JOURNAL OF APPLIED GEOSPATIAL INFORMATION

Vol 8 No 1 2024

http://jurnal.polibatam.ac.id/index.php/JAGI
ISSN Online: 2579-3608

Characterization of Iron Sand and Nickel Oxide on Crystal Structure as Microwave Absorbing Material

Linda E. Diana[1], Martha Rianna[1*], Syahwin Syahwin[1], Yeni P. S. Naibaho[1]
[1] Postgraduate Physics Study Program, University of North Sumatra, Medan City, North Sumatra 20155
*Corresponding Author e-mail: marthariannal@gmail.com

Received: March, 01 2024
Accepted: June 17, 2024
Published: June 17, 2024

Abstract

We have carried out a thorough investigation to scrutinize the characteristics of iron sand and nickel oxidizer, focusing on their crystal structure as microwave-absorbing materials. The study investigates the impact of these materials on microwave absorption characteristics and the frequency range of the resulting waves. The solid-state reaction method is used in the research methodology. The research findings indicate that the combination of iron sand and nickel oxide leads to the formation of a homogeneous substance. The X-ray diffraction pattern data reveals the presence of two single-phase materials: iron sand, which consists of hematite, and nickel oxide. The iron sand and nickel oxide materials underwent characterization using EDS, revealing a composition that closely approximated stoichiometry. A Vector Network Analyzer (VNA) test shows that the iron sand and barium hexaferrite mix may be able to effectively absorb electromagnetic waves at a radar frequency of 12 GHz, leading to a -24 decibels (dB) drop.

Keywords: Nickel Oxide, Iron Sand, Microwaves

1. Introduction

Indonesia boasts an extensive array of natural resources, including mining components that are found in virtually every region of the country. Mining harnesses natural resources as primary inputs for industrial applications and plays a pivotal role in driving scientific and technological progress in the materials sector. Iron sand and nickel oxide are two examples of natural resources. Iron and nickel oxide sand, characterized by its lustrous black appearance, is commonly found along the beach. Bahfie et al., 2022 found a direct relationship between the darkness of black sand and its iron content.

With the abundance of iron and nickel sand resources in Indonesia, this will open up great opportunities for these two materials to be processed into modern raw materials. In this research, an effort was made to increase the content of iron and nickel sand to produce a microwave absorbing material through characterization of these two materials.

It is anticipated that the combination of these characteristics would result in a microwave-absorbing substance that is efficient, affordable, and eco-friendly. This study utilizes naturally occurring raw materials, specifically limestone and iron sand, to manipulate and enhance their magnetic and electrical characteristics. The research will utilize the material mass ratio as the sample variation to create a magnetic material that possesses efficient microwave absorption properties.

The research aims to analyze the properties of iron sand and nickel oxide as radar absorbing materials, investigate the impact of adding nickel to iron sand on its microwave absorption capabilities, and determine the frequency range of microwave absorbers generated by iron sand and nickel oxide. The frequency of the waves generated by these materials influences their optimal microwave absorption capabilities.

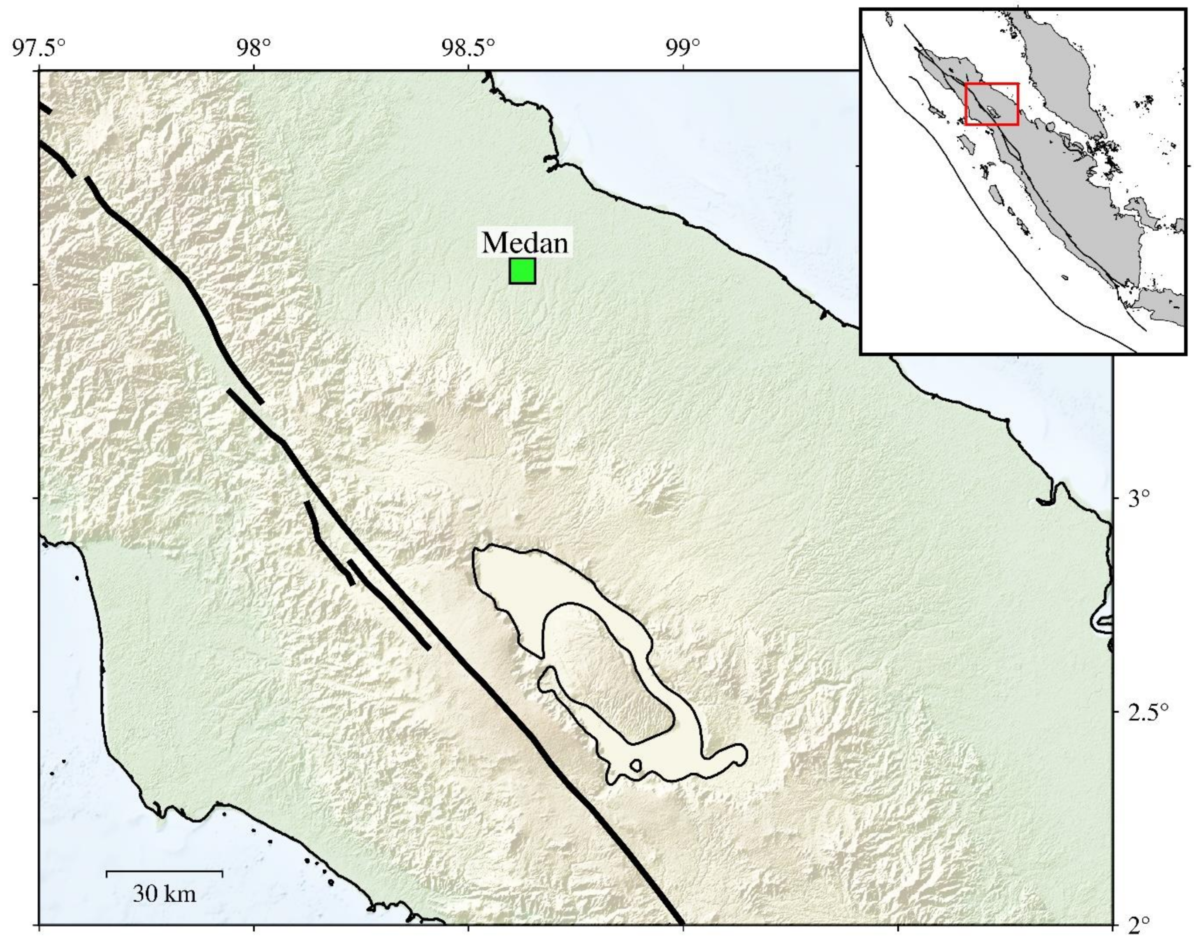

Figure 1. Map shows research location in Medan city, Sumatra Utara.

2. Literature Review

2.1 Crystal Structure Influence on Microwave Absorption

X-Ray Diffraction (XRD) is a technique that utilizes x-ray diffraction to analyze the crystal structure of a sample. X-ray diffraction (XRD) is a technique used to characterize materials, which relies on Bragg's law. When X-rays are directed towards the specimen, they will interact with the atoms present in the crystal structure of the specimen through collisions.

.

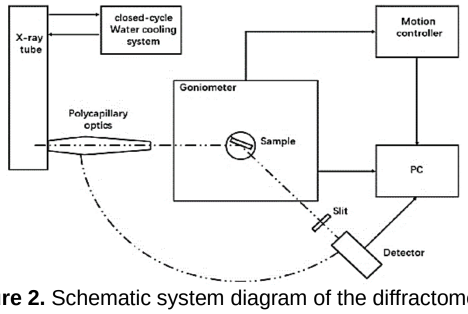

Figure 2. Schematic system diagram of the diffractometer.

Based on the image provided, it is evident that the incident ray strikes the sample at a specific place in the first plane that is scattered by the crystal. This scenario creates a reciprocal interference pattern that is strengthened when the angles satisfy Bragg's law.

2.2 Tool Characterization

This phenomenon can be observed in the graph depicting the correlation between the intensity of the distinct spectrum and the angle 2θ. The angle θ in a crystal can be measured by analyzing the crystal/atom system and examining the diffraction parameters or direction, which are influenced by the form and size of the unit cell. Figure 2 displays an example of X-Ray Diffraction test findings.

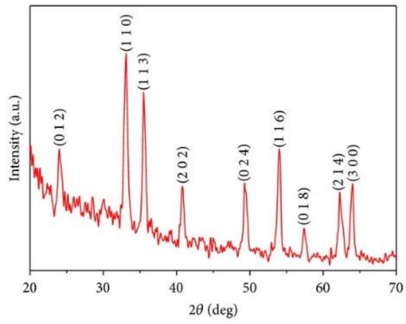

Figure 3. Example graph shows the relationship between intensity and degree for the XRD yield curve.

Peak The XRD curve shows high intensity. The intensity becomes high due to the constructive combination of X-ray reflections (*diffracted wavefront*) which are in the same phase. Different atoms in the crystal structure can cause phase differences in the reflected X rays.

3. Method

The research methodology employed is the Co-Precipitation technique. Combine iron sand and nickel oxide with distilled water using the correct mass ratio.

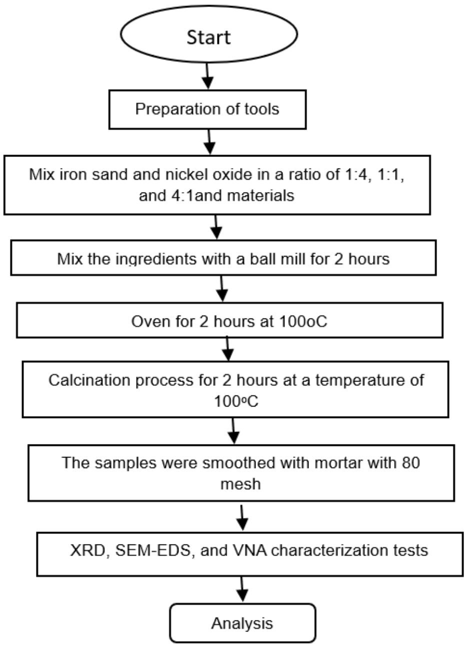

Figure 4. Research flow diagram and scheme in this research study.

The research was conducted at the Physics Laboratory of the University of North Sumatra (USU) between January 2024 and March 2024. The research utilized iron sand and nickel oxide procedures that were produced utilizing the Co-Precipitation process. The specified materials were dissolved in distilled water, followed by the addition of NaOH, and thereafter left undisturbed for a duration of 24 hours. The sediment was subsequently rinsed and dehydrated at a temperature of 1000C for a duration of 2 hours, followed by purification at the same temperature for an additional 2 hours. The samples were subsequently analyzed using X-Ray Diffraction (XRD), Scanning Electron Microscope-Energy Dispersive Spectroscopy (SEM-EDS), and Vector Network Analyzer (VNA). The objective of this research is to comprehensively comprehend the characteristics of this substance and explore its possible utilization in diverse domains.

4. Results and Discussion

The research commenced by quantifying the density of the sample utilizing a pycnometer. The initial procedure involves preparing three samples by measuring the masses of Fe2O3 and Ni in ratios of 1:4, 1:1, and 4:1. Subsequently, the sample underwent testing using a viscometer to determine the optimal composition, specifically Fe_2O_3 and Ni in a mass ratio of 4:1, with a density value of 4.95 gr/ml. Materials with greater density exhibit superior microwave absorption capabilities. The reason for this is that materials with greater density have a higher number of atoms inside a given volume, resulting in a greater capacity to absorb microwave radiation by these atoms. The Fe sample$_2O_3$ and Ni (4:1) proved to be the most effective sample utilized in this study.

3.1 Analysis samples

The Match!4 software does material phase matching. The iron sand and nickel oxide (4:1) samples exhibit a singular phase, as depicted in Figure 4. It is evident that the sample exhibits a solitary phase of barium hecaferrite.

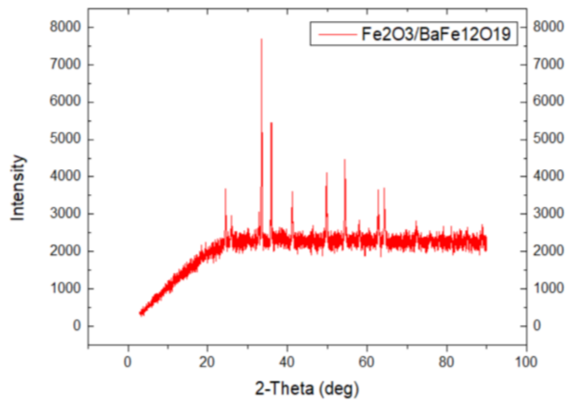

Figure 5. Example graph shows the results for the relationship analysis of Fe_2O_3 and Nickel Oxide samples using XRD

According to Figure 4, the peak shift is observed in the direction towards corner 2θ (O) and is reduced when coupled with iron sand. The variation in peak shift has an impact on the lattice parameters, as demonstrated in table 1. Combining these two materials leads to an increase in intensity, while simultaneously reducing the FWHM value. This demonstrates that the amalgamation of these substances exerts a significant impact on the proliferation of crystal grains derived from the fusion of Iron Sand and Nickel Oxide specimens. The trigonal crystal structure, specifically the features of the hexagonal axis, significantly impact the radar absorption properties of the material. Trigonal crystal formations typically exhibit magnetic anisotropy, where the magnet is more prone to rotating in one direction compared to the other. This anisotropy enhances the radar's ability to absorb electromagnetic waves at specific frequencies. This material possesses superior radar absorption characteristics due to its unique combination of materials, which also enables it to effectively support magnetic resonance modes.

Table 1. Crystal parameters Iron sand and Nickel Oxide for sample composition (4:1)

No.	2theta [°]	d [Å]	I/I0	FWHM	Matched
1	24.40	3.6451	214.25	0.2256	A
2	33.44	2.6775	1000.00	0.2176	A
3	35.88	2.5008	718.24	0.2427	A
4	41.14	2.1924	275.95	0.2476	
5	49.72	1.8323	356.95	0.2699	A
6	54.34	1.6869	496.67	0.2647	A
7	57.84	1.5929	126.49	0.3291	A
8	62.68	1.4810	263.00	0.2795	A
9	64.22	1.4492	290.07	0.2390	A
10	72.12	1.3086	92.69	0.6732	A

Through XRD tests, the crystal structure of the material has a big influence on microwave absorption.

4. Conclusion

This study demonstrates that the combination of iron sand and nickel oxide is synthesized via a solid-state reaction technique, resulting in the formation of a homogeneous material. The band x-ray diffraction pattern data indicates the presence of hematite and nickel. Observations conducted using a Vector Network Analyzer (VNA) indicate that Fe_2O_3 and NiO have the capability to effectively absorb microwaves, as seen by their high Fe and O curves.

5. Reference

Adi, S. P., Simanjuntak, A. V., Supendi, P., Wei, S., Muksin, U., Daryono, D., ... & Sinambela, M. (2024). Different Faulting of the 2023 (Mw 5.7 and 5.9) South-Central Java Earthquakes in the Backthrust Fault System. Geotechnical and Geological Engineering, 1-13.

Ansari, K., Walo, J., Simanjuntak, A. V., & Wezka, K. (2024). Crustal deformation from GNSS measurement and earthquake mechanism along Pieniny Klippen Belt, Southern Poland. Arabian Journal of Geosciences, 17(6), 180.

Ansari, K., Walo, J., Simanjuntak, A. V., & Wezka, K. (2024). Crustal deformation from GNSS measurement and earthquake mechanism along Pieniny Klippen Belt, Southern Poland. Arabian Journal of Geosciences, 17(6), 180.

Arifullah, A., Muksin, U., Simanjuntak, A., & Muzli, M. (2024, March). A preliminary result of automatic earthquakes localization from seismic temporary network in Northern Sumatra. In AIP Conference Proceedings (Vol. 3082, No. 1). AIP Publishing.

Asnawi, Y., Simanjuntak, A. V. H., Muksin, U., Okubo, M., Putri, S. I., Rizal, S., & Syukri, M. (2022). Soil classification in a seismically active environment based on join analysis of seismic parameters. Global Journal of Environmental Science and Management, 8(3), 297-314.

Asnawi, Y., Simanjuntak, A., Muksin, U., Rizal, S., Syukri, M. S. M., Maisura, M., & Rahmati, R. (2022). Analysis of Microtremor H/V Spectral Ratio and Public Perception for Disaster Mitigation. GEOMATE Journal, 23(97), 123-130.

Bahfie, F. (2022). Pengolahan Pasir Besi Untuk Meningkatkan Kadar Titanium (Ti) Dengan Metode Pemisahan Magnetik Secara Basah. *Inovasi Pembangunan: Jurnal Kelitbangan*, *10*(03), 237-237.

Bunaciu, A. A., UdriŞTioiu, E. G., & Aboul-Enein, H. Y. (2015). X-ray diffraction: instrumentation and applications. *Critical reviews in analytical chemistry*, *45*(4),

Danjumma, S. G., Abubakar, Y., & Suleiman, S. (2019). Nickel oxide (NiO) devices and applications: a review. *Int. J. Eng. Res. Technol*, *8*, 12-21.

Hududillah, T. H., Simanjuntak, A. V., & Husni, M. (2017, July). Identification of active fault using analysis of derivatives with vertical second based on gravity anomaly data (Case study: Seulimeum fault in Sumatera fault system). In *AIP Conference Proceedings* (Vol. 1857, No. 1). AIP Publishing.

Idha, R., Sari, E. P., Asnawi, Y., Simanjuntak, A. V., Humaidi, S., & Muksin, U. (2023). 1-Dimensional Model of Seismic Velocity after Tarutung Earthquake 1 October 2022 Mw 5.8. Journal of Applied Geospatial Information, 7(1), 825-831.

Idha, R., Sari, E. P., Humaidi, S., Simanjuntak, A. V., & Muksin, U. (2023, December). Response of Geologic Units to The Ground Parameters of Tarutung Earthquake 2022 Mw 5.8: A Preliminary Study. In IOP Conference Series: Earth and Environmental Science (Vol. 1288, No. 1, p. 012032). IOP Publishing.

Irwandi, I., Muksin, U., & Simanjuntak, A. V. (2021). Probabilistic seismic hazard map analysis for Aceh Tenggara district and microzonation for Kutacane city. In IOP Conference Series: Earth and Environmental Science (Vol. 630, No. 1, p. 012001). IOP Publishing.

Muksin, U., Arifullah, A., Simanjuntak, A. V., Asra, N., Muzli, M., Wei, S., ... & Okubo, M. (2023). Secondary fault system in Northern Sumatra, evidenced by recent seismicity and geomorphic structure. Journal of Asian Earth Sciences, 105557.

Muliawan, A. (2017). Studi Awal Bahan Dasar Piranti Solar Cell Pada Pasir Sambera Muara Badak Menggunakan XRF dan XRD. *Turbo: Jurnal Program Studi Teknik Mesin*, *6*(2).

Nurana, I., Simanjuntak, A. V. H., Umar, M., Kuncoro, D. C., Syamsidik, S., & Asnawi, Y. (2021). Spatial Temporal Condition of Recent Seismicity In The Northern Part of Sumatra. Elkawnie: Journal of Islamic Science and Technology, 7(1), 131-145.

Pasari, S., Simanjuntak, A. V., Mehta, A., Neha, & Sharma, Y. (2021). A synoptic view of the natural time distribution and contemporary earthquake hazards in Sumatra, Indonesia. Natural Hazards, 108, 309-321.

Pasari, S., Simanjuntak, A. V., Mehta, A., Neha, & Sharma, Y. (2021). The current state of earthquake potential on Java Island, Indonesia. Pure and Applied Geophysics, 178, 2789-2806.

Pasari, S., Simanjuntak, A. V., Neha, & Sharma, Y. (2021). Nowcasting earthquakes in Sulawesi island, Indonesia. Geoscience Letters, 8, 1-13.

Qadariah, Q., Simanjuntak, A. V., & Umar, M. (2018). Analysis of Focal Mechanisms Using Waveform Inversion; Case Study of Pidie Jaya Earthquake December 7, 2016. Journal of Aceh Physics Society, 7(3), 127-132.

Sari, E. P., Idha, R., Asnawi, Y., Simanjuntak, A., Humaidi, S., & Muksin, U. (2023). Faulting Mechanism of Tarutung Earthquake 2022 Mw 5.8 Using Moment Tensor Inversion. Journal of Applied Geospatial Information, 7(1), 840-846.

Sari, E. P., Idha, R., Nugroho, H., Humaidi, S., Simanjuntak, A. V., & Muksin, U. (2023). Model Mekanisme Patahan Gempa Bumi Tarutung 2022 Mw 5.8. Kesatria: Jurnal Penerapan Sistem Informasi (Komputer dan Manajemen), 4(2), 478-486.

Sihotang, B., Humaidi, S., & Simanjuntak, A. V. (2024). An updated 1-dimensional seismic velocity model has been developed for the Mw 6.1 Pasaman earthquake that occurred on February 25, 2022. Journal of Applied Geospatial Information, 8(1), 12-18.

Simanjuntak, A. V., & Ansari, K. (2022). Seismicity clustering of sequence phenomena in the active tectonic system of backthrust Lombok preceding the sequence 2018 earthquakes. Arabian Journal of Geosciences, 15(23), 1730.

Simanjuntak, A. V., & Ansari, K. (2024). Multivariate Hypocenter Clustering and Source Mechanism of 2017 Mw 6.2 and 2019 Mw 6.5 in the South Seram Subduction System. Geotechnical and Geological Engineering, 1-14.

Simanjuntak, A. V., & Olymphia, O. (2017). Perbandingan Energi Gempa Bumi Utama dan Susulan (Studi Kasus: Gempa Subduksi Pulau Sumatera dan Jawa). Jurnal Fisika Flux: Jurnal Ilmiah Fisika FMIPA Universitas Lambung Mangkurat, 14(1), 19-26.

Simanjuntak, A. V., Kuncoro, D. C., Irwandi, I., & Muksin, U. (2022). Understanding swarm earthquakes in Southeast Aceh, Sumatra. In E3S Web of Conferences (Vol. 339, p. 02011). EDP Sciences.

Simanjuntak, A., Muksin, U., Asnawi, Y., Rizal, S., & Wei, S. (2022). Recent Seismicity and Slab Gap Beneath Toba Caldera (Sumatra) Revealed Using Hypocenter Relocation Methodology. Geomate Journal, 23(99), 82-89.

Supendi, P., Rawlinson, N., Prayitno, B. S., Sianipar, D., Simanjuntak, A., Widiyantoro, S., ... & Sudrajat, A. (2023). A previously unidentified fault revealed by the February 25, 2022 (Mw 6.1) Pasaman earthquake, West Sumatra, Indonesia. Physics of the Earth and Planetary Interiors, 334, 106973.

Widianto, E., Kardiman, K., & Fauji, N. (2018). Karakterisasi pasir besi alam Pantai Samudera Baru dan pemanfaatannya sebagai filler pada sistem penyaring elektromagnetik. *JRST (Jurnal Riset Sains dan Teknologi)*, *2*(1), 15-20.