

A Study on the Mechanical Change of Emulsion-Treated Hair by Color

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Received_May 03, 2022

Revised_May 23, 2022

Accepted_June 10, 2022

Textile Coloration and Finishing

TCF 34-2/2022-06/127-133

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Abstract With the increasing interest in the expression of individuality and appearance of modern people, it is time to conduct research and development of novel hair coloring from various angles. Therefore, taking into account the order of discoloration of hair pigments, we selected a creative and novel emulsion as a novel material for hair coloring, rather than a cosmetic material such as hot water extract using natural products dealt with in previous studies, commercially available hair manicure, and oxidation hair dye for hair. Thus, the change in tensile strength and elongation of hair samples by color was studied. As a result of the study, hair with green emulsion paint had a significantly higher maximum load, maximum stress, maximum elongation and breaking load, breaking stress, breaking elongation values are shown. Maximum in terms of modulus, green emulsion applied hair and the control group were higher in the 0-15s strain and 15-145s sections, respectively, and the tangential modulus value was much higher in the control group than the experimental group hairs in all the 0-145s sections. This study, which analyzes the dynamic changes of hair samples that extend the daily color gamut, will greatly contribute to the development of innovative hair coloring materials in the research and production of hair beauty works, and it is judged that it will also contribute to the development of the beauty industry.

Keywords color, oil paint, mechanical change, tensile strength, breaking strength

1. Introduction

The modern society, which is rapidly changing at the speed of light, is living in the era of the 4th industrial revolution, and the social norms and values of modern people are also changing rapidly¹⁾. Here, with the basic human instinct for beauty and the rapid development of mass media, the interest in appearance of modern people increases and life becomes more diversified, and the beauty industry continues to develop as it becomes more specialized and subdivided²⁾. In addition, to express beauty, modern people prefer stylish hair styles through various hair dyes rather than natural hair³⁾. A hair style that can upgrade one's image while meeting the situation or purpose also reflects the social image because it contains the culture of the time⁴⁾.

The daily life and colors of modern people are always shared, so they are highly useful regardless of time and place, and are directly related to life within the sphere of influence both

mentally and physically. Light is a kind of electromagnetic wave, and it is divided into visible light, infrared light, and ultraviolet light according to the wavelength. Visible light that can be seen by the human eye refracts light through a prism to show seven colors. In the spectrum through a prism, the outer long wavelength of red is 'infrared rays', and the wavelengths in the range of approximately 380~780 nm are called 'visible light' and the short outer wavelength of purple is called 'ultraviolet rays'. Color was created by light, the first phenomenon in the universe, and when light hits the surface of an object, some of it is reflected or filtered to appear as color⁵⁾.

Light and color are directly related to the actions of the human brain, eyes, hormones, etc., and are also related to emotions, so there are many changes and can be very subjective⁶⁾. In addition, color has a unique wavelength and energy and physically affects the human body and psychological state⁷⁾. Therefore, color, which is a means to accurately and consistently measure, record, manage, and transmit color, refers

to the entire process of quantitatively quantifying light, a physical fluid. In the 'three attributes of color', which constituted this system of color theory in three dimensions, hue, lightness, and chroma are expressed as H, V, and C symbols⁸⁾.

Along with the basic human desire to beautify the appearance, the beauty industry has been developing within the range of changing the color of the hair, and for this reason, hair styles due to various hair dyes rather than natural hair are popular. Breaking away from the uniform hair color and treatment technique that was popular in the past, the emphasis has been placed on the individuality of creating a more unique individuality, and hair dye has become an important factor in determining aesthetic harmony⁹⁾. In addition, the aesthetic role of creating a new personality and expressing individual personality by creating more diverse and natural hair colors, from white hair cover dyeing to various stylish dyeing, has emerged.

As such, hair, makeup, and fashion are impossible to exist without color, and they greatly influence human beings psychologically and physiologically, and at the same time contribute to the mass production of various designs¹⁰⁾.

A lot of physical and chemical hair damage is caused by hair dyeing to artificially change hair color using scientific technology to improve an individual's image. Therefore, interest in natural hair dyes with color clarity with less hair damage is increasing. Among them, chemical henna, a plant hair dye, is added with 3 ~ 4% chemical components PPDA (Paraphenylenediamine) to increase dyeability¹¹⁾. On the other hand, synthetic hair dyes that can be selected in a variety of colors and are conveniently used have the advantages of quickness and convenience, but as the fact that PPDA, an important ingredient, is harmful to the human body, it is urgent to develop an alternative hair dye to PPDA¹²⁾.

In particular, beauty such as hair, makeup, and nails, food style, and fashion are essential to modern life. Since the beginning of hair dyeing with materials collected from animals, plants, minerals, etc. derived from diseases or folk beliefs, hair coloring has made remarkable progress. In addition to the magical purposes of the past, the expression of one's individuality has also been actively changing, and the types and colors of modern people's hair have been diversified, from white hair covers to stylish dyeing. Therefore, it is necessary to increase the quality of life and happiness of modern people through research on hair styles related to color from various angles. Since only existing hair coloring products have been used for research and production of hair beauty works, it is more novel and innovative hair coloring development is also necessary.

In the previous studies, most of the materials for hair dyeing or bleaching were hot water extracts using natural products, hair nail polishes sold in the market, and cosmetic materials such as oxidized hair dye for hair. However, in this study, it can be said

that it is groundbreaking because the experiment was conducted with oil paints for art, which are generally difficult to imagine or access. In addition when bleaching hair pigments at a hair salon, orange and green oil paints, which are one of the daily color materials, were selected, paying attention to the fact that the pigments usually fall out in the order of black, blue and red.

Through the stress applied in the axial direction and the resulting strain, the mechanical properties of the material such as yield strength, tensile-strength, and elongation can be obtained. These mechanical properties are very important factors in the structural design of hair fibers. The tensile strength of hair is due to the breakage of cystine and hydrogen bonds and molecular rearrangement¹³⁾.

The tensile strength test is measured by applying a constant load and speed to a hair sample of a certain length in a certain environment. Cystine bonds, which have an important effect on the tensile strength of hair, prevent hydrogen bonds between polypeptides from being exchanged with water molecules. Elongation refers to the ratio of the length of the extended hair at break compared to the initial length of the hair, and after the maximum tensile strength, the hair load decreases and leads to breakage¹⁴⁾. Factors that directly or indirectly affect the mechanical properties of hair include relative humidity, temperature, tensile speed, tensile load, chemical treatment, fiber diameter, surface uniformity, and hair pH.

In addition, by studying the change in tensile strength and elongation of hair samples, the dynamic relationship with hair color is analyzed. In addition, we intend to contribute to the development of the beauty industry and to provide basic data on hair science through hair coloring that expands the range of colors used in real life.

2. Experimental

2.1 Hair sample

Sample collection to study the mechanical changes including tensile strength and elongation of hair treated with emulsion paints for each color was carried out with reference to Lee¹⁵⁾. Virgin hair of a woman in her 20s was cut and collected at a point about 50 mm away from B.P.(Back point). Here, the powder-type bleaching agent and the second agent, each having a high affinity for application without clumping, were mixed and applied in a 1:1 ratio. Then, after a clean washing process, it was dried naturally to prepare a 10 level high-brightness bleached hair sample.

For the collected sample, only uniform hair with a thickness of 110 to 130 μm was selected, collected into a bundle of 0.8 g

each, and the top of the hair was fixed with silicone to a predetermined length of about 160 mm. The bleached hair was set as a control group, and orange and green, which are the most used colors in research and production of hair beauty works, were selected and applied with S company's professional oil color 20 ml 24 color oil paints orange and green, respectively. After a certain period of time has elapsed, it was thoroughly washed with W company's neutral shampoo, dried naturally, and used as a sample for the experimental group.

2.2 Measuring instrument

Model TXA™-Precision TXA™ Multi-axis Precision Texture Analyzer of yeon-jin S-Tech was used to measure the mechanical changes of hair treated with emulsion paints by color.

2.3 Measurement method

At room temperature, each hair sample was fixed with a texture analyzer tensile grip, and tensile strength measurement of hair was performed with a load cell of 1 kg and F1 class 100 g calibrated. The data were measured by repeatedly measuring the hair sample 3 times each at 300 pieces per second, filtering 20, and 0.33 mm/sec (20 mm/min) while checking the standard weight.

Through this process, maximum load, maximum stress, maximum elongation, breaking load, breaking stress, breaking elongation, strain maximum. The modulus and tangential modulus values were measured.

3. Results and Discussion

3.1 Diameter, length, speed

Table 1 shows the results of diameter, length, and speed of hair samples. The mechanical changes of the hair samples were analyzed three times at a rate of 0.33 mm/s for the control groups, bleached hair and orange and green emulsion paint, which were all 0.100 mm in diameter and 59.100 mm, 54.000 mm, and 45.300 mm in length, respectively.

3.2 Maximum load, maximum stress, maximum elongation

Maximum load, maximum stress, maximum elongation measurement results are shown in the Table 2.

Maximum load means the face value for the load measured by the measuring equipment when measuring the tensile strength of a hair sample. And the maximum stress, which is the maximum value of physical properties indicating the stress when the material is subjected to a physical blow, means the arithmetic calculation of the liquid level value for the load used in the measurement with the cross-sectional area of the sample. Maximum load, maximum stress, maximum elongation, hair (B') applied with green emulsion paint was 173.43 gf, 216.54 MPa, and 102.99 %, respectively, which was significantly higher than that of the control group or hair applied with orange emulsion paint. On the other hand, hair with orange oil paint applied maximum load and maximum stress showed a lower value than the control group, but maximum. In elongation, it was 78.96 %, which was higher than that of the control group, 43.09 %. This

Table 1. Diameter, length, speed

	Diameter (mm)	Length (mm)	Speed (mm/s)
Control	0.100	59.100	0.33
B	0.100	54.000	0.33
B'	0.100	45.300	0.33
Average	0.100	52.800	0.33
Standard deviation	0.000	6.978	0.00
Standard deviation(%)	0.0	13.2	0.0

*Control : bleach hair, B : hair with orange oil paint, B' : hair painted with green oil paint

Table 2. Maximum load, maximum stress, maximum elongation

	Maximum load (gf)	Maximum stress (MPa)	Maximum elongation (%)
Control	158.48	197.88	43.09
B	147.28	183.90	78.96
B'	173.43	216.54	102.99
Average	159.73	199.44	75.02
Standard deviation	13.12	16.38	30.14
Standard deviation(%)	8.2	8.2	40.2

*Control : bleach hair, B : hair with orange oil paint, B' : hair painted with green oil paint

is maximum stress is also reduced, and the stronger the hair, the maximum load and maximum. Based on the previous study¹⁶⁾ that stress increases, it is proved that the coating power of green oil paints on hair cuticles is superior to orange ones. However, in hair salon practice, the removal power of hair coating power for hair manicure is inversely proportional to that of green color rather than orange color.

3.3 Breaking load, breaking stress, breaking elongation

Breaking for a total of 3 times. Load, breaking stress,

breaking Elongation is shown in Table 3. Maximum load and breaking load of hair sample strain control is shown in Figure 1. And the maximum stress and breaking stress of hair sample strain control is shown in Figure 2.

Same as Table 3 maximum load, maximum stress. It showed a similar trend to the elongation result. That is the hair with green emulsion paint (B') was 150.42 gf, 187.81 MPa, and 103.10 %, respectively, which was significantly higher than that of the control group or hair applied with orange emulsion paint, whereas the hair with orange emulsion paint applied breaking load and breaking stress was lower than that of the control group, but break. Elongation was 79.02 %, which was higher

Table 3. Breaking load, breaking stress, breaking elongation

	Breaking load (gf)	Breaking stress (MPa)	Breaking elongation (%)
Control	135.09	168.68	43.17
B	122.54	153.01	79.02
B'	150.42	187.81	103.10
Average	136.02	169.83	75.10
Standard deviation	13.96	17.43	30.15
Standard deviation(%)	10.3	10.3	40.2

*Control : bleach hair, B : hair with orange oil paint, B' : hair painted with green oil paint

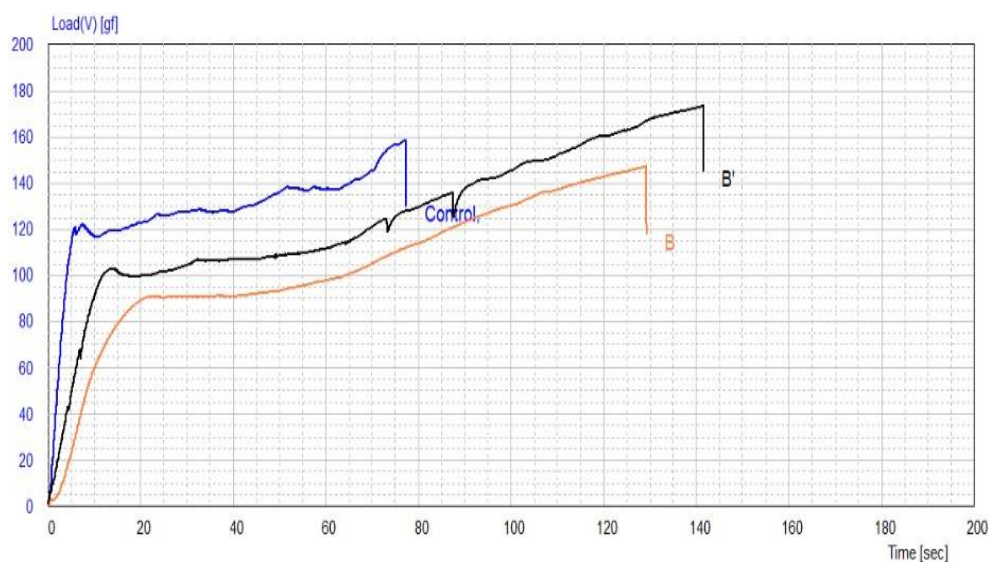


Figure 1. Maximum load and breaking load of hair sample strain; control : bleach hair, B : hair with orange oil paint, B' : hair painted with green oil paint.

than that of the control group 43.17 %.

This means that green emulsion-applied hair has stronger physical properties than the control or orange emulsion-applied paint, and has superior adsorption power to form a coating film on the hair cuticle surface. This is the result of supporting the previous study by Kang¹⁷⁾ that showed a significant difference in tensile strength in damaged hair than healthy hair when dyeing hair, and that as the degree of hair damage increases, the

influence of the coating agent increases. In addition, in a previous study by Cho¹⁸⁾, damaged hair with hair cuticle peeling, disorder of the hair surface, and decreased hair texture caused a decrease in hair strength, and elasticity. It is judged that the thickness and strength increased. In other words, it is separate from the supply of nutrients to the hair and repair of hair damage.

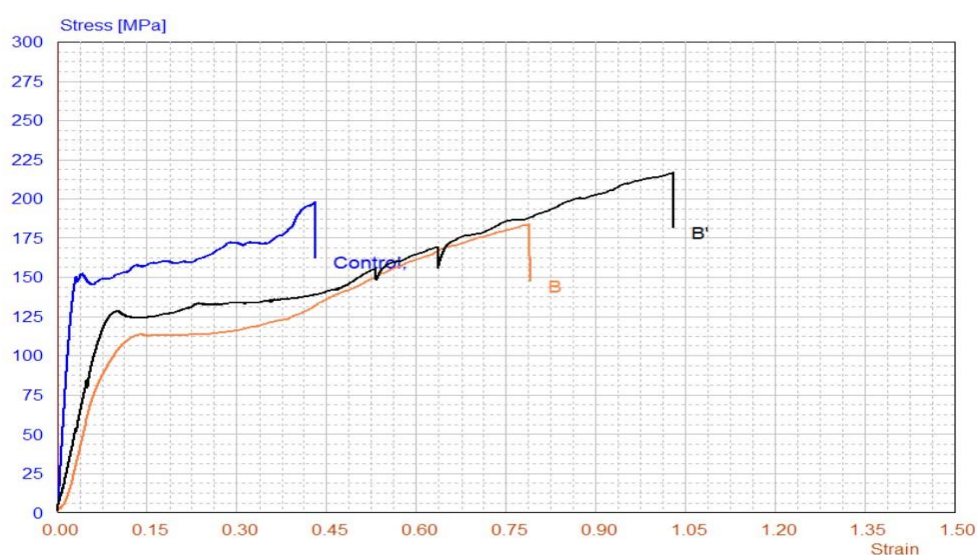


Figure 2. Maximum stress and breaking stress of hair sample strain; control : bleach hair, B : hair with orange oil paint, B' : hair painted with green oil paint.

Table 4. According to strain interval of hair samples maximum modulus and tangent modulus

	0-15s Maximum modulus (MPa)	0-15s Tangential modulus (MPa)	15-145s Maximum modulus (MPa)	15-145s Tangential modulus (MPa)
Control	91002.49	1814.69	1782.30	141.17
B	31830.71	1068.44	1075.85	122.46
B'	111441.78	1165.08	1165.57	100.31
Average	78091.66	1349.40	1341.24	121.31
Standard deviation	41346.07	405.83	384.24	20.45
Standard deviation(%)	52.9	30.1	28.7	16.9

*Control : bleach hair, B : hair with orange oil paint, B' : hair painted with green oil paint

3.4 According to strain interval of maximum modulus and tangent modulus

Maximum hair for a total of 3 times. Modulus and tangential modulus the slope results within the specified range are shown in Table 4.

Maximum in the 0-15s strain section, green emulsified hair (B') was 111, 441.78 MPa, which was higher than the control or orange emulsified hair (B), but in 15-145s, the control group reversed and showed high modulus. On the other hand, the tangential modulus value of the control group was significantly higher than that of the experimental group in all sections 0-145s.

4. Conclusions

The results of the study on the mechanical changes by color of the samples treated with orange and green oil paints on bleached hair are as follows.

Maximum load, maximum stress, maximum elongation and break load, break stress, break elongation. In all of the elongation, the hair applied with green emulsion paint was significantly higher than the control group or hair applied with orange emulsion paint. On the other hand, hair with orange oil paint applied maximum load, maximum stress, breaking load, breaking stress was lower than that of the control group, but maximum elongation and breaking elongation was higher than that of the control group.

Maximum in the 0-15s strain section, green emulsified hair

appeared higher than the control or orange emulsified hair, but in 15-145s, the control group showed higher modulus. On the other hand, the tangential modulus value of the control group was much higher than that of the experimental group in all sections 0-145s.

In this study, the change in tensile strength and elongation of hair samples by color was studied by selecting an emulsion as a novel material for hair coloring in consideration of the order of discoloration of hair pigments. However, although there are limitations to the research limited to orange and green color types, by identifying the correlation between color and the mechanical properties of hair, it contributes to the development of innovative and novel hair coloring materials for future research and production of hair beauty works, and the development of the beauty industry is also expected to contribute.

Acknowledgements

This study was supported by research fund from Songwon University 2022(A2022-04).

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