FORMULATION OF HAIR STRAIGHTENING CREAM FROM KERATIN PROTEIN

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ABSTRACT

A research was conducted on the formulation of hair straightening cream from keratin protein. The keratin that used in this formulation was extracted from chicken feathers. The keratin plays an important role during the hair straightening process in order to straighten the hair and reduce the damaged on the hairs. Our hair consists of mainly keratin but in normal condition the hair consists of alpha keratin. The original configuration of the hair is held in place by the bonding found in the cortex layers of the hair. There are four types of bonds which are hydrogen bond, sugar bond, cystine bond, disulphide bond and salt bond. The hair straightening cream will break the disulphide bonds in the hair during the hair straightening process and allowed the confirmation of the new disulphide bonds with the new arrangement, thus giving the hair a new shape. The formulation was made with the mixture of water based and oil based chemicals. Firstly, the oil based and water based mixture were prepared separately at temperatures 60-70 °C. After the mixture was soluble, the water based mixture poured into the oil based mixture at a temperature around 60-70 °C. The mixture then stirred immediately until the temperature dropped to 40 °C. Finally the keratin protein and the fragrance were added into the mixture and the mixture was continuously stirred at room temperature for 2 hours. The result shows that, the formulation has the ability to permanently straighten the hair without the damage to the hair. The SEM analysis proven that the keratin can reduce the damaged to the hair during the straightening process. The characterisation test to the hair straightening cream like pH analysis, colour analysis, centrifuge test, FTIR test, viscosity test, and cycle test (freeze and thaw) shows that the cream is stable and within the standard range. Chicken feather is one of the important source of keratin. This is a good idea because poultry feathers are dumped, used for land filling, incinerated or buried which involves problem in storage, handling, emission control and ash disposal. Therefore, the use of the chicken feather in this project can reduce the waste disposal of the chicken feathers.

ABSTRAK

Penyelidikan telah dilakukan untuk menghasilkan formulasi krim pelurus rambut yang mengandungi keratin. Keratin yang digunakan dalam formulasi ini adalah keratin yang telah diekstrak dari bulu ayam. Keratin memainkan peranan yang penting dalam proses meluruskan rambut dan ia juga mengurangkan kerosakan pada rambut. Rambut yang normal terdiri daripada alfa keratin. Konfigurasi asli rambut dapat dikekalkan oleh ikatan yang terdapat dalam lapisan korteks rambut. Terdapat empat jenis ikatan iaitu ikatan hidrogen, ikatan gula, ikatan cystine, ikatan disulfida dan ikatan garam. Krim pelurus rambut akan memutuskan ikatan disulfida antara rambut semasa proses pelurus rambut dan menghasilkan ikatan disulfida dengan susunan baru, sehingga memberikan bentuk rambut yang baru. formulasi krim pelurus rambut ini dibuat dengan campuran bahan kimia yang berasaskan air dan minyak. Pertama, campuran berasaskan minyak dan berasaskan air telah disediakan secara berasingan pada suhu 60-70°C. Setelah campuran itu larut pada suhu tertentu, campuran berasaskan air dituangkan ke dalam campuran berasaskan minyak pada suhu sekitar 60-70°C. Campuran kemudian dikacau dengan serta-merta sehingga suhu krim turun kepada 40°C. Akhirnya protein keratin dan pewangi akan ditambahkan ke dalam krim dan krim dikacau secara berterusan pada suhu bilik selama 2 jam. Hasil kajian menunjukkan bahawa, formulasi ini mampu untuk meluruskan rambut secara kekal tanpa merosakkan pada rambut. Analisis SEM membuktikan bahawa keratin boleh mengurangkan kerosakan pada rambut semasa proses pelurus rambut.Ujian pencirian krim pelurus rambut seperti analisis pH, analisis warna, ujian centrifuge, ujian FTIR, ujian kelikatan, dan ujian kitaran (beku dan cair) menunjukkan keadaan krim adalah stabil. Penggunaan bulu ayam sebagai sumber yang penting untuk keratin adalah idea yang baik kerana bulu ayam digunakan untuk mengisi tanah, dibakar atau ditanam akan menyebabkan masalah dalam penyimpanan, pengendalian, kawalan emisi dan pembuangan abu. Oleh itu, projek ini dapat mengurangkan masalah yand disebabkan oleh pembuangan bulu ayam.

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FTIR	Fourier transform infrared spectroscopy
SEM	Scanning electron microscope
RPM	Revolutions per minute
KAP	Keratin associated protein

1 INTRODUCTION

1.1 Research Background

Hair is generally can be divided into four types which were wavy, straight, curly and kinky. But many people often desire to straighten their hair permanently which will look shiny, silky and easy to manage. There are many methods available to straighten the hair, but these involve the use of harsh straightening agents such as alkaline and sulphite-based chemical to permanently alter the natural curl of human hair by break the bonds within the hair including salt bridges and disulphide bond (Mckay, 2004). This project is very useful and significance because the hydrolyse keratin use in hair straightening cream is from chicken feather. Worldwide 24 billion chickens are killed and almost 8.5 billion tons of poultry feathers are produced. The poultry feathers are dumped, used for land filling, incinerated or buried which involves problem in storage, handling, emission control and ash disposal (Arunkumar et al., 2013). So this project is a good idea to use waste poultry feathers in the manufacturing of the hair cream. Since the keratin has the same structure with human hair, it will absorb and repair the damage to the hair during the hair straightening process(Fujii & Li, 2008). As a result the hair after the straightening treatment will look smooth, shiny, and silky (Rouse & Van Dyke, 2010).

1.2 Problem statement

- The keratin protein has an effect in the hair straightening cream.
- The present hair cream containing harmful chemical which can damage the hair.
- The management of the waste product that is chicken feathers.

1.3 Objectives

The study is guided by the following research objectives:

- To analysis the effect of the amount of keratin in hair straightening cream.
- To produce the hair straightening cream with keratin protein, which cause reduced damage to the hair.
- To analysis the hair straightening cream.

1.4 Scope of this research

Based on the above objectives, the main scope of this project was to produce the hair straightening cream with keratin protein. The keratin protein that which used in this project is a hydrolyse keratin from the chicken feathers. The effect of the concentration of the hydrolyse keratin was studied in this project by changing the amount of the keratin. This product then tested by straightening testing, FTIR analysis, SEM analysis and stability test such as centrifuge testing and cycle test. During the stability test, the pH value, viscosity, colour and fragrance were monitored. FTIR analysis is to determine the presence of keratin protein in the product, while straightening test to determine the effectiveness of the product in straightening the hair. The stability test is to ensure that these products are stable when the store at appropriate conditions (Colipa March, 2004).

1.5 Rationale and Significance

Hair is generally can be divided into four types which are wavy, straight, curly and kinky. But many people often desire to straighten their hair permanently which will look shiny, silky and easy to manage. There are many methods available to straighten the hair, but these involve the use of harsh straightening agents such as alkaline and sulphite-based chemical to permanently alter the natural curl of human hair by break many bonds within the hair including salt bridges and disulphide bond (Carol J et al., 2003). By using keratin protein, the damaged on the hair cuticle during treatment will recovered. This project is very useful and significance because the hydrolyse keratin use in hair straightening cream is from chicken feather. According Arunkumar et al., (2013), worldwide 24 billion chickens are killed and almost 8.5 billion tons of poultry feathers are produced. The poultry feathers are dumped, used for land filling, incinerated or buried which involves problem in storage, handling, emission control and ash disposal. So this project is a good idea to use waste poultry feathers in the manufacturing of the hair cream. Since the keratin has the same structure with human hair, it will absorb and repair the damage to the hair. As a result the hair after the straightening treatment will look smooth, shiny, and silky.

1.6 Organisation of this thesis

The structure of the reminder of the thesis is outlined as follow:

There are five chapters in this research. Firstly, Chapter 1 was an overview about this research. It consists of the introduction of keratin protein that had been extracted from the chicken feathers as the one of the important material needed in the formulation to produce the hair straightening cream. The problem statements, research objectives, the scope of the studies and rationale and significance also are included in this chapter.

Figure 1.1: The outline for thesis

Chapter 2 was about a review of the human hair structure, chicken feathers, keratin protein, the application of the chicken feathers and the hair straightening with the others substances that include in the formulations. In this chapter, all the relevant technical paper, journals, books and others taken from those researches will be studied and discussed. In **Chapter 3** the methodology and procedures were discussed in detail. Besides that, the method and techniques used for this system were described in detail. In this chapter also explained the material used in this experiment and the method use to

analysis the data. In **Chapter 4** covered the discussion and result. All the result and data obtain were discussed in detail**.** The detailed report on the product quality analysis was evaluated. The process that was involved during the development of this analysis was explained in detail in this chapter. In **Chapter 5** the conclusion was making for the study by comparing the result obtained and some recommendations were taken.

2 LITERATURE REVIEW

2.1 Hair

Hair is made up of dead and hard protein called keratin. The structure of the hair can be divided into three layers; medulla, cortex, and cuticle. The medulla is the first layer followed by the cortex, which makes up a large part of the hair and finally the cuticle which protects the cortex and determines the health of hair. Hair consists of eighty percent of keratin proteins and other pigments such as lipids and minerals(Guerra-Tapia & Gonzalez-Guerra, 2014). The cortex is surrounded by the cuticle layers, and the cortex contains the major constituent of the fiber. The cortex consists of spindle-shaped cells that are aligned along the fiber axis. The fibrous proteins consist of the cortical. Thicker hairs often contain one or more loosely packed porous region which called the medulla, located near the center of the hair shaft.

2.1.1 Cuticle

The cuticle is the outer layer of the hair which act as a protective coating of the hair which formed from overlapping scales and can be several layers thick. These scales make the hair flexible look shiny and reduce the friction between hair shafts. The outer coating is translucent, which allows the colour of the hair from the cortex to be seen. A healthy cuticle is also controlling the water content in the hair by act as a barrier for the water (Meyers, 2013).

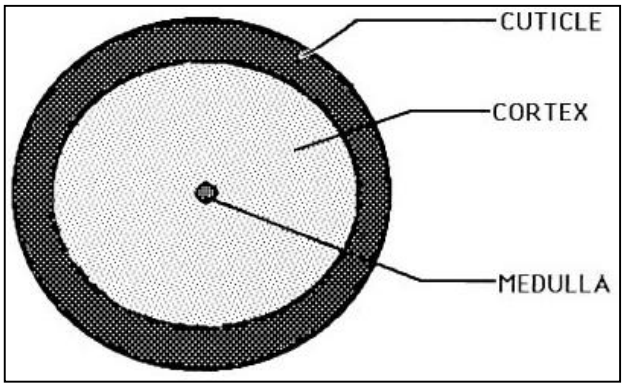

Figure 2-1: Schematic diagram of a cross section of a human hair fiber

Source: Google image

If the cortex determines the mechanical properties of our hair, then the optical properties of our hair are determined by the cuticle. The shine is determined by how the light catches your hair strands. The cuticle in the curly, wavy and fizzy hair will not really reflect the light and it causes the hair look dull. Over the time period, the cells in the cuticle will erode, break, lift, and get ragged edges and the cortex is unprotected. According Swift & Bews, (1974) each cuticle cell contains a thin outer membrane, the epicuticle. Beneath the cuticle cell membranes are three major layers which are the A layer, a resistant layer with a high cystine content, the exocuticle, sometimes called the B layer content less cysteine and the endocuticle content no cystine.

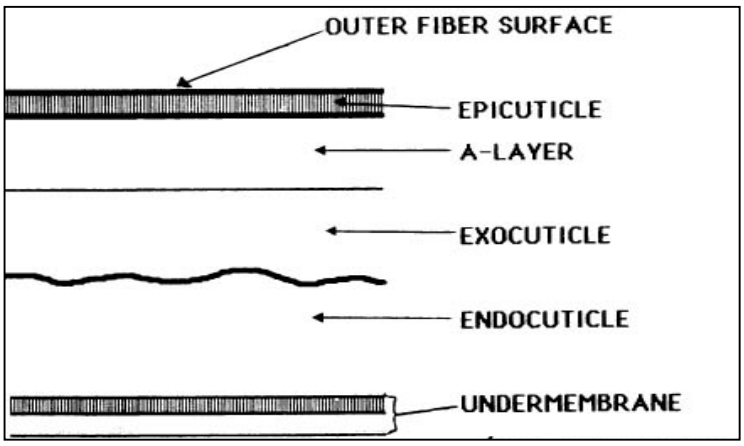

Figure 2-2: Schematic diagram of the proposed structure of a cuticle cell in cross-section

Source: Robbins (2001)

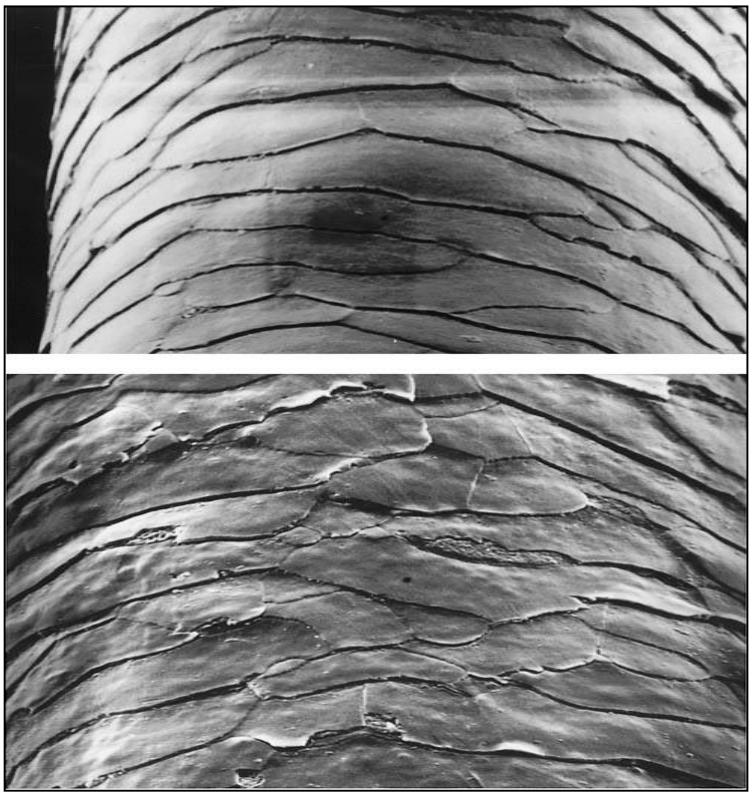

Figure 2-3**:** The cuticle of health and damaged hair
Source: Robbins (2001)

2.1.2 The Cortex

The cortex is the middle layer of the hair fiber with hair bundles are arranged in a structure such as the trunk. In addition to keratin, the cortex is also composed of keratin-associated protein (KAP) (Xavier et al., 2012). Cortex determines the colour of the human hair. There are two types of pigments Melanin, which gives us brown and black and pheomelanin, which gives us yellow and red. The cortex is made up about 80% of the hair mass and provides most of the mechanical strength of a hair fiber. Most of this strength is due to four types bond which are hydrogen bond, salt bond, sugar bond and cystine bond. The hydrogen bond is held two polypeptide in alpha helix form and it has made sure that the hair to be elasticity. These bonds are responsible for approximately 35% of the strength and 50% of the hair's elasticity. Next, the salt bond is an ionic bond formed through the transferring of the electrons from basic amino acid to acid amino group between the two polypeptide strands. It is responsible for approximately 35% of the strength of the hair and 50% of the hair's elasticity. The sugar bond is formed between the acid and the OH group of the amino acid. The last is cystine bond also known as the disulfide bond which formed by cross-links between cystine keratin of the polypeptide chains. This bond is perpendicular to the polypeptide chains. It is responsible for the hair's

toughness or abrasion resistance because of its position in the hair. There is more disulfide bond compared to other bonds with maximum of frequency of one cystine bond every four turns of the alpha helix. This bond is responsible for the wave of the hair. The disulfide bonds are the ones need to break if want to change the shape of the hair permanently, but the bond need break only 25 to 30 percent.

2.1.3 The medulla

The medulla located at the centre of the hair shaft. It consists of the medullary cells. Medullary cells are loosely packed spherical and hollow inside and are bound together with a cell membrane complex type material. The human hair can be divided into three categories which are primary, secondary, and tertiary. The primary hair is very tiny which can help to regulate the temperature of our bodies by evaporation and perspiration process. It grows all the parts of our body. Besides that, the secondary hair is short, bristly and coarse example our eyelashes and eyebrows. The characteristics of the secondary hair are no arector pili muscle, large medulla, and increases in density as we get older. The tertiary hair is the longer hair that grows on our scalps. Tertiary hair was probably there to keep our human body warm and protect human from the sun. Each tertiary hair has its own sebaceous gland to produce oil and an arector pili muscle to lift it up from the scalp.

2.1.4 Hair growth cycle

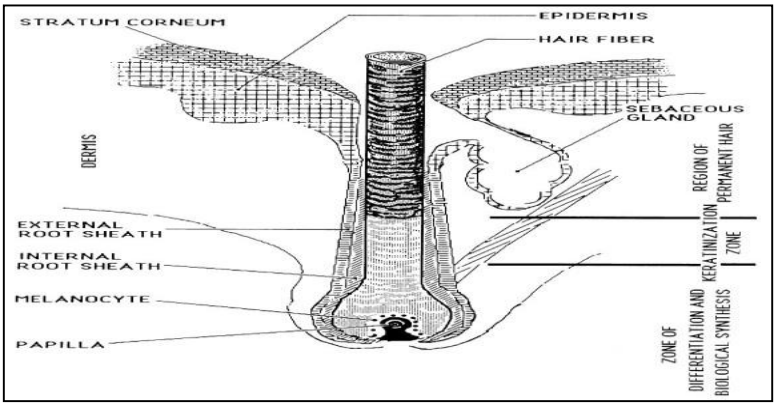

Figure 2-4: Hair follicle with its fiber and the different zones of growth

Source: Robbins (2001)

Hair grows in a cycle that consists of three phases which are anagen, catagen and telogen. The anagen phase is known as a rapid growth phase that lasts between two and eight

years(Lai-Cheong et al., 2013). During the anagen phase the rates of the dividing of growth cells is higher in the papilla and produce the hair shaft which becomes keratinized as it pushes up and out of the follicle into the pore. Simultaneously, the follicle grows down into the deeper levels into the skin to receive nutrients from the blood vessels. People who have long anagen growth rates have very long hair and who have short growth phases will short hair. In the normal condition the growth rate of the hair is about a ½ inch per month (Randall & Botchkareva, 2009). Next is the catagen phase which prolongs for two to four weeks after the anagen phase. In this phase the cell in follicles stop dividing and the hair stops growing but does not fall out. During these phases the hair follicle tends to contracts to about 1/6 of the normal length. The bottom part of dermal papilla detected from the blood supply and the hair shaft is moving up as the follicle disintegrates. The follicle then enter to the telogen or resting phase for two to four months, during this time the hair still does not grow but remains attached to the follicle while the dermal papilla is in a resting phase below. Approximately 10-15 percent of all hairs are in this phase at any one time. After the telogen phase the cycle is complete and the hair goes back into the anagen phase. It is at this time when the new hair shaft is forming that the old hair is pushed out and lost(Robbins, 2012).

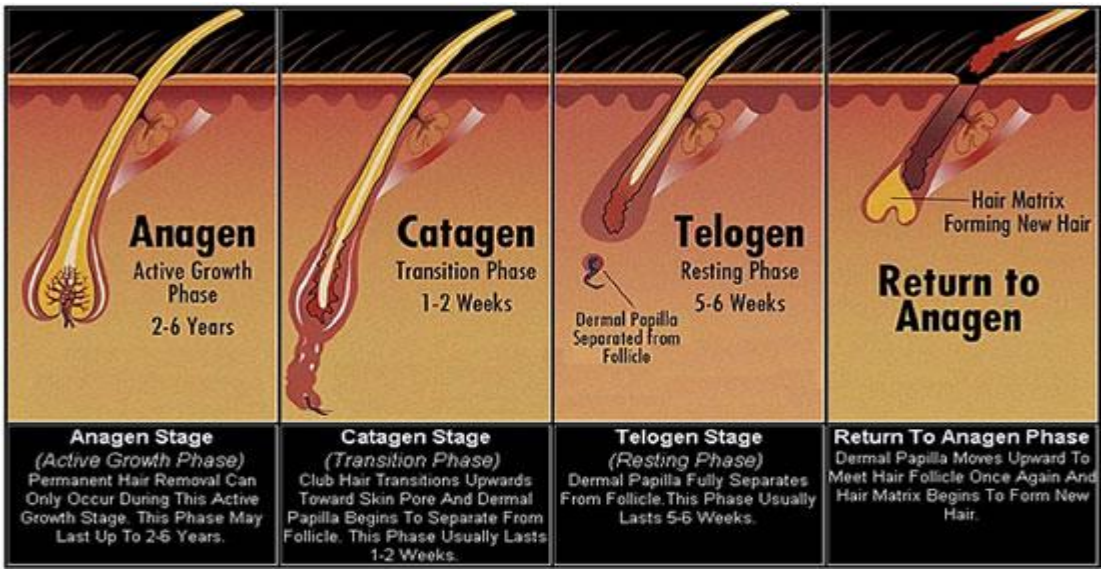

Figure 2-5: Hair growth cycle

Source: Goggle image

2.2 The chicken feathers

According to Chinta et al., (2013) around 15 million tons of chicken feathers are produced worldwide every year as a by-product. Currently the chicken feathers are disposed in many ways like landfill, burned and animal feedstock. These methods are created environmental pollution. Chicken feathers have a characteristic that not found in the other natural or synthetic fibers. The feathers are made up from the keratin which can divide into fiber and quill. The feathers can find only in the bird's group animals which differentiate with other vertebrate. He feathers play an important function. Besides use for fly the feathers also use as an insulator. The feathers can be divided into five major types that are contour, down, semiplume, filoplume and bristle. The keratin in the chicken feathers has the free OH group that gives the ability to absorb moisture from the air. The apparent density of the chicken feathers is 0.89 g/cm3. Since the feathers are made up by keratin, the durability of the feathers is determined by the characteristic of the keratin. The feathers have higher durability due to the structure of the keratin which have network of strong covalent bonds. The physical characteristics of the feathers are resistant to the mild acid and base, but dissolve in the strong acid and base (Arunkumar et al., 2013).

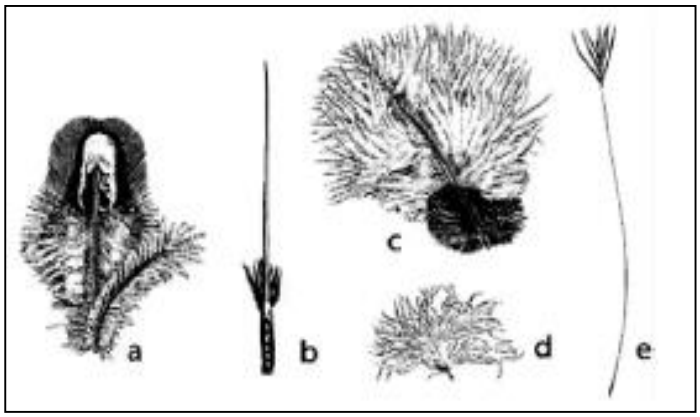

Figure 2-6:The five primary types of chicken feathers: (a) contour, (b) bristle, (c) semiplume, (d) down, (e) filoplume

Source: Arunkumar et al., 2013

Table 2-1: Chemical Composition of Chicken Feather

composition	percentage
Protein	91%
Lipids	1%
Water	8%

Table 2-2: Elemental Analysis of Chicken Feather

Element	percentage
Carbon	48%
Nitrogen	14%
Hydrogen	6%
Sulphur	2%
Others	30%

2.3 Keratin protein

Keratin is a main component in skin, hair, nails, hooves, horns, and teeth. The amino acids in the keratin combine chemically to form a strong keratin it can be inflexible and hard, like hooves, or soft, as is the case with skin. The keratin normally will find in the skin or hair, which formed with the dead cells. It will act as insulating layers that protect the newly formed cells. The old cell will replace as new cells push up from underneath. The keratin is hard and tough since it consists of the hydrogen bond, sugar bond, salt bond and disulfide bond. The disulfide bond form disulfide bridges between the cysteine in the keratin. The hardness of the keratin will increase as the amount of the disulfide bond increase. The Keratin is produced by keratinocytes, living cells that make up a large part of the skin, hair, nails, and other parts of the body. The cells slowly move up, eventually dying and forming a protective layer. However, damage to the external layer of keratin can cause skin, hair, and nails look unhealthy.

2.4 The application of chicken feathers

There are many applications of the chicken feather nowadays. According to Acda, (2010) the chicken feathers can be used as the reinforcement in cement-bond composite to

improve the mechanical strength of the cement. However the increase of the composition of chicken feathers results in the instability and decrease in the modulus of elasticity. Generally up to 100% of chicken feathers in the cement composition will benefit in terms of the strength. The keratin form the chicken feathers also can be used in the leather industry. The hydrolysed keratin in tanning, tanning is the process of the converting putrescible skin collagen into stable stage. Normally in the tanning process, chromium sulphate is used but at high pressures this process. Producing exhaustion with chromium, which is environmentally unfriendly. However, using hydrolysed keratin in the tanning process will reduce the concentration of the chromium in the exhaustion. The second advantage is hydrolysed keratin in retanning. Retanning is the process which improves the quality of the leather by using chemicals. This chemical can cause pollution. By using hydrolysed keratin it can reduce the pollution (Karthikeyan et al., 2007). The chicken feathers have a good adsorbent characteristic and effectively removed the heavy metals like copper, lead, chromium and mercury from the solution (Fan, 2008). Application of the chicken in the multilayer composite is to increase the thermal insulation and acoustic properties. The keratin in the chicken feather has the unique properties which are high thermal insulation because of the disulphide bonds (Arunkumar et al., 2013.). The keratin from the chicken feathers is also used in the cosmetic products. The hydrolyse keratin from the chicken feathers have almost the same structure with the keratin in the human begin. These cause the hydrolyse keratin will repair the damaged keratin in the human begin.

2.5 Method of extraction of the keratin

Before extraction process the chicken feathers must 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. First the chicken feathers are dissolving in the reducing agent such as are potassium cyanide, thioglycolic acid and sodium sulphide. After the feathers are dissolved, ammonium sulphate is poured in the solution to make the protein to precipitate. Then the solution is to 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 et al., 2012).

2.6 Hair straightening cream

Hair straightening cream can be divided into two types that are permanent and temporary hair straightening cream. The temporary hair straightening cream is only break the hydrogen bonds between the strands. When exposed to the air, it will oxidize back and the hydrogen bond will reform. However, for permanent hair straightening cream the active ingredient in the cream will break the disulphide bonds between the strands. This process is known as reducing process. The common reducing agent is sodium hydroxide, potassium hydroxide, lithium hydroxide and guanidine hydroxide (Xavier et al., 2012). The permanent hair straightening cream can subdivided into two that are lye and no-lye. The lye relaxer has a high pH value then no-lye. Higher the pH value means it is a stronger formulation therefore less time is needed to straighten the hair. This lye relaxer also pre-mixed that's mean the user can use it immediately. The lye relaxer makes the hair shiny and silky. The typical hair straightening cream comprises of dialdehyde, surfactant, emollient, emulsifier, preservative, diluent, and skin protecting agent (Grey et al., 2011).

2.6.1 Dialdehyde

Last time the hair care products use aldehyde but now they change to relaxer. The relaxer that contains sodium hydroxide is considered a lye relaxer and the strength varies from a pH of 10-14. The relaxer that contains guanidine hydroxide is considered non-lye. This relaxer is function as to break the disulphide bonds and straighten the hair. Once these bonds have been broken, the process is irreversible and the hair will be straight it grows out or cut it off.

2.6.2 Surfactant

Surfactants are molecules that consist both hydrophobic (water hating) and hydrophilic (water loving) segments. The surfactant is known as amphipilic. The long segment that is a nonpolar hydrocarbon chain and a polar head group (Agents, 2011). The long nonpolar segment will attract oil based solution and a polar head segment will attract water based solution. Surfactant is a surface-active agent that will be used to reduce the surface tension of water and cause the product to leave easily form body. There are many types of surfactants such as anionic, nonionic, zwitterionic and cationic. Anionic surfactants are used to remove dirt and oil from the hair and scalp. Non-ionic surfactants are working as

emulsion stabilization, mild detergent and viscosity modification. Zwitterionic surfactants are dual-charger which consists of both positive and negative charges of the molecules. Cationic surfactants have a positive charge on their head group (McKay, 2012).

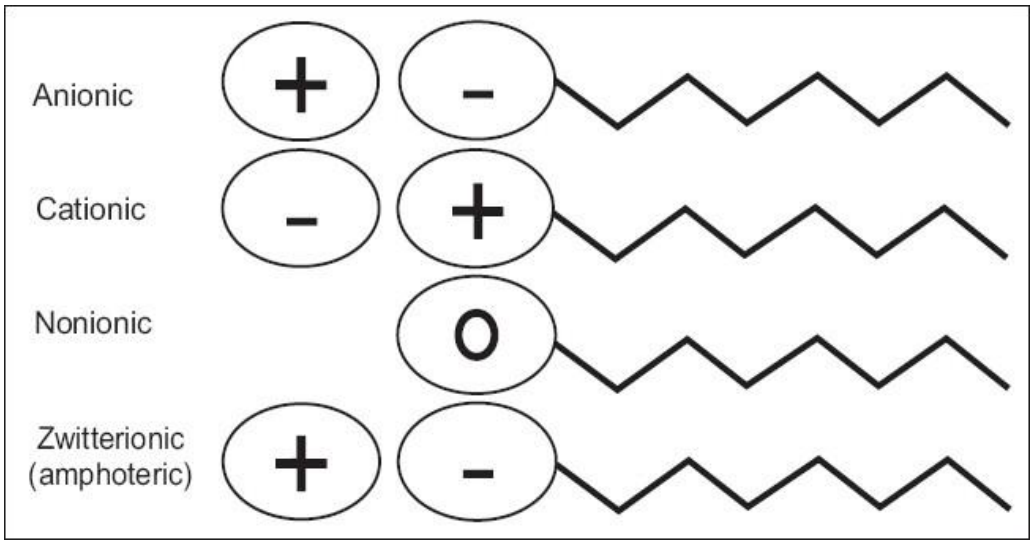

Figure 2-7: Surfactant

Source: Google image

2.6.3 Emollient

Emollient gives softens, soothes, lubricates, moisturizes, protects and cleanses the skin. The emollients also act as humectant, lubricant and occlude. The occlusion slows down the water loss by forming a layer of oil on the scalp. A humectant also reduces the water loss and lubricant reduces the friction between the hairs. The emollient plays an important role in many cosmetic products. The functions of the emollient are to reduce the water loss, moisturising dry skin, repair the damaged cells and allowing other chemicals to enter into the skin (Resnick et al., 2009).

2.6.4 Emulsifier

An emulsifier is a class of surfactant that is use in water-oil phase product. This emulsifier helps to stabilize the product in order to prevent the formation of the layers. It has both a hydrophobic and a hydrophilic end. The emulsifier will help to mixed both oil phase and water phase together to form homogeneous.

2.6.5 Preservative

Bacteria will grow when they are in optimum conditions like correct temperature, moist, pH value. The preservative tries to change the optimum condition for the bacteria to grow. There are two types of preservative, the natural preservative and synthetic preservative. The natural preservative is produce by the product itself in the small amount whereas the synthetic preservation the produce by varies chemical reaction by human. Normally the preservative will use to make sure the product o last longer.

2.6.6 Diluent

Diluent refers to the material that uses to dilute the active substances in the product. Normally water is preferable substances as the diluent. The weight of the diluent is around 80-90% of overall weight.

2.6.7 Skin protecting agent

The hair straightening cream formulations will comprise of one or more skin protecting agents. Skin protecting agents comprise one or more agents that prevent the transmission of microbes include antibacterial agents, skin cleansing agents like disinfectants and antiseptic agents and sunscreen agents. These substances form a protective layer to protect the skin and hair. The skin protecting agent generally 0.5-5.0 % by the weight of the formulation (Resnick et al., 2009).

2.7 Conclusion

Based on the literature review, the straightening cream is use to straighten the kinky, curly, or even wavy hair. There are a number of hair straightening compositions and methods are available today, but a correct methods and composition are needed to produce better and safe formulation. The methods that are used to formulate the hair straightening cream will be discussed in following chapter.