DEVELOPMENT OF PIGMENT FOR PAINT USING NICKEL FERRITE FOR EMI APPLICATION

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ABSTRACT

Electromagnetic interference pollution can be considered one of the big issues because it may interrupt, shield or otherwise degrade the effective performance of the circuit. These effects can range from a simple degradation of data to a total loss of data. Due to this matter, nickel ferrite ($Ni_xfe_2O_4$) utilized as a pigment in paint technology. Nickel ferrite ($Ni_xfe_2O_4$) is prepared by using sol-gel method which is combination of iron III nitrate and nickel nitrate. The characteristic of Nickel ferrite ($Ni_xfe_2O_4$) pigment was analysed using scanning electron microscope and x-ray diffraction. The results shows that the best ratio of paint component for nickel ferrite paint is 27.03% for pigment, 40.54% for binder, 27.03% for solvent and 5.40% for additives. Apart from that, Nickel ferrite ($Ni_xfe_2O_4$) as a pigment was mixed with paint component such as binder, solvent and additive to produced a paint. Furthermore, the properties of paint was undergone five tests namely gloss meter, tape adhesion test, viscometer, pH meter and pencil hardness test. Nickel ferrite ($Ni_xfe_2O_4$) also through electromagnetic interference (EMI) shielding analysis and the results shows it is good reflection and low transmission at 50 MHz frequency.

ABSTRAK

Pencemaran gangguan elektromagnet boleh dianggap salah satu isu yang besar kerana ia boleh mengganggu, menghalang atau sebaliknya menjejaskan prestasi litar. Kesan ini boleh mengakibatkan degradasi yang mudah data kepada kehilangan kesemua data. Disebabkan perkara ini, *nickel ferrite ($Ni_xfe_2O_4$)* digunakan sebagai pigmen dalam teknologi cat. *Nickel ferrite ($Ni_xfe_2O_4$)* disediakan dengan menggunakan kaedah sol-gel yang merupakan gabungan *iron III nitrate* dan *nickel nitrate.* Ciri-ciri *nickel ferrite ($Ni_xfe_2O_4$)* pigmen telah dianalisis dengan menggunakan *scanning electron microscope* dan *x-ray diffraction.* Keputusan menunjukkan bahawa nisbah yang terbaik daripada komponen cat untuk cat *nickel ferrite ($Ni_xfe_2O_4$)* adalah 27.03% untuk pigmen, 40.54% untuk pengikat, 27.03% untuk pelarut dan 5.40% untuk bahan tambahan. Cat telah menjalani lima ujian iaitu *gloss meter, tape adhesion test, viscometer, pH meter and pencil hardness test. Nickel ferrite ($Ni_xfe_2O_4$)* juga melalui *electromagnetic interference (EMI) shielding* analisis dan keputusan menunjukkan ia mempunyai sifat pantulan gelombang elektromagnetik yang tinggi dan sifat penembusan gelombang elektromagnetik yang rendah iaitu pada frekuensi 50 MHz.

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LIST OF SYMBOLS AND ABBREVIATIONS

Ni	-	Nickel
$NiFe_2O_4$	-	Nickel ferrite
$Fe(NO_3)_3.9H_2O$	-	Iron III nitrate
$Ni(NO_3)_2.6H_2O$	-	Nickel nitrate
MHz	-	Mega Hertz
XRD	-	X-ray powder diffraction
SEM	-	Scanning electron microscope
FTIR	-	Fourier transform infrared spectroscopy
^oC	-	Degree Celsius
ASTM	-	American Society for Testing and Materials
H_2O	-	Water molecule
Wt %	-	Mass percentage
h	-	Hour
min	-	Minute
g	-	Gram

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Recently, the usage of electronic appliance has become more widespread as a lot of innovation was invented. The electronic appliance that commonly used in daily life, such as radio, microwave ovens, television, mobile phone and etc. Since the early usage of these electronic appliances, people has been known that the existence of the negative effect of the electromagnetic interference. Electromagnetic interference (EMI) shielding refers to the reflection and absorption of electromagnetic radiation by a material, which thereby acts as a shield against the penetration of the radiation through the shield. As electromagnetic radiation, particularly that at high frequencies tend to interfere with electronics. The distraction of electromagnetic interference can be occurred once two electronic appliances are used at a same time [1]. As examples, in the real life situation, a passenger is not allowed to activate their mobile phone in the airplane. It is because, the usage of mobile phone in flight will affect the navigation system in the cockpit. Another example, one person who is watching television will see the snow effect on the screen while another person in the same house is using another electronic appliance [1]. This distraction occurred when electromagnetic shielding is weak.

Bandwidth is the difference between the highest-frequency signal and low-frequency signal of a band of electromagnetic radiation. The frequency of a signal can be measured in hertz (Hz) [2]. The important characteristics of bandwidth are the

band with given width can bring the same value or the amount of information that regardless of where the band is located in the frequency spectrum. Figure 1.1 shows the electromagnetic radiation spectrum, which from the figure, television broadcast bandwidth frequency range is between 54 MHz to 700 MHz. While, for a personal communication service such as mobile phone, the bandwidth frequency range is between 900 MHz to 2400 MHz [3].

Ferrite is magnetic ceramic material which is formed by reacting iron oxide (Fe_2O_3) with any of a number of other oxides, including magnesium, aluminium, barium, manganese, copper, nickel, cobalt, or even iron itself. Ferrite is very useful for many electronics applications [6]. Magnetic ferrites are good material for absorbing [4]. Other than that, electromagnetic wave absorber also use in military application. The function of electromagnetic wave absorber is to reduce the radar signature [5]. From the recent research, ferrite also a good material to be used in order to reduce the electromagnetic interference problem [4].

Worldwide, paints or coatings in some form have been used to decorate and protect the surfaces of the material. Paint was manufactured using four basic components, which is a pigment, binder, solvents and additives [7]. All the components are selected for use to manufacture paint and it will affect the application characteristics of the paint. Usually, paint is in liquid form and also can be found in solid and gas form. Typical products to which paint are applied include houses, appliances, electrical insulation, automobiles, furniture and etc.

Pigment is one of the important components in paint. Pigment can be defined as the particulate solid that spread in paints to provide some characteristics of paint. The characteristic that provide by pigment are including colour, durability, mechanical strength, opacity and corrosion protection. There are two types of pigment, which is organic pigment and inorganic pigment. Organic pigment is for decorative purpose. Whereas, inorganic pigment is for protective purpose [8].

Due to the major concerns regarding electromagnetic pollution, nickel ferrite is one of the solution to reduce the electromagnetic interference shielding as a pigment in paint application. This material might be can apply as an exterior coating of mobile phone cover, television cover and other electronic appliance.

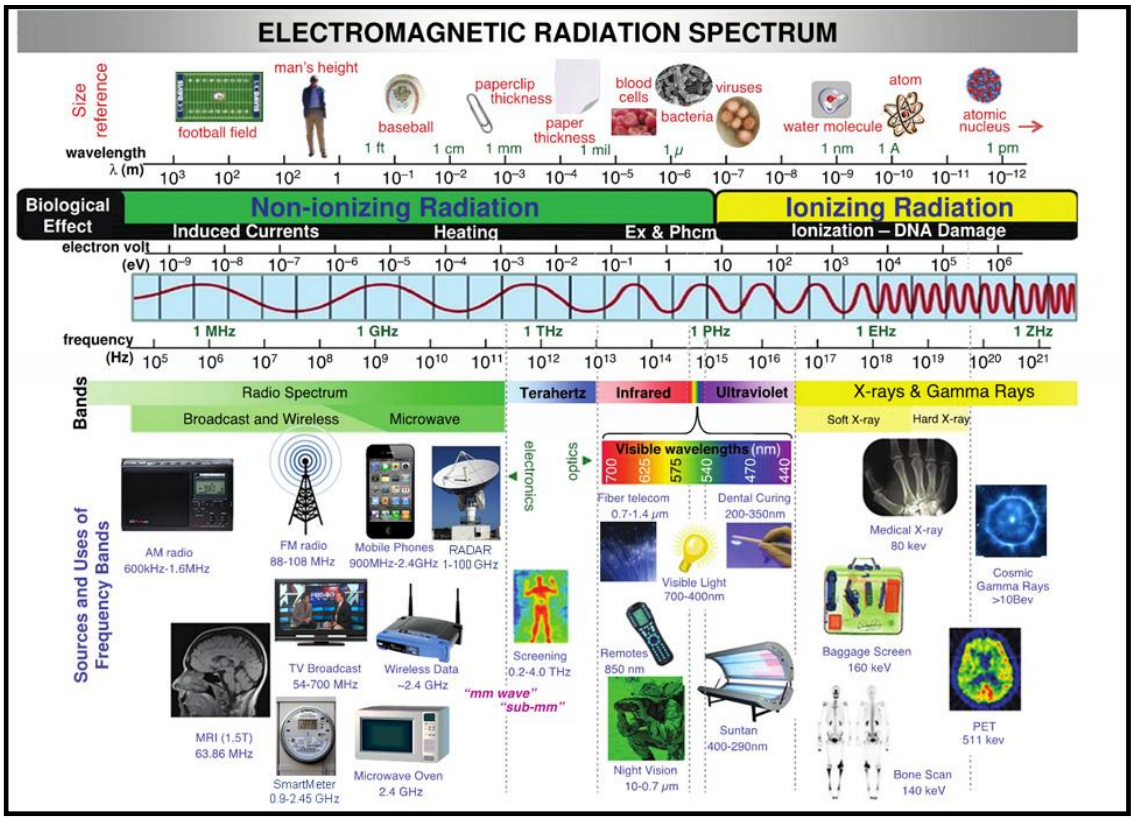

Figure 1.1: Electromagnetic radiation spectrum (Scientific American)

1.2 Problem statement

Obviously, current paint is only has a limited functionality such protect, colour, or provide texture to objects. Electromagnetic interference pollution is actually one of the major issue because it may interrupt, shield or otherwise degrade or limit the effective performance of the circuit. These effects can range from a simple degradation of data to a total loss of data.

Due to this matter, nickel ferrite utilized as a pigment in paint technology, especially for exterior electronic appliance coating. Therefore, the performance of the pigment of paint will be investigated.

1.3 Objective

The objective of this research is :

1. To determine the ratio of pigment using nickel ferrite in paint technology.
2. To prepare the mixture of pigment and paint component (binder, solvent and additives) as a paint application.
3. To investigate the effectiveness of nickel ferrite paint in reflection and transmission of electromagnetic interference (EMI) according to the bandwidth.

1.4 Scope

In achieving the objective, the scope of the study implemented as a guide to complement this project :

1. Determine the suitable composition ratio of nickel ferrite as a electromagnetic interference shielding in paint application.
2. Prepare and identify the making of paint by using standard operating procedure.
3. Focus to the performance of paint used nickel ferrite as a pigment in reflection and transmission of electromagnetic interference (EMI).

1.5 Significance of study

In general, the research hopes to contribute to the world and will reduce the electromagnetic interference problem in electronic appliance. It can also be a significant contribution in producing a better quality of paint in terms of the electromagnetic interference shielding. Through this study also, hopefully nickel ferrite is expected to compete others engineering selection and contribute to the industry nowadays in paint technology especially.

1.6 Limitation of study

1. This study is focusing on the composition ratio of nickel ferrite ($Ni_xFe_2O_4$) where x = 0.2, 0.4, 0.8 and 1.0.
2. The paint will be applied as an exterior cover for the electronic item.
3. The colour that will be produce is only dark colour.

1.7 Expected result

1. The optimum ratio of nickel ferrite able to use as a pigment in paint application.
2. The standard operating procedure of making paint by using nickel ferrite as a pigment can be discovered through experimentation.
3. The performance of paint when nickel ferrite as a pigment of paints can be determined.
4. The electromagnetic interference shielding properties of paints can be determined.

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CHAPTER 2

LITERATURE REVIEW

2.1 Paint Components

Paint is a complex liquid coating material made of several mixing different ingredients with its own properties. The main constituents of paint can be composed into four (4) broad categories which is binder, pigments, solvents and additives. All this paints components combines with consideration its stability, application, handling, cleanup and most importantly, the performance of the product [7]. The composition of paints and typical function of the components shown in table 2.1 [8].

Table 2.1: The composition of paints.

	Components	Typical function
Vehicle (Continuous phase)	Binder	The basis of continuous film or protecting the surface provide to which the paint is applied.
	Solvent	A small number of compositions are avoiding such as powder coatings and 100% polymerizable systems. The means by which the paint may be applied.
Pigment (Discontinuous phase)	Additives	Minor components, wide in variety and effect
	Primary pigment (fine particle organic or inorganic)	Provides opacity, colour and other optical effects

2.1.1 Pigment

Pigment described as a substance that can transmit light as a result to show different colour. The role of pigment in the paint coating provides certain characteristics, including colour, opacity, durability, mechanical strength and corrosion protection for metallic substrates [7]. There are two (2) types of pigment, known as inorganic pigment (longer-lasting and usually brighter) and organic pigment. Inorganic pigment is used for protective purpose, while organic pigment is the use of decorative. Some of them can be found naturally and the other is synthetic through the manufacturing process [7]. Most pigment in a crystalline form which is it will affect the characteristics of the pigment. It also affects the finished gloss, settling of the pigment during storage and wetting by the binders. Pigment must have characteristics that easily dispersed uniformly in binders to produce a consistent appearance. Furthermore, size and shape of the pigments are important properties of paint components. Size and shape affect the form of the molecular of paints or packing between the other components. The particle size, shape and distribution of a pigment affect the properties of paint include rheological properties, shades, gloss, weathering characteristics and ease of dispersion [7].

2.1.2 Binders

Binder also known as a resin is functioning as a vehicle in paint components[9]. Resin is the film-forming component that identifies the paints. Resin also is a main component gives the paint properties such as gloss, durability, flexibility and toughness. There are two types of paint binder where are convertible and non-convertible types. Convertible paints are materials that are uses in an unpolymerized or partially polymerized state and undergo reaction to form a solid film after application to the substrate. Convertible binders include oils, oleoresinous varnishes, alkyds, amino resins, epoxy resins, phenolic resin, polyurethane resins, and thermosetting acrylics. Non-convertible paints area based on polymerized binders dispersed or dissolved in a medium that evaporates after the coating has been applied to leave a coherent film on the substrate surface. Non-convertible binders include cellulose, nitrocellulose, chlorinated rubber, and vinyl resins [7].

2.1.3 Additives

Paint additives are chemicals added to paint to provide special effects or properties of paints. The additives used are in small quantities to prevent the other characteristics of paint changes. Additives can affect the paint material finished film properties. Other than that, additives will also influence the chemical and physical properties of the paint. The effects of additives are classified into 5 different types such thickening agents, surface active agents, surface modifiers, levelling agents, coalescing agents and catalytically active additives [7]. Furthermore, others function of additives improved the corrosion inhibitors, light stabilizers and flame retardants [7].

2.1.4 Solvents

A solvent is a medium where the binder, pigment and additives are dissolved in molecular form [10]. When the paint was applied, the solvent evaporates. It's allowing the binder and pigment to produce a film and to dry rapidly. Solvent are very important to produce durable, decorative and glossy paints [11]. Water is one of the types of the solvent. Water is inorganic or not containing carbon. Other than that, water has their advantage which is non-toxic, non-flammable, less expensive and availability. Another type of solvent is hydrocarbon solvent. Hydrocarbon solvents are common solvent used to carry pigment and binders. The examples of hydrocarbon solvents are toluene, mineral spirits and xylene. Oxygenated solvents also one type of solvent. Oxygenated solvent have a strong odour. The examples of oxygenated solvents are butyl alcohol, ethyl alcohol, ethyl glycol monoethyl ether, acetone, methyl ethyl ketone, methyl isobutyl ketone, butyl acetate and ethyl acetate [8].

2.2 Nickel ferrite

Nickel ferrite, $NiFe_2O_4$, a kind of soft magnetic semi conducting material, is an important member of the family of spinel ferrites. It also has a low coercivity means the material's magnetization can easily reverse direction without dissipating much energy, while the material's high resistivity prevents eddy currents in the core, another source of energy loss. The chemical compound formula for nickel ferrite is $NiFe_2O_4$. The chemical composition of nickel ferrite is nickel 25.0%, iron 47.7% and oxygen 19.7%. The density of nickel ferrite is 5.368 g/cm^3. While, the molar mass of nickel ferrite is 234.38 g/mol. Nickel ferrite was produced by combination of iron III nitrate ($Fe(NO_3)_3.9H_2O$) and nickel nitrate ($Ni(NO_3)_2.6\,H_2O$). Nickel ferrite is commonly used in electric and electronic device as well as in the catalysis [12 & 13]. Other than that, nickel ferrite also use as magnetic refrigeration.

2.3 Tests

2.3.1 X-Ray powder diffraction (XRD)

X-ray powder diffraction (XRD) is a non-destructive technique which is used for investigating the characteristics of crystalline materials, identification of fine-grained minerals such as clays and mixed layer clays that are difficult to determine optically, determination of the unit cell dimensions and measurement of sample purity[13]. With specialized techniques, XRD can be used to determine the thickness, roughness and density of the film using glancing incidence x-ray reflectivity measurements.Apart from that, XRD used to determine the lattice mismatch between the film and substrate and to inferring stress and strain[14]. Furthermore, XRD can determine the dislocation density and quality of film by using rocking curve measurements. Besides, the XRD pattern of nickel ferrite shown in figure 2.1 [16 & 17].

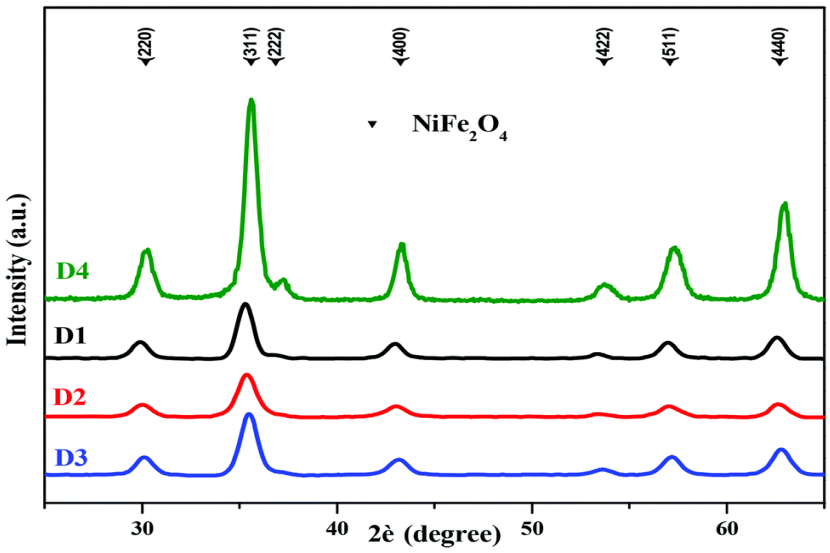


Figure 2.1: XRD pattern of nickel ferrite

2.3.2 Scanning electron microstructure (SEM)

The scanning electron microscope uses a focused beam of high-energy electrons to generate a variety of signals at the surface of the sample. The signals will who the morphology, chemical compositions and crystalline structure by deriving from electron-sample interactions. SEM is usually used to generate high-resolution images of the morphology of the sample and to show spatial variations in chemical compositions [18].

2.3.3 Electromagnetic interference (EMI) shielding effectiveness

Electromagnetic interference shielding effectiveness is important to ensure the quality for electromagnetic interference in coating industry. The ASTM standard for Electromagnetic interference shielding effectiveness testing is ASTM D4935-10 [19]. Electromagnetic interference shielding effectiveness tests are used to measure the shielding effectiveness of planar material under normal incidence, far field and plane wave conditions. One of the most fundamental concepts of high-frequency network analysis involves incident, reflected and transmitted waves travelling along transmission lines.

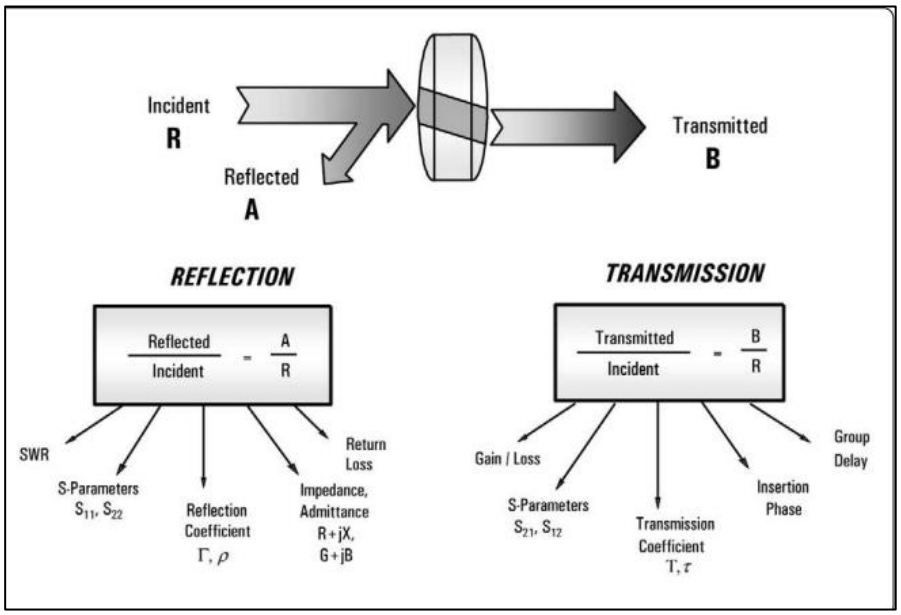


Figure 2.2 : Network analyzer terminology

Figure 2.2 shows the common network analyzer terminology which has the incident wave with the R (for reference) as a receiver. The reflected wave is measured by the A receiver and the transmitted wave is measured by the B receiver [20]. With an amplitude and phase information of these three waves, it can quantify the reflection and transmission characteristics of the device under test (DUT). Some of the common measured terms are scalar in nature (the phase part is ignored or not measured), while others are vector (both magnitude and phase are measured). Ratio reflection is often shown as A/R and ratio transmission is often shown as B/R, relating to the measurement receivers used in the network analyzer.[20]

Scattering parameters or S-parameters describe the electrical behaviour of linear electrical networks when undergoing various steady state stimuli by electrical signals. The parameters are useful for electrical engineering, electronics engineering, and communication systems design, and especially for microwave engineering. S11 and S21 are determined by measuring the magnitude and phase of the incident, reflected and transmitted voltage signals when the output is terminated in a perfect Zo (a load that equals the characteristic impedance of the test system). S11 is equivalent to the input complex reflection coefficient or the impedance of the DUT, and S21 is the forward complex transmission coefficient.

However, when describing the magnitude of the S-parameter, the unit "dB" is usually used with a common logarithm. Besides, the formula used to measure the percentage of reflection and transmission shown in equation (2.3) and equation (2.4) [21].

$$\text{Reflection}: S_{11} = 20\log\frac{Reflection\ ,R}{Incident\ ,I} \tag{2.3}$$

$$Transmission: S_{21} = 20\log\frac{Transmission\ ,T}{Incident\ ,I} \tag{2.4}$$

2.3.4 Pencil test

The pencil test is frequently used to measure the finish film hardness. The ASTM standard for this test is ASTM D3363. Hardness is very important properties to paint because it is related to the brittleness and water permeability. Pencil test is inexpensive and save time compared to other hardness test. So it is very popular used in the paint industry to determine the scratch or the gouge hardness of coatings. Figure 2.3 and Figure 2.4 shows the pencil hardness scale and the pencil grading chart [22-23].

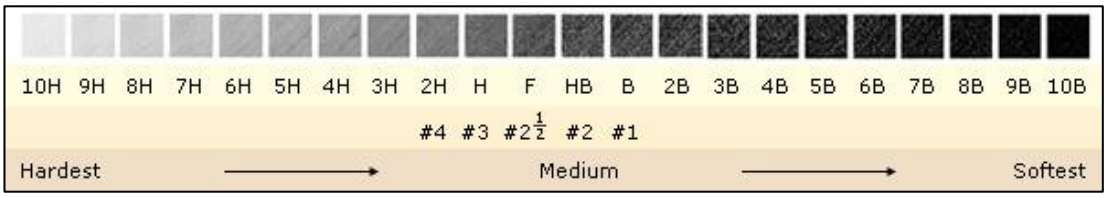


Figure 2.3: Pencil hardness scale

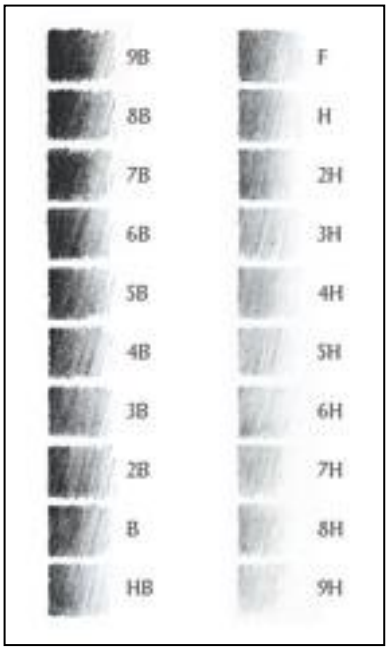
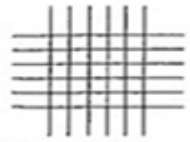
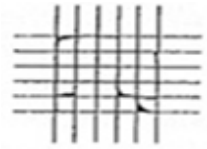
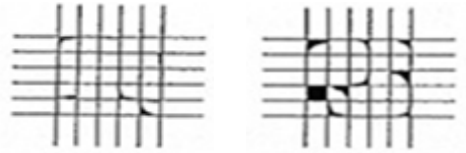
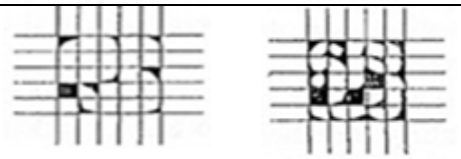
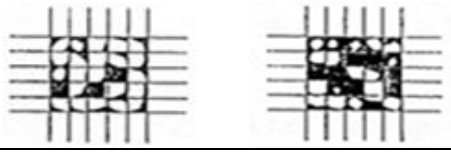
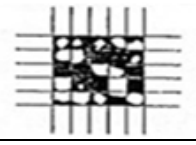


Figure 2.4: Pencil grading chart

2.3.5 Tape adhesion test

Adhesion of a paint film is often measured by the grid with a strip tape. The tape adhesion test result was determined by using a numerical rating system from zero (0) to five (5). Zero (0) is a total failure and five (5) is 100% adhesion with no loss. If a scribed grid has been used, the failure of adhesion may be expressed as the percentage of squares that have some loss of paint by using ASTM D3359 standard. Table 2.2 shows the classification of adhesive test result [24-25].

Table 2.2: The classification of adhesion test results

Classification	**Percentage of area removed (%)**	**The surface of cross-cut area from which flaking has occurred for 6 parallel cuts and adhesion range by percentage.**
5B	None (0%)	
4B	Less than 5%	
3B	5% - 15%	
2B	15% - 35%	
1B	35% - 65%	
0B	Greater than 65%	

2.3.6 Gloss Test

The amount of light reflected to the viewer's eye determines the gloss of a paint film. More reflection of light will appear as higher gloss. It is the smoothness of the surface that affects the reflection of light. The smoother the surface, the better the incident light can be reflected toward a viewer without scattering. Gloss properties of paint will test with a gloss meter with different angle of reflection 20, 60, and 85 degrees. Table 2.3 shows the Master Painters Institute (MPI) gloss standard ratings [28].

Table 2.3: Master Painters Institute (MPI) gloss standard ratings

Gloss Level	Description	Units @ 60 degrees
G1	Matte or Flat finish	0 to 5
G2	Velvet finish	0 to 10
G3	Eggshell finish	10 to 25
G4	Satin finish	20 to 35
G5	Semi-Gloss finish	35 to 70
G6	Gloss finish	70 to 85
G7	High-Gloss finish	> 85

2.3.7 Solid contain

Solid contain testing is to determine the solid contain in the paint. Besides, solid contain is also determining the quantity of evaporated paint during the drying process [29]. The solid contain and evaporator calculation is shown in equation (2.5) to (2.8).

Solid contain = Weight of specimen with dry paint (g) - Weight of specimen (g) (2.5)

Liquid contain = Weight of specimen with wet paint (g) - Weight of specimen (g) (2.6)

% Solid contain = (Solid contain / Liquid contain) X 100% (2.7)

Evaporated = Weight of specimen with wet paint (g) - Weight of specimen with dry paint (g) (2.8)

2.3.8 pH Value Test

pH meter is a device measure the acidity and alkalinity solution accurately. pH stands for “potential of hydrogen” Acidity is caused by hydrogen atoms that have lost their electrons and are roaming free in water [H+]. The opposite of acidic is alkaline (or basic). Alkaline gets its name from the "al kali" plant whose ashes are capable of neutralizing acids. pH value have range 1 pH values from 0 to 7 indicate a decreasing sequence of acidity,while pH values from 7 to 13 an increasing sequence of alkalinity. pH value test is important to determine the liquid properties of the paint and figure 2.5 shows the pH scale.

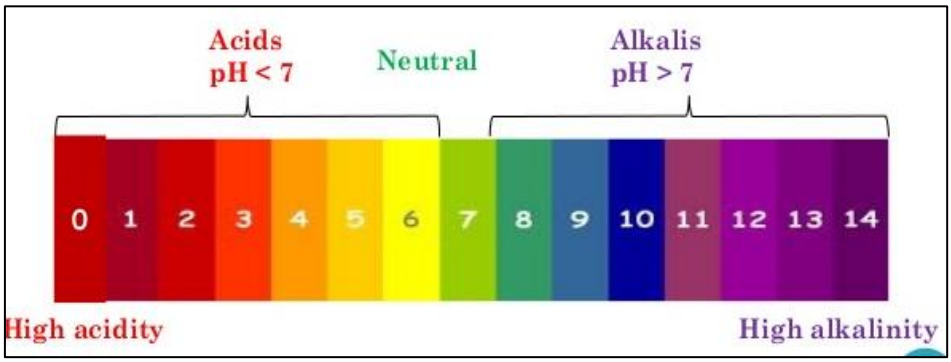


Figure 2.5: the pH scale

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains the method to develop the optimum ratio and prepare the nickel ferrite as a pigment in paint application and also the electromagnetic interference study application. This methodology include in four (4) phase, which is the first phase is preparing the pigment material that is nickel ferrite supported by crystallize phase analysis, thermal analysis and microstructure analysis. The second phase is paint component preparation such as binder, solvent, pigment and additives. Subsequently, mixing all paint component to produce paint by using magnetic stirrer. Finally, the last phase is the characteristics will be test is hardness, adhesion, gloss, outdoor exposure and electromagnetic interference shielding. The methodology flow chart shown in figure 3.1.

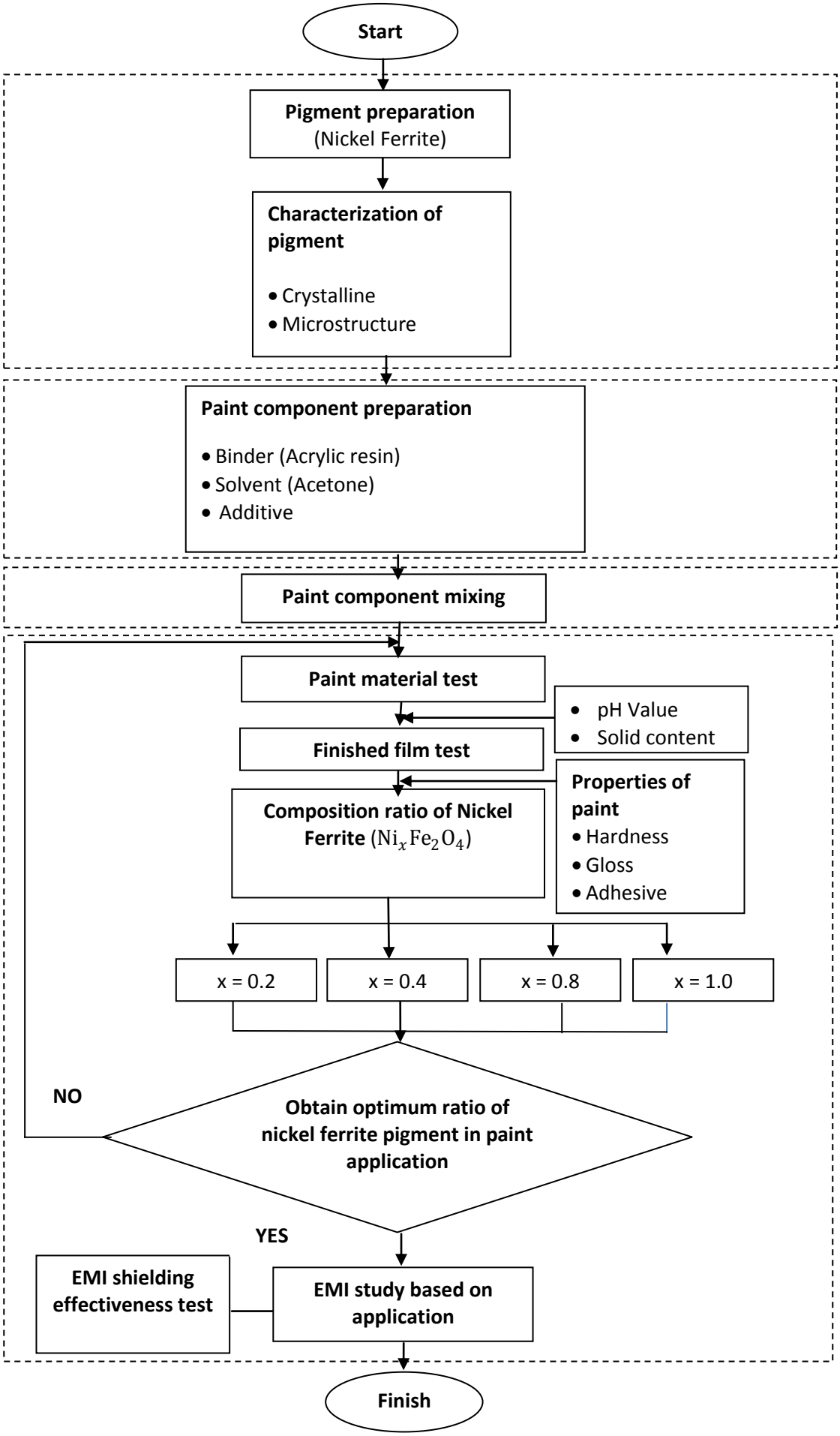


Figure 3.1 : Methodology Flow Chart

3.2 Preparations of material

3.2.1 Nickel ferrite

As a pigment preparation, Nickel ferrite ($Ni_XFe_2O_4$) where x = 0.2, 0.4, 0.8, 1.0 will be prepared using the sol-gel method. The sol-gel process is a method for producing solid materials from small molecules. Iron III nitrate will mix with nickel nitrate. Then, the mix of iron III nitrate and nickel nitrate will heating using high temperature furnace at 1200 °C constant 6 hours with increase rate 6 °C/min and follow by natural cooling. After that, the nickel ferrite sieved using 125 µm size. Iron III nitrate and nickel nitrate is shown in figure 3.2 and 3.3. Whereas, the preparation steps of nickel ferrite as shown in figure 3.4.

Figure 3.2: Iron III nitrate

Figure 3.3: Nickel nitrate

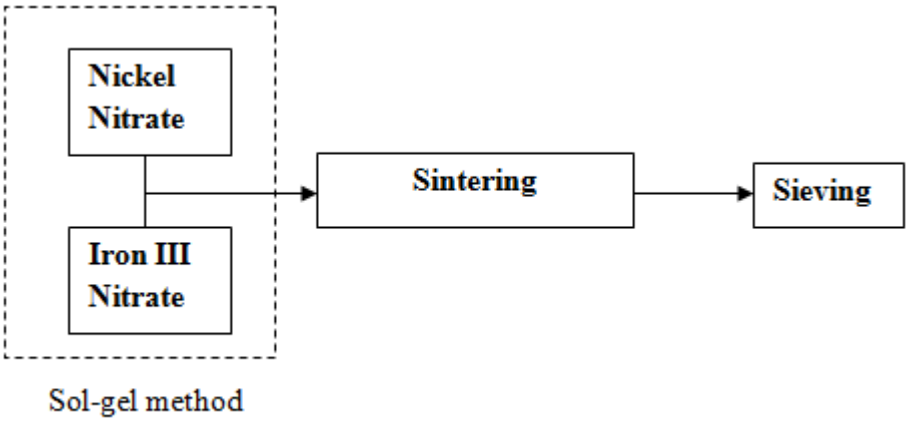


Figure 3.4: Preparation steps of nickel ferrite.

3.2.1.1 Nickel nitrate and iron III nitrate preparation

Nickel nitrate and iron III nitrate mix together with 5 ml of distilled water. Molar Weight of nickel nitrate ($Ni(NO_3)_2.6\,H_2O$) is 290.80 mol/g and molar weight of iron III nitrate ($Fe(NO_3)_3.9H_2O$) is 404.0 mol/g. Table 3.1 shows the weight of nickel nitrate and iron III nitrate. The example calculation to find the weight of iron III nitrate and nickel nitrate for nickel ferrite ($Ni_XFe_2O_4$) where x = 0.2 is as follows:

Nickel nitrate ($Ni(NO_3)_2.6\,H_2O$) weight (3.1)

$= \frac{0.2}{2+(x)}$ x 290.80 mol/g

$= \frac{0.2}{2+0.2}$ x 290.80 mol/g

= 26.44 g

Iron III Nitrate ($Fe(NO_3)_3.9H_2O$) weight (3.2)

$= \frac{2}{2+(x)}$ x 404.0 mol/g

$= \frac{2}{2+0.2}$ x 404.0 mol/g

= 367.27 g

Table 3.1: Weight of nickel nitrate and iron III nitrate

Materials	Weight (g)			
	X = 0.2	X = 0.4	X = 0.8	X = 1.0
Nickel nitrate	26.44	48.47	83.09	96.93
Iron III nitrate	367.27	336.67	288.57	269.33

3.2.1.2 Sintering

High temperature furnace, which at 1200 °C used for heating the mixture of iron III nitrate and nickel nitrate and it have been constant for 6 hours with increase rate 6 °C/min and follow by natural cooling. The temperature profile of preparation of nickel ferrite is shown in figure 3.5.

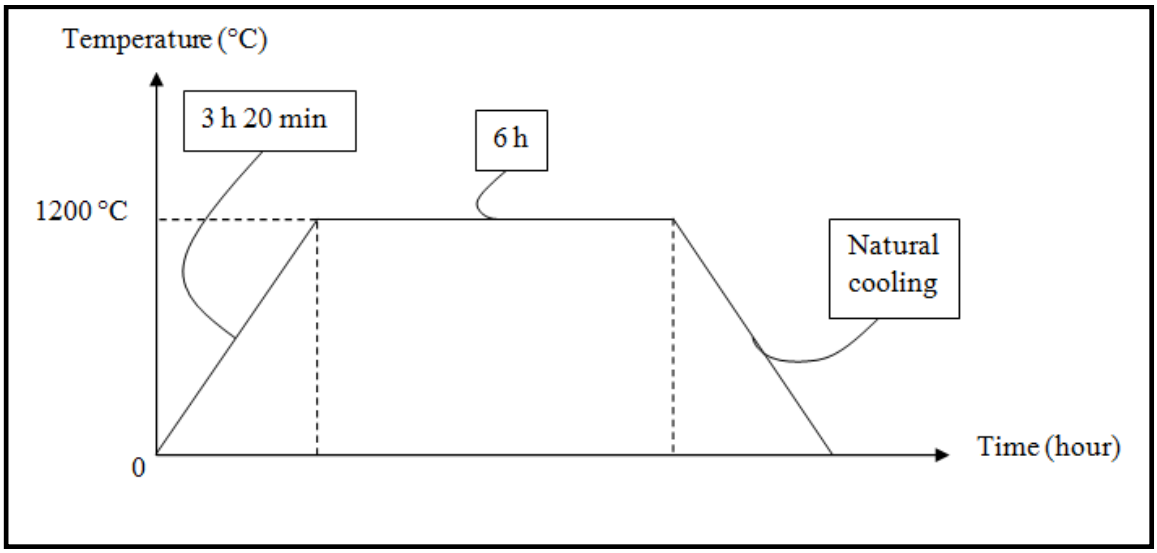


Figure 3.5: The temperature profile of nickel ferrite

3.2.1.3 Ball Milling and Sieving

The particle size of nickel ferrite will reduce through ball mill and sieving process after the heating process. Ball milling is a process where a particle size of solid material is reduced to the required size. It's also can produce fine, uniform dispersions of oxide particles. The sieving process continues by using sieve 125 µm. The function of sieving the nickel ferrite is to due to the ease the nickel ferrite pigment to dissolve in solvent and binder.

3.3 Paint component

Paint components are prepared with a few different ways, such as prepare at laboratory, supply from paint industry that is Ample Green Coating Enterprise Sdn. Bhd. and buy from the suppliers. The paint components prepared with four (4) major components of paint such as pigments, binder, solvent and additives.

3.3.1 Pigment

Nickel ferrite is a material used for the pigment. The preparation of nickel ferrite was discussed in the subtopic nickel ferrite. After nickel ferrite was prepared, the nickel ferrite will sieve using sieving size 125 µm. From the previous chapter, the function of pigment is to produce characteristics to the paint such as colour, opacity, durability, mechanical strength and corrosion protection for metallic substrates. Figure 3.6 shows the nickel ferrite before sieve and Figure 3.7 show the nickel ferrite after sieve.

Figure 3.6: Nickel ferrite pigment before sieve

Figure 3.7: Nickel ferrite pigment after sieve

3.3.2 Binders

The binder is bought from the supplier, Ample Green Coating Enterprise Sdn. Bhd. The specific name of the binder is polymethyl acrylate which is used by current market in the paint industry. Acrylic resin has the advantage as water resistance, better adhesion, and resistance to alkali. Figure 3.8 shows the acrylic resin binder.

Figure 3.8: Binder

3.3.3 Solvents

Acetone (thinner) is an organic compound with the formula $(CH_3)_2CO$ and it's used in this study. Acetone also has the properties non-toxic and known to be non harmful to human beings. The physical and chemical properties of acetone are miscible in all portions and colourless. Acetone need to be stored at the place where far from the fire because it is a flammable material. The ratio of acetone adds to the paint, will be discussed at mixing of paint components. Figure 3.9 shows the solvent.

Figure 3.9: Solvent

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