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Bibliometric Analysis of Magnetite Nanoparticle Production Research During 2017-2021 Using Vosviewer

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ABSTRACTS

Fe_3O_4 nanoparticles are magnetic materials that can use in various fields. Fe_3O_4 particles have several properties such as being super magnetic, having a high saturation field, being chemically stable, biocompatibility, and low production costs. The purpose of this study was to conduct a bibliometric analysis of the research on the production of Fe_3O_4 nanoparticles by using mapping analysis with VOSviewer software. The data used in the study were obtained and collected using the Publish or Perish software. The data obtained were obtained based on the keywords "magnetite, nanomaterial, Fe_3O_4 nanoparticle, production". Based on the analysis conducted, it was found that 994 articles relevant to the keywords used were obtained in the 2017-2021 range. The results show that the production of Fe3O4 nanoparticles increased from 2017-2019 and decreased after that. This research is expected to help and become a reference for other researchers as consideration for determining the research theme to be taken.

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1. INTRODUCTION

Fe_3O_4 particles as one type of functional materials are the most widely used magnetic materials in electronics, magnetic fluids, catalysis field, battery, magnetic storage media, adsorbent, and so on. According to Meng *et al.* (2013) the application of these Fe_3O_4 nanoparticles is very much the manufacture of cellulose acetate nan fibers–Nano magnetite for lead removal (Shalaby *et al*., 2017), magnetite for cancer hyperthermia (Li *et al*., 2010), analysis of Sudan I in food (Yin *et al*., 2011), modifying glassy carbon electrodes as electrochemical sensors (Sohouli *et al*., 2020; Yang *et al*., 2013), and many other useful applications.

Based on this description, it is known that nanoparticles have various advantages and promising applications. So that trend analysis on research in this area will be quite helpful in the development related to the production and application of Fe_3O_4 nanoparticles.

Analysis of bibliometric data displayed visually through a mapping tool will be very helpful for mapping the research trends being carried out. According to Al Husaeni and Nandiyanto (2022) Bibliometrics can be a tool used to evaluate research trends qualitatively and quantitatively in a study from time to time. This method uses a literature database and metrological characteristics from the literature. This method is quite popularly used to broaden the horizons of a particular research field. The free software available for bibliometric analysis is VOSviewer (Garfield, 1972; Iii *et al*., 2019; Malik *et al*., 2018). This software is quite popular to use because besides being free it is also easy to use (Orduña & Costas, 2021).

In this study, we analyze the trend of research conducted regarding the production of magnetite nanoparticles in the period 2017 to 2021. This study aims to conduct a bibliometric analysis of the production of Fe_3O_4 nanoparticles with bibliographic data on article titles, keywords, and abstracts. Bibliometric analysis was performed using VOSviewer software on data that had been collected with Publish or Perish. This research is expected to help and become a reference for other researchers as a consideration for determining the research theme to be taken.

2. METHODS

The research data used in this study is research data obtained from articles published in journals indexed by Google Scholar. Google Scholar is used because the site can be accessed for free, in contrast to Scopus which cannot be accessed freely. Of course, we will use the Scopus database in our future research for better research results. In this study, Publish or Perish as a reference manager was used to obtain research data. Every article data that has been obtained must be from articles indexed by Google Scholar and have relevance to the themes needed in this research and then will be backed up into a file that will use for analysis with VOSviewer.

In this study, each article was filtered only articles related to the production of Fe_3O_4 nanoparticles were taken. The data was obtained through a search on the Publish or Perish application with the keywords "magnetite, nanomaterial, Fe_3O_4 nanoparticle, production" which was adjusted to the criteria of title, keyword, and abstract. From the search results, 994 articles were obtained that matched the selected topics published in the 2017-2021 range. The data obtained is then collected and stored in *.ris format. Next, analysis is performed using VOSviewer to visualize and analyze trends using bibliometric maps. The data obtained were mapped using three types of mapping, namely network visualization, density,

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and overlay. In addition, the filtering of terms that will be included in the visualization of the VOSviewer network mapping is also carried out.

3. RESULTS AND DISCUSSION

3.1. Research Developments in The Field of Fe_3O_4 Nanoparticle Production

This study analyzes the development of research on the production of Fe_3O_4 nanoparticles carried out from 2017 to 2021. **Figure 1** shows the development curve of Fe_3O_4 nanoparticle synthesis research for five years. Based on **Figure 1**, it can see that the research related to the synthesis of Fe_3O_4 nanoparticles is quite a lot every year. It can be seen that from 2017 to 2019 the number of publications related to this topic increased, but from 2020 to 2021 it continued to decline. This can be seen with the number of articles in 2017 being 190 and in 2018 increasing to 207 and 2019 still increasing with 221 articles. However, in 2020 the number of articles decreased to 204 and in 2021 again decreased to 172.

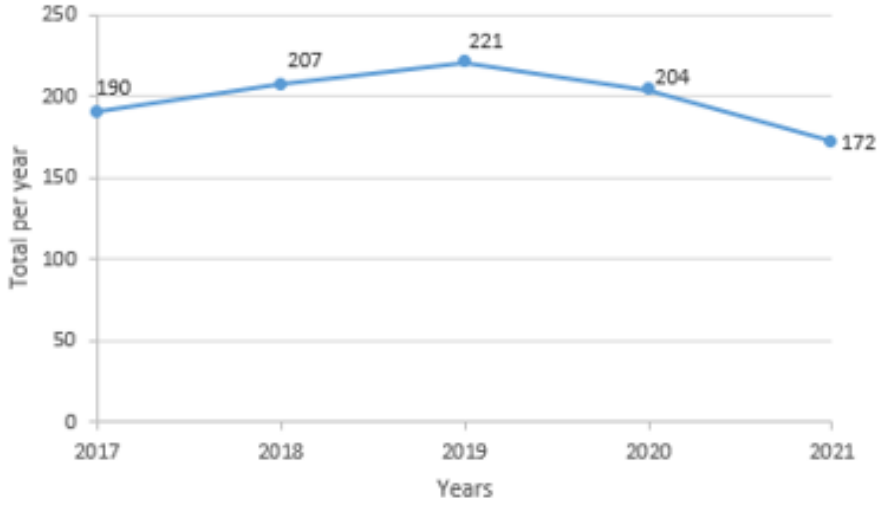

Figure 1. Level of development of research on Fe_3O_4 nanoparticle production

3.2. Visualization Fe_3O_4 nanoparticle production topic area using VOSviewer

Research related to the production of Fe_3O_4 nanoparticles analyzed based on mapping visualization is divided into 8 clusters, namely:

(i) Cluster 1 has 59 items, the 59 items are ammonia, aqueous medium, aqueous solution, bare magnetite nanoparticle, catalytic application, catalytic application, coprecipitation, coprecipitation method, coating, comparison, complex, core, core shell, core shell nanoparticle, crystal structure, effective removal, efficient catalyst, encapsulation, enzyme, fabrication, facile, Fe_3O_4 SiO_2 nanoparticle, functionalization, immobilization, ion, iron oxide magnetic nanoparticle, knowledge, layer, magnetic core, magnetic Fe, magnetic nanoparticle, magnetite core, magnetite nanoparticle, magnetite surface, modification, nickel, novel adsorbent, oxidation, photocatalytic degradation, pot synthesis, preparation, procedure, recyclable catalyst, scheme, shell, silica, silica coated Fe, silica coated magnetite, simple, SiO, SiO_2, solution, surface, surface modification, synthesis, system, TEM image, and XRD pattern.

(ii) Cluster 2 has 55 items activated carbon, antibacterial activity, cobalt, comparative study, composition, concentration, coprecipitation, ctab, current study, decomposition, diameter, efficient method, Fe_3O_4, Fe_3O_4 nanoparticle, form, formation, growth, humic acid, hydrothermal synthesis, iron oxide nanoparticle, iron sand, low cost, magnetic behavior, magnetic property, magnetite, magnetite Fe, magnetite nanoparticle,

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magnetite particle, magnetite phase, morphology, nanoparticle synthesis, NaOH, natural iron sand, nature, polyethylene glycol, powder, presence, process, product, property, research, shape, size, structural, structure, supermagnetic magnetite nanoparticle, supermagnetic nanoparticle, surfactant, synthesis condition, synthesis method, synthesis process, temperature, treatment, X-ray diffraction and XRD.

(iii) Cluster 3 has 43 items, namely adsorbent, adsorption, Au nanoparticle, biogenic synthesis, carbon, catalyst, catalytic activity, composite, cost, degradation, determination, efficient removal, extraction, Fenton, gold, gold nanoparticle, graphene, graphene oxide, graphene oxide sheet, green synthesis, magnetic Fe_3O_4 nanoparticle, magnetic nanocomposite, magnetic nanomaterial, magnetite iron oxide nanoparticle, mechanism, metal, metal nanoparticle, methylene, nanocomposite, nanomaterial, nanotechnology, performance, plant, production, reaction, reduction, reusable catalyst, separation, silica coated magnetic nanoparticle, silver nanoparticle, simple method, waste water, and water.

(iv) Cluster 4 has 35 items activity, agglomeration, aggregation, alkaline medium, application, bulk magnetite, core shell, drug delivery, Fe2O3, hematite, hyperthermia, incorporation, influence, interaction, investigation, iron oxide, maghemite, magnetite Fe_3O_4, magnetite NP, microwave, MNP, nanocarrier, nanofluid, oleic acid, optimization, particle, physical property, poly, potential, spions, stability, supermagnetic iron oxide nanoparticle, surface charge, synthesis route, and value.

(v) Cluster 5 has 30 items, namely agent, biosynthesis, cell, characterization, chemical, deionized water, dielectric property, ethanol, facile synthesis, Fe_3O_4 NP, FeCl, field, figure, green, iron nanoparticle, magnetic field, magnetic resonance imaging, magnetite Fe_3O_4 nanoparticle, magnetite nanocomposite, mixture, nanoparticle, polymer, potential application, precursor, present work, ratio, release, supermagnetic Fe, vitro, XRD analysis.

(vi) Cluster 6 has 14 items consist of antimicrobial activity, cancer therapy, characteristic, characteristic peak, characterization, chitosan, cytotoxicity, electrochemical synthesis, evaluation, particle size, physicochemical magnetization, pure magnetite, and spherical shape.

(vii) Cluster 7 has 14 items are analysis, average size, condition, electrochemical method, Fe_3O_4 magnetic nanoparticle, FTIR, hydrothermal method, metallic nanoparticle, room temperature, SEM, study, synthesized magnetite nanoparticle, technique, and TEM.

(viii) Cluster 8 has 11 items consisting of biomedical application, coprecipitation method, development, easy synthesis, EDTA, green biosynthesis, journal, magnetic iron oxide nanoparticle, PVA, superparamagnetic magnetite.

Cluster 1 is marked in red, cluster 2 is marked in green, cluster 3 is marked in dark blue, cluster 4 is marked in yellow, cluster 5 is marked in purple, cluster 6 is marked in light blue, cluster 7 is marked in orange, and cluster 8 is marked in brown.

3.1. Research developments in the field of Fe_3O_4 nanoparticle production

The visualization network displays the relationship between terms found and visualized through the displayed image. According to Al Husaeni and Nandiyanto (2022) **Figure 2** shows the relationship between the terms found which are described by networks or lines connecting one term to another. From Figure 2 it can be seen that each term found is divided into several clusters. The terms magnetite nanoparticles and Fe_3O_4 nanoparticles are combined in cluster 2 and connected to cluster 1 and cluster 3. In cluster 1, the terms

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synthesis and magnetic nanoparticles are found. Meanwhile, in cluster 3, the terms nanomaterial and production were found. For the term nanoparticles found in cluster 5.

In this visualization, the cluster size indicates the number of publications. The bigger the cluster, the more publications. The distance between the clusters shows the relationship between the clusters in the quote. The closer the distance between the clusters, the stronger the attachment. Curved lines connecting clusters represent the interrelationships between items (Eck & Waltman, 2017).

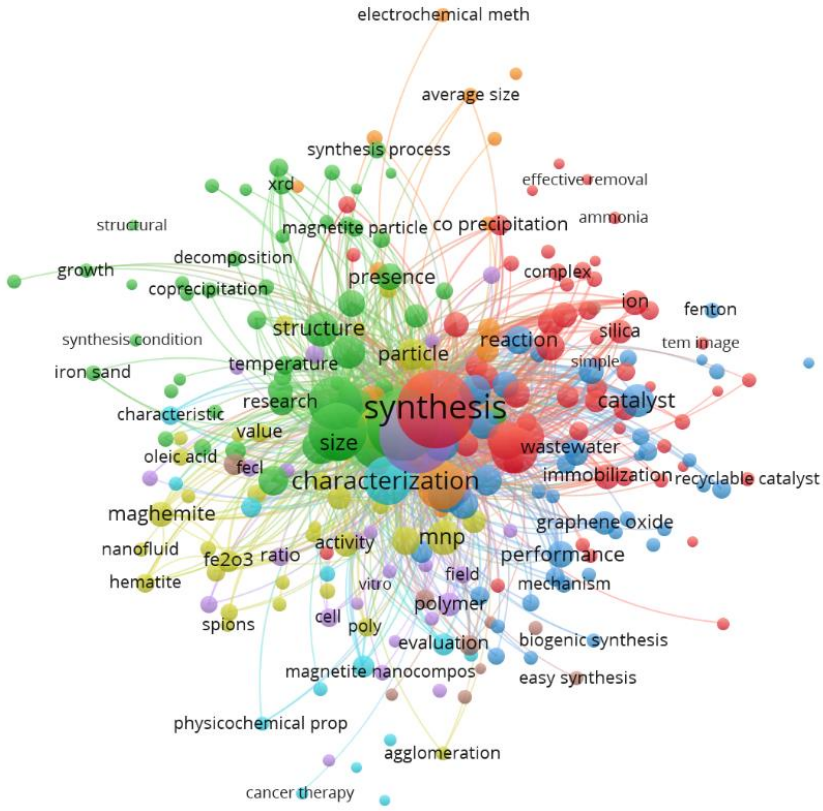

Figure 2. Network visualization of magnetite, nanomaterial, Fe_3O_4 nanoparticle, production keyword.

4. CONCLUSION

In this study, a bibliometric analysis was carried out related to research on the production of Fe_3O_4 nanoparticles using VOSviewer. The data analyzed was obtained from the reference manager application, namely, Publish or Perish. The data collected are articles published from 2017 to 2021 which are filtered based on the keywords "magnetite, nanomaterial, Fe_3O_4 nanoparticle, production". The bibliographic data used in this study are the topic area, title, keywords, and abstract. Based on the research results obtained 994 articles that are relevant to the keywords. By searching the data using the keywords “magnetite, nanomaterial, Fe_3O_4 nanoparticle, production”, you get 8 clusters with various numbers of terms.

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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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