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SYSTEMATIC LITERATURE REVIEW SYNTHESIS METHODS IN AFFECTING THE MORPHOLOGY AND MAGNETIC PROPERTIES OF IRON SAND

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ABSTRACT

This research focuses on the morphological characteristics and physical properties of iron sand synthesized using various methods, with the aim of finding the most effective synthesis method. Iron sand, consisting of minerals such as magnetite, hematite, and ilmenite, has wide applications in industry. The morphology and physical properties of iron sand, including hardness, density, thermal conductivity, and magnetic properties, greatly influence the material's performance in these applications. This research uses a Systematic Literature Review (SLR) approach by collecting and evaluating literature from the last 10 years, using Publish or Perish 8 software. Synthesis methods compared include solid state reaction (SSR), hydrothermal, sol-gel, and coprecipitation. The research results show that the coprecipitation method, especially sintering at a temperature of 400°C, produces the highest magnetic saturation value of 65 emu/g. The solid state reaction method gave the highest remanence value of 8.72 emu/g, while the coprecipitation method at a temperature of 120°C achieved the highest coercivity value of 851.68 Oe. For particle size, the coprecipitation method with ultrasonic irradiation and the use of 9M NaOH was proven to produce the smallest particle size, namely 20-25 nm. This research concludes that the coprecipitation method is the most effective in achieving optimal magnetic properties and very small particle sizes. These findings provide guidance for researchers in selecting synthesis methods according to specific needs and help the development of new materials with improved properties for various industrial and technological applications.

Keywords: SLR, Synthesis Method, Iron Sand, Magnetic Properties, Morphology

INTRODUCTION

Iron sand is a geological material consisting of fine particles which mostly consist of iron oxide compounds such as magnetite (Fe_3O_4), hematite (Fe_2O_3), and ilmenite ($FeTiO_3$) (Utoyo & Sarmili, 2016) . The main sources of iron sand are coastal areas and rivers which are rich in heavy minerals due to natural sedimentation processes. In Indonesia, iron sand is found along the southern coast of Java, Sumatra, as well as several areas in Sulawesi, Kalimantan and Nusa

Tenggara (Melinia et al., 2022) . Iron sand has high economic value because of its wide application in industry, including as a raw material in the production of steel, magnetic materials, and various other metallurgical products (Fatni Mufit et al., 2006) . The morphological characteristics and physical properties of iron sand greatly influence the performance of this material in various industrial applications (Zulaikah et al., nd) .

Morphology is the shape, size and surface structure of iron sand. Morphology determines how the particles interact with each other and their environment, and influences the performance of the sand when applied (Saniah et al., 2015) . An example of the importance of morphology in the application of iron sand is when it is used as an adsorbent, the surface area greatly influences the reaction speed and absorption capacity. In the realm of electronics, the morphology of iron sand can influence the magnetic properties in electric motors and generators. To analyze morphological characteristics, scanning electron microscopes and transmission electron microscopes can be used.

Physical properties are hardness, density, thermal conductivity and magnetic properties of iron sand (Kapasiang et al., 2018) . The hardness and density of iron sand is important for structural applications, determining the strength and durability of the material in extreme conditions (Sagala, 2021) . Good thermal conductivity allows iron sand to be used in applications that require thermal efficiency, such as cooling or insulation materials, then the magnetic properties of iron sand are very important in electronic and magnetic applications (Ramadhan et al., 2018) , such as in the manufacture of transformers, electric motors and data storage devices (Fauzan, nd) . For analytical measurement techniques for the physical properties of sand, you can use x-ray difraction and vibrating sample magnetometry techniques. Physical and morphological properties can be influenced by the synthesis method used. Synthesis methods are techniques and processes used to process and modify iron sand so that it has the desired properties for certain applications.

There are several synthetic methods that can be used to obtain the desired morphology and physical properties, including methods such as solid state reaction (SSR) (Ningsih et al., 2019; Setiadi et al., 2018) , hydrothermal, solgel (Fitria Murti, 2017).) , coprecipitation (Fahlepy & Tiwow, 2018) and sol gel (Mishra et al., 2017) and many more. The synthesis methods used have their respective advantages and disadvantages. Therefore, in this research the author will compare several synthesis methods using a literature review system based on a collection of articles from the last 10 years.

The research carried out was in the form of a systematic literature review, the data used to conduct this research was a collection of literature on the topic of morphological characteristics and physical properties of iron sand synthesized using several methods, and using publish or perish 8 software. This research is expected to provide clear guidance regarding the best synthesis method that can be used for iron sand. With this guide, it is hoped that optimal synthesis results can be obtained in terms of morphology and physical properties, which in turn will increase the application of these materials in various industrial and technological fields. It is also hoped that this research can serve as a reference for future researchers in selecting appropriate synthesis methods based on their specific needs, as well as assist in the development of new materials with improved properties.

RESEARCH METHODOLOGY

This research uses a Systematic Literature Review (SLR) approach, which is a methodology used in certain research. This development was carried out to collect and evaluate research related to a particular topic focus (Triandini et al., 2019) . The SLR method is used to evaluate various synthesis methods used in studies of the morphological characteristics and physical properties of iron sand (Afsari et al., 2021; L. Rahmawati & Juandi, 2022) . Systematic reviews focus on the use of topics that appear in articles. This research prioritizes synthesis methods, magnetic properties and particle morphology. The data sources in this research come from various journal articles in the last 10 years relating to iron sand synthesis methods. This SLR research procedure was adopted from Denyer and Tranfield (2009) which was also reported to have been used by other authors such as (Han et al., 2020) ; (Husamah et al., 2022) ; (Murti & Hernani, 2023) . The five SLR steps in this research are presented in Figure 1.

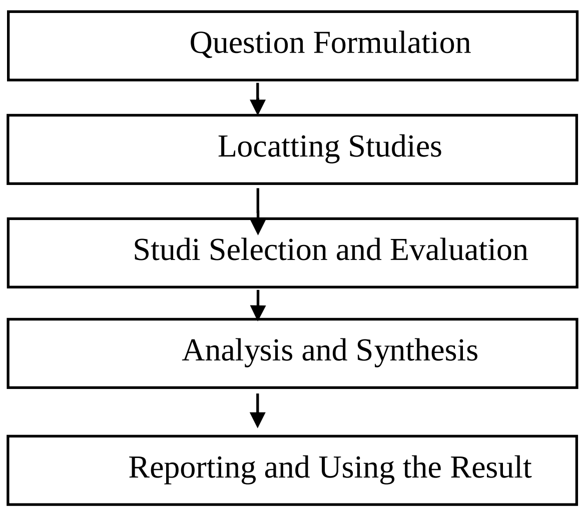


Figure 1. Steps to a systematic literature review

Question Formulation

The first step is to determine the scope to develop a clear research focus. This research ask several questions based on the selected topic. These questions serve as parameters in this research.

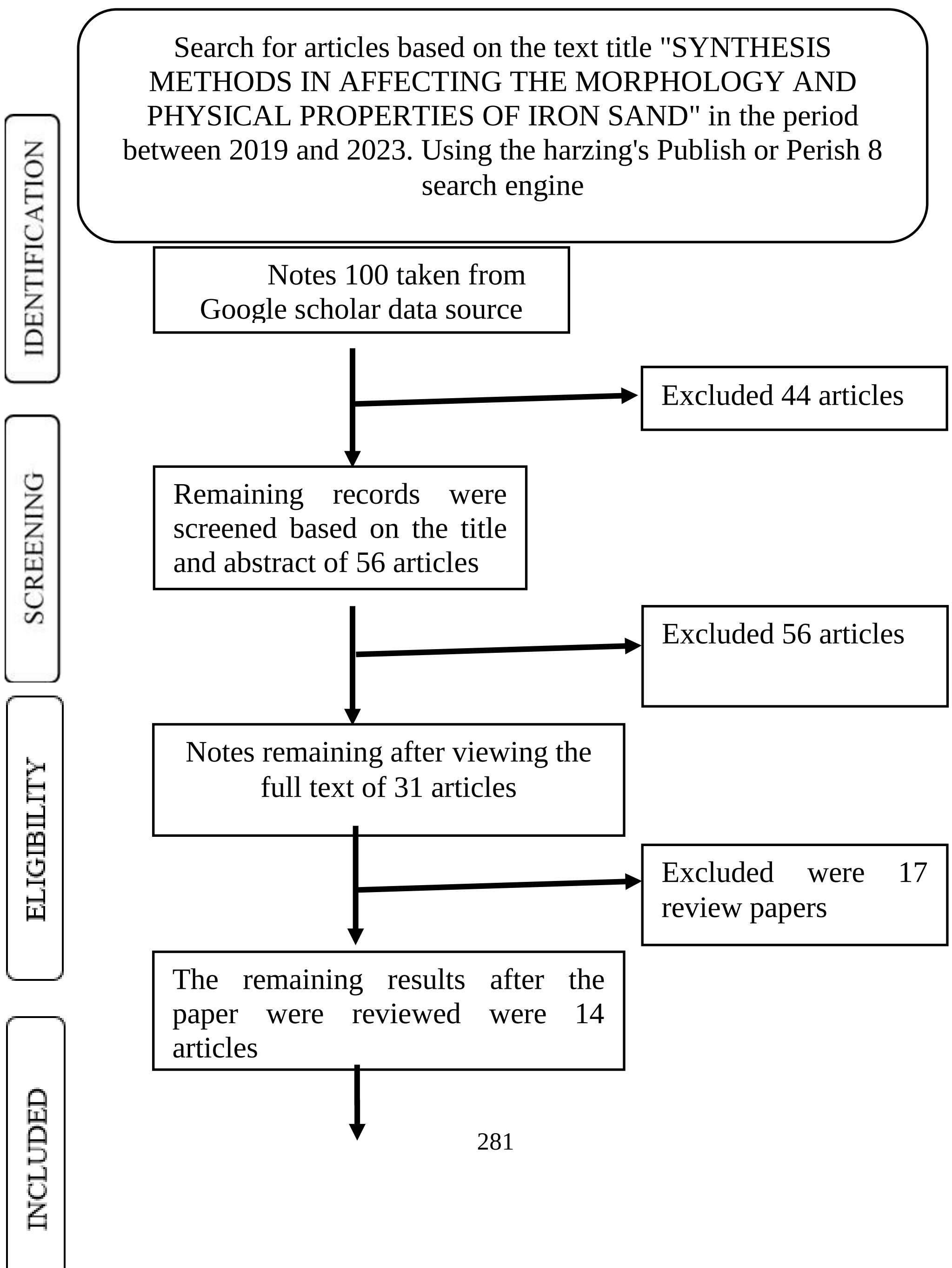
1. What is the most effective synthesis method used to produce high magnetic properties?
2. What synthesis method is most effective to use to produce the smallest grain size?

Locatting Studies

The second step aims to search for search databases related to review questions. The keywords used in the search are "Iron sand, synthesis methods, magnetic properties and morphology." The process of searching for data sources via Google Scholar and the Scopus database. Searches use these terms to explore relevant articles published in national and international journals indexed by Sinta and Scopus. The journal you are looking for must be published in 2014-2024. The search process uses the help of the Publish or Perish (POP) application.

Selection and Evaluation Studies Selection and Evaluation Studies

The articles used in this research are based on the following inclusion criteria: The inclusion criteria used include studies that report the use of solid state reaction (SSR), hydrothermal, sol-gel, and coprecipitation methods in the synthesis of iron sand, as well as studies that evaluate the morphological characteristics and physical properties of iron sand. Meanwhile, exclusion criteria include studies that are not relevant to the topic of iron sand synthesis, articles that are not available in full text, and publications that are not peer-reviewed. The data that was collected was then processed using the PRISMA method as shown in the image below.



The research study used 14 articles

Figure 2. PRISMA method

Analysis and synthesis

After the articles have been selected, the next step is to synthesize the results from the relevant literature. Data synthesis in this research was carried out in narrative form. Data analysis was carried out descriptively and comparatively. Descriptive analysis is used to describe and summarize findings from selected literature, while comparative analysis is carried out to compare the results obtained from various synthesis methods in order to determine the most effective method. The analysis steps include grouping studies based on synthesis methods, evaluating the reported morphological characteristics and physical properties, as well as comparing synthesis results based on predetermined criteria such as particle size, size distribution, crystal structure, and material purity.

Table 1. Review results of 14 journals related to synthetic methods in influencing the morphology and magnetic properties of iron sand

Writer	Synthesis Method	Magnetic Properties	Morphology (Average Grain Size)
(Puspita et al., 2022)	Coprecipitation	VSM results show that the iron sand sample is soft magnetic and anti-ferromagnetic with saturation (Ms), remanence (Mr) and coercivity (Hc) values of 0.53 emu/g, 0.04 emu/g and 376 respectively. .63 Oe.	SEM-EDX results show that the particles experience agglomeration and form aggregates with an average particle size of 12.495 µm
(Basith & Taufiq, 2012)	Coprecipitation	The saturation magnetic values for samples with sintering temperatures of 100°C and 400°C are 35 emu/g and 65 emu/g, respectively.	The size of magnetite particles is between 11.48 - 13.45 nm
(Melinia et al., 2022)	Solid State	Musi River iron sand is semi-	The average particle size is ± 0.5

LI G I B IL IT

N C L U D E

	Reactions	hardmagnetic and ferromagnetic with coercivity (Hc) 322.09 Oe, saturation (Ms) 46.61 emu/g, and remanance (Mr) 8.72 emu/g.	μm with a particle size range between 0.1 μm to 1.4 μm.
(Widianto et al., 2018)	Solid State Reaction (SSR)	-	The average diameter of iron sand samples is ± 78 μm.
(Karbeka, 2021)	Copreci pitation Method	Magnetic saturation (Ms) for Fe_3O_4 nanoparticles is 52.15 emu/gr. For nanocomposite samples at temperatures of 40°C, 70°C, and 100°C, Ms is 3.365 emu/gr, 4.635 emu/gr, and 4.75 emu/gr, respectively . Field coercivity (Hc) is 0.0102 T, 0.0112 T, and 0.0136 T, respectively.	The crystal size is 34.8691 nm.
(Karbeka, 2021)	SSR	Iron sand measuring 120 mesh has greater magnetic properties with a saturation value (Ms) of 25.42 emu/g, remanence (Mr) of 0.02 T, and coercivity (Hc) of 5 emu/g. For 80 mesh Ms is 0.98 emu/g, Mr 0.02 T, and Hc 0.4 emu/g.	-
(Elsafitri et al., 2020)	Copreci pitation Method	-	The particle size results from SEM characterization show a particle size range of

			30-90 nm.
(Puspitarum et al., 2019)	Coprecipitation Method	The maximum saturation magnetization value (Ms) is 5.78 memu (milli emu), remanent magnetization (Mr) is 1.13 memu and the coercivity field value is 851.68 Oe.	The results of the analysis of iron sand extraction with temperature variations of 80oC, 120oC and 160oC respectively measure 33.76 nm, 11.84 nm and 11.14 nm. Meanwhile, the results of the analysis of iron sand extraction with stirring times of 2 hours, 4 hours and 6 hours respectively had particle sizes of 43.12 nm, 11.14 nm and 11.32 nm.
(Jalil et al., 2014)	mechanical milling	Syiah Kuala Beach has a magnetic saturation of 0.333 T (before miling) and 0.188 T (after 20 hours of miling). While the remanence value (Br) was 0.022 T (before milling) and 0.075 T (after 20 hours of milling) and the coercivity (Hc) before milling was only 1.34 kA/m, but after 20 hours of milling it showed a quite significant increase, namely reaching 33 .31 kA/m.	-
(Didik & Wahyudi, 2020)	SSR and coprecipitation	-	The particle size of samples that have been synthesized using the SSR method is still micrometer size,

			namely 1.34 µm, while the particle size using the coprecipitation method is close to nanometer size, namely 210 nanometers.
(Unand & Manis, 2015)	Copreci pitation Method	-	Based on the SEM results, it can be seen that the Fe3O4 nanoparticles are spherical in shape with particle sizes of 85 nm, 67.75 nm, 86.5 nm and 60.75 nm, respectively.
(Putri & Puryanti, 2020)	Copreci pitation Method	-	The particle size calculated using Image-J Software shows that the particle size has not changed, namely 27 nm.
(Kiswanto et al., 2021)	Copreci pitation Method	Iron sand synthesized with 3M NaOH has Ms 11.2 emu/g, Mr is 4.7 emu/g and Hc is 101 Oe, Iron sand synthesized with 6M NaOH has Ms 11.4 emu/g, Mr is 3, 1 emu/g and Hc of 106 Oe, Iron sand synthesized with 9M NaOH has Ms of 12.5 emu/g, Mr of 4.2 emu/g and Hc of 98 Oe	The 3M NaOH concentration has a grain size of 25 nm, the 6M NaOH concentration has a grain size of 26 nm, the 9M NaOH concentration has a grain size of 20nm
(R. Rahmawati et al., 2017)	Copreci pitation Method	Magnetization is obtained Saturation (Ms) = 25 emu/gram, Magnetization Ramanen =	particle morphology what is formed is spherical in its presence single particle

		6.0562 emu/gram and Field Coercivity (Hc) = 0.0108	and combined particles with a particle size of 21-25 nm.

Reporting and use of results

This step is the final step in the Systematic Literature Review. The results of the analysis are interpreted to draw conclusions regarding the most effective synthesis method. Based on these findings, recommendations were developed for further research and practical application of the iron sand synthesis results. Finally, the research results are prepared in the form of a report that includes an introduction, methodology, results and discussion, as well as conclusions and recommendations, with the hope of being published in a scientific journal or conference proceedings to share the findings with the academic and industrial communities.

RESULTS AND DISCUSSION

Results from the relationship between synthesis methods and magnetic properties

Based on a review of 14 articles, it was found that research on the magnetic properties of iron sand when viewed from the synthesis methods used by researchers has varied, including solid state reaction, coprecipitation and mechanical milling methods. After conducting a search using Publish or Pherish regarding the topic "morphological characterization and magnetic properties of synthesized iron sand", with the keywords "iron sand, morphology, iron sand, magnetic properties, iron sand synthesis". From the various studies analyzed, it was found that the highest magnetic properties were achieved by several studies with significant values for each of the main parameters. Research conducted by (Basith & Taufiq, 2012) showed the highest magnetic saturation (Ms) value of 65 emu/g in samples produced via the coprecipitation method with a sintering temperature of 400°C. Meanwhile, research by (Melinia et al., 2022) reported the highest remanence (Mr) value of 8.72 emu/g for Musi River iron sand synthesized using the solid state reaction method. The highest coercivity (Hc) value was achieved in research by (Puspitarum et al., 2019) with a value of 851.68 Oe, using the coprecipitation method for iron sand from the Central Lampung region. These findings demonstrate significant variations in magnetic properties depending on the synthesis method and experimental conditions used, and highlight the potential of each method in producing materials with optimal magnetic properties.

Results from the relationship between synthesis methods and morphological measurements

Based on analysis of various studies, it was found that the smallest morphological sizes were obtained in several studies using the coprecipitation method. Research by (R. Rahmawati et al., 2017) succeeded in achieving the smallest particle size, namely in the range of 21-25 nm, using the coprecipitation-ultrasonic irradiation method. Apart from that, research by (Kiswanto et al., 2021) also reported a very small particle size, namely 20 nm for iron sand synthesized with a NaOH concentration of 9M. This very small particle size indicates that the coprecipitation method, especially when combined with additional techniques such as ultrasonic irradiation, is very effective in producing very small size nanoparticles. These nanometer-sized particles have wide application potential in various technological fields, including in the manufacture of magnetic materials with desired properties. These findings highlight the importance of synthesis methods and conditions in determining the final particle size and their potential application in advanced technologies.

CONCLUSION

The relationship between the synthesis method and the magnetic properties and morphological measurements shows that choosing the right synthesis method is very important to produce iron sand with the desired magnetic properties and morphology. The coprecipitation method, in particular, has proven effective in achieving these two goals, providing great opportunities for further applications in the field of magnetic materials. From these data it was found that the coprecipitation method with a temperature of 400 degrees Celsius is very effective in obtaining magnetic properties with relatively high magnetic saturation values. To get a high ramenance value, it is recommended to use the solid state reaction method and to get a high coercivity (Hc) value, it is recommended to use the coprecipitation method by heating at a temperature of 120 degrees Celsius. Meanwhile, to obtain the smallest grain size results, it is recommended to use the ultrasonic irradiation coprecipitation synthesis method and the coprecipitation synthesis method using NaOH with a concentration of 9M.

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