.F. (Brazil), each with 9 and 8 publications respectively. Additional notable authors include Kim, S.W. (South Korea), Guisan, J.M. (Spain), Palomo, J.M. (Spain), and Soares, C.M.F. (Brazil), each contributing 6 to 7 documents. The consistent presence of these key authors across both databases underscores their critical contributions and the collaborative nature of this research domain.

Web of Science has a Core Collection that selects the most influential and rigorous journals in each area, as well as other collections that cover regional, emerging and specialized sources. For the research in question, the top 10 journals are: Applied Biochemistry and Biotechnology (15.43%), Journal of Biotechnology (7.16%), Biotechnology and Bioengineering (6.89%), Journal Of Chemical Technology And Biotechnology (5.92%), Applied Microbiology And Biotechnology (4.41%), Biotechnology Progress (4.41%), Biotechnology Letters (3.17%), Preparative Biochemistry Biotechnology (2.62%), Biotechnology and Applied Biochemistry (2.42%) and Biotechnology and Bioprocess Engineering (2.34%). Springer Nature, Wiley and Elsevier are the largest and most important publishers. Although Scopus offers advanced search and analysis tools, plus artificial intelligence to improve the search experience, generating new insights and facilitating knowledge discovery, it is not yet possible to analyze publications by journal.

## 4 CONCLUSION

Recent trends in lipase immobilization aim at enhancing stability and reusability, using novel techniques, materials and proper selection of carriers and techniques significantly impacts catalytic performance in fostering sustainable and efficient biocatalytic processes. Academic databases are electronic information sources that facilitate the interactive search of scientific documents these field. The two databases used in this study, both prominent in academic research, exhibited notable disparities in the findings examined, including the number of articles, sources, country of origin, and authors. The higher number of documents in WoS compared to Scopus highlights the importance of database selection in bibliometric analyses. The databases which can significantly impact the observed trends and conclusions. The decision-making process between these databases may depend on the specific type of research, selectivity, indexing coverage, and update frequency. Researchers must recognize the variations between databases when choosing one for their studies. The selection of a database can greatly affect the amount and quality of academic literature they can access, which subsequently influences the quality of their research. This highlights the essential nature of researchers' awareness of these distinctions when choosing a database for their research. It is crucial that more comparative research be conducted between these two databases to examine the differences in specific requirements.

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