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Nanotechnology applications in structures

Aplicaciones de nanotecnología en estructuras

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Abstract

Technological development in nanotechnology has favored different areas of knowledge and has allowed the integration of diverse systems. Currently, it is not only focused on the areas of health, it has also ventured into production processes, the automotive sector, construction, housing sector and even shielding. The present work seeks to consult applications in the area of structures, using scientific databases and analyzing the results through bibliometric networks built with the VOSviewer software, which highlights concepts focused on the production of nanomaterials such as nanotubes and nanocements used in the construction of buildings, mainly those that have artificial intelligence and high security conditions. The networks allow us to see the influence of nanotechnology in the solution of engineering problems and its application in fields of construction and design of civil works and structures.

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The progress of nanomaterials allows considering new areas of application in the construction sector, however, it is necessary to improve their properties and characteristics.
Keywords: Construction, Nanomaterials, Nanotechnology, Structures.

Resumen

El desarrollo tecnológico en nanotecnología ha favorecido distintas áreas del conocimiento y ha permitido la integración de sistemas diversos, en la actualidad no sólo se enfoca en las áreas de la salud, también ha incursionado en procesos de producción, sector automovilístico, construcción, inmobiliario y hasta blindaje. El presente trabajo busca consultar aplicaciones en el área de estructuras, usando bases de datos científicas y analizando los resultados mediante redes bibliométricas construidas con el software VOSviewer, donde se destacan conceptos enfocados hacia la producción de nanomateriales como nanotubos y nanocementos empleados en la construcción de edificaciones, principalmente en aquellas que cuentan con inteligencia artificial y condiciones de alta seguridad. Las redes permiten ver la influencia de la nanotecnología en la solución de problemas de ingeniería y su aplicación en campos de construcción y diseños de obras y estructuras civiles. El progreso de nanomateriales permite considerar nuevas áreas de aplicación en el sector de la construcción, sin embargo, se requiere mejorar sus propiedades y características.
Palabras clave: Construcción, Estructuras, Nanomateriales, Nanotecnología.

1. Introduction

The improvements in the physical and chemical properties of materials thanks to nanotechnology have motivated their study to increase their applications. Various research on nanotechnology applications has been carried out in different areas such as production processes [1], automotive sector [2], health [3], food [4], logistics [5], housing sector [6] and construction [7]. In the construction area, the constant search for innovative solutions that

improve the efficiency, durability and sustainability of structures is a priority; in this sense, nanomaterials have emerged as a promising technology that is changing the way buildings and infrastructure are designed and constructed. This sector has involved nanotechnology in order to improve the chemical, physical and mechanical properties of elements used in buildings, coatings and other different materials. Some studies conclude that the use of nanomaterials is useful in improving the behavior of the element that is being studied.

For the controlled production of nanoparticles, the chemical method can be used, which consists of adjusting properties through reactions by modifying parameters such as temperature and concentrations, or the physical method that uses mechanical processes [8].

Nanotechnologies and nanomaterials allow increasing efficiency in construction, the real estate sector and related sectors [9].

1. Methodology

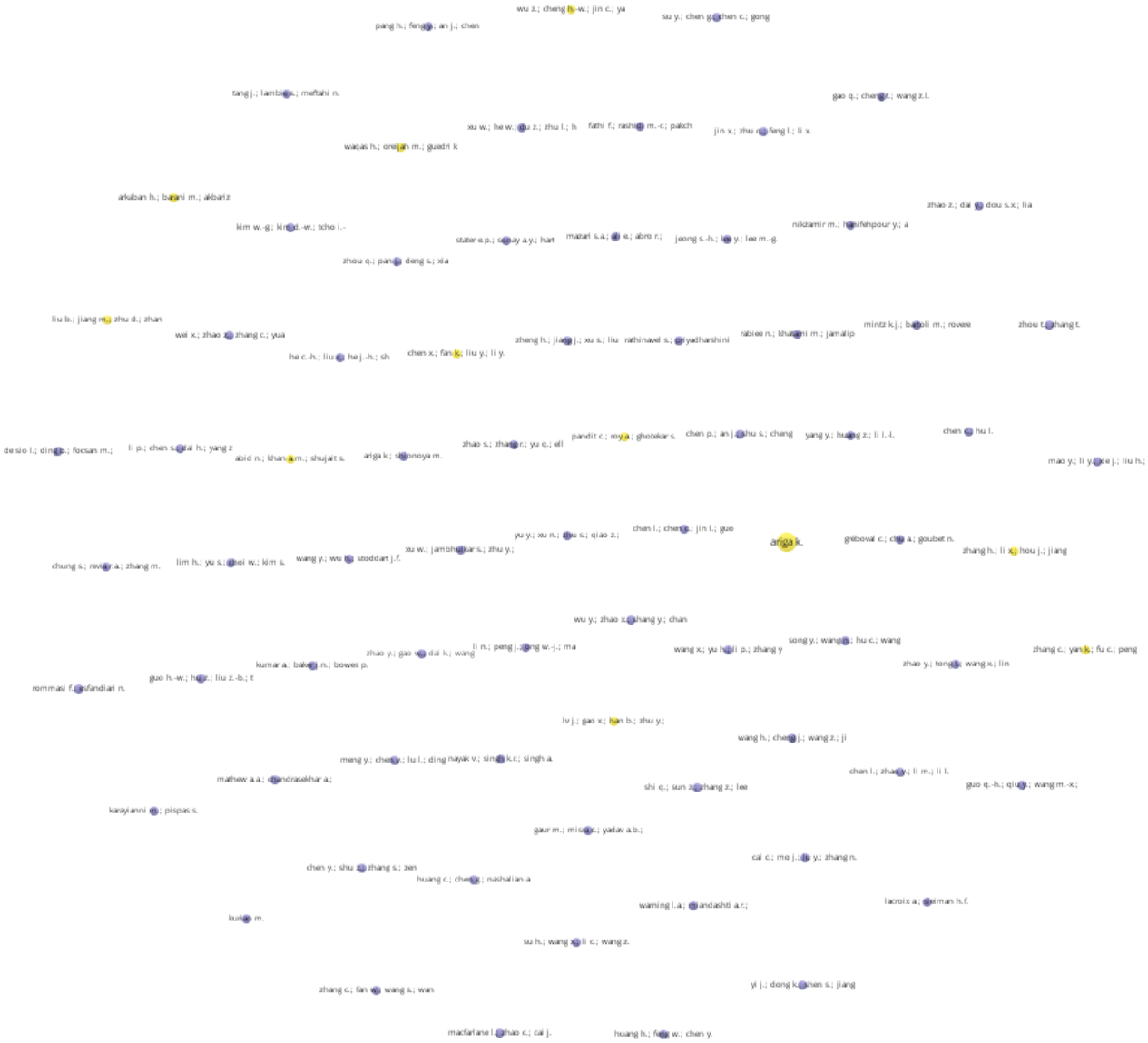
Using “nanotechnology AND applications AND structures” as search equation in the article title, abstract and keywords in the Scopus database, 29699 results are obtained, filtered for the last years (2021 to 2024), excluding the subject areas that are not directly related to the study, which are: business, management and accounting, veterinary, dentistry, decision sciences, psychology, nursing, arts and humanities; reducing their number to 1704 documents. These documents were analyzed by building bibliometric networks with the help of VOSviewer software, which allows identifying correlations between authors and concepts from bibliographic data. Finally, the information presented on the bibliometric networks is studied to conclude and discuss it.

2. Results

Bibliometric networks are built to identify relationships between the selected publications, firstly co-authorship networks are presented, followed by occurrence networks between keywords.

Figure 1 of co-authorship between authors shows the absence of notable relationships between documents.

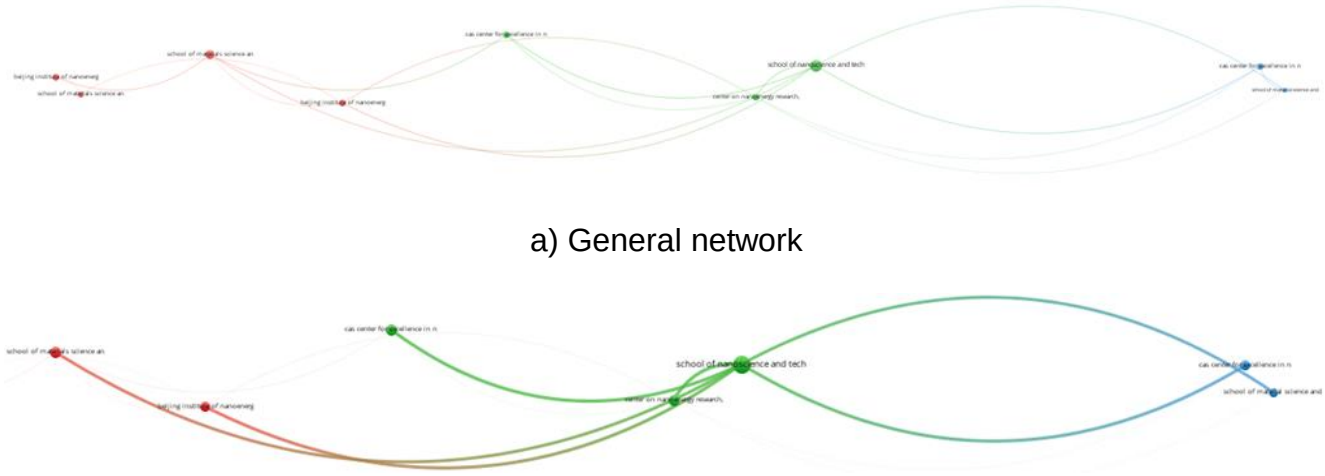
Figure 1. Co-authorship between authors



Source: own, using VOSviewer

At the organizational level, it was possible to identify co-authorship in the documents as shown in part a) of Figure 2. The organization with the greatest interaction is The Scholl of nanoscience and technology as seen in part b) of the Figure 2, where the organizations with which it works are also related.

Figure 2. Co-authorship between organizations



a) General network

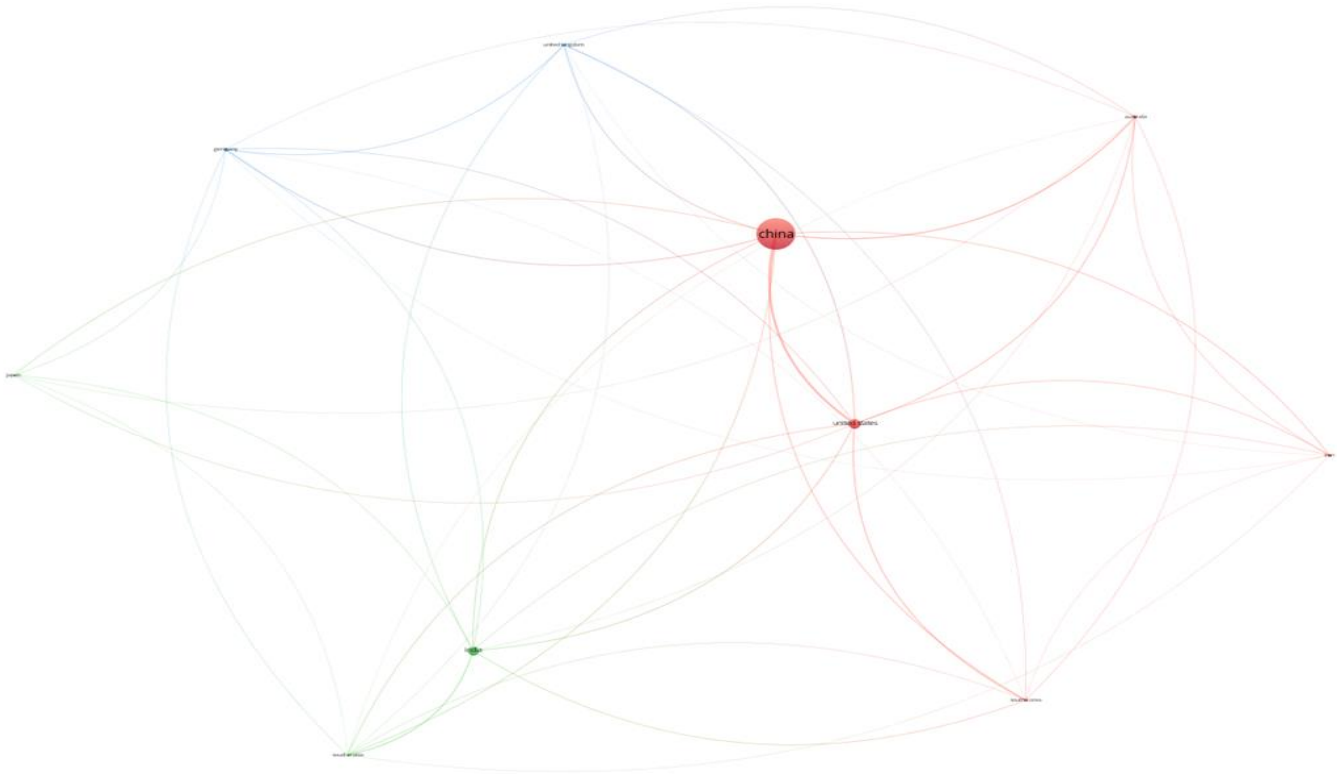
b) Organizations The Scholl of nanoscience and technology works with

Source: own, using VOSviewer

Figure 3 shows the co-authorship between countries, the top 10 was obtained considering the countries with more than 50 documents and with the greatest number of citations, this top is made up of: China, United States, India, Australia, United Kingdom, South Korea, Germany, Saudi Arabia, Iran and Japan, in order. Part a) of figure 3 shows the network with the top 10 countries and part b) highlights the connections of the leading country: China.

On the other hand, part a) of Figure 4 graphs the co-occurrence between all the keywords that appear more than 10 times. Part b) of Figure 4 highlights the most important direct relationship of nanotechnology with nanostructures, which in turn serves as a bridge for other connections.

Figure 3. Co-authorship between countries



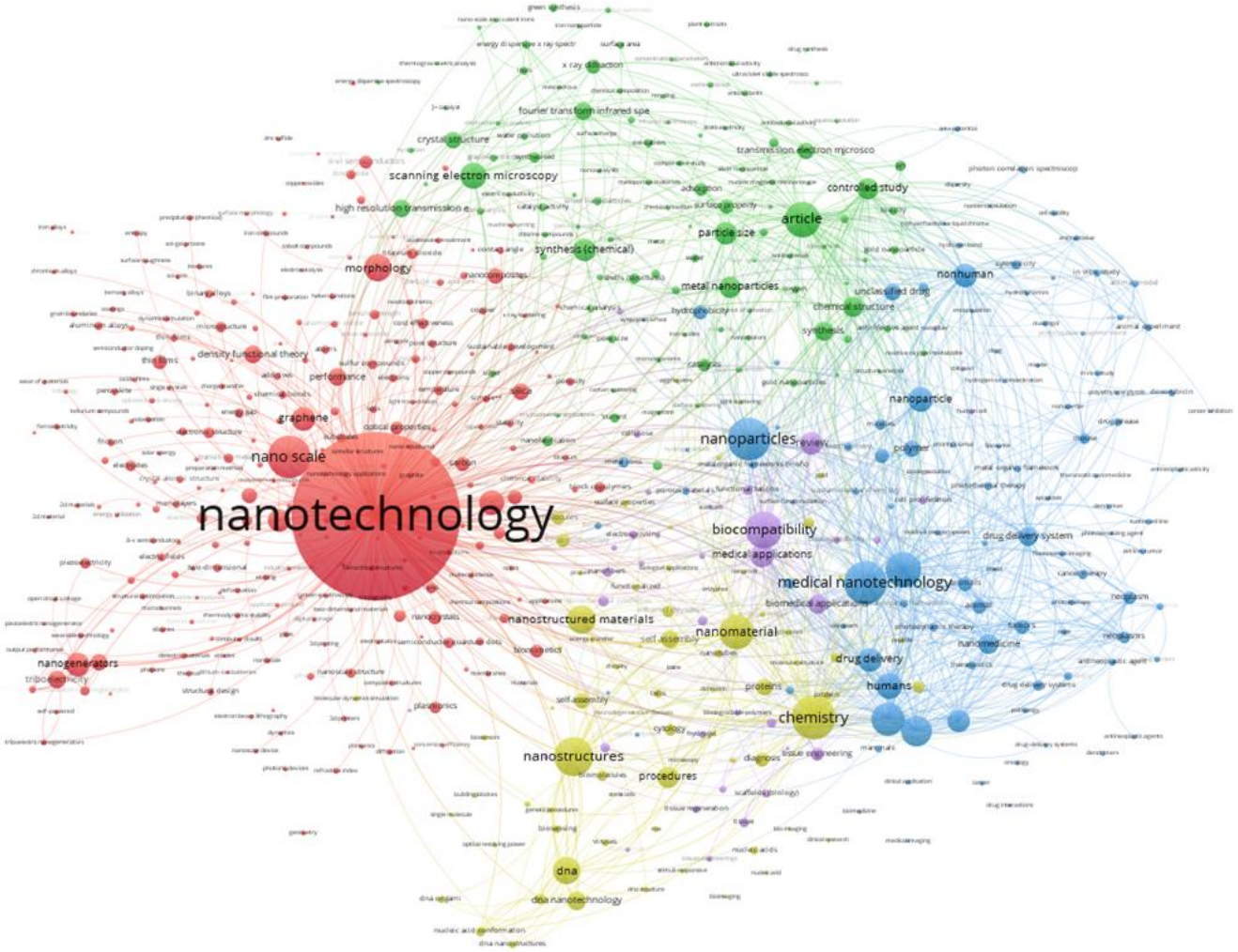
a) General network

b) Countries with the greatest connection with China.

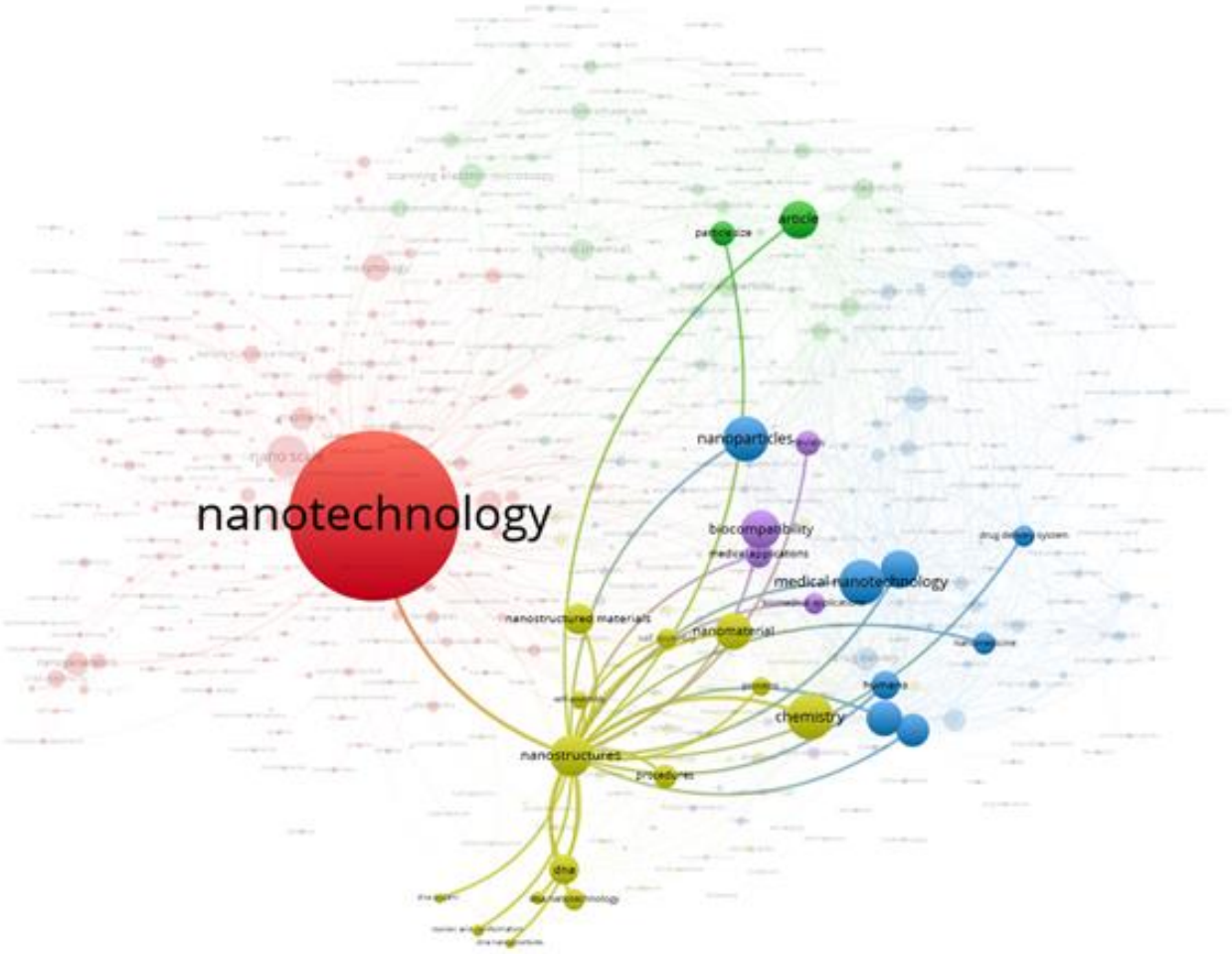
Source: own, using VOSviewer

The most representative key words selected by number of occurrences (greater than 60) by full and fractional couting are: Nanotechnology, nanoparticles, human, chemistry, nanoscale, medical nanotechnology, nanostructures, biocompatibility, article, nanomaterial, controlled drug delivery, targeted drug delivery, nanostructured materials, morphology, dna, scanning electron microscopy, property, medical applications, nonhuman, diseases, review, controlled study, chemical structure and, drug delivery system. The greatest progress is reported in applications related to the health sector.

Figure 4. Co-occurrence between all the keywords



a) General network



b) Keywords related to nanotechnology

Source: own, using VOSviewer

In general, these graphs are based on the distance then greater proximity means greater relationship between the elements.

3. Discussion

As mentioned in the introduction, generally, the application of nanomaterials in the construction sector is due to the search for improved properties. The incorporation of nanoparticles has had a long journey, whether in cements, insulators, pavements, glass or paints. The most used nanomaterials are nano aluminum oxide, nano silicon oxide, nano meta kaolin, nano zinc oxide and carbon nano tubes that develop an effect on resistance; but the performance of

nanomaterials depends on the technique with which they are synthesized, so it is somewhat variable and it is not appropriate to strictly define each compound and its expected effect [10].

The field of nanomaterials in the construction area covers a variety of elements and chemical compounds, among the most common are: titanium dioxide and carbon derivatives.

Titanium oxide was studied by [11] who found a striking characteristic that resulted from using nanosheets of this specific material, giving it stability and a low release of nitrogen dioxide, which is one of the largest atmospheric pollutants, which calls for special attention in terms of sustainability for future applications.

On the other hand, titanium dioxide was studied by [12], when it is applied to Portland cement, finding it reduces the hydration rate, which translates into an improvement in mechanical properties, the addition of nanomaterials makes the composite material dense and improve the hydration/geopolymerization process, which causes greater mechanical performance.

With carbon derivatives [13] develop nanotubes that increase resistance to fatigue, and damage, in turn, improve durability and lightness, for their application as nanofiller in different projects developed in the area of civil engineering; [14] studied the influence of the configuration of coated carbon nanotubes on the kinetic stability of short oligonucleotides [15].

Graphene oxide is another carbon derivative that has a future, it is widely used in the fields of science and technology due to its notable physicochemical properties, particularly its use in asphalt mixtures and as an additive for tempered mixtures shows the need for both of the chemical reaction as well as the physical mixture. Graphene oxide helps improve the adhesion between asphalt and aggregate, which increases moisture resistance and improves the material’s behavior against rutting and fatigue.

Other examples of improving properties in concrete are given by [9] through the introduction of carbon nanotubes in the concrete mixture used for asphalt coating, also [16] demonstrated that nanosilicon dioxide significantly increases the resistance of concrete; in another case, it is

indicated that nanomaterials can fill porosities, a condition that reduces the fragility and possible cracking of the cement [17].

Among other inventions in the area of nanotechnology related to the construction sector, [9] highlights security systems.

A characteristic that [18] presents is that the use of nanomaterials is more environmentally sustainable than traditional materials, which can mean a better and more responsible alternative for the future. In this same sense [19] mentions that nanomaterials can prevent energy loss, conserve energy, reduce the consumption of natural resources, take up less space than traditional materials, their application reduces the production of gases harmful to the environment, maintains the internal thermal balance, reduces cleaning time and the use of chemical substances in cleaning.

Nanomaterials have a great disadvantage that lies in their high production cost and the technology necessary for their development. In addition to this, it must be taken into account that it is an area that is barely being researched and tested, however, a priority that is What you should consider is its bulk production, with less human intervention and lower costs.

Just as traditional construction materials have certain warnings and precautions for their use and application, nanomaterials must have protocols for their production and handling, since being tiny particles they represent several risks if adequate prevention measures are not considered.

4. Conclusions

Nanotechnology constitutes an opportunity to improve the physical-chemical characteristics of materials from nanoparticles, with varied applications at all levels, with great relevance in the construction sector and especially in structures, with good results reported in scientific documents. However, future work is required focused on reducing the costs and risks associated with the production and use of nanomaterials in the construction sector.

The11eveloppment of nanotechnology is highlighted as a constantly evolving field and the landscape can change rapidly as more countries invest in this area. As science and technology advance, it is becoming evident that nanotechnology needs further exploration as nanomaterials possess immense application potential.

Collaborative work on the subject represents an opportunity that could lead to important results, in analysis of bibliographic networks it allows to show the little joint work between authors and the little between organizations. At the country level with notable performance, China can be considered the benchmark on the subject.

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