

## EFFECTIVENESS OF SULFATE FREE SHAMPOO FOR HAIR COLOR FADE REDUCTION

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### Abstract

The coloring hairs are still more popular in adolescent and elderly people for developing personal appearance and covering the grey hair. However, most consumer complaints are the fading of artificial hair color. The present study was aimed to investigate the effectiveness of sulfate free shampoo for reducing hair color fading as a result of shampooing process. The pre- questionnaires were used to determine the best type and tone of hair dye product from 30 dyed hair participants. Then, four shampoos were formulated (SLES, SLES with NaCl, SLS and sulfate free shampoo) and tested on four hair tresses. Each hair tress was prepared by bleaching and dying with a permanent hair dye, followed by shampooing for 3 minutes, 10 times. The color fading value ( $\Delta E$ ) of hair tresses was measured using colorimeter. The satisfaction of shampoos was determined by preference test (n=30). The result showed that  $\Delta E$  of sulfate free shampoo was significantly lower than three shampoos containing sulfate ( $p < 0.05$ ). It suggests that sulfate free shampoo can slow down the process of artificial hair color fade. In addition, most of participants satisfied sulfate free shampoo due to providing hair softness, cleanness, easy spreading and fine foaming. Therefore, sulfate free shampoo might be an effective shampoo for hair color fade reduction.

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**Keywords :** hair color, color fading, sulfate free shampoo, color wash fastness

### Introductions :

Hair coloring is widely used in women and men to improve their personality, change natural hair color, cover the grey hair (Marchioretto, 2004). However, the fading problem was become a common problem in artificial hair color (Zhou *et al.*, 2009). The influences factors of fading color were included two main factors, physical and chemical factors. The physical factor mostly found in daily life such as wash-out procedure during shampooing process. The chemical factor generally affect to chemistry of the colorants such as influence of sunlight (Blyumin *et al.*, 2014).

Shampoos are the cosmetic products that have property for cleansing hairs and scalp. (Badi and Khan, 2014). However, many shampoo in market contained Sodium Lauryl Sulfate (SLS) and Sodium Laureth Sulfate (SLES) which it is hard surfactants but good foam ability. These surfactants are cause of color fading by dropped out color molecules. So, these surfactants are not suitable for people who have artificial hair color because it have some ingredients that can fade color molecule by the washing out process on the hair shaft (Kortemeier *et al.*, 2014).

Sulfate free shampoos were formulated with little to no alkaline soap base (Merrison, 2014). There are no hard detergents stripping or drying the hair (Arnez, 2012). It have generated as wetting agents to be harmony with hair and soft water sources and generally

are known to be protect artificial hair color and maintaining the natural oil in the hair (Merrison, 2014).

Sulfate free shampoo is a new trend of shampoo which contained mild surfactants, wash fastness and conditioning agents (Kortemeier *et al.*, 2014).

The aim of this study was focused on the effectiveness of sulfate free shampoo for reducing the color fade by compare with primary surfactant.

## **Methodology :**

### **Hair samples preparation**

Virgins hair samples were obtained from two volunteers. Hair sample was prepared into two sets red and blue color. Hair tress sample is 0.8” wide, and 6.7” length. Each set of hair sample were contain 5 hair tresses. Hair preparations of this study were composed of bleach hair tresses

3 times per set and leave it at room temperature for 30 minutes per times. Hair tresses were treated with a mixture of 7 g of hair bleach base and 7 g of developer lotion that contain 12% of hydrogen peroxide.

After bleaching procedure, hair samples were dyed with commercial permanent red and blue color hair dye products. Both of hair dye products are composed of mixture of 7 g of hair dye base and 7 g of developer lotion. Each hair tress was dyed 1 time and leaf it at room temperature for 30 minutes. After bleaching and dying procedure, hair tresses were rinse off with water at room temperature for 2 minutes and then dried with hair blower.

This method was developed by researcher from protection of oxidative hair color fading from shampoo washing by hydrophobically modified cationic polymers (Zhou *et al.*, 2009)

### **Pre and post questionnaire**

These studies were used questionnaire both of before and after study. Pre-questionnaire was study hair dyed behavior following type of hair dye, color tone, frequency of hair dye and factor that make participants change their hair color and also to study about hair care regiment in participants who dye their hair. The participants were teenager amount thirty participants in Mae Fah Luang University. The ranges of age were 18-23 years old. The results of this study were used to determining the type and tone of hair dye product in our experiment.

Post-questionnaire were composed of two sections. The first section was survey for compare the shade of hair tresses by people observing. The second section was survey satisfaction of shampoo between sulfate free shampoo and commercial shampoo. The results of post- questionnaire were useful for developing new product in the future.

### **Washing procedure**

Hair tresses were divided into five tresses, including one control and four hair tresses for four shampoo formulations. Each hair tress was treated with 3-4 drops of shampoo and then washed with room temperate water for 3 minutes. After that rinsed shampoo off with room temperature water for 2 minutes and then dried with hair blower. The changing color tones of hair tresses were observed and recorded.

### **Shampoo formulation.**

The chemical and formulation was given by GeTeCe Co., Ltd. and Cosmetic laboratory, Mae Fah Luang University. Hair shampoos were formulated in four formulations. The compositions of the formulations are shown in Table 1.

**Table 1.** Ingredients of shampoo formulations

Part	Ingredient	Weight % (w/w)			
		F1	F2	F3	F4
A	D.I. water	q.s.	q.s.	q.s.	q.s.
	Propylene glycol	1.0	1.0	-	-
B	Sodium laureth sulfate	27.0	27.0	-	-
	Sodium lauryl sulfate	-	-	8.0	-
	Decyl glucoside	-	-	-	8.0
	Coco glucoside	-	-	11.0	11.0
	Cocamidopropyl betaine	5.0	5.0	5.0	5.0
	Cocamide DEA	3.0	3.0	-	-
	Amine oxide	-	-	2.0	2.0
C	Caprylyl glyceryl	-	-	0.05	0.05
	DI water	-	5.0	59.2	59.2
D	Sodium chloride	-	2.0	-	-
	Xantan gum	-	-	100	0.8
	Liquid germal plus	0.2	0.2	-	-
	Citric acid	q.s.	q.s.	q.s.	q.s.
<b>Total</b>					

\*F1 = SLES Shampoo

F2 = SLES Shampoo with sodium chloride

F3= SLS Shampoo

F4= Sulfate Free Shampoo

### Measurement color value

The Chroma meter CR400 (Konica Minolta CR400) is the equipment that used to measuring of color value. An international standard of color space was determined by the Commission International de'Eclairage (CIE) in 1976 which show color value as L\* (brightness component that show the value 0 to 100 ranges), a\* (green to red color direction), b\*(color value from blue to yellow color direction) (Papadakis *et al.*, 2000).

The objective was used in the experiment might change of color which it could not be observed by naked eyes but Chroma meter can measure the changing value of color immediately. A Chroma meter can divide into two main devices which are included measuring head and data processor. The first step, set up machine by connects measuring head and data processor together. The second step, calibrate the machine before using by calibrate with white calibration plate for setting standard value which the value will show on data processor display. The last step, measure the sample subject and print the data out. The color values were calculated by this equation (Kortemeier *et al.*, 2014):

$$\Delta E^* = \sqrt{((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)}$$

$\Delta L^*$  = lightness difference: lighter if positive, darker if negative

$\Delta a^*$  = red–green difference: redder if positive, greener if negative

$\Delta b^*$  = yellow–blue difference: yellowish if positive, bluer if negative

**Satisfaction data analysis**

This study used likert scales for analyzed data of shampoo satisfaction which likert scales are a comfortable method of collecting data with a number of different approaches concept. The information about a respondent’s opinion, feelings or satisfied on a special topic that is over easily receiving a disagree/agree or yes/no response (David and Sutton, 2011). The likert scales compose of five points: strongly like, like, moderate, unlike, and strongly unlike. This point used for shampoo satisfaction. In part of proximity of hair color shade used the scales following strongly similar, similar, moderate, different, and strongly different. The lastly, result were analyzed by using score following Table 2 and 3.

**Table 2.** Score of shampoo satisfaction

Level	Score	Agreement
5	4.21-5.00	Strongly like
4	3.41-4.20	Like
3	2.61-3.40	Moderate
2	1.81-2.60	Unlike
1	1.00-1.80	Strongly unlike

**Table 3.** Score of proximity color shade

Level	Score	Agreement
5	4.21-5.00	Strongly similar
4	3.41-4.20	Similar
3	2.61-3.40	Moderate
2	1.81-2.60	Different
1	1.00-1.80	Strongly different

**Data analysis**

Data were analyzed using SPSS v.21. Paired sample t-test was used for determining significances.  $P < 0.05$  was considered as significant

**Results and Discussion :**

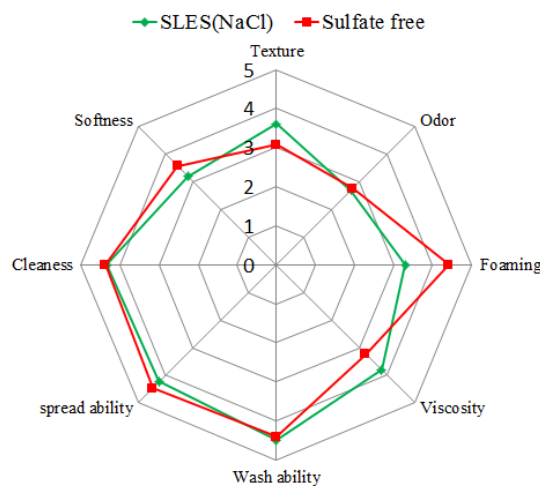
**Dye hair behavior**

From the general information, we observed hair dyeing behavior in Mae Fah Luang university (MFU) students for 30 people, aged 18-22 years old. From the result of survey we found that the majority type of hair dye were permanent hair dye coloring (85.7%), semi- permanent hair dye coloring (11.4%), and temporary hair dye coloring (2.9%). The most favorite tone of hair dye was bright tone (60.0%), brown tone (34.3%), and dark tone (5.7%) respectively. The participant would like to change hair color because they

want to improve personality (65.7%), just fashion (14.3%), increase a confidents (11.4%), and other (8.6%). The overall of period of time that color able to stain on hair fiber around 1-3 weeks (68.5%). However, the reason that faster color fading might be from hair care regiment. As the results of questionnaire were shown the most of participants washed their hair for 3 times per week (37.1%). Finally, all of participants (100%) need shampoo that can help to retard color fading and suitable for hair dyeing.

From the result of observation, Most of people used oxidative permanent hair dye because this type of hair dye were provided shampoo washing resistance, long lasting, have widely range of color shade and also have efficiency covering natural hair (Neuser and Schlatter,2010). The result of this observation has influenced to choose hair dyed product and color tone in this study.

The satisfaction of shampoo, we selected shampoo formulation 2 and formulation 4 to compare together. This satisfaction were observed the differences property of each shampoo such as texture, color, odor, foaming and cleansing ability, spread ability, viscosity, and softness of hair after use. The result is shown in Figure 1. There are no differences between both of them, but the most of participant are satisfied sulfate free shampoo more than commercial clarifying shampoo.



**Figure 1** The satisfaction of two shampoo formulation.

From the satisfaction result, most of participants are satisfied Sulfate free shampoo more than commercial clarifying shampoo because bubbles were fine and soft. Actually, non-ionic surfactant was less foaming but this formulation was contain Amine Oxide which act as foam booster and foam stabilizer for increasing the stabilizer of foaming ability (Karasova *et al.*,1987).

**Shampoo formulation**

There are 4 types of shampoo formulations that one shown in Table 1, they were different ingredients. Three surfactants were selected in this study: SLES, SLS and Decyl Glucoside. The formulation 1 and 2 contained SLS. SLS is an anionic surfactant which it have very good foaming ability but less mild to skin and hair. In cosmetic products, SLES was used as cleansing agent, solubilizing agent and stabilizer. (Robinson *et al.*, 2010). The formulation 3 contained SLS as a main surfactant which it have the property like SLES but SLES is lower mildness than SLS (Kortemeier *et al.*, 2014). Decyl Glucoside is a

nonionic surfactant that used in formulation 4. The function of Decyl Glucoside is made from natural fatty alcohol and glucose which are derived from coconut. Decyl glucoside is very mild, gentle and can be used on all kind of skin (Fiume *et al.*, 2013). All of formulations were clarifying shampoo, no odor and contain high efficiency of cleansing and washing ability. The differences between four formulations were viscosity of shampoo texture.

### **Color fading analysis**

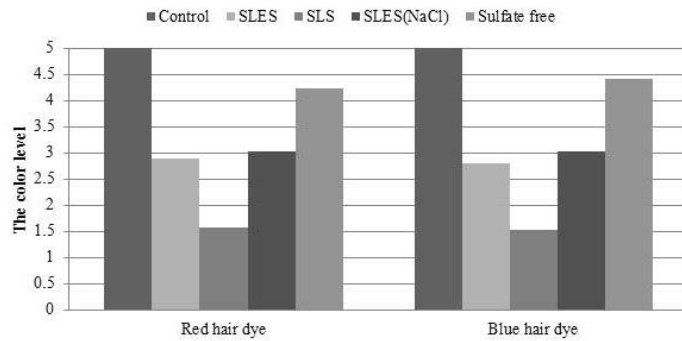
During the washing process, Hair samples were observed the color of bubble at the first to the fifth washing which the color of bubble comes from shampoo formulation 1 to 3, but the color bubble of shampoo formulation 4 has very light blue or almost no color. The bubble colors were found in both of red hair and blue hair. Hair samples were washed and measured color change by using Chroma meter 400. Table 5 shows the result of wash fastness study of 4 shampoo formulation. The first shampoo formulation lead to significant faster color fading was SLS shampoo which it significantly fading since second wash cycle. The second shampoo formulation lead to significant faster color fading were SLES and SLES with NaCl shampoo which it significantly fading since thired wash cycle. The last shampoo formulation lead to significant faster color fading was SLS free shampoo which it significantly fading since fifth wash cycles. Figure 2 and Figure 3 were value from Table 5. The graph shows the tendencies of value were increase color fading. All of values were crowd together but value of SLS free was separated from other formulation because the rate of fading was slower than other shampoo formulation.

The assessment of physical appearances of hair color fading was evaluated and analyzed by naked eyes, likert scale satisfaction of 30 participants of Mae Fah Luang University was shown in Figure 4. Both of red and blue color fading was shown in the same way. The result of hair color fading was observed with naked eyes. The result was shown that Sulfate free shampoo which the most to slow down the color fading when compared with other formulation ( $4.23 \pm 0.5$ ) in red and ( $4.3 \pm 0.53$ ) in blue. Both of color fading of SLS free shampoo closed to the control.

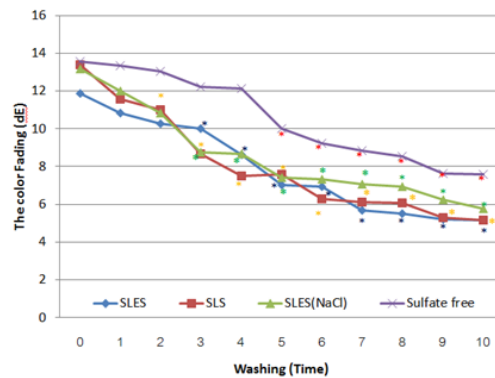
Due to the effect of hair damaged from hair coloring was contributed to hair color fade faster when wash the hair. Due to there are many step of using chemical product for dyed hair such as coloring and bleaching hair that lead to destruction of hair structure and mechanical properties (Bhushan, 2010). The hydrogen peroxide of coloring product is an oxidizing agent that degraded hydrogen bond of hair structure (Robbins, 1979). It affect to the cuticle damaged because the procedure coloring and bleaching hair need to open the cuticle for ensure to cortex layer (Dias, 2015). Shampooing action is a cause the cuticle lifting of scales. This action lead to color rinse out with water due to the small molecule of color can drop out easily from cortex layer of hair fibers (Robbins, 1979). The other hairs dyed stripped factor were depended on the hard surfactant property in shampoo (Koh, 2011). In this case, it could be explained that shampoo contain hard surfactant such an anionic surfactant including SLS and SLES could not protect hair fading. Meanwhile, Sulfate free shampoo was contain mild surfactant as a nonionic surfactant such as Coco Glucoside and Decyl Glucoside can slow down color fading process.

Furthermore, the electrical charge of surfactant is a factor of hair color fading because charge of surfactant has a reaction with cuticle on hair fiber. When shampooing, the

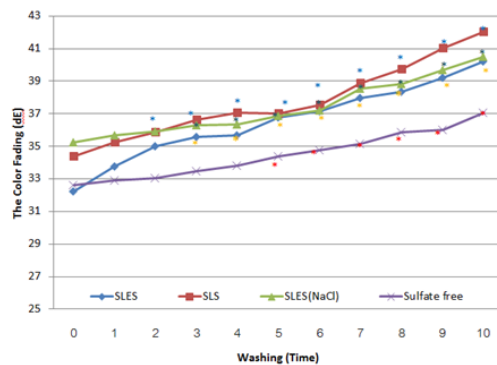
negative charge on hair fiber and anionic surfactant repel each other which it has reaction to cuticle and then color molecule can fade out easily (Robbins, 1979). This principle can explain the result of experiment that sulfate free shampoo no charge to catch with negative charge of hair because it composed of non-ionic surfactant.



**Figure 2** The color fading value (dE) of blue hair with differences shampoo by using Chroma meter CR-400 which it measure after 1-10x shampooing.



**Figure 3** The color fading value (dE) of red hair with differences shampoo by using chroma meter CR-400/410 which it measure after 1-10x shampooing.



**Figure 4** The comparison red and blue color of hair dyed after washing process between control and different shampoos, which hair tresses observed the color level in students at Mae Fah Luang University (5 = strongly similar, 4 = similar, 3 = moderate, 2 = different and 1 = strongly different.)



**Figure 5** Red hair dye before and after 10 washing process with each shampoo formulation (CT = control, 1 = Sulfate free shampoo, 2 = SLS shampoo, 3 = SLES shampoo and 4 = SLES with NaCl shampoo), (a) red hair after bleaching and dyeing (b) red hair dyed after 10 washes



**Figure 6** Blue hair dye before and after 10 washing process with each shampoo formulation (CT = control, 1 = SLES shampoo, 2 = SLS shampoo, 3 = SLES with NaCl shampoo and 4 = Sulfate free shampoo), (a) blue hair after bleaching and dyeing (b) blue hair dyed after 10 washes.

### Conclusion :

Sulfate free shampoo is able to slow down the process of artificial hair color fading which it can protect both of bright color tone and dark color tone. In addition, sulfate free shampoo is suitable for every people because most of ingredients are very mild and gentle. However, the fading of artificial hair color not come from washing but it also come from other factor such as heat from electric hair equipment, and sunlight. So, sulfate free is one factor that might be help to slow down the color fading process.

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