Analysis and Visualisation of Research Trends in Nano Material: A General Review

Ranvijay Kumar

1Department of Mechanical Engineering Chandigarh University, Gharuan, Mohali, Punjab, 140413

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Abstract: Technically, the material possessing a minimum, one external dimension measuring 1-100nm is called Nanomaterial, and cannot be seen by the naked eye. The bibliometric analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of “Nanomaterial”[1], [2]. All published articles related to “Nanomaterial” from “Scopus”, were analyzed using the VOS viewer to develop analysis tables and visualization maps. This article had set the objective to consolidate the scientific literature regarding the “Nanomaterial” and also to find out the trends related to the same. The most active journals in this research domain were Construction and Building Materials and Composites Science and Technology. The most active countries were China and the United States of America. The leading organizations engaged in the research regarding Nanomaterial was the Chinese Academy of Sciences, the North Eastern University of China, and the Ministry of Education of China. The most active authors who had made valuable contributions related to Nanomaterial were Wang Y. and Yang H.

Keywords: Nanomaterial, Bibliometric analysis, VOS viewer

1. Introduction

The material possessing minimum, one external dimension measuring 1-100nm is called Nano material[3]–[5]. Most of the Nanomaterials are too small and cannot be seen by the naked eye. Nanomaterials are being used in numerous fields like chemicals, pharmaceutical sector, textile, cement, energy, transportation, electronics, and bioengineering. The Nanomaterials are extremely useful due to their smaller size and versatility; high catalytic activity and high solubility features[6]. However, the major concerns of Nanomaterials are their effect on health and knowledge gaps. There is numerous definition for Nanomaterial and “Material with any external dimension in the Nanoscale (Size range 1-100nm) or having an internal structure or external structure in Nanoscale”– ISO 2015. Similarly according to the definition of European Commission 2011 for Nanomaterial, “natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm - 100 nm.”[7]–[9]. Nanomaterials can be generally of three types of origin, a) Nanomaterials with natural origin (Example: Volcanic ash) b) by-products of combustion process (Example: Diesel engines) c) engineered Nanomaterials for specific purposes.

1.1 Research Objectives

a) To consolidate the literature regarding the Nanomaterial
b) To find out the trends related to research in the Nanomaterial

The following research questions are framed for conducting bibliometric analysis systematically.

1.2 Research Questions

a) Who are the active researchers working on the Nanomaterial?
b) Which are the main organizations and countries working on Nanomaterial?
c) Which are the main journals related to Nanomaterial?

1.3 Significance of this research

The nanomaterials is an important research niche in material engineering. This article points out the need for future research regarding Nanotechnology and Nanomaterial. This bibliometric analysis will be a useful platform for future researchers by realizing the top researchers, organizations, and countries involved in research regarding Nanomaterial. This bibliometric article is arranged in four sections. The first section is the introduction, followed by the discussion of the methodology by which the research was conducted. The third section deals with results and discussion. The fourth section deals with the conclusion.

2. Research Methodology

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE (“Nanomaterial”) on 03/01/2020. All the tables in this paper were created by using Microsoft Excel and VOS Viewer. Grammarly was used for spelling and grammar checks. Mendeley was used for article review and citation. This paper had been inspired by bibliometric analysis in its presentation style, analysis, and methodology from the works.[7]–[11]

3. Results and discussion

3.1 Results

This first round of search produced an outcome of 1015 documents, in multiple languages, out of which 837 documents were in English. The classification of document categories is shown in Figure 1. For improving the
quality of the analysis, we had selected only the peer-reviewed articles and all other documents had not been considered. Thus after using filters “Article” and “English” the second round search produced an outcome of 395 English articles (both open access and others) and had been used to conduct bibliometric analysis and visualization using VOS Viewer. The English research articles in this domain since 1995 had been shown in Figure 2.

Figure 1: Classification of the documents on “Nanomaterial”, Source: www.scopus.com

Figure 2: Period wise publication of articles, Source: WWW.scopus.com

Co-authorship analysis of top authors had been shown in figure 3. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as four and the minimum number of citations of authors as one. This combination plotted the map of 30 authors, in 10 clusters. The overlay visualization map of co-authorship analysis plotted in Figure 3, points out the major researchers with their strong co-authorship linkages and clusters involved.
The citation analysis of top authors had been shown in table 1, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of an author as one and the minimum citations of an author as one.

| Description                                      | Authors     | Documents | Citations | Average citations per documents | Link strength |
|--------------------------------------------------|-------------|-----------|-----------|---------------------------------|---------------|
| Authors with the highest publication co-authorship links | Wang Y.     | 11        | 143       | 13                              | 20            |
| Authors with the highest citation               | Yang H.     | 8         | 223       | 28                              | 14            |

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as 15. This combination plotted the map of 21 thresholds, in three clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Figure 4.
The leading organizations engaged in research on “Nanomaterial” had been found out by the volume of publications and citation analysis, the parameters used are the minimum number of documents of an organization as one and the minimum number of citations of organizations as one. This combination plotted the map of 736 organizations, in 300 clusters.

The leading organization in the research regarding “Nanomaterial”, with the highest number of publications and citations, were the Chinese Academy of Sciences, North Eastern University of China, and Ministry of Education of China (Refer to table 2).

Table 2: Highlights of the most active organization

| Organizations                        | Country      | Documents | Citations | Average Citations per document |
|--------------------------------------|--------------|-----------|-----------|-------------------------------|
| Chinese Academy of Sciences          | China        | 14        | 164       | 11.7                          |
| Ministry of Education                | China        | 13        | 160       | 12.3                          |
| North Eastern University of China    | China        | 08        | 223       | 28                            |

Co-authorship analysis of the countries engaged in the research on “Nanomaterial” had been shown in Figure 5. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as five and the minimum number of citations of authors as one. This combination plotted the map of 26 countries, 5 clusters. The overlay visualization map of co-authorship analysis plotted in Figure 5, points out the main countries with their strong co-authorship linkages and clusters involved.

Figure 5: Co-authorship analysis on basis of countries

The citation analysis of top countries had been shown in table 3, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of a country as one and the minimum citations of the country as one.

Table 3: Highlights of Active Countries

| Description | Country | Documents | Citations | Average citations per | Link strength |
|-------------|---------|-----------|-----------|------------------------|---------------|
|             |         |           |           |                        |               |
The country with the highest publication, citation, and co-authorship links

| Description | Journal details | Documents | Citations | Average citations per document | Link strength |
|-------------|----------------|-----------|-----------|--------------------------------|---------------|
| Journal with the highest publications | Construction and Building Materials | 09 | 208 | 13.1 | 0 |
| Journal with the highest citation | Composites Science and Technology | 03 | 249 | 83 | 0 |

From the above discussion regarding the bibliometric patterns in the research regarding the Nanomaterial, this research had observed a gradual increase in research interest regarding the Nanomaterial from the starting of the millennium and the momentum is going on positively. This points out the relevance and potential of this research domain (Refer to Figure 2). The most active author in this research domain is Wang Y. and Yang H. with the highest publication, citations, and co-authorship links (Refer to Table 1). The overlay analysis of top countries researching Nanomaterial indicates that the China and United States of America were the leading country in research regarding Nanomaterial with the highest publications, citations, and co-authorship links (Refer to Figure 5). The top journals of this research domain were identified as Construction and Building Materials and Composites Science and Technology. From these wide sources of information, researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding Nanomaterial.

4. Conclusion

The nanomaterials is an interesting research domain and the most active journals related to this research domain are Construction and Building Materials and Composites Science[3], [10], [11] and Technology. The most active countries were China and the United States of America. The leading organizations engaged in the research regarding Nanomaterial were the Chinese Academy of Sciences, North Eastern University of China, and the Ministry of Education of China. The most active authors who had made valuable contributions related to Nanomaterial were Wang Y. and Yang H. This research domain offers a new avenue for researchers and the future research can be on Nanomaterial and disease control, and developing chemical control.

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