

# Bibliometric Analysis of Solid Lipid Nanoparticle in Drug Delivery Applications Using VOSviewer

Journal of Mechanical Engineering,  
Science, and Innovation  
e-ISSN: 2776-3536  
2022, Vol. 2, No. 2  
DOI: 10.31284/j.jmesi.2022.v2i2.3582  
ejournal.itats.ac.id/jmesi

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## Abstract

*Solid Lipid Nanoparticle (SLN) is a carrier colloid system to control the repair of the body's chemical composition. SLN can increase the solubility of drugs that have low solubility in water and can also control the release. This study aimed to determine the level of research interest, developments in this research, and the latest developments that can be developed in research related to solid lipid nanoparticles using the VOSviewer application. The data used in this study were obtained and collected using the Publish or Perish software. The data obtained is based on the keywords "Solid Lipid Nanoparticle, SLN, drugs delivery". Based on the analysis conducted, obtained 1000 articles that are relevant to the keywords used in the 2012-2022 range. There are fluctuating results in the publication trend, with the highest number of publications in 2014 and the lowest in 2022. This shows that research interest has recently decreased. However, this research has the opportunity to conduct new research related to terms that are still rarely researched.*

**Keywords:** Bibliometric, Solid Lipid Nanoparticle, drugs delivery, VOSviewer.

Date received: September 25, 2022 Accepted: October 27, 2022

Handling Editor: Ika Nurjannah

## INTRODUCTION

In recent years, the application of nanotechnology in various fields has grown very rapidly. Nanotechnology is a very multidisciplinary field, ranging from applied physics, materials science, science, colloids and interfaces, supramolecular chemistry,



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self-replicating machines and robotics, chemical engineering, mechanical engineering, biological engineering, and electrical engineering [1]. Currently, many researchers are getting interested in developing nanotechnology. One of the nanotechnology approaches in the pharmaceutical field is Solid Lipid Nanoparticle (SLN). SLN is a novel drug delivery system consisting of a phospholipid-coated solid hydrophobic core matrix (containing a hydrophobic tail from the phospholipid moiety). The lipids used in the formation of SLNs are stabilized surfactants [2,3]. The development of the SLN system is carried out to improve solubility, stability, and loading capacity. The SLN system can also increase the solubility of drugs with low solubility in water and control the release. It is expected that hydrocortisone acetate formed by SLN has a particle size shape, large surface area, high loading dose, interactions at the interface, and potential to improve pharmaceutical performance from its properties [4].

In the description, it is necessary to analyze trends to assist in the development of SLN as drug delivery and also to determine the level of research interest in the development of the SLN. One trend analysis that can be used is bibliometric analysis. Bibliometric analysis is an approach to examining the evolution of a research domain, including topics and authors, based on the social, intellectual, and conceptual structure of the discipline [5].

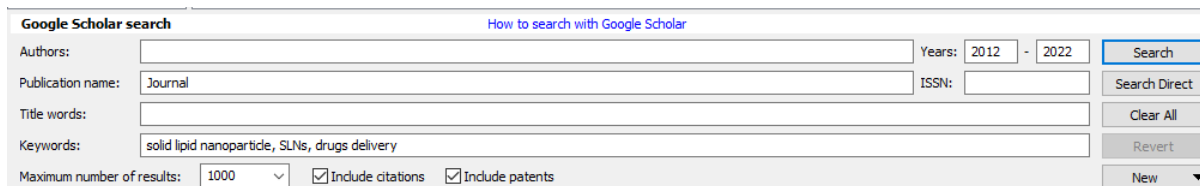
Many researches on drug delivery have been carried out using bibliometric analysis, including an overview and bibliometric analysis on the colorectal cancer therapy by magnetic functionalized nanoparticles for the responsive and targeted drug delivery [6], Publication trends in drug delivery and magnetic nanoparticles [7], A bibliometric investigation of research performance in emerging nanobiopharmaceuticals [8], A global bibliometric and visualized analysis of bacteria-mediated cancer therapy [9], A bibliometric analysis of nanocrystalline cellulose production research as drug delivery system using VOSviewer [10], Bibliometric and visualized analysis of ocular drug delivery from 2001 to 2020 [11], Bibliometric analysis of articles on nanoemulsion and/or in-situ gel for ocular drug delivery system published during the 2011–2021 period [12], The Trend of Drug Therapy on Uveitic Macular Edema: A Bibliometric Analysis of the 100 Most Cited Articles [13], and Bibliometric analysis of nanotechnology applied in oncology from 2002 to 2011 [14].

Previous studies in bibliometric analysis with the scope of drug delivery research have not discussed bibliometric analysis with SLN research topics. SLN can be important research because SLN functions as a carrier colloid for various compounds, helps bring drugs to treatment targets, and is widely used to improve the quality and function of cosmetic products. Therefore, we analyze research trends to determine the level of research interest, and the development of SLN research as drug delivery in the period 2012 to 2022. This study was conducted to show that solid lipid nanoparticle research still has a large enough opportunity to conduct new research related to some terms that are still rarely used in research. Bibliometric analysis in this study uses VOSviewer software on data that has been collected with Publish or Perish. The results of this study are expected to help and become a reference for other researchers as consideration for determining the research theme to be taken.

## METHODS AND ANALYSIS

The data used in this article uses bibliometric analysis. In this study, researchers used data from international publications sourced from the Google Scholar database. Which is Google Scholar being an open-source database, so researchers can access the data freely. Data collection was carried out in several stages, namely: (i) Collection of publication data using the Publish or Perish (PoP) application, (ii) processing of bibliometric data using the Microsoft Excel application, (iii) analysis of compilation of publication data for bibliometric publications using the VOSviewer application, and (iv) analysis of the results of photographic analysis[15].

In the search for this data, it is limited in three aspects, namely: (1) the selected scientific papers are only the type or types of journals; (2) the words entered in the keyword search column are "Solid Lipid Nanoparticles, SLN, drugs delivery"; and (4) the journals taken are journals published in the period 2012-2022. The search for the PoP application was carried out on Wednesday, September 14, 2022. The data search process for the PoP application is shown in Figure 1.



**Figure 1** Search data using the Publish or Perish app

The data that has been collected and in any research analysis criteria is then saved into two types of files with \*.ris and \*.csv formats. These files can be used in the VOSviewer application. It is also used to visualize and evaluate trends using bibliometric maps. The article data from the source database is then mapped. The author uses the VOSviewer application to assist bibliometric analysis by visualizing the results of the analysis. VOSviewer is used to create 3 variations of mapping publications, namely network visualization, overlay visualization, and density visualization based on the network (co-citation) between existing items. When creating a bibliometric map, the keyword frequency is set to be found at least 3 times. Therefore, 207 terms and keywords that were less relevant were omitted.

## RESULTS AND DISCUSSIONS

### Publication Data Search Results

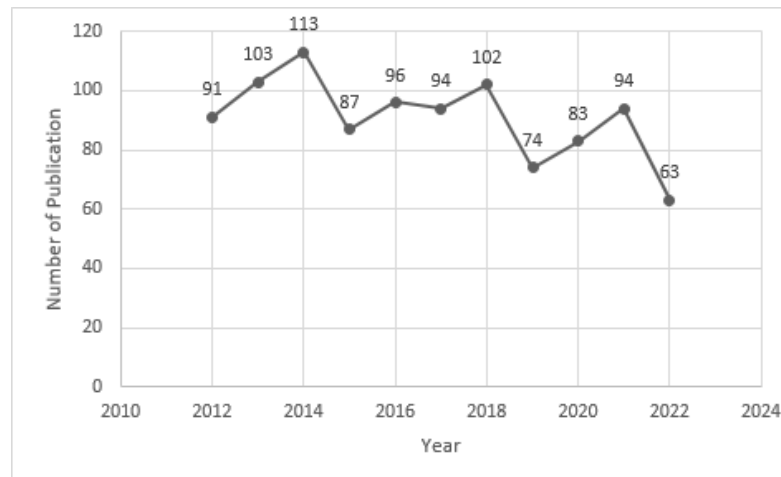
There are 1000 data articles that meet the research criteria, the data was obtained using the publish or perish application from the Google Scholar database in the form of article metadata consisting of the author's name, title, publisher name, number of citations, and article links. The number of citations from all articles is 38934, with the number of citations per year being 3893.40. In addition, all articles have an average h-index of 94, and an average g-index of 139. The data that meet the research criteria and have the most citations are shown in table 1.

**Table 1** Solid Lipid Nanoparticle Publication Data

| No | Authors                                   | Title   | Cites | Year |
|----|---|---|-------|------|
| 1  | M Paranjpe, CC Müller-Goymann             | Nanoparticle-mediated pulmonary drug delivery: a review   | 384   | 2014 |
| 2  | MA Iqbal, S Md, JK Sahni, S Baboota...    | Nanostructured lipid carriers system: recent advances in drug delivery  | 348   | 2012 |
| 3  | P Severino, T Andreani, AS Macedo...      | Current state-of-art and new trends on lipid nanoparticles (SLN and NLC) for oral drug delivery                               | 272   | 2012 |
| 4  | M Sala, R Diab, A Elaissari, H Fessi      | Lipid nanocarriers as skin drug delivery systems: Properties, mechanisms of skin interactions and medical applications        | 252   | 2018 |
| 5  | A Garcês, MH Amaral, JMS Lobo, AC Silva   | Formulations based on solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC) for cutaneous use: A review     | 235   | 2018 |
| 6  | A Gordillo-Galeano, CE Mora-Huertas       | Solid lipid nanoparticles and nanostructured lipid carriers: A review emphasizing on particle structure and drug release      | 235   | 2018 |
| 7  | A Garud, D Singh, N Garud                 | Solid lipid nanoparticles (SLN): method, characterization and applications  | 215   | 2012 |
| 8  | S Jose, SS Anju, TA Cinu, NA Aleykutty... | In vivo pharmacokinetics and biodistribution of resveratrol-loaded solid lipid nanoparticles for brain delivery               | 213   | 2014 |
| 9  | V Kakkar, SK Muppu, K Chopra, IP Kaur     | Curcumin loaded solid lipid nanoparticles: an efficient formulation approach for cerebral ischemic reperfusion injury in rats | 175   | 2013 |
| 10 | G Yoon, JW Park, IS Yoon                  | Solid lipid nanoparticles (SLNs) and nanostructured lipid carriers (NLCs): recent advances in drug delivery                   | 169   | 2013 |

### Research Development related to Solid Lipid Nanoparticle

The results of the analysis of publication trends or the development of publications on data taken from 2012-2022. The number of publications shown in Figure 2 is not constant (fluctuating). If seen in Figure 2, the level of development of Solid Lipid Nanoparticle research in 2012 to 2014 the number of publications increased significantly, from 91 journals to 113 journals. After that, there were ups and downs in the number of publications and in 2022 it decreased with the number of publications being 63 journals. The fluctuating developments are caused by the lack of up-to-dateness in this research which results in a decrease in research interest from year to year.



**Figure 2** The level of research development of Solid Lipid Nanoparticles as a drug delivery

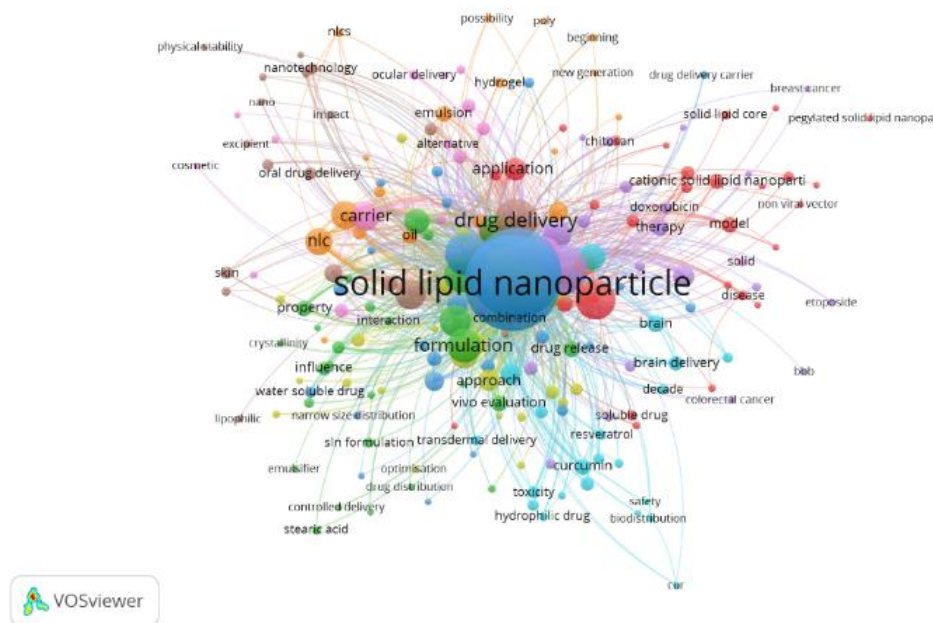
### Visualization of Solid Lipid Nanoparticle topic areas using VOSviewer

The VOSviewer application is used to visualize bibliometric maps. From the results of computational mapping found 207 items. Each item found related to SLN in the data mapping is divided into 9 clusters, namely:

- a. Cluster 1 contains 29 items, namely addition, alternative drug delivery, Alzheimer, cationic solid SLN, characteristic, colloidal carrier, colloidal drug carrier, delivery, disease, dispersion, drug carrier, fabrication, gene delivery, gene therapy, intranasal delivery, lipid, lipid nanocarrier, microemulsion, model, nanocarrier, new approach, new class, non-viral vector, pegylated solid lipid nanoparticle, pulmonary delivery, solid lipid core, soluble drug, vector.
- b. Cluster 2 contains 27 items, namely characterization, controlled delivery, crystallinity, cyclodextrin, dermal delivery, determination, drug distribution, drug release, emulsifier, formulation, ibuprofen, incorporation, influence, interaction, lipid matrix, lipid nanoparticle, matrix, mechanism, mixture, physicochemical property, preparation, property, SLN formulation, solid lipid, solid lipid matrix, stearic acid, vivo evaluation.
- c. Cluster 3 contains 27 items, namely ability, bioavailability, cellular uptake, docetaxel, drug delivery carrier, drug delivery system, enhancement, hydrophobic drug, improvement, insulin, lymphatic uptake, modification, narrow size distribution, oral administration, oral bioavailability, oral delivery, peptide, praziquantel, production, promising drug delivery, protein, SLN, solid lipid nanoparticle, strategy, vivo evaluation, water soluble drug.
- d. Cluster 4 contains 25 items, namely activity, amount, approach, concentration, development, drug, effectiveness, entrapment efficiency, evaluation, gel, investigation, lipophilic drug, loaded solid lipid nanoparticle, morphology, nanoparticulate drug delivery, nanostructured optimization, particle size, particle size distribution, physicochemical character, potential, qbd, raloxifene, size distribution, zeta.
- e. Cluster 5 contains 22 items, namely anticancer drug, antitumor activity, bbb, breast cancer, cell, chitosan, co delivery, colorectal cancer, comparison, cytotoxicity, delivery system, doxorubicin, encapsulation, etoposide, paclitaxel, pbx, sins, solid lipid nanoparticles, surface, targeted delivery, therapy, tumor

- f. Cluster 6 contains 21 items, namely biodistribution, brain, brain delivery, Cur, curcumin, decade, drug loading, formulation developme, hydrophilic drug, new drug delivery system, optimization, pharmacokinetic, resveratrol, safety, solubility, stability, toxicity, transdermal delivery, vehicle, vitro characterization, vivo
- g. Cluster 7 contains 21 items, namely advantage, beginning biocompatibility, colloidal drug delivery system, combination, dermal drug delivery, distribution, emulsion, hydrogel, lipid carrier, liquid lipid, nanostructured lipid carrier, new generation, nlc, nlcs, oil, poly, possibility, preparation method, skin delivery, solid lipid nanoparticle formulation
- h. Cluster 8 contains 19 items, namely drug delivery, excipient, impact, lipophilic, nano, nanoemulsion, nanotechnology, oral drug delivery, physical stability, potential application, quercetin, recent advance, size, skin, solid matrix, surfactant, system, topical application, topical delivery.
- i. Cluster 9 contains 16 items, namely alternative, attention, carrier, controlled release, cosmetic, liposome, methazolamide, nanoparticle, ocular delivery, ocular drug delivery, particle, polymeric nanoparticle, solid, topical treatment, tansdermal drug delivery, vivo study

In the mapping results using VOSviewer, there are three different visualizations, namely network visualization, overlay visualization, and density visualization. The results of the mapping are shown in Figures 3, 4, and 5, respectively. The figure shows the relationship between the terms found with other terms, which are depicted by lines.



**Figure 3** Network visualization with keywords Solid Lipid Nanoparticle as drug delivery

In Figure 3, the results of the network visualization mapping will show the network between the visualized terms. In the picture it can be seen that the terms have different colors and different sizes, this shows that the terms obtained have different clusters. Cluster 1 is marked in red, cluster 2 is green, cluster 3 is dark blue, cluster 4 is yellow, cluster 5 is purple, cluster 6 is light blue, cluster 7 is orange, cluster 8 is brown and lastly cluster 9 is pink. While the term size indicates that the larger the size, the



## CONCLUSIONS

In this study, a bibliometric analysis with the theme of Solid Lipid Nanoparticles as drug delivery was carried out using VOSviewer. Data collection using the Publish or Perish application for the period 2010-2022 obtained data as many as 1000 articles according to the research. In the publication trend, there are fluctuating results with the highest number of publications in 2014 and the lowest in 2022. This shows that research interest has recently declined. However, this research has a great opportunity to conduct new research related to terms that are rarely studied such as breast cancer, colorectal cancer, ocular delivery and cationic solid lipid nanoparticles which are still very rarely studied.

## ACKNOWLEDGEMENTS

### DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### FUNDING

The author(s) disclosed receipt of the following no financial support for the research, authorship, and/or publication of this article

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