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# Microwave Absorption Analysis of Barium Hexaferite And Iron Sand

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## Abstract

The goal of this study is to investigate the properties of barium hexaferrite and iron sand as microwave absorbers. The focus is on understanding how these materials affect microwave absorption and the specific frequency range of waves they produce. The solid reaction method was used in the study. The study's findings indicate that the combination of iron sand with barium hexaferrite material leads to the formation of a homogeneous material with a single phase. X-ray diffraction pattern data confirms the presence of a single-phase material, specifically iron sand and barium hexaferrite, which consists of hematite and barium hexaferrite. The VNA observations reveal that the iron sand and barium hexapherite materials can absorb electromagnetic waves at a radar wave frequency of 11.1 GHz, resulting in a loss of -23.86 dB. Furthermore, the material demonstrates its ability to absorb microwaves. The absorption of microwaves relies on the quantity of particles in the absorbent substance and its microwave-absorbing capacity. To thoroughly assess the absorption properties of various samples, it is essential to not only evaluate their reflection loss but also analyze how well they operate as microwave absorbers.

**Keywords:** Barium Hexaferite, Iron Sand, Microwaves

## 1. Introduction

The emergence of electromagnetic wave technology, namely in the telecommunications sector, has raised worries about the possibility of electromagnetic wave interference in wireless electronic devices. Research has shown that emitting sounds at high frequencies might cause harm to security systems and essential technological gadgets. Furthermore, exposure to the microwaves emitted by mobile phone signals correlates with an increased risk of cancer in body cells. In order to lessen the impact of this radiation, researchers have identified microwave-absorbing polymers as a practical alternative. Indonesia's long coastline and abundance of iron sands make it an attractive marine destination.

Commonly found in iron sand, magnetite serves as a material that absorbs radar waves. A 2013 study demonstrated the production and transformation of magnetite nanoparticles from iron sand in East Java into a magnetic material known as barium hexaferrite. This material has an exceptional ability to absorb microwaves. We need to conduct further research to investigate the properties of barium hexaferrite and iron sand as microwave-absorbing materials.

We anticipate that these characteristics will combine to create efficient, affordable, and eco-friendly microwave-absorbing materials. This study utilizes natural raw materials, specifically limestone and iron sand, to manipulate and enhance their magnetic and electrical characteristics. The research will use the material mass ratio as a sample variation to create magnetic materials with efficient microwave absorption properties.

This study aims to examine the qualities of barium hexaferrite and iron sand as materials that may absorb microwaves. The goal is to assess how these materials affect their ability to absorb microwaves and determine the specific range of wave frequencies that they can create. The research aims to comprehend the impact of these materials on microwave absorption, analyze the spectrum of wave frequencies generated by these materials, and ascertain the most favourable microwave absorption features. The research location in Medan city, Sumatra Utara can be seen on Figure 1.

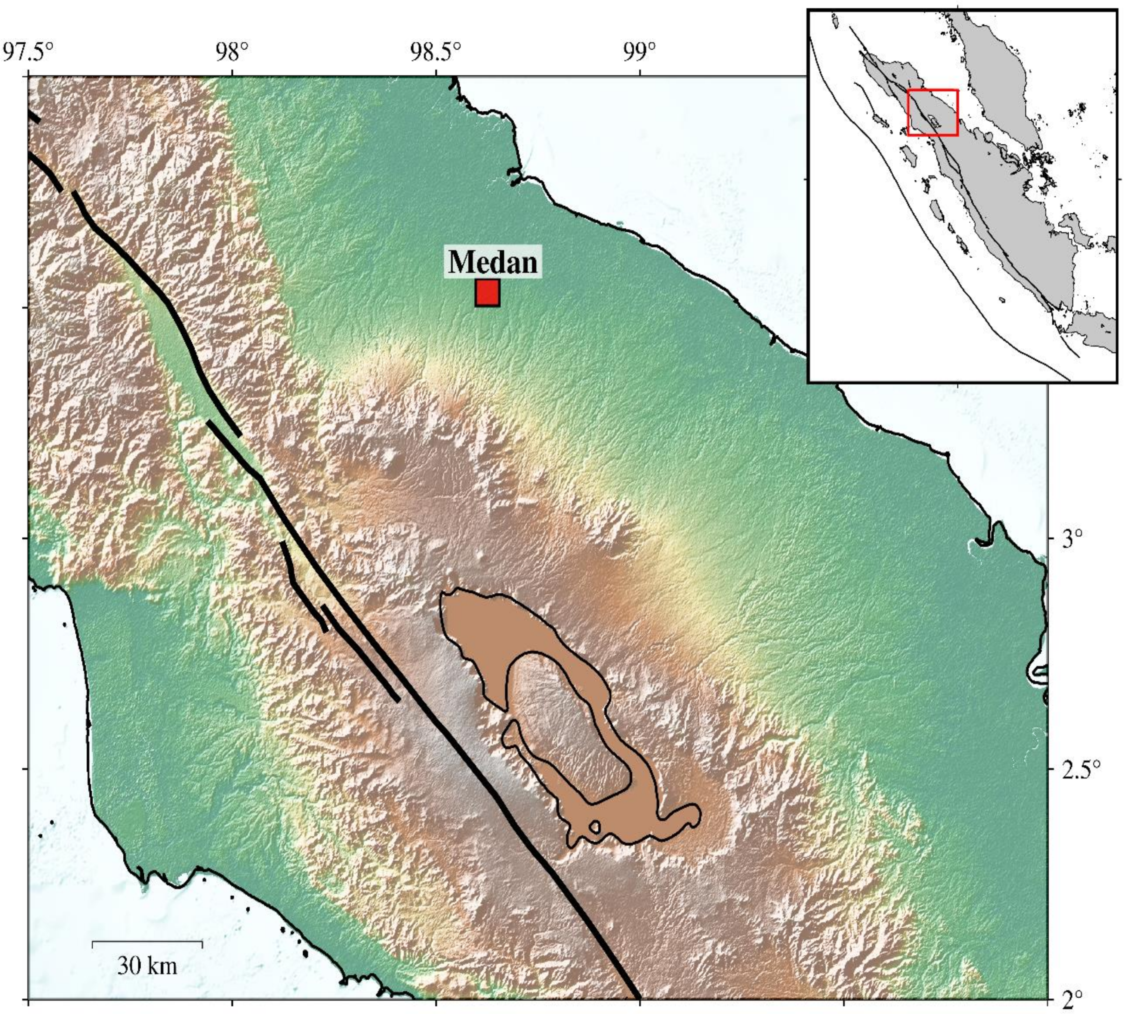

**Figure 1.** Map shows research location in Medan city, Sumatra Utara.

## 2. Literature Review

### 2.1 Microwave absorption

Vector Network Analyzer (VNA) equipment analyzes the absorption characteristics of electromagnetic waves. The VNA specifically analyzes the reflection and transmission of electromagnetic waves at a specific frequency. Port 1 receives both the incident wave (Si) and the reflected wave (Sr), whereas the port 2 receives only the transmitted wave (St). Figure 1 depicts the transmission pattern of electromagnetic waves associated with the airline wave concept.

A Vector Network Analyzer model ADVANTEST R3770 measured the samples' reflection loss (RL) over a frequency range of 300 kHz to 20 GHz. Studies were performedWe conducted studies to measure the transmission and reflection of microwaves within a frequency range of 5 to 18 GHz. prototype bulk sample with a diameter of 15 mm and a thickness of 2 mm (Marker, 2010).

**Figure 2**. Schematic of the process of an Electromagnetic Wave Propagation in the *Air Line Wave Guide* between two ports. The process shows the different propagation wave such as incident wave, reflected wave and transmitted wave (Marker B 2010).

### 2.2 Characterisation of the Tool

A highly popular piece of equipment for evaluating materials' responses to electromagnetic radiation is the Vector Network Analyzer (VNA). Engineers specifically engineered the device to measure variations in the energy of either transmitted or reflected electromagnetic waves. An advantage of this tool is its ability to provide precise results and handle data efficiently. This equipment has the advantage of simplifying the testing of materials or samples based on their ability to absorb electromagnetic wave energy. Figure 2 displays the findings of the VNA characterization test.

According to Varshney, 2002, there is a direct relationship between the reflection loss value and the specimen's ability to absorb electromagnetic waves.

The higher the reflection loss value, the better the specimen's ability to absorb these waves.

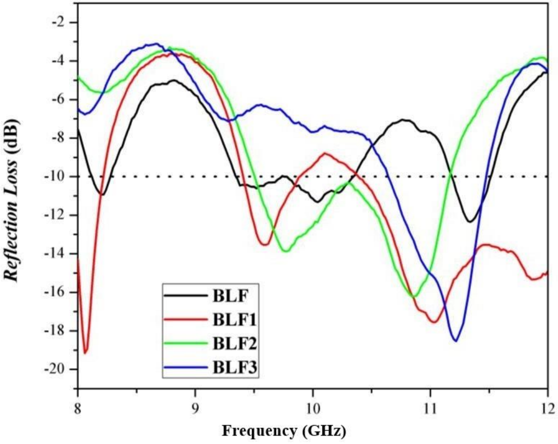

**Figure 2**. Example of VNA test result curve (Ramadhan, et al., 2018)

## 3. Method

We employ the solids reaction method as our research methodology. The synthesis process begins with the gathering of ingredients, followed by the amalgamation of iron sand and nickel oxide. An 80-mesh sieve subsequently filters the resultant mixture. Next, we prepared the samples with a mass ratio of 1:4, 1:1, and 4:1. We acquired the ideal sample with a ratio of 4:1, resulting in the creation of a uniform mixture. We completed the homogenization procedure in two hours using a ball mill, resulting in a slim, mud-like specimen.

Subsequently, the sample was permitted to evaporate for a period of three days, after which it was dried in an oven maintained at a temperature of 1000°C for a duration of two hours. The calcination process is then carried out, resulting in the release of the gas in the form of carbonate/hydroxide. This results in a high purity oxide powder. The objective of the calcination process is to remove any impurities or foreign matter.

Afterwards, we crushed the samples using a mortar until they reached a particle size of 80 mesh, ensuring they were sufficiently powdered. Following the calcination procedure, we transferred the samples to sample bottles for further material characterization testing. This included using a vector network analyzer (VNA) to measure the absorption area of the synthesized sample towards microwaves in the X-band frequency range.

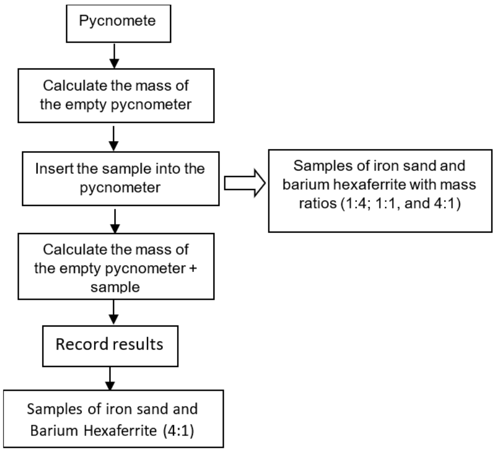

**Figure 3.** Flowchart of density analysis research.

## 4. Results and Discussion

The research commences with the measurement of the density of the sample utilising a pyscometer. A total of three samples were provided, with the mass ratio of $Fe_2O_3$ and $BaFe_{12}O_{19}$ samples being 1:4, 1:1, and 4:1. Subsequently, the sample was subjected to analysis using a pixometer, resulting in the identification of the optimal sample of $Fe_2O_3$ and $BaFe_{12}O19$, with a mass ratio of 4:1, exhibiting a density value of 4.95 g/ml. In accordance with the results of previous research (Martha R., 2020), materials with higher densities tend to be more effective at absorbing microwaves.

This is due to the fact that materials with a higher density contain a greater number of atoms per unit volume, thus allowing for a greater absorption of microwave energy by these atoms. Consequently, the Fe2O3 and BaFe12O19 (4:1) sample represents the optimal sample employed in the present study.

### 3.1 VNA sample analysis

The diffraction pattern reveals phase variations in iron sand and barium hexaferrite materials. Phase identification is necessary to determine the specific phase present in the substance. The origin software includes the Crystallography Database (COD) for this procedure, as illustrated in Figure 5. Additionally, for moAdditionally, Table 4.1 provides more comprehWe measured the RL values using the TRL (Transmission/Reflection Line) method, specifically in the X band, within the frequency range of 8 GHz to 12 GHz.

We analyze the reflection loss (RL) value, which indicates the extent to which the material absorbs microwaves, using the Vector Network Analyzer (VNA). We measured the RL values using the TRL (Transmission/Reflection Line) method within the 8 GHz to 12 GHz (X band) frequency range.

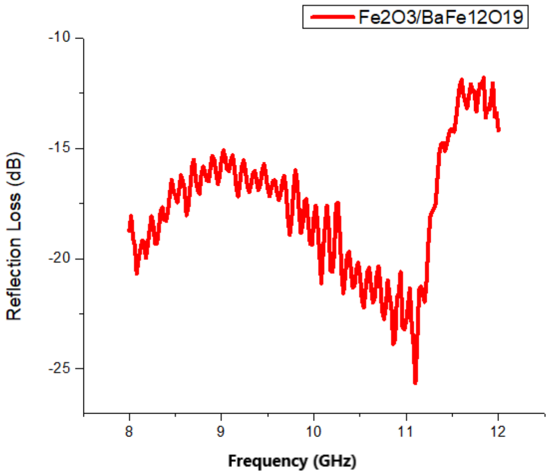

**Figure 4**. VNA sample analysis of Fe2O3 and BaFe12O19.

Figure 4 depicts the observed sample signal in the frequency range of 8 GHz to 12 GHz, encompassing the region associated with microwave absorption. Wahyuni Lestari and Mashuri (2015) conducted a study which found that barium hexaferrite and iron sand samples exhibit the highest amount of reflection loss at a frequency of 7.11 GHz, with a reflection loss of -8.37 dB. On the other hand, this study shows that barium hexaferrite and iron sand samples exhibit the highest reflection loss at a frequency of 11.1 GHz, resulting in a reflection loss of -25.64 dB and an absorption rate of 94%. As the crystal and grain sizes decrease, a rapid and broad reduction in size enhances the absorption of microwaves. This is because when magnetic particles take the form of spheres, their small size and geometric shape create large surface areas. This leads to increased contact interactions, which in turn allow for better absorption of microwave energy by the magnetic dipole moments (Mashuri, 2012).

The surface area of these particles plays a vital role in the absorption of microwaves, as it represents the most volatile atomic region. This means that energy absorption will happen at a certain frequency when microwave energy of a size equal to the necessary potential energy of the magnetic dipole moments is present. Moreover, there is a significant quantity of atoms that do not successfully form bonds on the surface, resulting in their instability. These actions encourage the creation of free electrons that can move around, which allows the spin directions to change and for spin connections to form between them. Consequently, this leads to the assimilation of microwave energy, facilitating shifts to more elevated energy states.

A comparison of the absorption of magnetite material with that of ecosorb material, as studied by Mashudi in 2012 for reflection loss values in different microwave frequency band ranges, namely X-band, reveals that the hematite sample derived from iron sand exhibits greater microwave absorption properties than those observed in this study. This suggests that magnetite material may be suitable for use as a wave absorbing material (absorber).

Percent Reflection Loss (RL) is a crucial parameter in the analysis of a Vector Network Analyser (VNA), indicating the extent to which a component or system reflects the signal power. A high RL value indicates that the component or system has the capacity to absorb and dampen the signal effectively, thereby enhancing efficiency and reducing interference. (Vishnu A. 2016). The percentage of microwave absorption is derived from the literature in Appendix 5 (Anggun, 2016).

Furthermore, the material demonstrates its ability to absorb microwaves. The absorption of microwaves is contingent upon the quantity of particles in the absorbent substance and its capacity to absorb microwaves. To thoroughly assess the absorption properties of various samples, it is essential to not only evaluate their reflection loss but also analyze how well they operate as microwave absorbers. According to Phang et al., 2008, a higher negative reflection loss value indicates a stronger ability of the material to absorb microwaves.

## 4. Conclusion

Based on the VNA measurements, $Fe_2O_3$ and BaFe12O19 can absorb electromagnetic waves with a radar frequency of 11.1 GHz, leading to a reflection loss of -25.64 dB. The reflection loss value has the ability to absorb microwaves at X-band frequencies.

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