ASEAN Journal of Science and Engineering

Journal homepage: http://ejournal.upi.edu/index.php/AJSE/

A Bibliometric Analysis of Nano Metal-Organic Frameworks Synthesis Research in Medical Science Using VOSviewer

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ABSTRACT

Nano MOFs (nMOFs) have now evolved as a new class of MOF with exciting applications. The purpose of this research is to perform bibliometric analysis on nMOFs for medical science by combining mapping analysis using VOSviewer software. Application reference manager used to obtain research data. The data obtained is the result of a search based on the keyword "nano metal-organic framework and madical science". From the search results, 1000 relevant published articles were found in the range of 2017-2021. The results showed that research on nano metal-organic frameworks and medical science has increased in 2017-2020, but it decreases since 2021. The main reason for the increase is the need for human health which continues to increase along with the emergence of new diseases. Although the increase should continue to occur every year, the decline in 2021 is due to social restrictions due to the COVID-19 pandemic, thus limiting the work space in the field of research. This study shows the importance of bibliometric analysis in providing analytical data about what phenomena occur. This research is expected to help and become a reference for researchers in conducting and determining the research theme to be taken.

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ARTICLE INFO

Article History:
Submitted/Received 09 Dec 2021
First Revised 13 Jan 2022
Accepted 15 Mar 2022
First available online 17 2022
Publication date 01 Mar 2023

Keyword:
Bibliometric,
Data analysis,
Metal-organic framework,
Nano-sized,
VOSviewer.

1. INTRODUCTION

VOSviewer is a software tool for creating maps based on network data and for visualizing and exploring these maps (title, author, author, journal, etc.) (Trotta, 2019; Al Husaeni & Nandiyanto, 2022; Nandiyanto *et al.*, 2021). VOSViewer software can be used as a source for further study and reflect the trend and impact of the topic's research (Nicolaou, 2021; David, 2021; Moshobane *et al.*, 2021). The bibliography itself comes from the Greek "bilio" (book) and "grafi" (writing) (Nandiyanto *et al.*, 2021). Bibliometrics is a statistical method which could quantitative analysis the research papers concerned about one special topic via mathematical ways. It could also access the quality of the studies, analysis the key areas of researches and predict the direction of future studies (Yu, 2020).

The successful marriage between nanotechnology and medical science has verified the biomedical efficacy of a series of nanomaterials and promoted some of them available in clinic (Lin *et al.*, 2020). Metal-organic frameworks (MOFs) are types of permeable materials containing metal sites attached through organic bridging ligands forming a frame-like structure and are appreciated broadly owing to large surface area, tunable hole arrangement and manageable functionalities (Ahmed *et al.*, 2019; Ahmed *et al.*, 2020).

Nano-sized structures of MOFs (typically known as nano MOFs or nMOFs) have now evolved as a new class of MOF with exciting applications (Ahmed *et al.*, 2019; Ahmed *et al.*, 2020). This emerging class of nMOFs, combining the intrinsic properties of the porous materials and the benefits of nanostructures, are expected to improve in some cases the performances of classical bulk crystalline MOFs. In the field of biomedicine, the benefits of MOF miniaturization have already been proved to be effective, not only because establishes a strong influence over the choice ofthe administration route but also governs their in vivo fate and therefore, their toxicity and/or activity (Cabrera-García *et al.*, 2019).

Many reports on nMOFs and medical science have been carried out, including research conducted by Song, *et al.* (2020) in researching synthesis of uniform hollow MIL-125 Titanium-based nanoplatform for endosomal esacpe and intracellular drug delivery, research conducted by Yang, *et al*. (2021) in examining nanosized metal organic frameworks for drug delivery and tumor therapy, research conducted by Meng, *et al*. (2020) in application of molecular imaging technology in tumor immunotherapy, and research conducted by Deleu, *et al*. (2015) in examining photocleavable capsules for UV-Light triggered catalysis with nMOFs. However, research on bibliometric analysis is still lacking in the fields of nMOFs and medical science, especially by using VOSviewer software as a tool for mapping analysis. This analysis is important to determine the quantity and up-to-date of a term.

This research is expected to help and become a reference for researchers in conducting and determining research topics to be taken, especially those related to the field of nMOFs for applications in medical science.

2. METHODS

The global literatures about nMOFs for medical science published between 2017 to 2021 range. The search terms applied to identify the closest matching publication included "Nano Metal-Organic Frameworks" or "nMOFs" or "Nanoscale Metal-Organic Frameworks", "Synthesis" and "medical science" which was used as the keyword in the title. The reference managers application used in this research is Publish or Perish. Thus, 1000 articles were obtained which were assessed according to the chosen topic. The collected articles were then saved in *.ris format. Next, we used the VOSviewer application to visualize and analyse trends in the form of bibliometric maps. We did data mapping articles from database sources that

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

have been prepared. Data mapping consists of three types, namely network, density, and overlay visualization. In addition, we also filtered the terms that would be included in the VOSviewer network mapping visualization.

The article data used in this study is research data from articles that have been indexed by Google Scholar. In this study, we use Google Scholar because Google Scholar can be accessed for free, in contrast to Scopus which is not freely accessible to readers (Nandiyanto *et al*., 2021).

3. RESULTS AND DISCUSSION

3.1. Research Developments in The Field of Nano Metal-Organic Frameworks in Medical Science

Figure 1 shows the development curve of nMOFs research in medical science from 2017 to 2021. Based on **Figure 1**, the development of nMOFs research in medical science during the last 5 years, namely from 2017-2021 has increased from 2018 to 2020 and then decreased from 2021. This increase is indicated by the number of articles in 2017 to 2020, respectively, 112, 188, 235, and 305 articles. However, this number has decreased drastically in 2021 to 160 articles.

Based on **Figure 1**, we found that an increasing and decreasing number of publications were found since2017-2021. The main reason for the increase is the need for human health (Benton, *et al*., 2021) which continues to increase along with the emergence of new diseases. Although the increase should continue to occur every year, the decline in 2021 is due to social restrictions due to the COVID-19 pandemic, thus limiting the work space in the field of research (physical distancing (Ana, 2020).

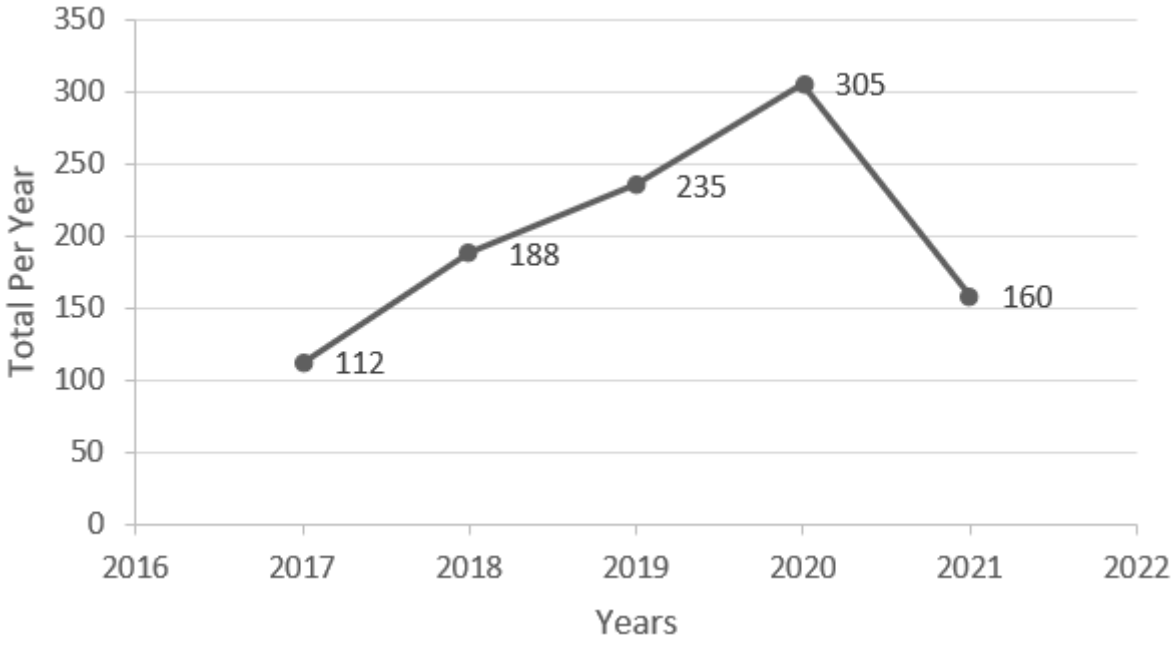

Figure 1. Level of development of research on nMOFs for medical science.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

3.2. Visualization Nano Metal-Organic Frameworks and Medical Science Topic Area Using VOSviewer

According to Al Husaeni and Nandiyanto (2020); Nandiyanto *et al*. (2021), the minimum number of relationships between terms in the VOSviewer is regulated by 2 terms.

Research related to nMOFs in medical science based on analysis mapping visualization is divided into 9 clusters, namely:

(i) Cluster 1 has 56 items, the 56 items are ability, antibody, approach, article, based metalorganic framework, basis, biological application, biosensing, carbon, catalytic activity, condition, coordination, crystaline porous material, Cu MOF, Cu MOF np, current study, defect, detection, DNA, drug carrier, email, enzyme, facile synthesis, gold nanoparticle, iii, medical diagnostic, medical field, medical treatment, metal organic framework nanoparticle, metalorganic framework, metalorganic framework nanoparticle, microwave, modification, nano MOFs, nanocomposite, nanomaterial, nanozyme, new material, new strategy, order, PCN, peroxidase, phosphate, potential, protein, reaction, researcher, sensitive detection, series, simple, simple synthesis, synthesis condition, synthetic method, synthetic process, work, and Zr MOFs.

(ii) Cluster 2 has 55 items, namely acid, adsorbent, adsorption, analysis, antibiotic, aqueous solution, BDC, BTC, catalyst, compound, degradation, determination, dmf, dye, efficient removal, ethanol, extraction, fe mof, fourier, ft ir, human medicine, investigation, magnetic metalorganic framework, malvern, mechanism, medical, science, metal organic framework, metal organic framework material, mil, mixture, multimodal imaging, organic synthesis, particle, particle size, perfomance, pesticide, photocatalyst, photocatalytic activity, photocatalytic degradation, product, removal, sample, sem, solvent, sorbent, spectroscopy, study, terephthalic acid, UiO, use, veterinary medicine, water, XRD, zeta potential, and zirconium.

(iii) Cluster 3 has 47 items consisting of addition, advance, application, attention, biomedical application, challenge, chemical, chemistry, coworker, composition, COOH, decade, energy, engineering, evaluation, example, field, function, gas, gas separation, interest, ion, lot, materials science, medicine, metal organic frameworks, micro, MOFs, nano metal organic framework, nano MOF, nanocrystal, nanomedicine, nanotechnology, polymer, post synthetic modification, progress, PSM range, rational design, recent advance, recent development, research interest, review, strategy, synthesis method, synthetic strategy, and technique.

(iv) Cluster 4 has 46 items consisting of activity, biosensor, clinical medicine, coating, composite, construction, device, electrochemical detection, environment, environmental monitoring, fabrication, food, glucose, glycopeptide, group, growth, hydrogen peroxide, immobilization, integration, ionic liquid, lanthanide, magnetic metal organic framework, material science, medical diagnosis, metal, nanosheet, paper, perspective, porous structure, property, rapid development, reduction, selective detection, self, sensing, sensor, solvothermal methode, step, step synthesis, surface, synthesis process, synthesis strategy, system, template, titanium, and way.

(v) Cluster 5 has 40 items, which consist of assembly, biomedicine, cancer, cancer therapy, carboxyphenyl, combination, crystalline material, drug delivery, effect, first time, great potential, imaging, iron, layer, ligand, light, linker, metal center, metalorganic framworks, nano metalorganic framework, nanoparticle, nanoscale, nanoscale metal organic framework, nanoscale metalorganic framework, NIR, nMOF, nMOFs, organic linker, PDT, photodynamic therapy, photothermal therapy, platform, porous metalorganic framework, porphyrin, and SBU.

DOI: http://dx.doi.org/10. 17509/xxxx.xxxx
p- ISSN 2776-6098 e- ISSN 2776-5938

(vi) Cluster 6 has 37 items consisting of agent, bacterium, biocompatibility, capture, carrier, cell, cobalt, controlled release, delivery, development, drug, drug delivery system, drug release, encapsulation, framework, knowledge, literature, medical application, membrane, metal organic framework MIL, metalorganic framework material, nanocarrier, novel, pore, porous metal organic framework, pot synthesis, present work, problem, process, release, solution, synthetic route, vitro, year, zeolitic imidazolate framework, ZIF, and zinc.

(vii) Cluster 7 has 28 items consisting of biology, class, controllable synthesis, copper, date, figure, folic acid, form, formation, high porosity, hkust, kind, medical device, new class, part, porosity, porous coordination polymer, porous crystalline material, porous material, presence, production, room temperature, structure, successful synthesis, surface area, ultrasound, variety, and zirconium metal organic framework.

(viii) Cluster 8 has 25 items consisting of advantage, catalysis, characterization, cluster, control, coordination polymer, crystal, crytal structure, functional material, gas storage, hybrid material, hydrothermal synthesis, metal ion, nanostructure, organic ligand, potential application, precursor, preparation, procedure, recent year, report, research, separation, solvothermal reaction, and synthesis.

(ix) Cluster 9 has 14 items consisting of cd mofs, context, crystalline, cyclodextrin, cyclodextrin metal organic framework, functionalization, green synthesis, morphology, nano, recent progress, size, stability, synthesized MOF, and time.

Cluster 1 is marked in red, cluster 2 is marked in blue, cluster 3 is marked in yellow, cluster 4 is marked in black, cluster 5 is marked in dark blue, cluster 6 is marked in mustard, cluster 7 is marked in white, cluster 8 is marked in brick red and cluster 9 is marked with pink.

3.3. Network Visualization of Nano Metal-Organic Frameworks in Medical Science Keyword

The visualization network displays the network between the visualized terms (Al Husaeni & Nandiyanto, 2022; Nandiyanto, *et al.*, 2021). **Figure 2** shows the relationship between various terms. The relationship from one term to another in network visualization is depicted in a grid or line. **Figure 2** also shows clusters in each of the researched topic areas.

In **Figure. 2**, nMOFs itself is included in cluster 5 with a totaling strength of 348 and occurrence of 28. Nano metal-organic frameworks and medical science is connected to cluster 8, namely term synthesis, cluster 7, namely term biology.

4. CONCLUSION

This study aims to conduct bibliometric research in nMOFs in medical science by combining mapping analysis using VOSviewer software. Publish or Perish is a references manager application used to collect data in this research. The data obtained is the result of filtering based on the keywords “Nano Metal-Organic Frameworks” or “nMOFs” or “Nanoscale Metal-Organic Frameworks”, “Synthesis” and “medical science”. The bibliographic data used in this study concerns the topic areas, titles, keywords, and abstracts. From the search results, we obtained 1000 relevant articles published in the range of 2017-2021. The results showed that research on nMOFs for medical science has increased in 2017-2020, but it decreases since 2021. Research that is being popularly studied by researchers today is about drug delivery and biosensing. To search using the keyword “Nano Metal-Organic Frameworks” or “nMOFs”

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

or “Nanoscale Metal-Organic Frameworks”, “Synthesis” and “medical science” produces 9 clusters that have a different number of items in each cluster.

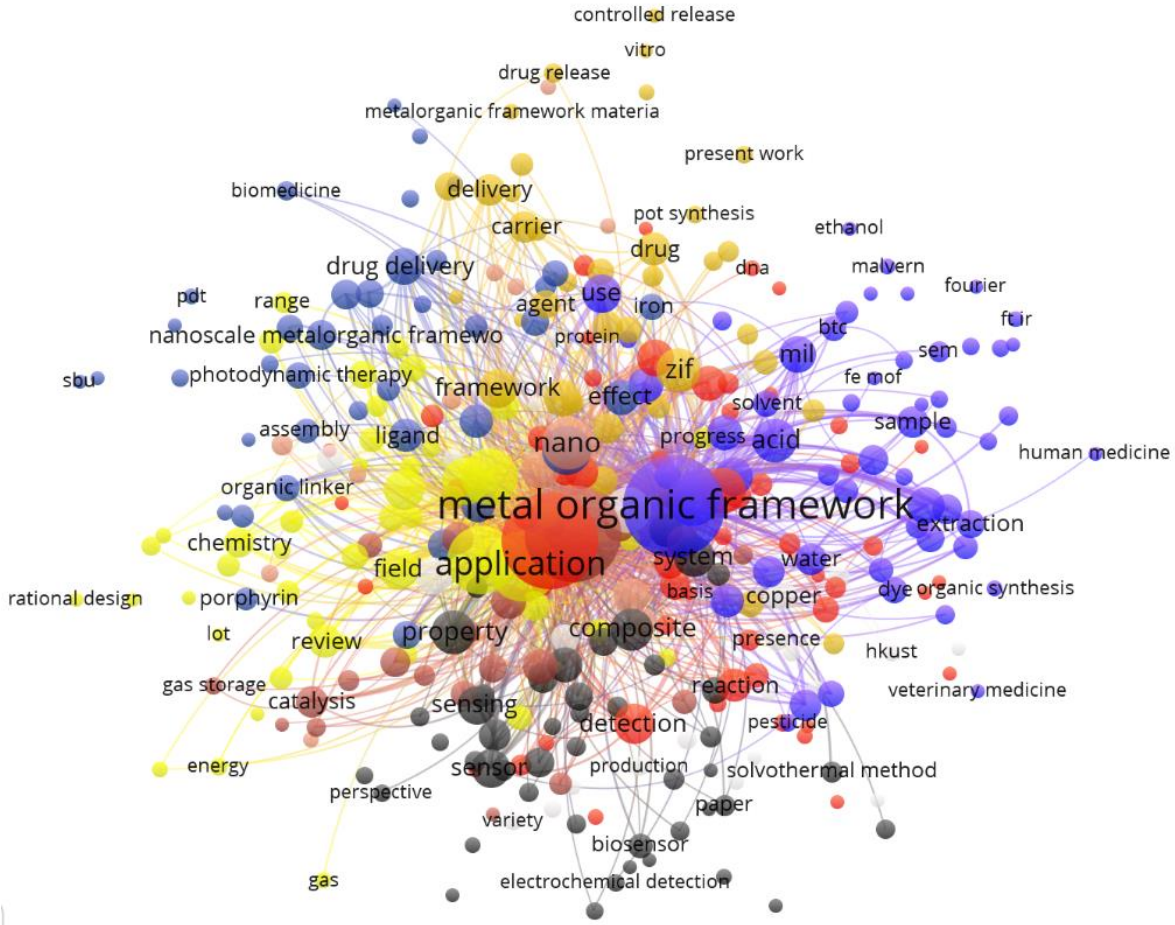

Figure 2. Network visualization of nMOFs and medical science keywords**.**

5. ACKNOWLEDGMENTS

This study acknowledged RISTEK BRIN for Grant-in-aid Penelitian Terapan Unggulan Perguruan Tinggi (PTUPT) and Bangdos Universitas Pendidikan Indonesia.

6. AUTHORS’ NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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