

## Optimization of Chemical Synthesis Processes on an Industrial Scale: Advances in Chemical Engineering and Sustainable Technologies in Peru

Fernando Eduardo Cano Legua<sup>1</sup>, Rosalio Cusi Palomino<sup>2</sup>, Cesar Augusto Ediberto Levano Salazar<sup>3</sup>, Rosa Luz Galindo Pasache<sup>4</sup>, Juan Alfredo Toledo Huamán<sup>5</sup>, Raúl Gerardo Avila Meza<sup>6</sup>

### Abstract

*A documentary review was carried out on the production and publication of research papers related to the study of the variables Chemical Synthesis, Chemical Engineering and Sustainable Technologies. The purpose of the bibliometric analysis proposed in this document was to know the main characteristics of the volume of publications registered in the Scopus database during the period 2017-2022, achieving the identification of 190 publications. The information provided by this platform was organized through graphs and figures, categorizing the information by Year of Publication, Country of Origin, Area of Knowledge and Type of Publication. Once these characteristics have been described, the position of different authors on the proposed topic is referenced through a qualitative analysis. Among the main findings made through this research, it is found that China, with 40 publications, was the Latin American country with the highest scientific production registered in the name of authors affiliated with institutions of that nation. The Area of Knowledge that made the greatest contribution to the construction of bibliographic material related to the study of Chemical Synthesis, Chemical Engineering and Sustainable Technologies was Chemical Engineering with 75 published documents, and the most used Publication Type during the period indicated above were Journal Articles with 48% of the total scientific production.*

**Keywords:** *Chemical Synthesis, Chemical Engineering, Sustainable Technologies.*

### 1. Introduction

In the dynamic environment of industrial processes, chemical optimisation plays a key role in improving efficiency, reducing waste and promoting sustainability. Peru, a country known for its rich natural resources and thriving industrial sector, has been a leader in using advances in sustainable chemistry and technology to fuel its industrial growth while reducing its environmental impact. This article provides an overview of chemical optimization processes on an industrial scale and highlights Peru's significant progress in implementing sustainable practices in its chemical industry.

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<sup>1</sup> Universidad Nacional "San Luis Gonzaga", fcano@unica.edu.pe, <https://orcid.org/0000-0002-6881-4313>

<sup>2</sup> Universidad Nacional "San Luis Gonzaga", rosalia.cusi@unica.edu.pe, <https://orcid.org/0000-0003-1075-5725>

<sup>3</sup> Universidad Nacional "San Luis Gonzaga", cesar.levano@unica.edu.pe, <https://orcid.org/0000-0002-5922-1305>

<sup>4</sup> Universidad Nacional "San Luis Gonzaga", rosa.galindo@unica.edu.pe, <https://orcid.org/0000-0001-8696-5185>

<sup>5</sup> Universidad Nacional "San Luis Gonzaga", juan.toledo@unica.edu.pe, <https://orcid.org/0000-0003-2455-588X>

<sup>6</sup> Universidad Nacional "San Luis Gonzaga", raul.avila@unica.edu.pe, <https://orcid.org/0000-0002-8533-4258>

Chemical optimization processes on an industrial scale involve the systematic refinement and improvement of chemical processes, from the extraction of raw materials to the distribution of final products. These processes are essential for industries as diverse as mining, agriculture, manufacturing, and energy production. By adjusting reaction conditions, optimizing catalysts, and using innovative technologies, the industry can achieve higher yields, lower energy consumption, and limit the generation of harmful byproducts.

In recent years, Peru has become a world leader in chemistry, driven by its abundant natural resources and growing focus on sustainability. China's chemical industry has made significant strides in optimizing industrial processes to balance economic growth with environmental responsibility. Peru's commitment to sustainable development is in line with global efforts to combat climate change, protect ecosystems, and reduce carbon emissions.

Research on chemical optimization in Peru will delve into the country's progressive initiatives, from sustainable mining that reduces environmental degradation to the development of green agricultural technologies that increase yields and maintain soil health. In addition, we will examine Peru's progress in clean energy production, with a special focus on renewable energy sources such as hydroelectric and solar, which play a key role in the sustainable development of the country's industry.

In this comprehensive study of Peru's chemically optimized processes and sustainable technological advancements, we will highlight the innovative solutions, groundbreaking research, and collaborative efforts that make Peru a leader in the pursuit of a more sustainable industrial future. By harnessing the transformative potential of chemistry and harnessing sustainable technologies, Peru is not only improving its industrial competitiveness, but also contributing to a greener and more sustainable global landscape. For this reason, this article seeks to describe the main characteristics of the compendium of publications indexed in the Scopus database related to the variables Chemical Synthesis, Chemical Engineering and Sustainable Technologies, as well. Such as the description of the position of certain authors affiliated with institutions, during the period between 2017 and 2022.

## **2. General Objective**

To analyze, from a bibliometric and bibliographic perspective, the preparation and publication of research papers in high-impact journals indexed in the Scopus database on the variables Chemical Synthesis, Chemical Engineering and Sustainable Technologies during the period 2017-2022.

## **3. Methodology**

This article is carried out through a research with a mixed orientation that combines the quantitative and qualitative method.

On the one hand, a quantitative analysis of the information selected in Scopus is carried out under a bibliometric approach of the scientific production corresponding to the study of the variables Chemical Synthesis, Chemical Engineering and Sustainable Technologies. On the other hand, examples of some research works published in the area of study mentioned above are analyzed from a qualitative perspective, based on a bibliographic approach that allows describing the position of different authors on the proposed topic. It is important to note that the entire search was carried out through Scopus, managing to establish the parameters referenced in Figure 1.

### 3.1. Methodological design

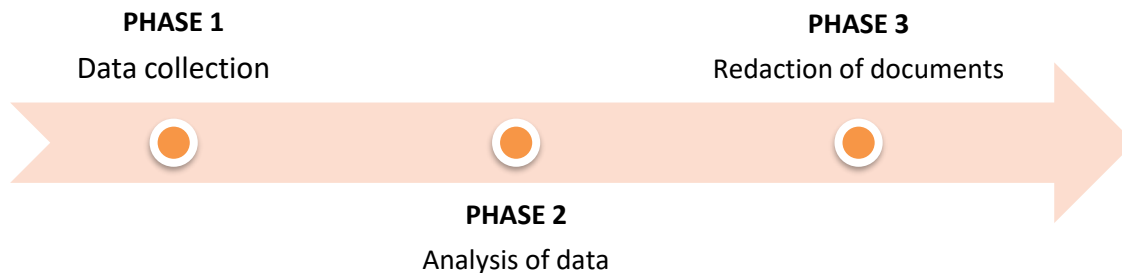


Figure 1. Methodological design

Source: Authors' own creation

#### 3.1.1 Phase 1: Data collection

Data collection was carried out from the Search tool on the Scopus website, where 190 publications were obtained by choosing the following filters:

TITLE-ABS-KEY ( chemical AND synthesis, AND chemical AND engineering, AND sustainable and technologies ) AND PUBYEAR > 2016 AND PUBYEAR < 2023

- Published documents whose study variables are related to the study of the variables Chemical Synthesis, Chemical Engineering and Sustainable Technologies.
- Limited to the period 2017-2022.
- Without distinction of country of origin.
- Without distinction of area of knowledge.
- No distinction of type of publication.

#### 3.1.2 Phase 2: Construction of analytical material

The information collected in Scopus during the previous phase is organized and then classified by graphs, figures and tables as follows:

- Co-occurrence of words.
- Year of publication
- Country of origin of the publication.
- Area of knowledge.
- Type of publication.

#### 3.1.3 Phase 3: Drafting of conclusions and outcome document

In this phase, the results of the previous results are analysed, resulting in the determination of conclusions and, consequently, the obtaining of the final document.

## 4. Results

### 4.1 Co-occurrence of words

Figure 2 shows the co-occurrence of keywords found in the publications identified in the Scopus database.

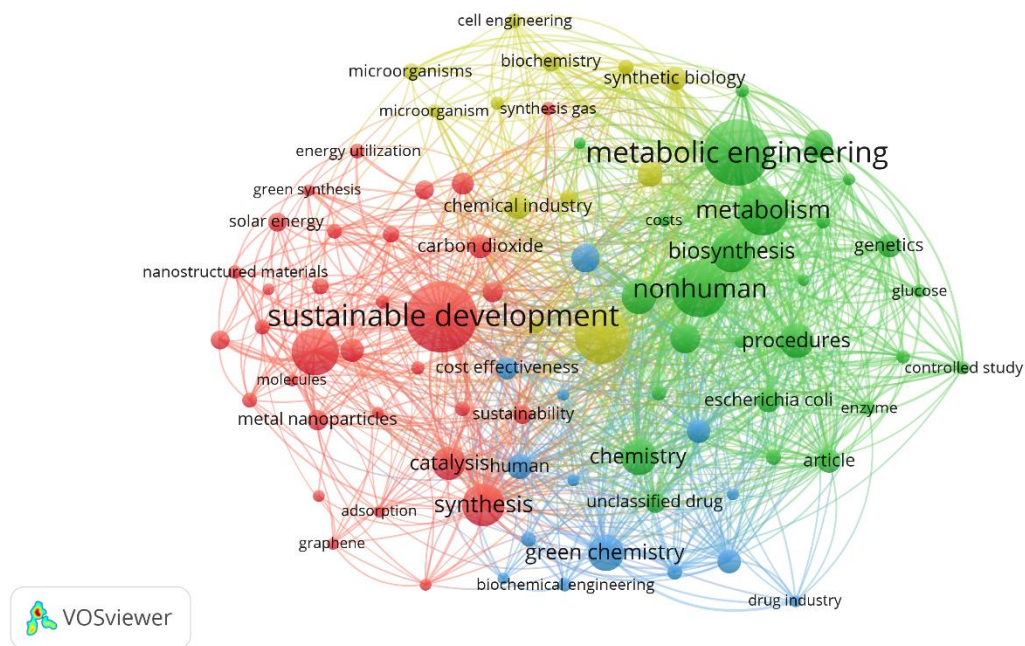


Figure 2. Co-occurrence of words

Source: Authors' own elaboration (2023); based on data exported from Scopus.

Sustainable development was the most frequently used keyword within the studies identified through the execution of Phase 1 of the Methodological Design proposed for the development of this article. Chemistry is among the most frequently used variables, associated with variables such as Metabolic Engineering, Synthesis, Chemical Processes, Chemical Engineering, Biosynthesis, Microorganisms. From the above, it is noteworthy, Peru seeks to strengthen its position in the global industrial sector, optimizing chemical processes and incorporating sustainable technologies. By taking advantage of advances in chemistry and adopting sustainable practices, Peru can not only increase industrial efficiency but also contribute to a cleaner, more environmentally friendly future. In the following pages, we'll look at specific examples and case studies that illustrate how chemical optimization and sustainable technologies are reshaping Peru's industrial landscape for the better.

#### 4.2 Distribution of scientific production by year of publication

Figure 3 shows how scientific production is distributed according to the year of publication.

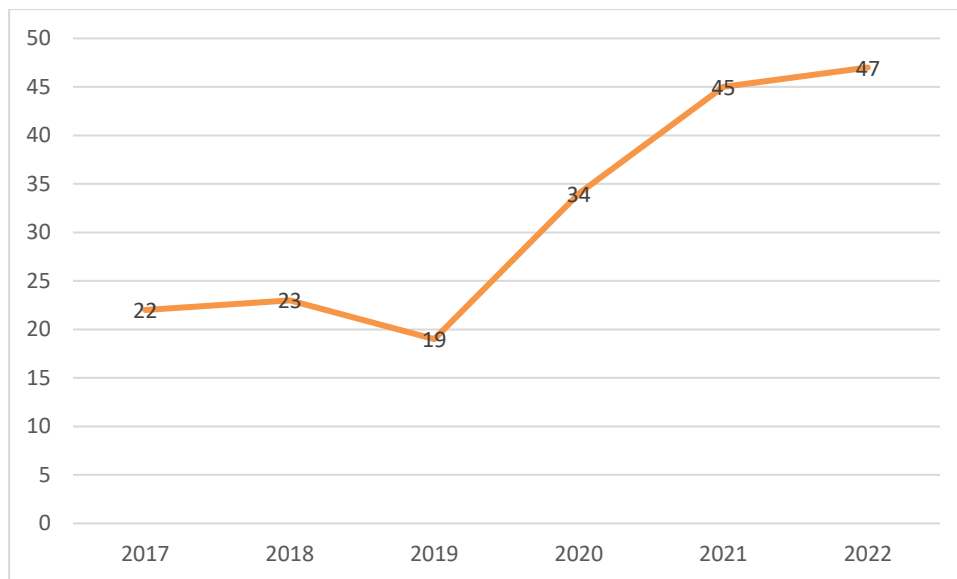


Figure 3. Distribution of scientific production by year of publication.

Source: Authors' own elaboration (2023); based on data exported from Scopus

Among the main characteristics evidenced through the distribution of scientific production by year of publication, the number of publications registered in Scopus was in 2022, reaching a total of 47 documents published in journals indexed on this platform. This can be explained by articles such as the one entitled "Opportunities and Potential of Green Chemistry in Nanotechnology" This article discusses the application and impact of modern green technologies, as well as the future potential for transdisciplinary interaction. The 12 Principles of Green Chemistry, first published in 1998, provide a framework accepted not only by chemists, but also by designers and policymakers. The implementation of the principles was driven by decades of inadvertent environmental damage and the human health effects of the production and use of hazardous chemicals. But the principles for the synthesis and fabrication of man-made nanomaterials (ENMs) have been in use for more than decades. Even though the entire scientific community promotes advances in nanotechnology, there are still considerable gaps in research and the possibility of safe and responsive application of the great economic, social and environmental benefits of MNAs. In the context of the notion of "Green Economy", the social and economic relationship between the environment and the economy can be properly managed.(Soni, 2022)

#### 4.3 Distribution of scientific production by country of origin.

Figure 4 shows how the scientific production is distributed according to the nationality of the authors.

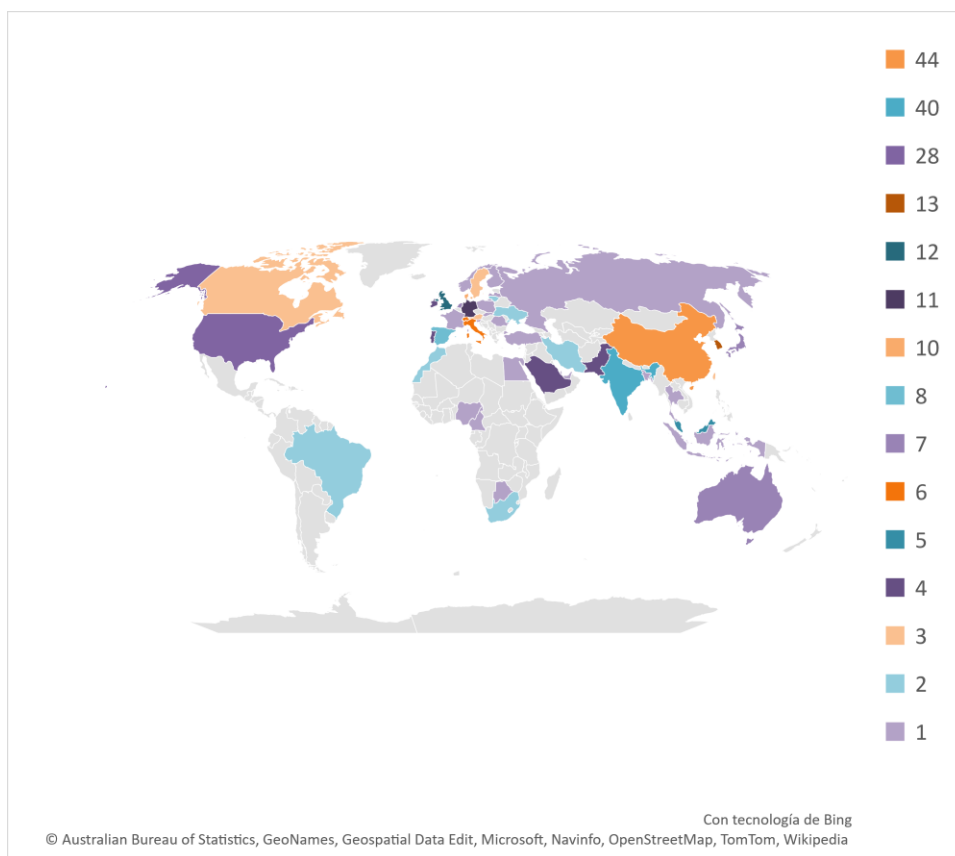


Figure 4. Distribution of scientific production by country of origin.

Source: Authors' own elaboration (2023); based on data provided by Scopus.

Within the distribution of scientific production by country of origin, registrations from institutions were taken into account, establishing China as the country of that community, with the highest number of publications indexed in Scopus during the period 2017-2022, with a total of 44 publications in total. In second place, India with 40 scientific papers, and the United States occupying the third place presenting to the scientific community, with a total of 28 papers among which is the article entitled "Highly elastic, durable and transient conductive hydrogel for signal transmission applications and multifunctional sensors" this article proposed an interfacial engineering strategy to fabricate a transient conductive hydrogel with well-defined properties. addressing the long-standing problem of interfacial incompatibility between solid conductive fillers and a soft polymer matrix. Using oxidized cellulose nanofibrils (CNFs) with TEMPO as an interfacial stabilizer, stable liquid metal nanoparticles (LMNPs) encapsulated in CNFs are synthesized, which can initiate free radical polymerization of acrylic acid (AA) monomers, forming a fully physically cross-linked PAA-CNF. -Hydrogel LMNPs. This hydrogel exhibits several advantages that have not been obtained in a single hydrogel, including environmentally friendly manufacturing without the addition of chemical initiators or crosslinkers, excellent stretchability, satisfied solvent-independent conductivity, high stress sensing sensitivity, stable signal transmission, and crack resistance. , self-healing, antifreeze and transient properties. Due to these superb properties in all respects, this resulting hydrogel is considered a sustainable, durable, and high-performance platform for soft and portable electronic devices.(Ye, 2022)

#### 4.4 Distribution of scientific production by area of knowledge

Figure 5 shows the distribution of the elaboration of scientific publications based on the area of knowledge through which the different research methodologies are implemented.

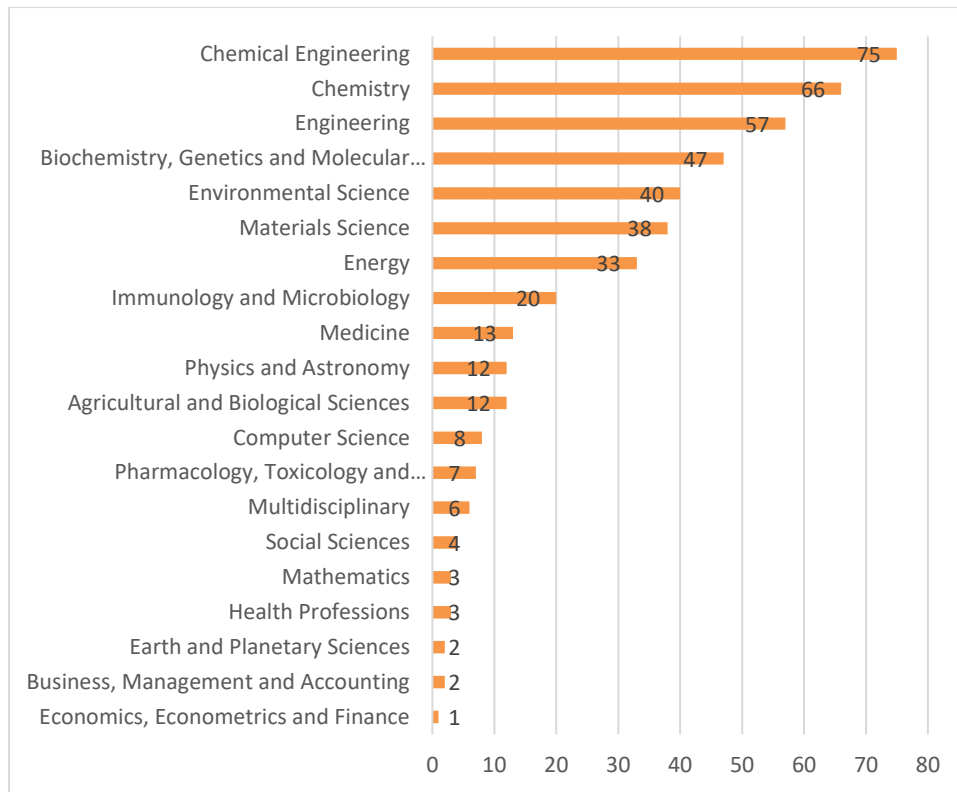


Figure 5. Distribution of scientific production by area of knowledge.

Source: Authors' own elaboration (2023); based on data provided by Scopus.

Chemical Engineering was the area of knowledge with the highest number of publications registered in Scopus with a total of 75 documents that have been based on its variable methodologies Chemical Synthesis, Chemical Engineering and Sustainable Technologies. In second place, Chemistry with 66 articles and Engineering in third place with 57. This can be explained thanks to the contribution and study of different branches, the article with the greatest impact was registered by the Chemical Engineering area entitled "Thiocarbamoyl disulphides as inhibitors of urease and ammonia monooxygenase: crystal engineering for novel materials" This article reveals the high efficacy of three molecules of the thiuram family, namely, tiram (tetramethyltiuram disulfide, TMTD), disulfiram (tetraethyltiuram disulfide, TETD) and tetraisopropyltiuram disulfide (TIPTD), as inhibitors of both activities of the bean (*Canavalia ensiformis*). urease (JBU) and *Nitrosomonas europaea* AMO. The water solubility of these compounds was significantly improved by the preparation of three novel  $\beta$ -cyclodextrin inclusion complexes with TMTD, TETD and TIPTD by mechanochemical synthesis, using eco-friendly technology. The resulting  $\beta$ -CD·tiuram complexes  $\beta$ -CD· TMTD, ( $\beta$ -CD)<sub>2</sub>· TETD and ( $\beta$ -CD)<sub>2</sub>· TIPTDs were characterized by powder X-ray diffraction, thermogravimetric analysis, and solid-state NMR. . A conformational polymorph of TIPTD was also detected and isolated by hot-stage microscopy and structurally characterized by monocrystalline X-ray diffraction. Biological enzyme inhibition tests performed on JBU and AMO with the  $\beta$ -CD·thiuram complexes showed the same inhibitory efficacy as the isolated molecules, suggesting that the active species is, in all cases, free thiuram, probably in equilibrium with the adduct in solution. These results have great potential to improve the nitrogen use efficiency of soil fertilizers for a greener environment.(Casali, 2022)

#### 4.5 Type of publication

In the following graph, you will see the distribution of the bibliographic finding according to the type of publication made by each of the authors found in Scopus.

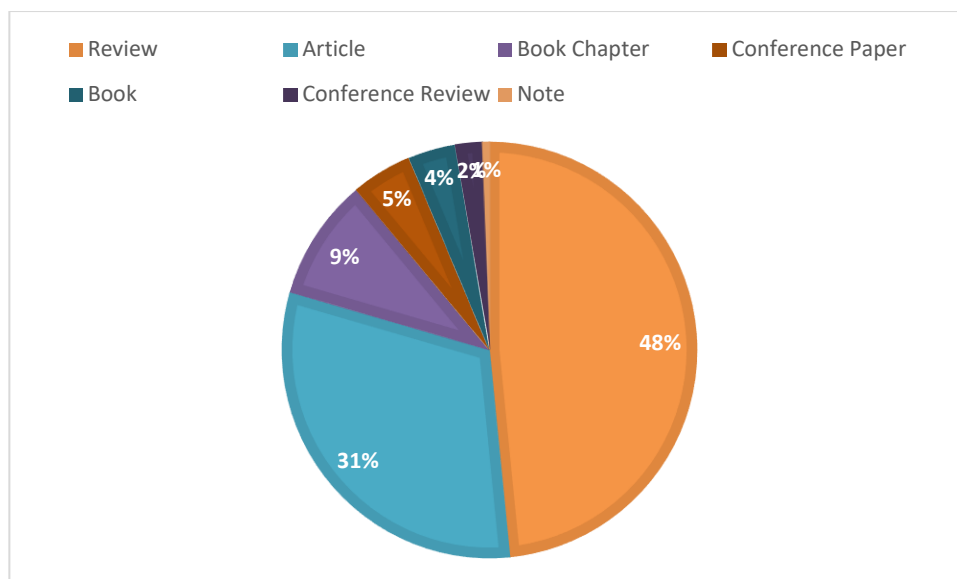


Figure 6. Type of publication.

Fountain: Authors' own elaboration (2023); based on data provided by Scopus.

The type of publication most frequently used by the researchers referenced in the body of this document was the one entitled Journal Articles with 48% of the total production identified for analysis, followed by Article with 31%. Chapter of the Book are part of this classification, representing 9% of the research papers published during the period 2017-2022, in journals indexed in Scopus. In this last category, the one entitled "Engineering of oxygen vacancies of new ultrafine nanosheets of Bi<sub>12</sub>O<sub>17</sub>Br<sub>2</sub> to boost the photocatalytic reduction of N<sub>2</sub>" stands out. In this work, we report the successful synthesis of ultrafine nanosheets of Bi<sub>12</sub>O<sub>17</sub>Br<sub>2</sub> by a simple alkaline treatment and a solvothermal method. Ultrathin nanosheets of Bi<sub>12</sub>O<sub>17</sub>Br<sub>2</sub> can improve carrier separation and transfer of photogenerated electrons to N<sub>2</sub> molecules, thereby improving photocatalytic efficiency. It is noteworthy that the higher atomic ratio Bi/Br in Bi<sub>12</sub>O<sub>17</sub>Br<sub>2</sub> is beneficial for widening the light-absorbing edge, and the high concentration of O atoms is easy to produce oxygen vacancies on the surface during the Bi<sub>12</sub>O<sub>17</sub>Br<sub>2</sub> synthesis process. The abundant oxygen vacancies and high specific surface area allow N<sub>2</sub> molecules and water to have powerful chemical adsorption and activation. In addition, the photocatalytic reduction of N<sub>2</sub> to NH<sub>3</sub> in pure water shows excellent and stable performance, and the average generation rate of NH<sub>3</sub> reaches up to 620.5 μmol·L<sup>-1</sup>·h<sup>-1</sup>. This study finds that oxygen-rich vacancies and ultrafine morphology may play an important role in the process of the nitrogen reduction photocatalytic reaction.(Gao, 2022)

## 5. Conclusions

Through the bibliometric analysis carried out in this research work, it was possible to establish that China was the country with the highest number of published records for the variables Chemical Synthesis, Chemical Engineering and Sustainable Technologies. with a total of 44 publications in the Scopus database. In the same way, it was established that the application of theories framed in the area of Chemical Engineering, chemical optimization processes on an industrial scale benefit enormously from advances in sustainable chemistry and technology. These advancements have resulted in more efficient and environmentally friendly manufacturing processes that reduce waste generation, increase energy efficiency, and reduce environmental impact. A major achievement in chemistry is the development of catalysts that increase the efficiency of chemical reactions. These catalysts allow the use of lower temperatures and pressures, reducing energy consumption and increasing reaction rates. In addition, the use of



recycled and bio-based materials as raw materials has become increasingly important, reducing dependence on fossil fuels and reducing greenhouse gas emissions. Sustainable technologies also play a crucial role in the chemical optimisation process. The introduction of process improvement technologies, such as continuous-flow reactors and microreactors, has reduced space, material consumption, and better controlled reaction conditions. In addition, the integration of renewable energy sources such as solar and wind into industrial processes contributes to the overall sustainability of chemical optimization. Overall, the combination of chemical advances and sustainable technologies has revolutionized chemical optimization processes on an industrial scale. These advancements enable more efficient, cost-effective, and environmentally friendly production processes that contribute to the overall goal of a sustainable chemical industry.

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