JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

BIBLIOMETRIC ANALYSIS OF PUBLICATION ON PROTEIN NANOPARTICLE USING VOSVIEWER

Riska Kurnelia Ananda[1*], Asep Bayu Dani Nandiyanto[2]
[1]Undergraduate Program, Departement of Chemistry Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]Departement of Chemistry Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
* Corresponding Author : E-mail: riskakurnelia@upi.edu

ABSTRACT

Background: A study to determine the development of research can be done by bibliometric analysis technique. Many studies on bibliometric analysis have been carried out. However, to determine the development, there is no research specifically on bibliometric analysis of published data in the field of protein nanoparticles. **Objective:** This study assesses the development of protein nanoparticle research through a bibliometric approach. **Methods:** The Google Scholar database on the publish or perish software is used to obtain article data. The keyword "Protein Nanoparticles" is used with a publication time span from 2012 to 2022. Data processing uses Microsoft Excel. VOSViewer is used to perform computational mapping. **Results:** Obtained data of articles that are considered, relevant as many as 390 articles. The results of the analysis show that the development of protein nanoparticle publications has fluctuated quite often in the last 10 years. Research fluctuations occurred in 2012 to 2020. There was a decline in 2020-2022 from 35 in 2020 to 19 in 2022. In 2012 and 2014 research on protein nanoparticles became popular, with 47 studies each. **Conclusion:** From the results of mapping, it can be seen that the keyword protein nanoparticles is still rarely used in research. Thus, it is still very possible to conduct research in the field of protein nanoparticles and be associated with other terms. Of course, this ball will have a higher impact on the newness of the research.

Keywords: *Bibliometric Analysis, Protein Nanoparticle, Publication, VOSviewer*

INTRODUCTION

Recently, nanoparticles have become a topic that has attracted the attention of scientists around the world. Various studies on nanoparticles and their applications continue to be developed because of their promising potential and wide research area. This is indicated by the increasing number of publications on nanoparticles.

Nanoparticles are defined as solid colloidal particles having a size of about 10-1000 nanometers.[1] In medicine, nanoparticles are developed in drug delivery systems. Drug delivery systems have great therapeutic potential, this is why nanoparticle-based drug delivery systems to developing rapidly. Various types of materials as drug delivery carriers have been explored including polysaccharides, polymers, lipids, and proteins.[1] Protein nanoparticles have gained considerable interest in recent years. This is because protein nanoparticles which are biopolymer-based nanoparticles have many desirable properties such as low toxicity and biodegradability.[2]

Proteins are a large group of biomolecules that have potential functions and applications in materials science and biomedicine.[3] Protein are considered as ideal material in the manufacture of nanoparticles. This is because proteins have an amphiphilicity that allows them to interact well with drugs and solvents.[4]

The development of research in the field of protein nanoparticles can be known by conducting bibliometric analysis. Bibliometric analysis is one way to assist researchers in conducting citation analysis and studying bibliographic content of articles that have been published in journals and other scientific works in the form of meta-analysis of research data.[5]

There are many studies that have been carried out on bibliometric analysis, including bibliometric analysis in chemical research[6,7] and chemical engineering,[8,9] materials research,[10] covid-19 research,[11] bibliometric analysis in economics,[12-16] bibliometric analysis in economic technology education,[17] datasets depicting a decrease in the number of scientific publications,[18] scientific publications,[19] machine performance,[20] applications in robotic hand systems,[21] bioenergy management,[22] magnetite nanoparticles,[23] and research on the production of nanocrystalline cellulose.[24,25]

However, research has not been carried out specifically to determine the development of research on bibliometric analysis of published data in the field of protein nanoparticles. Specifically bibliometric analysis for research in the last 10 years from 2012 to 2022 through the VOSviewer application.

Therefore, this study aims to perform a bibliometric analysis of articles indexed by Google

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

Scholar using VOSviewer software. The results of this study are expected to be a reference for researchers to conduct and determine the research themes to be taken, especially those related to the field of protein nanoparticles.

METHOD

The research was conducted through several stages, namely, collecting publication data using the publish or perish application, processing bibliometric data for articles that have been obtained using the Microsoft Excel application, computational mapping analysis of bibliometric publication data using the VOSviewer application, and analyzing the results of computational mapping analysis.[5]

To obtain research data, a literature review was conducted on the research topic using a reference manager application, namely Publish or Perish. Research from publications that have been published in journals indexed by Google Scholar was chosen to obtain article data because the Google Scholar database is open source. We used the keyword "Protein Nanoparticles" to filter publications in the search of article data based on the terms of the publication title. The articles used were published over a 10 year period from 2012 to 2022. All data were obtained in September 2022. The articles that had been collected and sorted based on the research analysis criteria were then exported into two types of files: research information system (.ris) and comma-separated value format (*.csv).

Article data from the source database is mapped through a bibliometric map to visualize and evaluate trends. This mapping was carried out using the VOSviewer software. There are 3 variations of mapping publications, namely network visualization, density visualization, and network-based overlay visualization (co-citation) between terms. The keyword frequency is set to be found at least 3 times when creating a bibliometric map. Therefore, 88 less relevant terms and keywords were removed.

RESULTS AND DISCUSSION

Publication Data Search Results

Based on the search for article data from the Google Scholar database through the publish or perish application, 390 articles were obtained that met the research criteria. Article data is obtained in the form of metadata consisting of title, author's name, name of journal, year, number of citations, publisher, article link, and related URL. Table 1 shows some examples of published data on protein nanoparticles used in the VOSviewer analysis of this research. The best articles were taken as a data sample of 20 articles with the highest number of citations. All articles used in this study had a total of 47193 citations, with a total 4719.30 citations per year, and 121.01 citations per article. The average of authors in the articles used is 4.10, all articles have an avarage h-index of 99, and a g-index of 207.

Table 1. Protein nanoparticle publication data

No.	Authors	Title	Year	Cites
1.	Baden et al.[26]	Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine	2020	6193
2.	Walkey et al.[27]	Nanoparticle size and surface chemistry determine serum protein adsorption and macrophage uptake	2012	1712
3.	Elzoghby et al.[28]	Albumin-based nanoparticles as potential controlled release drug delivery systems	2012	1298
4.	Shang et al.[29]	Engineered nanoparticles interacting with cells: size matters	2014	1214
5.	Slavin et al.[30]	Metal nanoparticles: understanding the mechanisms behind antibacterial activity	2017	1131
6.	Saraiva et al.[31]	Nanoparticle-mediated brain drug delivery: overcoming blood–brain barrier to treat neurodegenerative diseases	2016	963
7.	Keech et al.[32]	Phase 1–2 trial of a SARS-CoV-2 recombinant spike protein nanoparticle vaccine	2020	949

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

8.	Saptarshi et al.[33]	Interaction of nanoparticles with proteins: relation to bio-reactivity of the nanoparticle	2013	931
9.	Lesniak et al.[34]	Nanoparticle adhesion to the cell membrane and its effect on nanoparticle uptake efficiency	2013	693
10.	Desai, N.[35]	Challenges in development of nanoparticle-based therapeutics	2012	692
11.	Elzoghby et al.[36]	Protein-based nanocarriers as promising drug and gene delivery systems	2012	690
12.	Zhang et al.[37]	Nanoparticle–liver interactions: cellular uptake and hepatobiliary elimination	2016	688
13.	McShan et al.[38]	Molecular toxicity mechanism of nanosilver	2014	680
14.	Svensson et al.[39]	Exosome uptake depends on ERK1/2-heat shock protein 27 signaling and lipid Raft-mediated endocytosis negatively regulated by caveolin-1	2013	611
15.	Kraft et al.[40]	Emerging research and clinical development trends of liposome and lipid nanoparticle drug delivery systems	2014	525
16.	Lee, B.J.[41]	Protein corona: a new approach for nanomedicine design	2017	505
17.	Shinde et al.[42]	Efficacy of NVX-CoV2373 Covid-19 vaccine against the B. 1.351 variant	2021	475
18.	Banerjee et al.[43]	Role of nanoparticle size, shape and surface chemistry in oral drug delivery	2016	451
19.	Heath et al.[44]	Safety and efficacy of NVX-CoV2373 Covid-19 vaccine	2021	450
20.	Kannan et al.[45]	Emerging concepts in dendrimer- based nanomedicine: from design principles to clinical applications	2014	446

Protein Nanoparticles Research Development

Development of research related to Protein Nanoparticles published in Google Scholar indexed journals is shown in Table 2. From table 2 it can be seen that the number of studies on Protein Nanoparticles from 2012-2022 was 388 articles. The number of articles published every year has been up and down. From these data, it can be seen that in the last 10 years research on protein nanoparticles is still relatively rare every year. The development of protein nanoparticle research is quite volatile as can be seen in Figure 1.

Table 2. Development of protein nanoparticle research

Publication Year	Number of Publications
2012	47.0
2013	41.0
2014	47.0
2015	39.0
2016	44.0
2017	31.0
2018	36.0
2019	24.0
2020	35.0
2021	25.0
2022	19.0
Total	388.0
Average	**35,27**

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

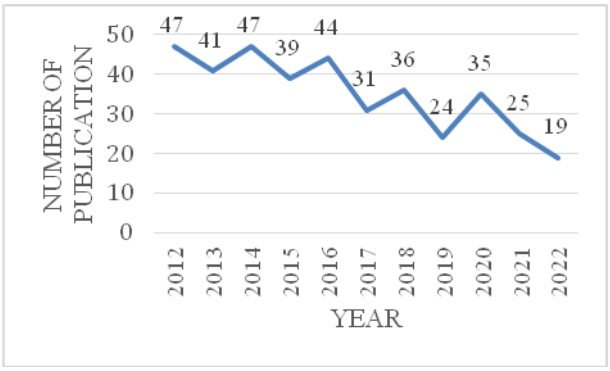

Figure 1. Level of development in protein nanoparticle research

The development of research on protein nanoparticles from 2012 to 2022 (the last 10 years) is shown in Figure 1. From Figure 1 it can be seen that the development of research related to protein nanoparticles has fluctuated from 2012 to 2020. And from 2020 to 2022 there has been a drastic decline, namely respectively 35, 25, and 19 articles. Based on this, it can be seen that the popularity of protein nanoparticle research tends to be unstable because the interest in protein nanoparticle research has decreased.

Visualization protein nanoparticle topic areas using VOSviewer

The article data obtained were computationally mapped using VOSviewer. From the computational mapping, 88 items were found. In data mapping, each term found related to protein nanoparticles was divided into 7 clusters. The division of this cluster is based on a set of terms that are connected to each other. The division of each cluster is as follows:

(i) Cluster 1 marked in red has 19 items, namely, biomedical application, bsa, delivery, drug, exposure, expression, magnetic nanoparticle, modulation, nanoparticle, peptide, perspective, preparation, protein adsorption, protein expression, self, toxicity, use, in vitro, and in vivo.

(ii) Cluster 2 marked in green has 17 items, namely, binding, comparison, concentration, effect, formation, gold nanoparticle, impact, nanoparticle size, presence, property, protein content, corona protein, protein molecule, role, serum, surface, and surface chemistry.

(iii) Cluster 3 marked in blue has 15 items, namely, addition, advantage, application, cell, characterization, detection, development, mechanism, nanoparticle system, nanoparticle tracking analysis, nanoparticle protein corona, particle, protein binding, protein delivery, and study.

(iv) Cluster 4 marked in yellow has 13 items, namely, adsorption, change, function, human serum albumin, insight, interaction, nanoparticle surface, order, protein conformation, protein corona formation, protein nanoparticle interaction, silver nanoparticle, and work.

(v) Cluster 5 marked with purple color has 11 items, namely ability, covid, disease, efficacy, mouse, protein, protein level, protein nanoparticle, safety, sars cov, and vaccine.

(vi) Cluster 6 which is marked with sky blue color has 9 items, namely, cellular uptake, drug delivery, implication, influence, nanomaterial, potential, protein interaction, size, and surface charge.

(vii) Cluster 7 which is marked with orange color has 4 items including protein structure, protein nanoparticle complex, stability, and structure.

Between one term with other related terms will be in the same cluster. The label of each term is represented by a colored circle. Meanwhile, the frequency of occurrence of the term will be indicated by the size of the circle. The larger the circle size, the more frequent it appears in titles and abstracts. On the other hand, the larger the circle size, the less frequent the occurrences in titles and abstracts.[5,10] In this study, there are 3 sections of mapping visualization analyzed, including network visualization (Figure 2), density visualization (Figure 3), and overlay visualization (Figure 4).[11]

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

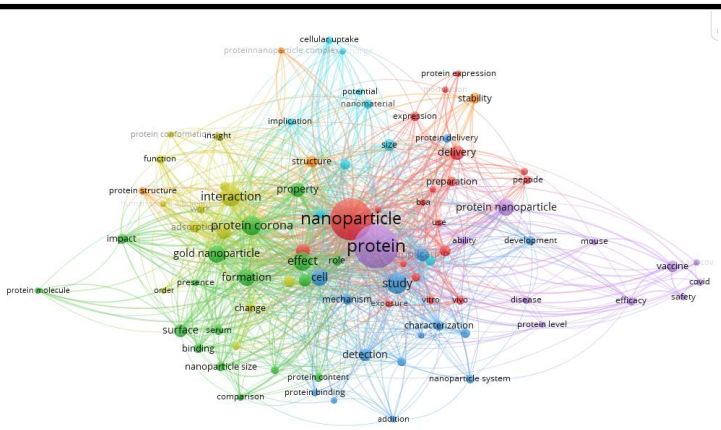

Figure 2. Network visualization with protein nanoparticle keyword

Figure 2 shows the visualization of the protein nanoparticle keyword network. Terms that have a relationship will be connected to the same cluster as shown in Figure 2. Research on protein nanoparticles can be divided into 3 terms, namely the term protein, term nanoparticle, and term protein nanoparticle based on Figure 4. The first term is protein belonging to cluster 5 which has 231 occurences, 86 links, and 781 total link strengths as shown in Figure 5. The second term is nanoparticles belonging to cluster 1 having 213 occurrences, 85 links, and 731 total link strengths as shown in Figure 6. The last term is protein nanoparticles belonging to cluster 5 has 33 occurrences, 45 links, and 111 total link strengths as shown in Figure 7.

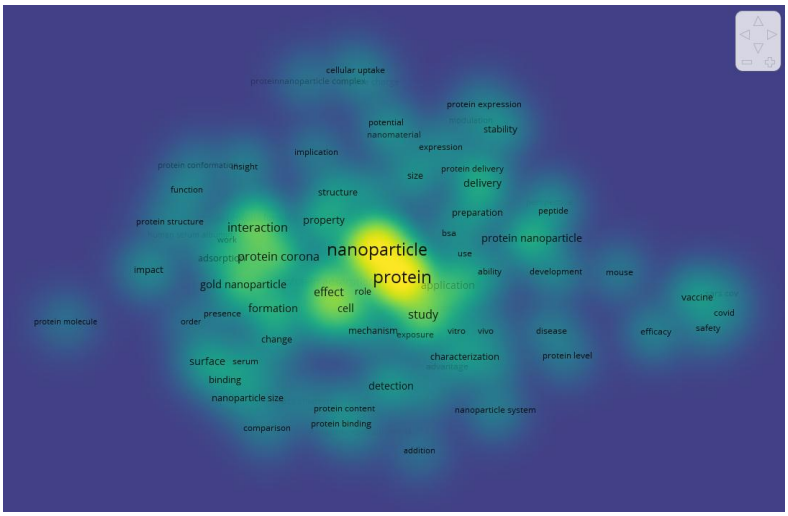

Figure 3. Density visualization with protein nanoparticle keyword

Figure 3 shows the density visualization in the study of protein nanoparticles. In density visualization, the frequency of occurrence of terms is positively correlated with the diameter of the circle of the term label and the brightness of its yellow color. Thus, the larger the diameter of the circle and the brighter the yellow color of the label, the more often the term appears.[10,19,46-47] Meanwhile, if the color label of the term fades closer to the background color, the smaller the number of studies on that term. In Figure 3 it can be seen that the number of studies related to the terms protein and nanoparticles is very high.

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

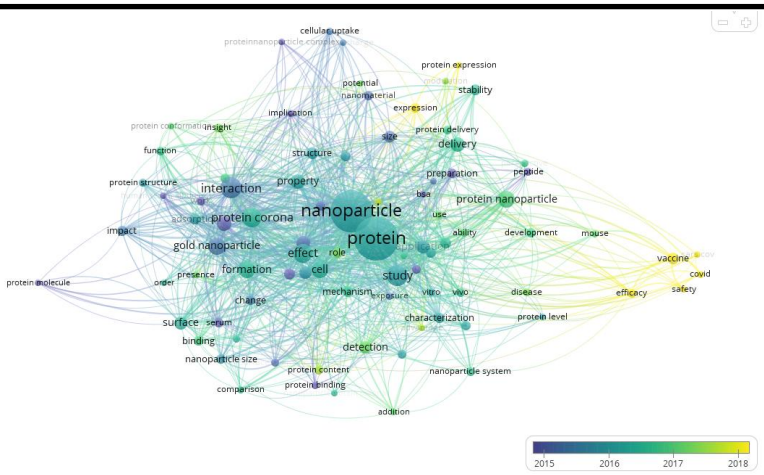

Figure 4. Overlay visualization with protein nanoparticle keyword

The novelty of research on related terms can be seen from the overlay visualization. [10-11,46] Through overlay visualization, it can be seen that most of the research on protein nanoparticles was carried out from 2016 to 2017 (see Figure 4) and clarified in Figure 8. In research, the term protein nanoparticles has been popular for a long time. Thus, new research on protein nanoparticles can be easily developed.

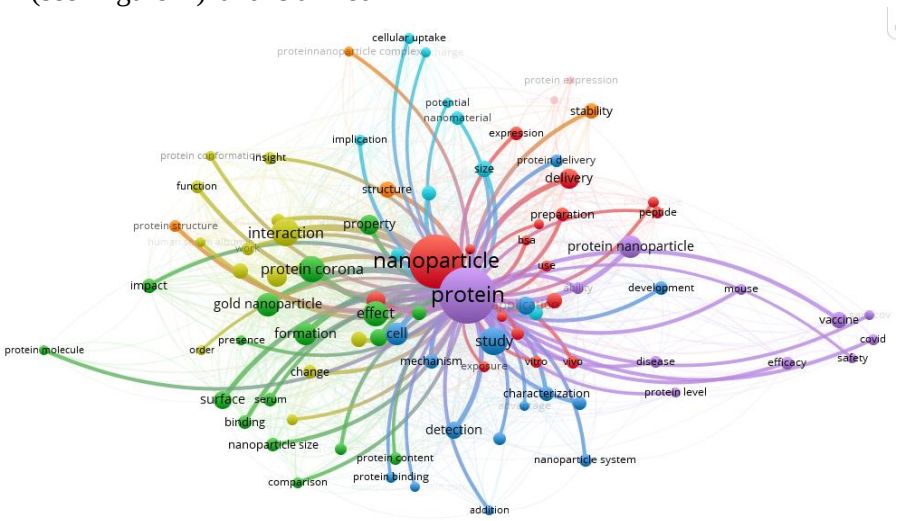

Figure 5. Network visualization with protein term

In Figure 5 involved the relationship network of protein terms with other terms, namely nanoparticle, expression, delivery, preparation, peptide, bsa, use, vitro, vivo, exposure, study, characterization, detection, nanoparticle system, protein content, protein binding, cell, mechanism, development, protein delivery, size, nanomaterial, cellular uptake, implication, addition, protein nanoparticle, mouse, vaccine, covid, safety, efficacy, disease, protein level, stability, structure, insight, function, interaction, protein structure, protein conformation, order, change, property, corona protein, impact, gold nanoparticle, effect, formation, presence, protein molecule, surface, serum, binding, nanoparticle size, and comparison.

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

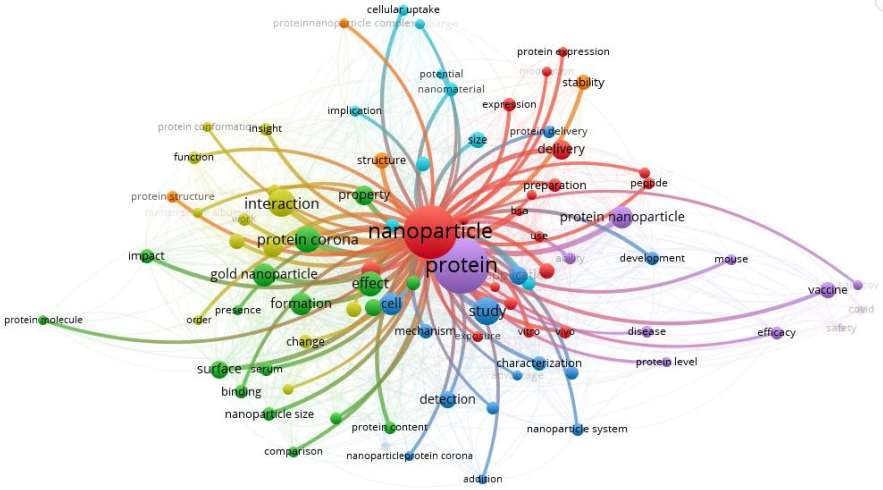

Figure 6. Network visualization with nanopartikel term

In Figure 6 involved the relationship network of nanoparticle terms with other terms, including protein, expression, delivery, preparation, peptide, bsa, use, vitro, vivo, exposure, study, characterization, detection, nanoparticle system, protein content, nanoparticleprotein corona, cell, mechanism, development, protein delivery, size, nanomaterial, cellular uptake, potential, implication, addition, protein nanoparticle, mouse, vaccine, covid, safety, efficacy, disease, protein level, stability, structure, insight, function, interaction, protein structure, protein conformation, order, change, property, protein corona, impact, gold nanoparticle, effect, formation, presence, protein molecule, surface, serum, binding, nanoparticle size, dan comparison.

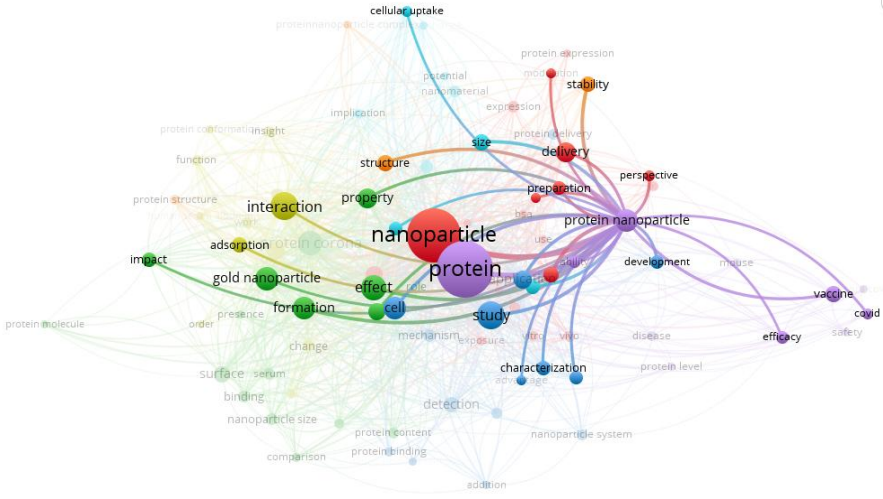

Figure 7. Network visualization with protein nanoparticle term

Whereas in Figure 7 it can be seen that the protein nanoparticle network, which is associated with the term, nanoparticles, protein, preparation, delivery, perspective, efficacy, vaccine, covid, development, cellular uptake, size, study, cell, characterization, stability, structure, interaction, adsorption, property, impact, gold nanoparticle, formation, and effect.

JURNAL KEDOKTERAN DIPONEGORO
(*DIPONEGORO MEDICAL JOURNAL*)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

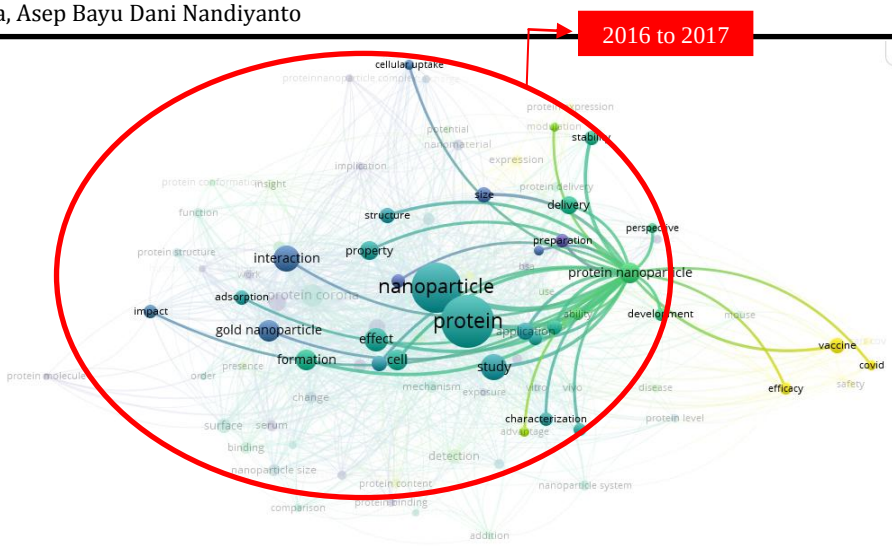

Figure 8. Overlay visualization of protein nanopartikcle term in 2016 to 2017

From these data, it can be seen that the term protein nanoparticles is not associated with other terms. In addition, computational mapping results show that protein nanoparticles are only connected by 23 terms with 45 links. Meanwhile, the field of protein and nanoparticles are often associated with various terms and have a fairly high degree of relevance. Thus, it can be concluded that research in the field of protein nanoparticles is still very possible and associated with other terms. Of course this will have a higher impact on the novelty of the research.

CONCLUSION

From the search results, relevant articles published in the range of 2012 to 2022 were found, as many as 390 articles. The results of the mapping analysis showed that research on protein nanoparticles has decreased from 2020 to 2022 and experienced fluctuations in research from 2012 to 2020. The results showed that research opportunities on protein nanoparticles still have quite high odds and related to other terms.

ETHICAL APPROVAL

There is no ethical approval.

CONFLICTS OF INTEREST

The authors declare no conflict of interest in this article.

FUNDING

No specific funding was provided for this article.

AUTHOR CONTRIBUTIONS

Conceptualization, collecting literature, editing, software, and writing draft: Riska Kurnelia Ananda; supervision, review: Asep Bayu Dani Nandiyanto.

REFERENCES

1. Lohcharoenkal, W., Wang, L., Chen, Y. C., and Rojanasakul, Y. Protein nanoparticles as drug delivery carriers for cancer therapy. *BioMed research international*, 2014.
2. Jahanshahi, M and Babaei, Z. Protein nanoparticle: a unique system as drug delivery vehicles. *African Journal of Biotechnology*, 2008; 7 (25): 4926–4934.
3. Jahanshahi,M. Re-design of downstream processing techniques for nanoparticulate bioproducts. *Iranian Journal of Biotechnology*, 2004; 2(1): 1–12.
4. Marty, J. J and RC, O. Nanoparticles-a new colloidal drug delivery system. *Pharmaceutica Acta Helvetiae*, 1978; 53(1): 17–23.
5. Al Husaeni, D. F and Nandiyanto, A. B. D. Bibliometric computational mapping analysis of publications on mechanical engineering education using vosviewer. *Journal of Engineering Science and Technology*, 2022; 17(2): 1135-1149.
6. Modak, N. M., Lobos, V., Merigó, J. M., Gabrys, B., and Lee, J. H. Forty years of computers and chemical engineering: A bibliometric analysis. *Computers and Chemical Engineering*, 2020; 141: 106978.
7. Grandjean, P., Eriksen, M. L., Ellegaard, O., and Wallin, J. A. The Matthew effect in environmental science publication: a bibliometric analysis of

Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
DOI : https://doi.org/10.14710/dmj.v11i6.35942
JKD (DMJ), Volume 11, Number 6, November 2022 : 275-284

chemical substances in journal articles. *Environmental Health*, 2011; 10(1): 1-8.
8. Mulyawati, I. B and Ramadhan, D. F. Bibliometric and visualized analysis of scientific publications on geotechnics fields. *ASEAN Journal of Science and Engineering Education*, 2021; 1(1): 37-46.
9. Nandiyanto, A. B. D., Biddinika, M. K., and Triawan, F. How bibliographic dataset portrays decreasing number of scientific publication from Indonesia. *Indonesian Journal of Science and Technology*, 2020; 5(1): 154-175.
10. Nandiyanto, A. B. D and Al Husaeni, D. F. A bibliometric analysis of materials research in Indonesian journal using VOSviewer. *Journal of Engineering Research*, 2021; 9(ASSEEE Special Issue): 1-16.
11. Hamidah, I., Sriyono, S., and Hudha, M. N. A Bibliometric analysis of Covid-19 research using VOSviewer. *Indonesian Journal of Science and Technology*, 2020; 5(2): 209-216.
12. Bonilla, C. A., Merigó, J. M., and Torres-Abad, C. Economics in Latin America: a bibliometric analysis. *Scientometrics*, 2015; 105(2): 1239-1252.
13. Firmansyah, E. A and Faisal, Y. A. Bibliometric analysis of Islamic economics and finance journals in Indonesia. *Al-muzara'ah*, 2019; 7(2): 17-26.
14. Rusydiana, A. S. Bibliometric Analysis of Scopus-Indexed Waqf Studies. *Ekonomi Islam Indonesia*, 2019; 1(1): 1-17.
15. Castillo-Vergara, M., Alvarez-Marin, A., and Placencio-Hidalgo, D. A bibliometric analysis of creativity in the field of business economics. *Journal of Business Research*, 2018; 85: 1-9.
16. Nederhof, A.J and Van Raan, A. F. A bibliometric analysis of six economics research groups: A comparison with peer review. *Research Policy*, 1993; 22(4): 353-368.
17. Ragahita, R and Nandiyanto, A. B. D. Computational bibliometric analysis on publication of techno-economic education. *Indonesian Journal of Multidiciplinary Research*, 2022; 2(1): 213-220.
18. Nandiyanto, A. B. D., Biddinika, M. K., and Triawan, F. How bibliographic dataset portrays decreasing number of scientific publication from Indonesia. *Indonesian Journal of Science and Technology*, 2020a; 5(1): 154-175.
19. Mulyawati, I. B and Ramadhan, D. F. Bibliometric and visualized analysis of scientific publications on geotechnics fields. *ASEAN Journal of Science and Engineering Education*, 2021; 1(1): 37-46.
20. Setiyo, M., Yuvenda, D., and Samue, O. D. The concise latest report on the advantages and disadvantages of pure biodiesel (b100) on engine performance: Literature review and bibliometric analysis. *Indonesian Journal of Science and Technology*, 2021; 6(3): 469-490.
21. Castiblanco, P. A., Ramirez, J. L., and Rubiano, A. Smart materials and their application in robotic hand systems: A state of the art. *Indonesian Journal of Science and Technology*, 2021; 6(2): 401-426.
22. Soegoto, H., Soegoto, E. S., and Luckyardi, S. A bibliometric analysis of management bioenergy research using VOSviewer application. *Indonesian Journal of Science and Technology*, 2022; 7(1): 89-104.
23. Nugraha, S. A. Bibliometric analysis of magnetite nanoparticle production research during 2017-2021 using VOSviewer. *Indonesian Journal of Multidiciplinary Research*, 2022; 2(2): 327-332.
24. Fauziah, A. A bibliometric analysis of nanocrystalline cellulose production research as drug delivery system using VOSviewer. *Indonesian Journal of Multidiciplinary Research*, 2022; 2(2): 333-338.
25. Maulidah, G. S., & Nandiyanto, A. B. D. (2021). A Bibliometric analysis of nanocrystalline cellulose synthesis for packaging application research using VOSviewer. *International Journal of Research and Applied Technology (INJURATECH)*, 2021; 1(2): 330-334.
26. Baden, L. R., El Sahly, H. M., Essink, B., Kotloff, K., Frey, S., Novak, R., et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. *New England journal of medicine*, 2020.
27. Walkey, C. D., Olsen, J. B., Guo, H., Emili, A., and Chan, W. C. Nanoparticle size and surface chemistry determine serum protein adsorption and macrophage uptake. *Journal of the American Chemical Society*, 2012; 134(4): 2139-2147.
28. Elzoghby, A. O., Samy, W. M., and Elgindy, N. A. Albumin-based nanoparticles as potential controlled release drug delivery systems. *Journal of controlled release*, 2012; 157(2): 168-182.
29. Shang, L., Nienhaus, K., and Nienhaus, G. U. Engineered nanoparticles interacting with cells: size matters. *Journal of nanobiotechnology*, 2014; 12(1): 1-11.
30. Slavin, Y. N., Asnis, J., Häfeli, U. O., and Bach, H. Metal nanoparticles: understanding the mechanisms behind antibacterial activity. *Journal of nanobiotechnology*, 2017; 15(1): 1-20.
31. Saraiva, C., Praça, C., Ferreira, R., Santos, T., Ferreira, L., and Bernardino, L. Nanoparticle-

mediated brain drug delivery: overcoming blood–brain barrier to treat neurodegenerative diseases. *Journal of controlled release*, 2016; 235: 34-47.
32. Keech, C., Albert, G., Cho, I., Robertson, A., Reed, P., Neal, S., et al. Phase 1–2 trial of a SARS-CoV-2 recombinant spike protein nanoparticle vaccine. *New England Journal of Medicine*, 2020; 383(24): 2320-2332.
33. Saptarshi, S. R., Duschl, A., and Lopata, A. L. Interaction of nanoparticles with proteins: relation to bio-reactivity of the nanoparticle. *Journal of nanobiotechnology*, 2013; 11(1): 1-12.
34. Lesniak, A., Salvati, A., Santos-Martinez, M. J., Radomski, M. W., Dawson, K. A., and Åberg, C. Nanoparticle adhesion to the cell membrane and its effect on nanoparticle uptake efficiency. *Journal of the American Chemical Society*, 2013; 135(4): 1438-1444.
35. Desai, N. Challenges in development of nanoparticle-based therapeutics. *The AAPS journal*, 2012; 14(2): 282-295.
36. Elzoghby, A. O., Samy, W. M., and Elgindy, N. A. Protein-based nanocarriers as promising drug and gene delivery systems. *Journal of controlled release*, 2012; 161(1): 38-49.
37. Zhang, Y. N., Poon, W., Tavares, A. J., McGilvray, I. D., and Chan, W. C. Nanoparticle–liver interactions: cellular uptake and hepatobiliary elimination. *Journal of controlled release*, 2016; 240: 332-348.
38. McShan, D., Ray, P. C., and Yu, H. Molecular toxicity mechanism of nanosilver. *Journal of food and drug analysis*, 2014; 22(1): 116-127.
39. Svensson, K. J., Christianson, H. C., Wittrup, A., Bourseau-Guilmain, E., Lindqvist, E., Svensson, L. M., et al. Exosome uptake depends on ERK1/2-heat shock protein 27 signaling and lipid Raft-mediated endocytosis negatively regulated by caveolin-1. *Journal of Biological Chemistry*, 2013; 288(24): 17713-17724.
40. Kraft, J. C., Freeling, J. P., Wang, Z., and Ho, R. J. Emerging research and clinical development trends of liposome and lipid nanoparticle drug delivery systems. *Journal of pharmaceutical sciences*, 2014; 103(1): 29-52.
41. Van Hong Nguyen, B. J. L. Protein corona: a new approach for nanomedicine design. *International journal of nanomedicine*, 2017; 12: 3137.
42. Shinde, V., Bhikha, S., Hoosain, Z., Archary, M., Bhorat, Q., Fairlie, L., et al. Efficacy of NVX-CoV2373 Covid-19 vaccine against the B. 1.351 variant. *New England Journal of Medicine*, 2021; 384(20): 1899-1909.
43. Banerjee, A., Qi, J., Gogoi, R., Wong, J., and Mitragotri, S. Role of nanoparticle size, shape and surface chemistry in oral drug delivery. *Journal of Controlled Release*, 2016; 238: 176-185.
44. Heath, P. T., Galiza, E. P., Baxter, D. N., Boffito, M., Browne, D., Burns, F., et al. Safety and efficacy of NVX-CoV2373 Covid-19 vaccine. *New England Journal of Medicine*, 2021; 385(13): 1172-1183.
45. Kannan, R. M., Nance, E., Kannan, S., and Tomalia, D. A. Emerging concepts in dendrimer- based nanomedicine: from design principles to clinical applications. *Journal of internal medicine*, 2014; 276(6): 579-617.
46. Nandiyanto, A. B. D., Al Husaeni, D. N., and Al Husaeni, D. F. A bibliometric analysis of chemical engineering research using vosviewer and its correlation with covid-19 pandemic condition. *Journal of Engineering Science and Technology*, 2021; 16(6): 4414-4422.
47. Schrlau, M. G., Stevens, R. J., and Schley, S. Flipping core courses in the undergraduate mechanical engineering curriculum: Heat transfer. *Advances in Engineering Education*, 2016; 5(3): n3.