

**DEVELOPMENT OF HAIR TREATMENT CREAM BY USING  
KERATIN PROTEIN**

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**BACHELOR OF CHEMICAL ENGINEERING  
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**THE DEVELOPMENT OF HAIR TREATMENT CREAM BY USING KERATIN  
PROTEIN**

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Thesis submitted in partial fulfilment of the requirements  
for the award of the degree of  
Bachelor of Chemical Engineering

**Faculty of Chemical & Natural Resources Engineering  
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Dedicated to my family for always believed in me.

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## ABSTRACT

This work presents the development of hair treatment cream by using keratin protein. Keratin derived from chicken feather is used as an active ingredient in the hair treatment cream. The extracted keratin protein will act as replacement for the damaged or missing keratin inside the hair since it has a huge advantage in repairing damaged hair. It can also add smoothness to the hair and reducing the brittle cuticle cells. The objectives of this experiment are to formulate a hair treatment cream by using keratin protein and to analyze and characterize the properties of the hair treatment cream and the treated hair. Hair damage can happen when the protective cuticle cell of the hair is weakened and vulnerable therefore a hair treatment cream is needed to overcome this problem. Furthermore, the cuticle cells would not be able to protect its inner layer from the brittleness of hair and this will lead to a dry hair and splits end occurrence. Therefore, the treatment cream developed will improve the surface layer of the damaged hair. The formulation is made by mixing both oil and water phase at desire temperature and finally mix the solution until it homogenize. Both oil and water phase are prepared separately at the desired temperature and then after both solution are stable, they are mixed together to form the complete hair treatment cream. There were six analysis perform to test the cream stability and it capability to repair the damaged hair. All the results show a positive result in the stability of the cream and improving the damaged hair especially in repairing the hair surface. As the conclusion, the development of hair treatment cream by using keratin protein as an active ingredient managed to develop a good cream to treat the damaged hair by repairing the protein linkage especially on the hair surfaces.



## ABSTRAK

Projek ini diadakan untuk merumus krim rawatan rambut dengan menggunakan keratin protein. Keratin yang diperolehi daripada bulu ayam digunakan sebagai bahan aktif dalam krim rawatan rambut. Keratin protein yang diekstrak akan bertindak sebagai pengganti keratin yang rosak atau hilang di dalam rambut. Keratin protein mempunyai banyak kelebihan dalam membaiki rambut yang rosak. Ia juga boleh menambah kelancaran untuk rambut dan mengurangkan sel-sel kulit luar rapuh. Objektif eksperimen ini adalah untuk merumuskan krim rawatan rambut dengan menggunakan protein keratin dan untuk menganalisis dan mengklasifikasikan sifat-sifat krim rawatan rambut. Kerosakan rambut boleh berlaku apabila sel kulit luar yang menjadi pelindung rambut menjadi lemah dan mudah terjejas. Oleh itu, apabila sel-sel kulit luar pada rambut tidak akan dapat melindungi lapisan dalaman, hal ini akan menyebabkan kerapuhan rambut, rambut kering dan berpecah. Krim rawatan rambut ini akan berfungsi untuk meningkatkan lapisan permukaan rambut semasa menggunakan krim ini. Formulasi untuk krim rawatan rambut tersebut dibuat dengan mencampurkan bahan-bahan dalam fasa minyak dan fasa air pada suhu keinginan dan akhirnya campuran penyelesaian sehingga ia menyeragamkan. Campuran untuk fasa minyak dan fasa air disediakan secara berasingan pada suhu yang dikehendaki dan kemudian selepas kedua-dua fasa itu stabil, ia dicampur pada suhu yg dikehendaki untuk membentuk krim rawatan rambut yang lengkap. Terdapat enam analisis yang telah dilaksanakan untuk menguji kestabilan krim dan keberjayaan untuk membaiki rambut yang rosak. Semua keputusan menunjukkan keputusan yang positif dalam kestabilan krim dan membaiki rambut yang rosak. Oleh itu, pembangunan krim rawatan rambut dengan menggunakan protein keratin sebagai bahan aktif berjaya mewujudkan krim yang baik untuk merawat rambut yang rosak.

## TABLE OF CONTENTS

	<b>Page</b>
<b>SUPERVISOR’S DECLARATION</b>	<b>iiiv</b>
<b>STUDENT’S DECLARATION</b>	<b>v</b>
<b><i>DEDICATION</i></b>	<b>vi</b>
<b>ACKNOWLEDGEMENT</b>	<b>vii</b>
<b>ABSTRACT</b>	<b>viii</b>
<b>ABSTRAK</b>	<b>x</b>
<b>TABLE OF CONTENTS</b>	<b>ix</b>
<b>LIST OF TABLES</b>	<b>xi</b>
<b>LIST OF FIGURES</b>	<b>xi</b>
<b>LIST OF SYMBOLS</b>	<b>xiii</b>
<b>CHAPTER 1: INTRODUCTION</b>	<b>1</b>
1.1 Background of the Study	1
1.2 Motivation	1
1.3 Problem Statement	2
1.4 Objectives	3
1.5 Scopes of Study	4
<b>CHAPTER 2: LITERATURE REVIEW</b>	<b>5</b>
2.1 Overview	5
2.2 Hair	5
2.3 Chicken feather	7
2.4 Keratin Protein	8
2.5 Extraction of keratin protein	8
2.6 Hair damaged treatment cream	9
<b>CHAPTER 3: MATERIAL AND METHODS</b>	<b>14</b>
3.1 Overview	14
3.2 Research design	14
3.3 Overall workflow	15
3.4 Material	16
3.5 Research Methodology	17
3.6 Formulation of cream	18
3.7 Method validation	19

<b>CHAPTER 4 : RESULTS AND DISCUSSION</b>	<b>23</b>
4.1 Introduction	23
4.2 Results	23
4.3 Discussion	32
<b>CHAPTER 5 : CONCLUSION AND RECOMMENDATION</b>	<b>40</b>
5.1 Conclusion	40
5.2 Recommendation	41
<b>REFERENCES</b>	<b>42</b>

**LIST OF TABLES**

<b>Table No.</b>	<b>Title</b>	<b>Page</b>
<b>Table 3.1:</b>	Formulation of ingredients	16
<b>Table 3.2:</b>	Formulation of cream	18
<b>Table 4.1:</b>	Formulation of hair treatment cream	23
<b>Table 4.2:</b>	Phase condition of the cream	24
<b>Table 4.3:</b>	pH value for each formula	25
<b>Table 4.4:</b>	Centrifuge result for each formula	26
<b>Table 4.5:</b>	Colour evaluation on the cream	26
<b>Table 4.6:</b>	Viscosity analysis result for each formulation	27
<b>Table 4.7:</b>	Observation on the hair sample	30
<b>Table 4.8:</b>	Observation on human skin	31

**LIST OF FIGURES**

<b>Figure No.</b>	<b>Title</b>	<b>Page</b>
<b>Figure 2.1:</b>	The formation of chicken feather	7
<b>Figure 3.1:</b>	Methodology of cream preparation	17
<b>Figure 4.1:</b>	Graph of average pH value for each formula	25
<b>Figure 4.2:</b>	Graph of viscosity value for each cream	27
<b>Figure 4.3:</b>	Surface imaging of hair before treatment	28
<b>Figure 4.4:</b>	Surface imaging of hair after treatment by formula 1	28
<b>Figure 4.5:</b>	Surface imaging of hair after treatment by formula 2	28
<b>Figure 4.6:</b>	Surface imaging of hair after treatment by formula 3	28
<b>Figure 4.7:</b>	Surface imaging of hair after treatment by using local product	30

**LIST OF SYMBOLS**

%	Percentage
C	Celsius
Cps	Centipoises
Pas	Pascal second
Rpm	Revolution per Minute

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background of the Study

Chicken feather have high level of keratin content and can become one of the protein sources. With the availability of keratin in chicken feather that is almost 91%, the chicken feather can be used as a main component for the extraction of keratin protein in the development of hair treatment cream. Hair damage can cause a very unpleasant feeling to a person. The hair damage that mostly occurs in human hair is the brittle hair, dry hair and splits end problems. Therefore, a hair treatment cream can be developed in order to cure this problem on normal hair which is the hair that never involve with any straightening or curling process. Thus, the extracted keratin from chicken feather can act as a replacement to the loss of our natural keratin protein in hair.

Hair damaged can occur due to few reasons. For split ends problem, it usually occurs when large area of the cuticles has split way, showing the cortex underneath. Beside, perm and relaxer can cause severe damage to hair due to the chemical used in the products that can break the disulfide bond in the hair. Regarding to the chemical effects on hair, hair color also caused damaged hair.

Other than chemical effects, the sun that is essential for life also can caused damage to human hair. This is because the ultraviolet rays in sunlight break down the keratin protein in the hair and affecting the cuticle in the same way as bleach does. In addition, sun also extremely harmful to colored hair as it cause light streaks and dryness. Last but not least, vigorous combing especially of wet and tangled hair can cause immense damage to hair. Thus, metal combs and backcombing are to be avoided as an excessive use of force will cause the hair cuticle to be ripped off. Heat is also an obvious cause of dryness of hair because it robs the moisture of the hair which is essential to the shine and lush feel of hair. Therefore, the treatment cream will help to improve the surface layer of the hair and cure the damage hair problem when the cream is apply to the hair. The formulation is made by mixing both oil and water phase at the desire temperature until it homogenize.

## 1.2 Motivation

Keratin is the protein that is the major component in hair, skin and nails. Keratin acts both as an external protective protein in the cuticle (the outer layers of a hair strand) and as an internal structural protein in the cortex (the inner core of the hair that helps to determine its strength). Besides of keratin protein that contain in the human body, a keratin protein can also be develop from chicken feathers. Due to this issue, the development of keratin protein from a chicken feathers will not be a problem since the feathers itself can be get from the poultry sector. Moreover, the chicken feathers are commonly not being use as the main product of the poultry sector so this can lead to the usage of the chicken feathers to develop a keratin protein in terms of recycling the minor product that can also contribute to environmental friendly process. Thus, this keratin can be processed and used as the replacement for the missing or damage keratin inside the hair.

Beside the usage of chicken feather for the keratin extraction, the chicken feather is also currently used in various applications like textiles, crafting, decorations and even in bio-composite manufacturing. These applications are due to the abundance availability and compatible characteristics of the chicken feather itself. According to Bansal (2016), the characteristics of the keratin fibers that are non-abrasive, biodegradable, renewable, eco-friendly, insoluble in organic solvents, low density, hydrophobic behavior, warmth retention and cost effective make the keratin protein from chicken feathers to be a suitable material to be used as a high structural reinforcement in polymer composites. Therefore, this statement definitely supported the usage of keratin protein extracted from chicken feather as the main product in the hair treatment cream.

## 1.3 Problem Statement

Since hair damaged can happen with un-noticed, a product is needed in order to repair the structure of the damaged hair. The type of hair damage can be divided in few categories. Firstly is the regular breakage outside of the normal shed hair and occasional breakage. Secondly is the dull hair problem that has no natural shine and thirdly is the difficulty in retaining length that is outside of intentional haircuts. Next, uneven fullness from root to tips is also known as one of the categories for damaged hair. Hair damage occurs for all hair types and textures from the regular handling. Therefore, if hair is dry, brittle, has lots of splits end and so forth, it is visibly damaged. Damaged hair cannot be cure but it can be repair either



cutting the edges or repair using the hair products. One of the methods to repair the hair damaged is by using keratin protein than can be extracted from chicken feathers. The feather composed of 91% keratin, 1.3% fat and 7.9% water (Fan and Broughton, 2008). According to Goddard (1934), chicken feather keratins can be converted to natural protein soluble in alkali or acid and digestible by trypsin and pepsin. This was accomplished by breaking the disulphide bonds of the keratin. The protein of chicken feather consist of  $\alpha$ -keratin type with about 25% crystalline protein but the  $\alpha$ -keratin in the feather probably has the different structure and arrangement than the protein in the feather's rachis (Akhtar, 2011).

Nowadays, the existence of personal care products contributed a very huge impact on the consumer's life. Almost all physical problems regarding to human can be treat or cure with the use of chemical substances that was designed in the correct formulation. According to Mercola (2016), roughly 13,000 chemical have been used for cosmetics sector of which only ten percent have been evaluated for safety, and new ones are introduced every year. Therefore, the possibilities for human to consume a toxic chemical in daily life are high. Due to the exposure to these toxic chemicals, there will be a skin or eye irritation for the short term effects and this exposure can also lead to increase the risk of getting cancer as for the long term effect (Draelos, 2011).

#### **1.4 Objective**

The following are the objectives of this research:

- To formulate the hair repair cream using keratin protein.
- To analyze and characterize the properties of the hair treatment cream and the treated hair.

## 1.5 Scopes of Study

Based on the objectives, the main scope of this research was to produce the hair treatment cream with keratin protein. Firstly, the cream is formulated by using keratin protein, cetyl alcohol, glycerine, polysorbate 80, citric acid, stearic acid, dimethicone, DMDM Hydantoin, butyl stearate, coconut oil, jojoba oil, rose oil, sorbitol and lavender oil. The keratin used in this research is an extracted keratin from the chicken feathers. Besides, other than using the keratin protein as an active ingredient, the essential oils such as jojoba oil, rose oil and lavender oil are also inserted in the formulation since all of these oils have their own benefits for human hair. After the cream has been formulated, the properties of the product will be tested with a few tests. For the stability of the product, centrifuge test, viscosity test, and pH test will be used in this test. During the stability test, the pH value, viscosity, color and fragrance are observed. Other than that, surface imaging analysis will be done in order to determine the hair structure before and after applying the treatment cream on hair sample under 1000x magnifications. The purpose of this stability test is to ensure that the hair treatment cream is stable when it is stored for a longer time.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Overview**

In this chapter, the literature is reviewed in order to introduce the anatomy of hair which is the cuticle, the cortex and the medulla. Other than that, there are also the characteristics of damaged hair, the chicken feather composition, the extraction of keratin protein and the hair treatment cream composition.

#### **2.2 Hair**

Hair is simple in structure but has important functions in social functioning. Hair is made of a tough protein called keratin. A hair follicle anchors each hair into the skin and the hair bulb form the base to the hair follicle. In the hair bulb, living cells divide and grow to build the hair shaft. Besides, blood vessels also nourish the cells in the hair bulb and deliver hormones that can modify hair growth and structure at different times in life. Hair growth occurs in cycles consisting of three phases which are anagen (growth phase), catagen (transitional phase) and telogen (resting phase). According to Hoffman (2014), hair grows at different rate in different people and the average rate is around one-half inch per month. Hair colour is created by pigment cells producing melanin in the hair follicle and with aging, when the pigment cells die, the hair turns grey. Other than that, the hair follicle also consist of nine different epidermal layer: hair matrix, medulla, hair cortex, hair cuticle, cuticle of the inner root sheath, Huxley's layer, outer root sheath and Henle's layer (Laboratories, 2015).

##### **2.2.1 Cuticle**

A hair cuticle is a protective layer composed of overlapping dead cells which form scales that give the hair shaft strength and provide protection for it (Kingsley, 2016). It also functioned to minimize the movement of water (moisture) in and out of the underlying cortex. However, chemical processes and weathering can lift the cuticle and disrupt the balance. For a healthy cuticle, it will give your hair shine and protects the inner layer from damage. According to Persadsingh (2012), the appearance of the hair depends largely on the cuticle, the protective sheath under the whole hair. The cuticle layer consists of protein based scales that open and close when activated. When this scales rise, chemical and ingredients

can pass through the cuticle layer to the control center of the hair strand which is the cortex. All cuticle layers are not created the same which the cuticle layer is naturally align varies according to hair type. For example, for straight, type one hair, the cuticle layer hugs the cortex very tightly and the layer's scale naturally lay flat. Therefore, this is why straight hair shines more often and tends to stay moisturized for a longer period of time than any other hair type. For curly hair types, the cuticle layer's scale are naturally raised and do not lay flat. As a result, curly hair tends to shine less and do not feel smooth to the touch. In addition, raised cuticles are also the reason why curvy hair tends to look frizzy and tangles easily.

### **2.2.2 Cortex**

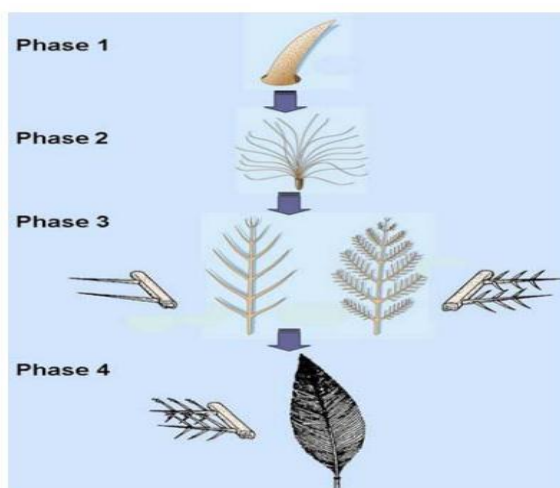
The cortex of the hair shaft is located between the hair cuticle and medulla and it is the thickest hair layer. The middle layer of the hair is known as the cortex, and it has many different functions. Approximately the cortex structure covers almost 90 percent of hair's total weight (Bhushan, 2010). It also consists of elongated cells which form a fibrous substance that gives strength and elasticity to the hair. The cortex is also the houses of the pigment called melanin that gives hair its natural color. Services such as chemical hair relaxing, thermal styling, wet setting and hair coloring oxidation cause temporary and permanent changes to the hair. All these changes mentioned previously take place in the cortex layer. The melanin that can be found in cortex layers can be divide into two categories which is eumelanin and pheomelanin. For eumelanin, it produces brown and black color and it is the most prevalent type of melanin. Compare to pheomelanin, it imparts yellow, blonde, red and auburn hues. Therefore, natural color is derives from a pheomelanin and eumelanin ratio combined with the size and number of pigment granules (Forslind, 2004). When hair is grey, there is an absence of melanin pigment in the cortex layer.

### **2.2.3 Medulla**

The medulla of a hair is the innermost layer of the hair. When present, the medulla of a hair extends all the way along its length. However, a medulla is not present in all hairs, only in large thick ones (Ivyrose, 2010). Besides, the medulla also referred as pith of marrow of the hair. The function of this layer of hair does not affect the hair care services conducted by professional salon.

## 2.3 Chicken Feather

According to Reddy (2007), feather weight 5% to 7% of the total weight of mature chickens and are generated in huge amounts as a waste by products at commercial poultry processing plant. For the chemical composition for chicken feather, it consists of 91% protein, 1% lipid and 8% water. In term of elemental analysis of chicken feather, it consists of 48% carbon, 14% nitrogen, 6% hydrogen, 2% sulfur and 30% of other elements. Chicken feathers possess a unique properties including low relative density and good thermal acoustic insulating properties which can be used in advantageously in number of applications which would serve as alternatives to feather meal and feather disposal. According to Dullaart (2012), chicken feathers can be found as a waste product in large quantity. Feathers are composed of complex level of hierarchical arrangements which start with the shaft (rachis), barbs and barbules. Figure 2.1, shows graphically the evolution process of feathers which divided into 4 phases. For the phase 1, feathers originate from a hollow tube, that changes into phase 2 which is a series of barbs, then in phase 3 the barbs self-organize along a rachis and finally in phase 4, it is characterize by the origin of barbules, which are close related with the self-organization of the feather.



**Figure 2.1:** The formation of chicken feather

## **2.4 Keratin Protein**

Keratin is known for giving hair its toughness and for making skin and nails sturdy. Callused skin has higher levels of keratin than soft, delicate skin. Keratin's toughness is derived from its molecular structure. According to Rele (1999), the thin filaments that combine to form keratin are very tightly wound together and held in place by intermolecular hydrogen bonds. Many beauty products that contain keratin have emerged in the recent years. These products typically contain a form of keratin known as hydrolyzed keratin, which is small enough to enter skin and hair when applied topically. These products are intended to make skin smoother and more elastic. Those designed for hair are intended to make it thicker and stronger. Besides, the important quality of keratin is its ability to flex in multiple directions without tearing (Hoffman, 2014). Keratin's microscopic structure is the key to durability and flexibility. According to Buffoli (2014), the molecules of this protein twist into coils called alpha helices and contain many disulfide bonds (bond between pair of sulfur ions) that are particularly stable and can resist the action of proteolytic enzymes, which specialize in breaking apart proteins. In addition, keratin is also insoluble in water. Due to this issue, there are also process called keratinization which always being perform on hair that involve in providing the protective structures containing keratin to hair.

## **2.5 Extraction of Keratin Protein**

Keratin is a fibrous, flexible and strong protein. Keratin is often derived from natural sources such as sheep's wool, bird feathers and animal hooves for use as a straightening agent in beauty product. According to Mario (1977), the extraction of keratin protein can done by using reducing agent that will help in decreasing the stability of keratin fiber in the solid form found in the feathers. The reagents will break the disulfide bonds, hydrogen bonds and salt linkages of the keratin fiber in order to dissolve it into protein solution. Before the extraction process, the chicken feathers must be soak in the ether for a day to remove stains, oil, and grease. Then washed the chicken feathers with soap and dried it under the hot sun. Firstly, the chicken feathers are dissolving in the reducing agent such as are potassium cyanide, thioglycolic acid and sodium sulfide. After the feathers are dissolved, ammonium sulfate is poured in the solution to make the protein to precipitate. Then the solution is filter using the filter paper to obtain the precipitate protein. The protein then washed for several times with water and sodium hydroxide is use to get the protein. After the extraction process, the

percentage of keratin protein is evaluated by means of biuret test and FTIR analysis (Gupta, 2012).

## **2.6 Hair Damaged Treatment Cream**

Treatment cream can be divided into two categories. The two categories are leave-on cream and temporary hair repair cream. Leave-on condition is the type of cream that are applied on the hair with rinsing the hair however, the temporary hair cream are the creams that needs to be rinse off after applying. Both types of cream will have different conditioning effect to the hair but will have the same result in treating the hair. According to Pinto (2013), in a repairing cream, the most important component is the conditioning agent. Without the conditioning agent, the effectiveness of improving hair texture is less effective. There are few types of hair damaged that can be cure with treatment cream. Firstly is heat damage. Heat damage is one of the most common types of hair damage caused by the high temperatures to which our hair is subjected. It may be obvious to mention that the used of electrical appliances such as hairdryers and curling tongs can lead to this issue. Next, hair damage can also occur due to poor nutrition. This is because lack of beneficial elements for the body such as iron, protein, zinc, keratin, and etc., which can cause mineral deficiencies. Therefore, to avoid this problem, a treatment cream will be much useful in order to keep the hair healthy.

### **2.6.1 Surfactant**

Surfactant is a must have ingredient in a formulation of a hair care product. The term surfactant brings the meaning of surface agent active. In surfactant solution, the molecule migrates to the surface and aligned them in a manner which reduces surface tension. Surfactant is a molecule that has the ability to be both hydrophobic and hydrophilic. This is achieved by having two very different functional groups attached to each other. According to Fainerman (2001), the hydrophobic part of the molecule usually consists of a hydrocarbon of variable length. Common chain lengths are between C8 and C18, the most used being C12 in cosmetics formulations. This strikes the balance between mildness and detergency or the ability to remove grease from the hair. Shorter chain lengths have stronger grease removing properties, longer chain lengths have greater mildness but less lathering properties and a balance has to be achieved in the formulation. The hydrophilic part of the molecule can be of many and varied functional groups and will determine the nature of the surfactant and a lot of

its properties (Fainerman, 2001). These include sulphate, ethoxy sulphate, succinates, polyhydroxylates, quarternised groups and many more. Surfactants can be divided into four groups, according to their ionic nature. These are anionic that carries a negative charge when ionized, cationic that carries a positive charge when ionized and nonionic that has no charge to the molecule (unionizable). Last but not least, there is also an amphoteric surfactant that carries both positive and negative charges when ionized. General properties can be attributed to the different classes of surfactants.

According to Hargreaves (2003), anionic provide a lot of the lather and detergency in the shampoo. The most commonly used anionic are sodium laureth sulfate and sodium lauryl sulfate. Occasionally ammonium lauryl ether sulfate and ammonium lauryl sulfate are used too. The increase in steric hinder and lower the ionization level of the ammonium group help prevent precipitation in the presence of conditioning agents in a 2-in-1 type formulation. It can also prevent precipitation of surfactants due to the common ion effect if a lot of sodium ions are otherwise present in the formulation. Besides, nonionic are often not included in hair product now due to the harshness of their detergency. They can strip the hair and lead to scalp irritation due to excessive defatting. The few that do appear in formulations are very mild and act as foam stabilizer, thickeners and may be more necessary in formulations for greasy hair types. These include laureth-3 or 4, cocamide DEA or coco glucosides. According to Hargreaves (2003) amphoteric surfactants are used a lot in hair product formulations now. They are very useful for decreasing the irritancy of a formulation while increasing the active contents level of the product and quality of the lather produced. According to Hargreaves (2003), amphoteric are so mild that baby shampoos often consist entirely of them. By far the most used is cocamido propyl betaine, or occasionally cocamido betaine. Cationic is used mostly in conditioners. Cationic molecules have the ability to cling to wet surfaces by static attraction. Consequently they are not easily removed during the rinsing process and form the basis of conditioning. Polyquarternium-10 is one of the most common cationic conditioners. It is based on a cellulose polymer that is then quarternised to give the desired properties. For the formulation of hair treatment cream in this paper, the nonionic surfactant which is sorbitol is used for the gentle cleansing and emulsion stabilization.



### **2.6.2 Humectant**

Humectant is an important cosmetic ingredient since it prevent loss of moisture thereby retaining the hair's natural moisture. Humectants are the key ingredients in most hair care products to protect the hair by attracting moisture which expands the hair shaft. Chemically, humectants form hydrogen bonds with water molecules. Humectants are like water magnet which they pull the water from cuticle of the hair into the cortex of hair and if humidity is above 70 percent, humectant can also draw in moisture from the air (Johnson, 2002). Humectant is extremely important in keeping hair soft and supple. For the usage of humectant in hair treatment cream, it is also functioned to repair dry, cracked hair by providing maximum hydration and reducing the hair's cuticle irritation. Besides, humectants also act as a barrier by preventing outside chemicals from making contact with the hair's cuticle.

There are two types of humectant that are present in a number of different cosmetic and personal care product which is synthetic humectant and natural humectant. According to Johnson (2002), synthetic humectants are quite common because it is less expensive to produce the natural humectants. For synthetic humectant, they do lock in moisture to some extent but they do not provide any noteworthy nutrients or benefits to the hair. In the other hand, natural humectants serve a dual purpose which it attracts moisture to the surface of the hair and they deliver major moisture and nutrient to the deepest layer of the hair. Basically, natural humectants improve hair's ability to hydrate itself on its own. The example of natural humectant includes hyaluronic acid, aloe, alpha hydroxyl acid, honey and seaweed. For the development of hair treatment cream, synthetic humectants which are glycerin and sorbitol are used since it is an effective humectant in hair care product and not harmful to the user (Johnson, 2002).

### **2.6.3 Emulsion**

Emulsion is a mixture of liquids at least two immiscible phases via creation of an interface. Properties of emulsion (eg. stability, rheological properties) and their industrial uses are governed not only by variables such as temperature and composition but also by the droplet size distribution (Calderon & Schmitt, 2007). Emulsion can be formed spontaneously or by agitation (mechanical means) provided that the mixed liquid has no mutual solubility. Emulsion present a dispersed phase, usually in the form of droplets, surrounded by complete

matrix. There are two phase in emulsion; one phase is called “oil phase” which is organic while the other phase is called “aqueous phase”, the inorganic. Since water and oil do not mix, an additional agent (emulsifier) is needed to form a homogeneous mixture keeping the oil and water together. In 1949, William C. (Bill) Griffin developed the Hydrophille-Lipophile Balance System (HLB). HLB formula can be used to calculate which emulsion and surfactant is suitable.

#### **2.6.4 Adjustment Agents**

When developing cosmetic formulations, it is important to know each raw material specification to ensure that the same product is made each time. However, it is not easy to truly determine the raw materials variations so it necessary to add ingredients to the formula that can adjust things like pH, viscosity, color and other characteristics in the specification. In this paper, the example of adjusting agent used to control the pH is citric acid.

#### **2.6.5 Emulsifier**

Emulsifier is used in creams and lotions to mix water with oils. Since water and oil do not mix, an emulsifier additional agent (emulsifier) is necessary to form a homogenous mixture keeping water and oil together. According to Calderon & Schmitt (2007), there are two types of emulsifier that mostly used in industry. Oil-in-water (o/w) emulsifiers keep oil drops packed in water, while water-in-oil (w/o) emulsifies are used for a fatty feel (e.g night and sun protection creams). However, O/W emulsifiers are used more in hair care products.

#### **2.6.6 Emollient**

Emollient for hair are usually hydrophobic oils that form films on the surface of the hair, where there often acts as anti-humectants or sealers. It is lubricants and provides increased slip between adjacent hair strands, which makes detangling much easier. Emollient also reduce tangling in general by smoothing and flattening the cuticle surface, which can also add shine and gloss to the hair. Some of the emollient can also penetrate the interior structures of the hair and act as plasticizers, improving elasticity, toughness and suppleness. Common emollient ingredients include silicone (dimethicone, amodimethicone, cyclomethicone), fatty alcohols, mineral oil, petrolatum and etc. According to Mckay (1999), emollients can penetrate through the cuticle layer into the cortex and significantly improve

the mechanical properties of hair but in extreme humidity conditions, the films comprised of these oils can become sticky and dull-looking due to inclusion of water molecules.

### **2.6.7 Preservative**

Commercial products are typically loaded with preservatives to allow them to remain fresh during the long span between the time of manufacture and the time the customers finishes using it. Therefore, preservative is used to extend the longevity of the products and help it to free from bacteria. An antimicrobial preservative is needed especially for a product that contains water, milk, hydrosols and other aqueous liquid. According to William (1992), essential oils are the most natural antimicrobial that can be used but the percentage required to adequately protect a product from microbial growth generally exceeds the recommendation for safe amounts of essential oils to use in a products, therefore manufacturer prefer the usage of others preservatives.

### **2.6.8 Conclusion**

Based on the literature review, the treatment cream is use to repairing the dry, split ends, or even color hair. There are a number of hair treatment compositions and methods available today, but a safe method and the right amount of composition are needed to produce better and safe formulation. The method that was used to formulate the hair repairing cream will be discussed in following chapter.

## **CHAPTER 3**

### **MATERIALS AND METHODS**

#### **3.1 Overview**

Hair is made of protein which originates in the hair follicles. Human hair consists of approximately 65% to 95% protein. Each hair strand contains a cuticle, cortex and medulla. Cuticle is the outermost layer which is a protective layer composed of overlapping dead cells and form scales that give the hair shaft strength and provide protection for it. For cortex, it is the hair shaft that is located between the hair cuticle and medulla and is the thickest hair layer in the hair strand. Next, the medulla is the innermost layer of the hair at which, when present, the medulla of a hair extends all the way along its length (Beigel, 1869). Damaged hair can be characterized whether it is chemically damaged or physically damaged. The services such as bleaching, permanent perm and curling are example of method that leads to chemically damaged of hair. Besides, abrasion associated with hair grooming is an example of physical altered hair. Regarding to that issue, keratin proteins were used as a main ingredients to treat damaged hair.

#### **3.2 Research Design**

For this research, three sample of damaged hair are used. The hair strands used is a hair that experiencing hair splitting and dry at which the problem with this sample cannot be seen with naked eyes. In order to get this kind of hair samples, the samples were collected from cosmetically altered hair such as bleaching, re-bonding and colored using dye. Apart of that, this research also focuses on the effects of the concentration of keratin protein and essential oil in hair treatment and evaluates the stability of this hair treatment cream under room condition for a better storage. This research will be tested on clinical trial physical testing and chemical testing which include the surface imaging analysis and centrifuge test. Besides, the color, pH value and viscosity of the end product will be constantly monitored.

### 3.3 Overall Workflow

The data provided (see Table 3.1) shows the ingredients that are used to formulate treatment cream in this paper. Since the stability of the cream is the most important, emulsion is a must use item in this research. In this work, there are three treatment cream samples are developed. There are three important phase in producing the treatment cream which is the oil phase, water phase and cooling phase. Before making the cream, all ingredients need to be calculated and weigh according to the formulation (see Table 3.2). Cetyl alcohol, stearic acid, polysorbate 80, coconut oil, rose oil, lavender oil and jojoba oil are the oil phase and glycerine and distilled water are in the water phase.

In the formulation of the hair treatment cream, water bath were used to mix all the ingredients in the beaker at 70°C. Oil phase and water phase was prepared separately. First, polysorbate 80 will be mix with coconut oil until it is less viscous. Then, cetyl alcohol, lavender oil and stearic acid will be added into the mixture and will be stir using glass rod until there is no solid form. The temperature of the mixture is maintained at 70°C. At the same time, water phase solution was prepared by dissolving glycerine in the distilled water. The temperature of water phase is also maintained at 70°C. Both oil phase and water phase are continuously stirred with glass rod. Besides that, when both of the mixture reach at 70°C, both the mixture are hold for 20 minutes to kill unwanted badness. After 20 minutes, the water phase is poured into the oil phase inside water bath condition. The solutions were stirred continuously inside water bath condition for 5 minutes until cream mixture formed.

Then, the cream mixture formed was transferred out from the water bath and left to cool it down and continuously stirred by using magnetic stirrer on the hot plate. When the temperature cools down to 45°C, the heat sensitive ingredient such as dimethicone, keratin protein, citric acid and preservative were added into the cream mixture. The cool down phase mixture were mix using magnetic stirrer until the solutions form creamy texture. Next, it was mix homogenously with a homogenizer. The mixing with stirrer was stir until cream texture was form. Finally mix the solution with homogenizer until the cream texture formed is more stable.

### 3.4 Material

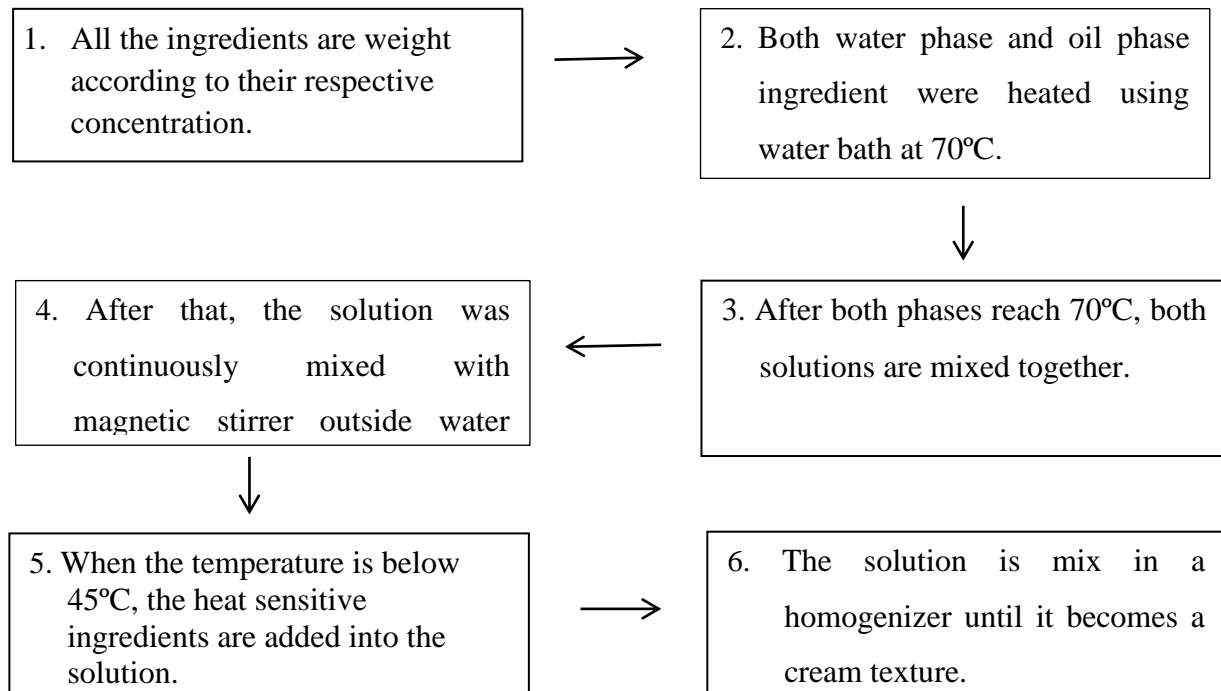
The apparatus can be found inside the compound of University Malaysia Pahang (UMP). Most of the equipment and apparatus can be found inside the laboratory in Gambang campus. Chemicals are obtained from sources namely YKL Multi Sdn. Bhd (Cethyl Alcohol, Polysorbate 80, Dimethicone, DMDM Hydantoin, Caprylic, Coconut Oil, Jojoba Oil, Rose Oil, Sorbitol and Lavender Oil) and UMP Laboratory (distilled water, Stearic Acid, Citric Acid)

Ingredients
Cethyl Alcohol
Glycerin
Polysorbate 80
Citric Acid
Stearic Acid
Dimethicone
DMDM Hydantoin
Coconut Oil
Jojoba Oil
Rose Oil
Lavender Oil
Sorbitol
Distilled Water

**Table 3.1:** Formulation of Ingredients (Abigail, 2014)

### 3.5 Research Methodology

The development of hair cream is going to be done inside the laboratory. The ingredient concentrations are use based on their MSDS sheet limitation usage.



**Figure 3.1:** Methodology of cream preparation (Abigail, 2014)

### 3.6 Formulation of Cream

Table 3.2 shows the treatment cream formulation for this work. The formulation is created based on previous research and the composition for the hair treatment cream is a based on trial and error method and MSDS of the chemical used. There are three formula developed for this paper.

Ingredient	Formula		
	1	2	3
Glycerine	4%	4%	4%
Sorbitol	3%	3%	3%
Distilled Water	c.s	c.s	c.s
Stearic Acid	1%	1%	1%
Cetyl Alcohol	6%	6%	6%
Polysorbate 80	8%	8%	8%
Keratin Protein	15%	15%	15%
Citric Acid	1%	1%	1%
DMDM Hydantoin	1%	1%	1%
Dimethicone	3%	3%	3%
Coconut Oil	7%	-	-
Jojoba Oil	-	7%	-
Rose Oil	-	-	3%
Lavender Oil	3%	3%	-

**Table 3.2:** Formulation of cream



### **3.7 Method Validation (Testing)**

There are a few test have been performed to check the performance of the cream on the sample hair. Stability testing is an experiment for the batch of formula that was already produced and put the sample in same environment condition for a set period of time. These conditions are meant to see how the samples react to its environment during its life cycle.

Other than that, there are also two forms of stability tests that consist of physical and chemical integrity tests. The purpose of this stability testing is to ensure that the new products formed meet the intended physical, chemical and the microbiological quality standards as well as the functionality when stored under appropriate conditions. For the physical integrity test, the sample have been evaluate on its colour, fragrance , pH value, viscosity, texture, flow, and emulsion stability. In the other hand, for the chemical integrity test, microbiological stability test is done on the sample which evaluates the degree of contamination with bacteria, mold, and yeast.

#### **3.7.1 pH analysis**

The pH (potential of hydrogen) analysis used to show whether the product produced are acidic or alkaline. The average pH range of human hair is 4.5 – 5.5. According to Kelly (2014), this natural hair acidity prevents fungi and bacteria in the hair, scalp and keep the cuticle closed and healthy. Therefore, to treat damaged hair, the suitable pH value for the cream is mildly acidic. The acidity of the cream falls within a pH range of 3.0-5.0 which is to ensure the actives remains in its cationic forms and maximised its substantivity on hair (Knowlton & Pearce, 2013). The pH value of the product is measured after the entire ingredients are homogeneously mixed.

##### **3.7.1.1 Procedure for pH Analysis**

###### **pH meter calibration**

Calibrations were made each time the pH meter is used. The calibration steps are done by following the instruction given by the lab owner. Figure 3.3 shows the calibration quick guide.

###### **Measuring pH value**

1. After 24 hours, the samples prepared for pH testing.

2. Place the pH indicator into the samples and press “Read” for it to start measuring.
3. After getting  $\sqrt{A}$  from the meter, record the final pH value.
4. Rinse the holder with distilled water.
5. Repeat step 1 until 3 for each of the sample.

### **3.7.2 Viscosity testing**

Viscosity is the measure of a substance’s resistance to motion under an applied test. The substances might contain molecules that are different in size, shape, and cohesiveness or a single type of molecule. Since the molecules are forced to move past each other, the molecular properties will determine the force needed to move and this is called shear. Viscosity is defined as shear stress or shear force. According to Paye (2005), rheological properties are important for liquid and semiliquid cosmetic formulations because this characteristics determine the product’s properties meaningful in mixing and flow when produced, filled into containers and removed before use, as well as sensory properties when applied, such as consistency, spread ability, and smoothness. The viscosity of a system depends on multiple factors: oil versus water content, concentration of thickeners and emulsifier, electrolytes, type and amount of surfactants, pH, and temperature (Baki and Alexander, 2015). There are two types of measuring device used for viscosity evaluation of different cosmetic systems which are viscometers and rheometers (Baki and Alexander, 2015). Viscosity is measured by obtaining the force required to spin a plate through the fluid. For ternary creams, it is considered stable when the viscosity is maintained above 2000 Pa.s (Matijevic, 2001).

#### **3.7.2.1 Procedure for Viscosity Testing**

1. Check to confirm that the viscometer has been calibrated.
2. For the Brookfield DV-II, AUTO ZERO the instrument with no spindle attached and the speed set as designated in the product specification.
3. The main display will flash 00.0 after 10 seconds.
4. Immerse the spindle designated in the product specification into the sample to the groove on the spindle shaft. Do not allow air bubbles to form.

5. Attach the spindle to the viscometer. The spindle should not touch the bottom or sides of the container and should be centred.
6. Reconfirm that the viscometer is level.
7. Set the speed as designated in the product specification, start the viscometer and read at constant reading.

### **3.7.3 Centrifuge testing**

Emulsion characteristic contain materials of differing specific gravities. The water phase component has higher specified gravity than the oil phase. Due to the difference in specific gravities, the internal phase (of oil-in-water emulsion) has a tendency to separate and rise to the top of the emulsion forming a layer of oil droplets which called creaming (Klein). Creaming Index (CI), represent the instantaneous global volumetric water fraction for which it is a measure of emulsion instability reflecting phase separation. The higher the creaming index value, the more destabilized the emulsion is. Therefore, centrifuge method is used for prediction of emulsion of the cream. According to Klein, the emulsion samples should be heat to 50°C and centrifuge it for thirty minutes and 3000 rpm to test the best stability of the cream.

#### **3.7.3.1 Procedure for Centrifuge Testing**

1. The tubes were prepared for sample 1.
2. Two tubes were filled with cream until 20mL.
3. The tubes were placed inside the centrifuge. The tubes were placed opposite to each other so that it will be balanced.
4. Next, 1000 rpm and 15 minutes was set for the first testing.
5. The observation was recorded.
6. Repeat step 1 until 5 for 2000 rpm, 3000 rpm, 4000 rpm and 5000 rpm.

### **3.7.4 Colour evaluation**

For the colour evaluation, the colour changes need to be monitored and this testing will be tested for 3 weeks.

### **3.7.5 Scanning Electron Microscope Analysis**

Scanning electron microscope (SEM) analysis is a process that used a focus beam of high energy electrons to generate a variety of signals at the surface of the solid specimens. In the other words, SEM is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons and these electrons interact with atoms in the sample producing various signals that contains information about the surface of the sample topography and composition. As this microscope is a transmission electron microscope, it manages to achieve better than 50 pm resolution and magnifications of up to about 10000000x. According to Mumtaz (2015), statistical evaluation of results obtained from SEM analysis revealed that human hair show morphological variation with respect to age, gender, hair's pigmentation, chemical and physical treatments.

### **3.7.6 Skin irritation evaluation**

For the skin irritation evaluation or a patch test, the cream developed is rubbed on human skin and it is left for 24 hours to see if there are any effects of the cream on skin. This evaluation is conducted twice for each cream at every 24 hours.

## CHAPTER 4

### RESULTS AND DISCUSSIONS

#### 4.1 Introduction

The objectives of this experiment are to formulate a hair treatment cream with the right amount of chemicals in the cream and to analyze and characterize the characteristics of the hair treatment cream and the treated hair. The method used to determine the correct formulation for the cream is based on try and error method. For this experiment, three types of samples are prepared with different formulations. Generally, both water phase and oil phase are prepared separately at 70 °C. Later, the two phases are mixed together to form the cream and it is stirred until it homogenize. The cream is continuously stirred until the temperature is below 45 °C and the heat sensitive ingredients such as dimethicone, keratin protein, DMDM hydantoin and citric acid are added to the cream. For all the formulations created, all the creams are stable and it will be further analyzed to check on the efficiency of the cream.

#### 4.2 Results

##### 4.2.1 Formulation of cream

Table 4.1 shows the hair treatment cream formulation for this experiment. There are three different formulations developed for this paper.

Ingredient	Formula		
	1	2	3
Glycerine	4%	4%	4%
Sorbitol	3%	3%	3%
Distilled Water	c.s	c.s	c.s
Stearic Acid	1%	1%	1%
Cetyl Alcohol	6%	6%	6%
Polysorbate 80	8%	8%	8%
Keratin Protein	15%	15%	15%
Citric Acid	1%	1%	1%

DMDM	1%	1%	1%
Hydantoin			
Dimethicone	3%	3%	3%
Coconut Oil	7%	-	-
Jojoba Oil	-	7%	-
Rose Oil	-	-	3%
Lavender Oil	3%	3%	-

**Table 4.1:** Formulation of cream

After the development of the cream, the creams are left for one month to see the separation between the phases in the cream. The first observation is made after 24 hours and at this moment, there is no phase separation between the creams. Besides, the cream still look thick, sticky and white in colour. After one month, there is also no separation between the phases in the cream. Table 4.3 shows the phase condition of each formula of the hair treatment cream.

Separation at	After 24 hours	After 1 week	After 2 week	After 3 week
Formula 1	No separation	No separation	No separation	No separation
Formula 2	No separation	No separation	No separation	No separation
Formula 3	No separation	No separation	No separation	No separation

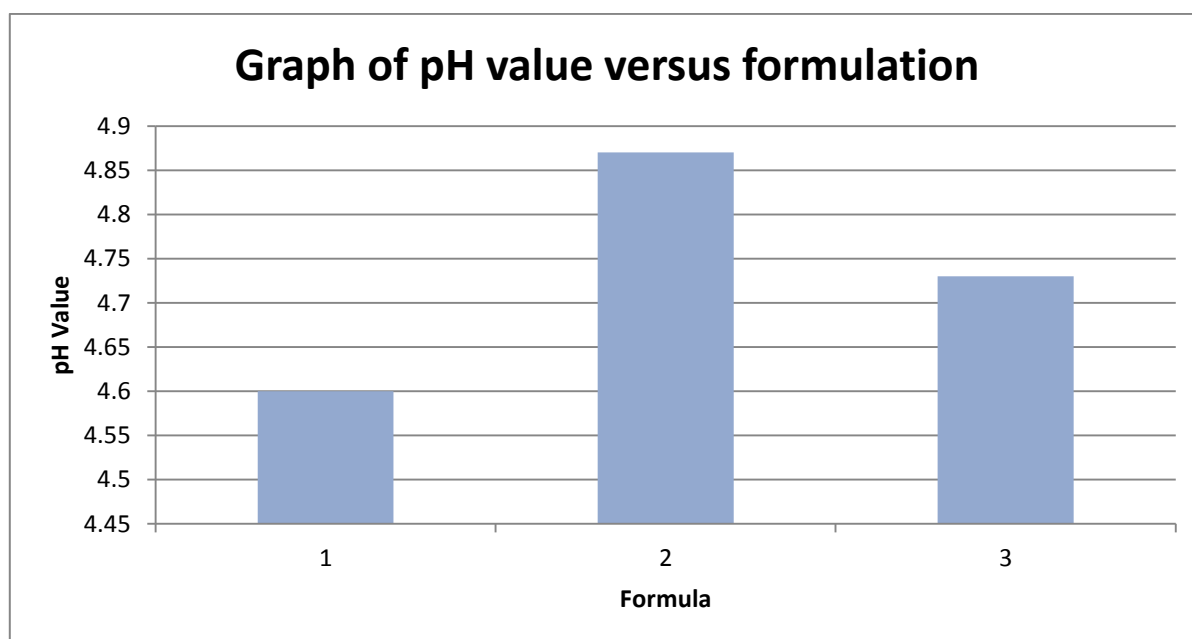
**Table 4.2:** Phase condition of the cream

### 4.2.2 pH Analysis

The pH value of the cream is recorded after the cream is left still for 24 hours. The pH value is measured by using a pH meter.

Formula	pH Value			
	1	2	3	Average
Formula 1	4.8	4.6	4.4	4.6
Formula 2	4.9	5.0	4.7	4.87
Formula 3	4.6	4.9	4.7	4.73

**Table 4.3:** pH value for each formula



**Figure 4.1:** Graph of average pH value for each formula

### 4.2.3 Centrifugal Testing

Centrifuge testing is done 24 hours after the cream is formed to ensure the stability of the cream. The centrifuge testing is run at 1000 rpm, 2000 rpm, 3000 rpm and 4000 rpm.

Table 4.5 shows the result of the centrifuge testing for each formula.

Formulation	Speed (RPM)			
	1000	2000	3000	4000
1	No separation	No separation	No separation	No separation
2	No separation	No separation	No separation	No separation
3	No separation	No separation	No separation	No separation

**Table 4.4:** Centrifuge result of each formula

### 4.2.4 Color Evaluation

Table 4.6 shows the result of color evaluation for storage of three weeks. For this test, the color of the cream is evaluated by using the naked eye.

Formula	Time (hours)			
	24	168	336	504
1	White	White	White	Yellow
2	White	White	Yellow	Yellow
3	White	White	Yellow	Yellow

**Table 4.5:** Color evaluation on the cream

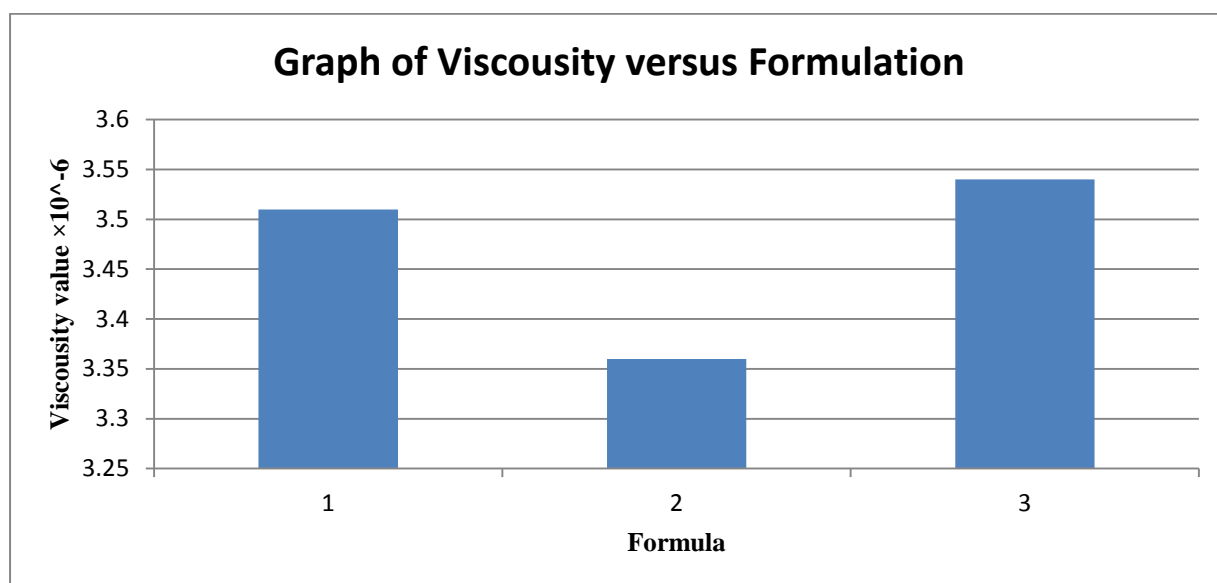


### 4.2.5 Viscosity Test

Viscosity test is done on the cream to measure the oil's resistance to flow since it is the mixture of water phase and oil phase. Table 4.6 shows the viscosity value recorded for each formulation after 24 hours the cream are developed.

Formulation	Viscosity (cps)		
	1	2	Average
1	344e4	358e4	354e4
2	329e4	342e4	336e4
3	357e4	351e4	351e4

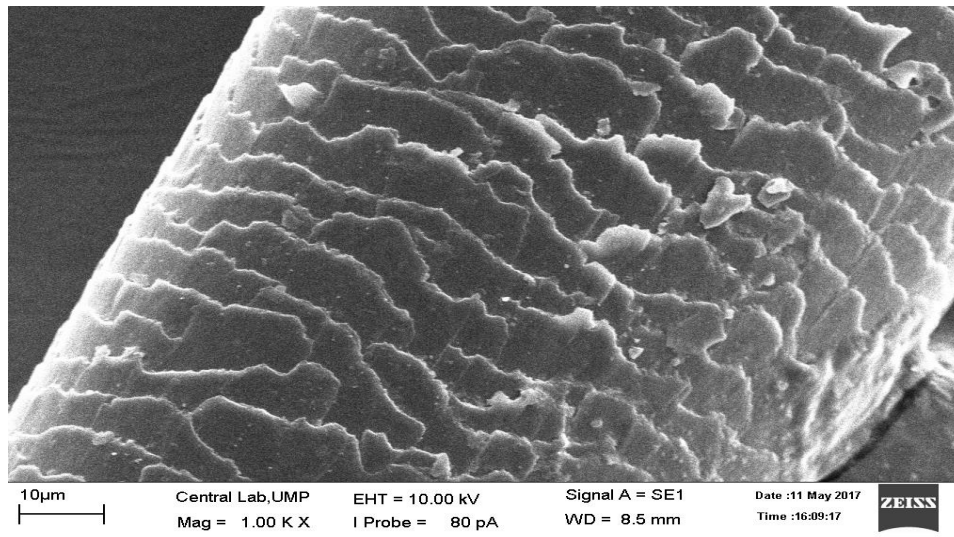
**Table 4.6:** The viscosity analysis result for each formulation



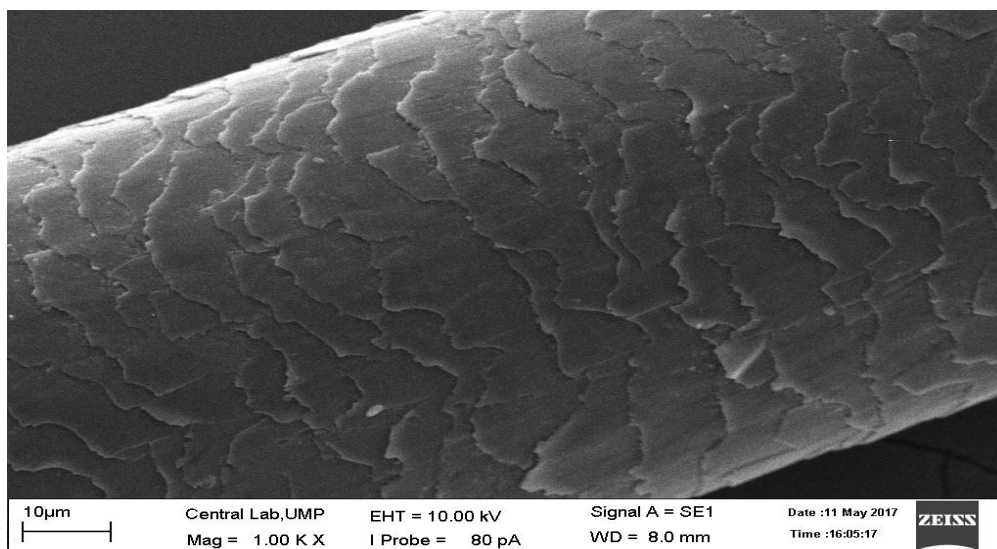
**Figure 4.2:** Graph of viscosity value for each cream

#### 4.2.6 Surface Imaging Analysis (SEM)

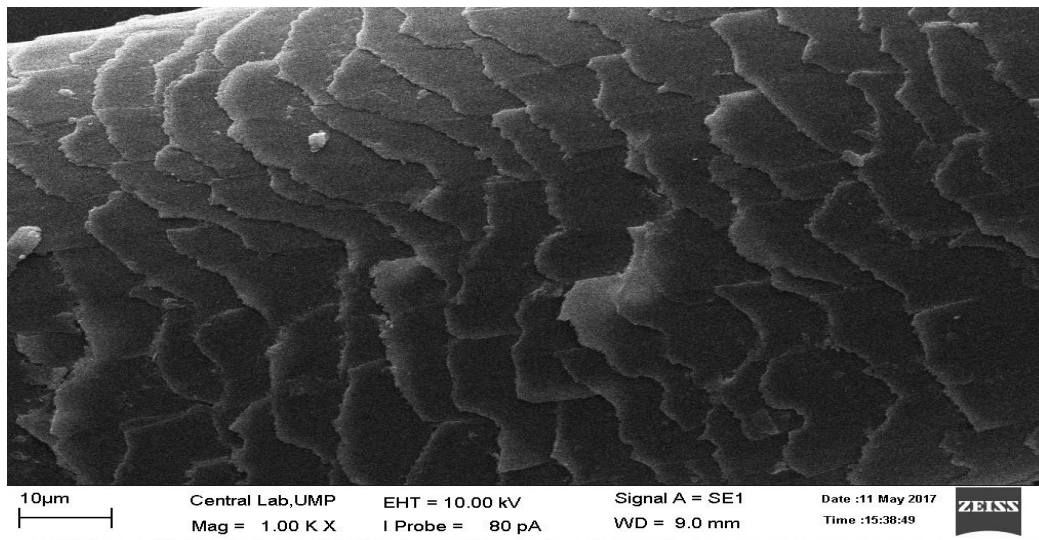
Figure below show the surface imaging analysis of the hair strand after the cream is applied to the hair for one month. Beside the sample, the surface imaging analysis is also done on the original hair and hair treated with a commercial product for a better comparison. The surface imaging of the hair samples are done at 1000x magnification.



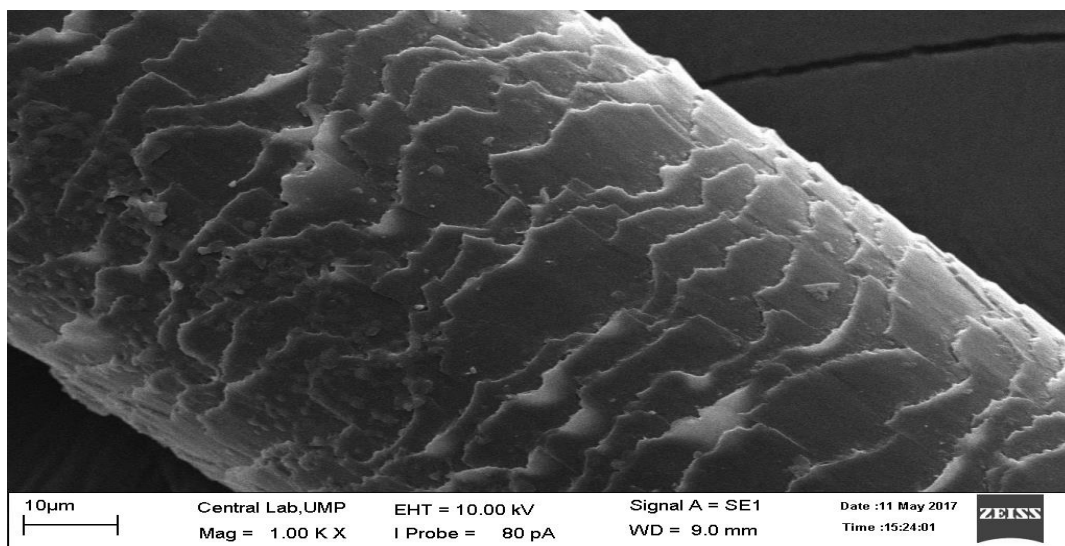
**Figure 4.3:** Surface imaging of hair before treatment



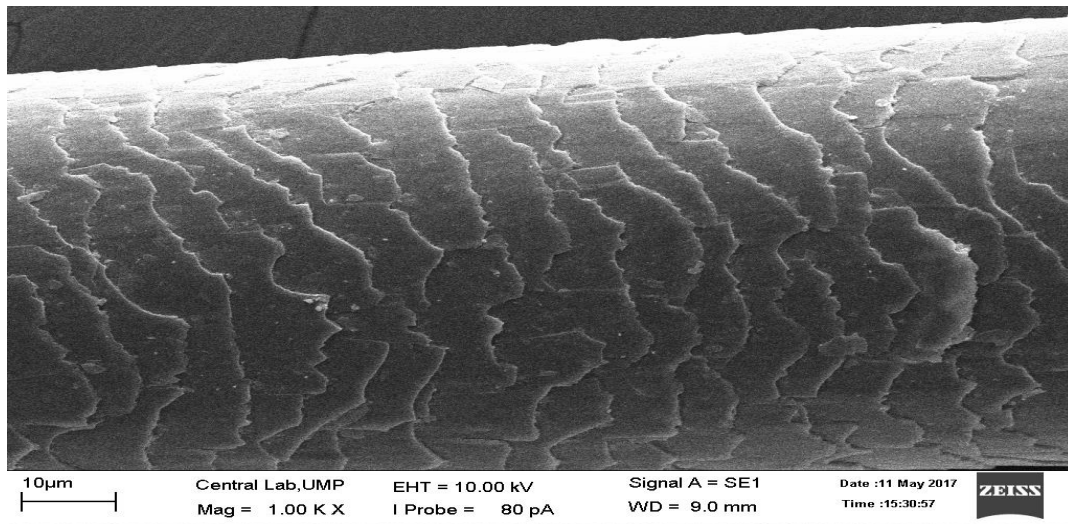
**Figure 4.4:** Surface imaging of hair after treatment by formula 1



**Figure 4.5:** Surface imaging of hair after treatment by formula 2



**Figure 4.6:** Surface imaging of hair after treatment by formula 3



**Figure 4.7:** Surface imaging of hair after treatment by using local product

Formulation	Observation	
	Before treatment	After treatment
Local Product	Rough surface	Smooth surface
Formula 1	Rough surface	Smooth surface
Formula 2	Rough surface	Rough surface
Formula 3	Rough surface	Rough surface

**Table 4.7:** Observation on the hair sample

#### 4.2.7 Skin Irritation Evaluation

Table 4.8 shows the effect of rubbing the hair treatment cream on human skin after the skin is developed for 24 hours and 48 hours. The effect of the cream on skin is evaluated by using naked eyes.

Formulation	Effect on skin after the cream is store for	
	24 hours	48 hours
Local product	No effect	No effect
Formulation 1	No effect	No effect
Formulation 2	No effect	No effect
Formulation 3	No effect	No effect

**Table 4.8:** Observation on human skin

## 4.3 Discussion

### 4.3.1 Formulation of cream

For this paper, there are three formulations of cream developed in order to test its efficiency on damaged hair. For the formulation of hair treatment cream, in the three creams prepared, there are few ingredients that are kept constant. For every formula, the glycerin, sorbitol, stearic acid, cetyl alcohol, polysorbate 80, citric acid, DMDM hydantoin and dimethicone are kept constant while the keratin protein, coconut oil, lavender oil and jojoba oil are manipulated in order to get the good texture and function of the hair treatment cream.

Glycerin is maintained at 4% in each formulation. Glycerin is a humectant that can be naturally derived from plant oils or synthetically produced. Glycerin is used in this hair treatment cream because it functions to moisturize the hair by absorbing water from the air into the hair surface. Besides it is also used due to its function that can form a protective layer that helps to prevent moisture loss. Dry hair is caused by a loss of water in the upper layer surface of the hair and due to this issue, humectant such as glycerin works by forming an oily layer on top of the skin that traps water in the hair layer to keep it moist and fresh (“Drug and Medication: Glycerin Liquid”, 2005). For the composition, glycerin is used around 4% for each formulation to avoid any harm to the user because according to the material safety datasheet, the large dose of glycerin may cause skin irritation for human.

The function of stearic acid in this formula is to act as surfactant which is to reduce the surface tension of the hair when in contact with oil or water solution. This is one of the important factors in order to have a hair that free breakage since with the presence of the surfactant, less tension will be faced by the hair. For these formulations, only 1% of stearic acid is used in each formula. According to Romanovski (2017), when surfactants are put into solutions, the molecules have tendency to line up in a certain way depending on the solution composition, the concentration of the surfactant and the temperature but in water solution with extremely low surfactant concentrations, the molecules tend to bounce around randomly without forming structures that can protect the hair layer. However, according to Rieger (2006), the mildness of nonionic surfactant with respect to the skin irritation and related effects cause this ingredient (stearic acid) is used only at low concentration. Therefore, that's the reason of only 1% of stearic acid is used in all formulations.

In the formulations, only 8% of sorbitol is used in each of them. Sorbitol plays a role as a humectant which to retain or preserve the moisture of hair. Besides, sorbitol is also used to enhance the shelf life of the confectionary product and to create a smoother texture of the cream itself. Since the water content is responsible for the softness in hair, the gradually evaporates will cause the hardness, dryness, cracks, shrinking and discoloration which are undesirable. Therefore, according to Mark (2012), the addition of small quantity of sorbitol liquid (5%-8%) can significantly reduce the tendency due to its ability to bind with the water molecules and thereby stabilize the mass. Therefore that is why there is 8% sorbitol used in these formulations. Indeed, sorbitol is used as ideal base in personal care applications in order to prevent the product from drying out and gives the required viscosity to the product (European Association of Polyol Producers, 2013, "Sorbitol", para. 2).

Cethyl alcohol is used in each formulation at 6% proportion due to its role as emulsifier and thickener which to keep an emulsion from separating into its oil and liquid phase. Since this cream is the mixture of oil phase and water phase, an emulsifier must be used in this cream to ensure the cream will be long lasting and the application of this cream on hair will efficiently functioned. According to Charlie (2012), derived from alcohol, cethyl alcohol is a must for all cosmetics used as and emollient, emulsifier and thickening agent since it is one of the most non-toxic cosmetic ingredients available. Besides, the recommended usage of cethyl alcohol is about 1% to 6% and for a cream especially for hair treatment cream, the maximum usage (6%) is good for the cream texture and function (Charlie, 2012).

Polysorbate 80 is an emulsifier that used to combine water and oil in an emulsion. Although there are many other emulsifier in the market, polysorbate 80 is used in this formulations at 8% proportion because it has the best function that helps in combining the essential oils with water. Since the essential oil (cocnut oil, rose oil, lavender oil) that are thicker and heavier than normal oil are used in each formulation, the presence of polysorbate 80 is definitely help in enhance the efficiency of the cream to work with the damaged hair. Besides, polysorbate is also approved for use in Europe by the EC and approved in the USA by the FDA as it is consider as a low hazard ingredients (Naturally Thinking, 2000, "Polysorbate 80", para.4). According to Carol (2008), polysorbate 80 is a must use in cream product because other than functioned as a emulsifier, it also used as a solubilizer that helping

to dissolve the ingredients so that they can more easily blend together and then, makes the cream looks creamier and more attractive.

Keratin protein is the main ingredients in this treatment cream formulation. For the composition of keratin protein, it is maintained at 15% for each formulation in order to achieve the pH stability in the cream. Since it is the main ingredients, the composition of keratin plays a main role in the stability and efficiency of the cream. As in damaged hair where the cysteine bridges are broken and weak hair cuticle formed, adding the keratin protein no only protects the hair but also increase the amount of cysteine available to hair, minimizing damage and increasing tensile strength and as for other protein, keratin protein also has a protective colloid effect in reducing chapping and irritancy caused by other harsh products (Classic Distributing Company, 2010, "Hydrolyzed Keratin Protein", para. 2).

1% of citric acid and DMDM hydantoin are added to the formulation to act as the preservative for the cream. Beside, citric acid also function to adjust the pH of the cream since the main ingredients is in alkali concentration, the citric acid is needed in order to adjust the pH of the cream to mildly acidic. According to Laura (2014), hair products usually contains small quantities of citric acid as it can sliver mineral from water however, an excess of this acid could remove essential minerals from hair and may even leave it slightly bleached, therefore only 1% is used in the creams. For DMDM hydantoin, it functioned in the cream as increasing the shelf life of cosmetics by releasing formaldehyde and thus killing bacteria. For the formulation, the amount of DMDM Hydantoin required to preserve the product within 0% to 1% does not expose the consumer to any harm from formaldehyde as recommended by the CIR Expert Panel (Quora, 2015, " DMDM Hydantoin as Preservatives", para. 2).

For this formulation, 3% of dimethicone are added to each sample as an emollient. Dimethicone is a must have product in the hair care products since it also help to keep the hair moist and shiny. According to Frank (2016), the low surface tension of the dimethicone enables it to spread thinly and evenly along the hair shaft and producing an even looking conditioning effect and in fact, the product that contain dimethicone is applied to hair, they quickly form protective films, locking in water in order to optimize strength and also premature wash out of hair dyes and tint. Other than that, dimethicone also influence the



viscosity of the hair treatment cream and for this formulation, high viscosity dimethicone is used to increase the efficiency of the cream produced.

The difference in the three formulations is based on the essential oil content in the cream. For formulation 1, the coconut oil is added to the hair at 7% proportion. This is because coconut hair has the ability to remove sebum build up from the hair follicles. According to McKeir (2013), the use of coconut oil on hair helps to reduce the protein loss in both damaged as well as undamaged hair because since this oil is rich in lauric acid, it has a high affinity for hair protein and easily penetrates inside the hair shaft due to its low molecular weight. In the second formulation, jojoba oil is used to remove sebum which is present at the scalp there by promoting hair growth. Consequently, the jojoba oil will also protect hair strands from breaking and drying up. According to Shaath (2012), jojoba oils help hydrate hair and scalp very effectively by forming a semi permeable protective layer around the hair, hereby sealing the moisture but still allowing the scalp to breathe. Therefore, by the composition of 7% jojoba oil in the cream, the moisture retained will help to strengthen the hair shaft by promoting elasticity thus preventing any form of hair brittleness.

In the third formulation, rose oil is added to the formulation at 3% proportion in the cream. Since the rose oil is very thick and have a quite strong smell, only small quantities of rose oil is added to the cream. In 2010, Chinese researchers published a study uncovering that rose oil exhibited one of the strongest bactericidal activities compared to 10 other oils and therefore, the maximum of about 5% composition of rose oil is sufficient for the hair treatment cream (Dr. Axe Food Medicine, 2017, “Rose Essential Oil Benefits Skin, Depression and Hormones”, para. 2). Lavender oil is also used in formulation 1 and 2 in order to add fragrance to the hair treatment cream and for each formulation only 3% proportion is added. Besides, in one study of 86 people with an autoimmune disease that causes hair to fall out, often in patches, those who massaged their scalps with lavender and other essential oils daily for 7 months experienced significant hair regrowth compared to those who massaged their scalps without the essential oils (University of Maryland Medical Centre, 2017, “Lavender”, para. 7).

### 4.3.2 pH Analysis

Human hair is a solid material that composed protein molecules with three distinct layers. For hair, it is covered by a very thin fluid layer comprised of oil, salt and mantle called mantle, which is slightly acidic (pH = 4.5 -5.0) and this acid mantle is very important in maintaining the proper moisture balance in hair. Therefore, with the normal exposure to the washing and styling, this acid mantle can be contaminated or removed and in order to restore it, it must be done by the use of properly pH-balanced products. For human hair, mildly acidic (pH = 4.0 -5.0) can be applied in order to protect the hair.

Based on the result of pH analysis in Table 4.4, the hair treatment cream can be assumed stable in term of pH concentration. The average pH for all formulation lies within the mildly acidic range which the pH value for formula 1 is 4.6, for formula 2 is 4.87 and for formula 3 is 4.73. The pH values for each of these formulas are influenced by the citric acid which is the pH adjuster in the formulation. Besides, the ingredients such as cethyl alcohol, stearic acid and keratin protein of the cream also affected the pH value of the cream. However, since the composition of citric acid, cethyl alcohol, stearic acid and keratin protein in the cream is maintained for each formula, the pH result for each formula is can be close to each other.

Since the manipulated ingredient in each cream is the composition of the essential oil, the pH value also might be influenced by the essential oil. For formula 1 that contained coconut oil that has pH around 3.5 to 5.5 (acidic), formula 1 has the pH value of 4.6 which is the lowest compared to the other 2 formulation. According to Hew (2016), the pH of jojoba oil is 4.21, thus with the addition of citric acid in the formula, it makes formulation 2 (pH = 4.87) more acidic compared to formulation 1. For formula 3, the average pH value of the cream is 4.73 which also lie within the mildly acidic range. Therefore, based on the pH value, the creams are suitable to be applied to the human hair because the pH of each cream falls within the range of pH value of the hair's mantle.

### 4.3.3 Centrifugal Testing

For the centrifugal testing, based on the result obtain, there is no separation in all the three cream sample formed at 1000 rpm, 2000 rpm, 3000 rpm and 4000 rpm. This could be the oil phase and water phase are homogeneously mixed at the optimum temperature which is 70 °C. Besides, the amount of keratin protein and dimethicone also influenced the viscosity of the cream and since the amount of these ingredients is maintained for all formulation, the three formulations show no separation between the phases until 4000 rpm. According to Akhtar (2011), the cream is considered stable if there is no phase separation at 4000 rpm during the centrifugal testing. Therefore, all the cream are stable and homogeneously mixed since there is no separation between the oil phase and water phase till 4000 rpm.

### 4.3.4 Color Evaluation

The samples are stored at room temperature in a beaker for a month. For the first 24 hours, all the samples show no changes in color. This situation is maintained for the first two weeks which the cream is still in white color. However, during the third week, the cream with formula 2 and formula 3 start to change color into light yellow while for formula 1, the cream maintained in white color. For formula 2 and 3, not only the color change, the smell also started to smell pungently. For formula 2, the smell of the lavender oil start to become thicker and not friendly to the user and the condition same goes to formula 3 where the rose smell start to become thicker and pungent. During the third week, the cream with formula 1 still maintained its smell that have the light lavender smell and still in white color.

For the formula 2, the change in smell could be due to the smell of the jojoba oil itself. Since jojoba oil have a very strong smell of the concentrated jojoba, it might be difficult for the lavender oil to overcome the smell of the pure jojoba. For formula 3 which is the usage of rose oil, the smell become too strong may be due to the high concentration of the pure rose. According to Ali (2015), the mechanism of the essential oil involves the integration into a biological signal of the receptor nose when inhaled and then the signal is transmitted to limbic and hypothalamus parts of the brain via olfactory bulb and thus these signal cause brain to release neuromessengers like serotonin which to link our body system and provide a feeling of relief. For the fourth week, the cream with formula 3 started to

change color into light yellow while for formula 2 and 3, the color of light yellow maintained as from the previous week. However, even the color of formula 3 start to change into light yellow, the smell of the cream still remain as the smell during the first day. Therefore, based on the color evaluation, the cream with formula 1 is the most stable compared to formula 2 and 3 due to consistency of physical appearance of the cream.

#### **4.3.5 Viscosity Test**

Based on table 4.7, the viscosity for each creams are closed to each other. This is due to the usage of dimethicone in each formulation which the main function of dimethicone is to give the viscosity properties to the cream. Based on the result, the cream with formula 3 has the highest viscosity, followed by formula 1 and formula 2. Other than the presence of dimethicone, the viscosity of the creams also depends on the proportion of keratin protein within each cream. Therefore, since the amount of keratin proteins are kept constant at for each formulation, that is why all the formulations managed to have the closed value for the viscosity. According to Matijevic (2011), viscosity test is to ensure the suitable thickness of cream and for a good result, the viscosity of the cream should be within the range of 3000000 to 4000000 cps. Therefore, this proves that all creams with formula 1, 2 and 3 are within the preferable viscosity.

#### **4.3.6 Surface Imaging Analysis (SEM)**

Based on figure 4.3, it can be seen that for the original hair, there are a rough surface of the hair with the obvious gap on the hair cuticle and that's might be due to the treatment applied on the hair previously. However, for figure 4.4, after the hair is being treated by cream with formula 1, the cuticle gap on the hair strand has become less obvious and the hair surface start to look smoother. It shows much improvement compare to the original hair surface. For figure 4.5 and figure 4.6, the application of the hair treatment cream also managed to reduce the visibility of the cuticle gap on the hair but not as much as been done by formula 1. Besides, the surface imaging of the treated hair by using local product, "Sunsilk Instant Damage Reconstruction Cream with Keratin Complex". Based on the result in figure 4.7, the surface imaging of the hair sample also show the smooth surface with the less visibility of the cuticle gap.

As for the result, the application of the local product and hair treatment cream with formula 1 show the smooth surface with reducing gap on the hair's cuticle into less visible. For formulation 2 and 3, the application of the hair treatment cream managed to reduce the visibility of the cuticle's gap on the hair surface but for overall surface, the surface of the hair samples still look quite rough. According to Vala and Kapadiya (2014), coconut oil is the best natural nutrients for hair that helps in healthy growth of hair with a shiny quality and in fact, coconut oil is also effective in reducing protein loss which can lead to various unhealthy growth in human's hair. For formulation 2, by using jojoba oil as the essential oil, the result is less obvious might be due to the function of jojoba oil. Jojoba oil is good for hair because human sebum and jojoba oil are virtually identical so it is more to protect and moisturizes the hair by restores them to their natural pH (Joshi & Pawar, 2015). In addition, according to Joshi and Pawar (2015), the nutrients in rose oil are more effective in dandruff treatment other than repairing the hair structure. Therefore, that is why formulation 1 is more effective to repair to damaged hair compare to formulation 2 and 3.

#### **4.3.7 Skin Irritation Evaluation**

For the skin irritation evaluation or patch test is always recommended to be done whenever someone is about to try a new product and in this case, the creams that have been developed had been rubbed on human skin for 24 hours. For this test, the cream is rubbed on the inside of the elbow and for the first 24 hours after the rubbing process, did not show any effect on the elbow's skin. In order to gain a better result, the creams are applied on skin for 48 hours and the results remain the same which there are still no effects such as reddish, itchy or swelling on the skin. According to Pai (2017), when someone is about to apply the new product, the person must patch the skin like applying the cream behind the ear or even on the inside of the elbow and for this test to be done. Then, it is supposed to wait for 24 hours to see if there is any irritation or allergic effect on the skin. Since the application of the cream does not show any effect, the cream is suitable to be applied and does not cause any harm to the user.

## CHAPTER 5

### CONCLUSION AND RECOMMENDATION

#### 5.1 Conclusion

The research is done to develop a hair treatment cream that can repair the damaged hair by repairing and replacing the hair keratins. Keratin and essential oils are used as the active ingredients in this research to repair and protect the damaged hair. Based on the results, formulation 1 shows the best result since it managed to achieve the cream stability according to the industrial cosmetic standard. Besides, the combination of the coconut oil and keratin protein with acidity of 4.6, help the cream to penetrate through the hair cuticle and repair the hair structure since the cream acidity is closed to the hair's acidity. Other than that, formula 1 is also can be considered stable since it did not show any separation even after the centrifuge testing at 4000 rpm. In addition, the cream with formulation 3 has the highest viscosity compare to the other cream sample and thus, this also helps the cream to stay longer on the hair surface to undergo the repairing action. For the surface imaging analysis, the hair treated by the cream with formulation 1 show the protein on the hair's cuticle surface is improving by reducing the cuticle gap and looks even smoother than the original hair's surface. Last but not least, the creams application on human skin did not show any effect so it can be used by people without causing any harm to them. Therefore, it can be concluded that the objective of this research is achieved.

## 5.2 Recommendation

For this research, there are few recommendation can be applied during the experimental works to increase the result of the research. Firstly, the cream should be mixed by using a homogenizer at higher speed in order to ensure that the cream is more homogenize and not easy to be separated into two phases. Besides, the oil and water phase should be heat at 70 °C for 20 minutes after the phases is prepared in order to ensure that the ingredients in both the oil and water phases is really mixed before the phases are combine to form the solution. Next, it is also advisable to use more than one emulsifier in the cream preparation. This is made in order to ensure the emulsion system of the cream is achieved and less error would occurred when using more than one emulsifier and when choosing the emulsifier, it is better to choose any other emulsifier rather than co-emulsifier. Other than that, preservative is very important in this research in order to ensure the creams stay in its stable condition without any contamination for a long time. Last but not least, an ingredient such as zinc oxide can be added to the cream in order to maintain the white color of the cream.

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