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A study on the Morphological Changes of Hair after Treatment with Neutral Oxidative Dyeing Agent

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중명도(中明渡) 산화염모제 처치 후 모발의 형태학적 변화 연구

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Abstract As the importance of the beauty to pursue beauty comes to the fore, the market size of hairdressing industry including hair dyeing is getting bigger. In case of continuously applying an oxidative dyeing agent commonly used in hair salons, as hair damage is inevitable, we investigated morphological changes of hair treated with a neutral oxidative dyeing agent. In the experiment results, Between the control and the 6N-7N experimental groups, there was a significant difference in Max. modulus and Tangential modulus according to Max. load, Max. stress, Max. elongation, Break load, Break stress, Break elongation, and strain section. There were the highest values in Max. load, Max. stress, Max. elongation, Break load, Break stress and Break elongation in the control group, and there was no tendency to decrease significantly according to the treatment of the experimental group. Max. modulus and Tangential modulus according to the strain evaluation section did not show a tendency to increase or decrease constantly, although there was a difference between the control and experimental groups. This study attempts to provide basic data for the development of oxidative dyeing agent that minimizes hair damage and to establish the foundation for understanding the correlation between hair designers' oxidative dyeing agent and hair health.

Key Words : Oxidative dyeing agent, Hair coloring, Morphology, Tensile strength, Break load

요 약 아름다움을 추구하려는 외모의 중대성이 부각됨에 따라 모발 염색을 포함한 미용 산업의 시장규모도 점점 커지고 있다. 헤어살롱에서 보편적으로 사용되는 산화염모제를 지속적으로 시술할 경우 모발 손상은 피할 수 없게 되므로 중명도 산화염모제를 시술한 모발의 형태학적 변화에 관하여 연구하였다. 실험결과 control과 6N-7N 실험군 간에 Max. load, Max. stress, Max. elongation, Break load, Break stress, Break elongation, strain 구간에 따른 Max. modulus 및 Tangential modulus는 유의적인 차이를 보였다. Max. load, Max. stress, Max. elongation, Break load, Break stress 및 Break elongation은 모두 대조군이 가장 높은 값으로 나타났으며, 실험군의 처리에 따른 유의적으로 감소하는 경향은 보이지 않았다. strain 평가구간에 따른 Max. modulus와 Tangential modulus는 대조군과 실험군 간에 차이가 있음에도 일정하게 증가하거나 감소하는 경향이 뚜렷하게 나타나지 않았다. 본 연구를 통해 모발손상을 최소화하는 산화염모제 개발 연구의 기초자료 제공 및 헤어디자이너들의 산화염모제와 모발 건강과의 상관관계 이해를 위한 초석을 다지고자 한다.

주제어 : 산화염모제, 헤어컬러링, 형태학, 인장강도, 파단하중

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1. Introduction

Beauty in the dictionary meaning can be said to be a beautiful decoration of the outward appearance. It is the practice of adding physical or chemical techniques to the appearance of human beings in various ways other than costumes[1]. In modern society, human appearance plays a role important enough to have a profound impact on family ties, education, work, even court decisions and politics, beyond a simple individual problem. Men as well as women are showing considerable changes in appearance, style change, appearance management behavior and pursuit value[2]. Therefore, in modern society, it is not an exaggeration to say that it is the appearance superficialism, and many people are investing a lot of time and material cost in shaping appearance.

As a result, the market size and importance of the beauty industry has been increasing[3]. In addition, modern people are increasing their consciousness to improve the quality of life through social participation such as wellbeing culture and leisure activities pursuing health, and the active consumption of beauty for the elderly as well as the younger generation is greatly increasing. As a result of this social change, the marketing strategy of the beauty industry according to consumer behavior is required[4]. Among the demographic characteristics, age, income level, education level, and economic activity seem to directly and indirectly affect the actual use of beauty salon. It is necessary to improve the customer satisfaction by understanding the demographic characteristics of the major customers of the beauty room, providing the appropriate services, and understanding the psychological characteristics[5]. Among the beauty occupations, hair design jobs occupying the largest size of the industry include hair stylists, tricologists, hair coloring, up stylists, haircuts, and permanent waves. Hair colorist, hair artists, hair designers, and hair coordinators can often be referred to as those in the beauty industry[6]. Of these hairdressing jobs, hair coloring, that is, hair dyeing, has a very long history. The earliest dyeing in human history is believed to have been the dyeing of Henna by the Egyptian Queen about 4,600 years ago. The present synthetic hair dye was discovered by Hoffman in 1863 and was developed by Enge'ne Schueller of France in 1907, and it is not until the middle of the 20th century that a hair dye that uses hydrogen peroxide as an oxidizing agent has been commercialized[7]. Hair dyeing means changing the natural hue of hair using chemicals. At this time, the hair dye used according to the duration of the color tone of the dyeing hair is classified into four types such as temporary hair dye, progressive hair dye, semi-permanent hair dye, and permanent hair dye[8]. Permanent oxidative dyeing agents, such as 6N or 7N, are commonly used in hair salons as tactics coverings white hair or a styling aid, and hair damage can not be avoided if the permanent hair dye is continuously applied. Therefore, we attempt to analyze and study the morphological changes of the hair treated with the neutral level oxidative dyeing agent to provide basic data on the development of oxidative dyeing agents that minimize hair damage and to establish a foundation for understanding the correlation between hair designers' oxidative dyeing agents and hair health.

2. Theoretical background

2.1 Principle of hair dyeing

The principle of dyeing with the permanent oxidative dyeing agent is to mix the first and second agents, and during the procedure, both decolorizing and coloring are performed simultaneously. The second was a hair swelling of the hair cuticle, the hair dye molecules penetrated into the hair cortex, and oxygen in the oxidant acts to decompose the melanin pigment. Through this process, hair dye is combined with oxygen by polymerizing color of oxidation, and hair color is created. The color developed by oxidation and at the same time the pigment was soluble in water, but it gradually becomes insoluble and does not wash even if washed. When the diamines are oxidized, the molecules condense and polymerize, and it gradually becomes a large molecule and cannot escape from the cuticle layer, but remains in the hair and becomes a permanent dyeing[9].

Coloring agents that discolor hair are opaque compared to pigments and dyes, coats the hair, the dye is dissolved in water and oil, and it combines with molecules of fiber or hair to produce a color by coloring. The pigment is insoluble in water, ethanol, and oil and can not penetrate into the hair tissue, but it is possible to penetrate the dye, and because the pigments have no penetration but can cover the surface, it can be colored regardless of the color of hair[10]. For modern people who are investing time and effort in managing and managing the fusion of scalp and hair[11], hair dyeing works differently depending on the chemical properties of the hair.

Hair dyeing functions differently depending on the chemical properties of the hair, according to the type of hair-dyeing agent. The principle of dyeing is divided into two types, namely Ionic dyeing and oxidation polymerization reaction. The principle of Ionic dyeing is to make the dye electrically negative (-) by utilizing the electrical properties of hair, and it is absorbed into the electric state (+) inside and outside the hair and penetrates into the inside of the hair. The principle of the oxidation polymerization reaction is divided into a first agent which is a diamine type hair dye and a hydrogen peroxide which is a second agent, and at the same time, the principle of mixing and acting is somewhat different from the principle of reduction and oxidation, which is the principle of permanent[12].

2.2 Tensile strength and elongation

Through a stress applied in the axial direction and the strain by stress, the mechanical properties of the material such as yield strength, tensile strength, and elongation can be obtained[13]. This mechanical property is an important factor in the design of hair fiber structures. The yield strength refers to the elasticity that is returned when a given stress is applied and then released. In hair, there is an elastic region and a yield region which is a 'Burk' region, which leads to fracture through the plastic region. When stress is removed in the yield zone, then there is hysteresis. In other words, if you return to your original length, you need more than you need to restore it. The stress (σ, σ=F/A) is the applied force (F) against the unit area (A), and when the object is subjected to a tensile load, it is elongated in the axial direction and contracted in the transverse direction. The ratio of the initial length to the deformation is called the strain (e, $e=(\ell-\ell i)/\ell 0$). The tensile test is to measure a specimen of a certain length at a constant speed under a constant load in a certain environment. The tensile properties of hair are caused by multiple factors, and peptide bond breakdown in the hair cortex indicates destruction after dislocation behavior from 'α-helix' structure to 'β-helix'. Hair cystine binding serves to prevent hydrogen bonds between polypeptides from exchanging with water molecules, and it has a significant effect on the tensile properties of hair. The tensile strength of hair is due to destruction and molecular rearrangement such as cystine binding and hydrogen bonding[14].

Elongation is the ratio of the length of the hair to the initial length of the hair when stretched.

After the maximum tensile strength, the load is reduced and the material is fractured. Observation of the fracture surface after fracture is used as an important data to investigate the fracture behavior. Factors affecting the mechanical properties of hair include relative humidity, temperature, tensile load and tensile speed of the measurement environment, and are affected by fiber dimeters, chemical treatment, hair pH, and surface uniformity[15].

3. Experimental Method

3.1 Sampling

The hair sample used in this experiment is the hair of a woman in her early thirties who lives in Seoul, and a slightly damaged hair which is used for dyeing in 9 levels. The hair to be used as a sample was bundled at a distance of 130mm from the occipital scalp, and a bundle of hair was taken using a cutter scissor. Each hair sample was weighed 1.5g each, and the upper point was fixed firmly with silicone, and cut to a length of 220 mm. The hair piece to be used in the experiment was cleaned with a neutral shampoo. After rinsing neatly with distilled water, it was naturally dried at room temperature and used as an experimental sample.

3.2 Treatment agent

Neutral hair oxidative dyeing agents used in this study are 6N and 7N products that are commonly used in hair salons. Table 1 shows the display components and types of treatment agents.

Table 1. Components of 6N-7N oxidative dyeing agent

group \ kind		6N	7N
Processing solution	component	Toluene-2	Toluene-2
		5-Diamine Sulfate	5-Diamine Sulfate
		m-amino phenol	m-amino phenol
		picramic acid	picramic acid
		m-phenylene diamine	m-phenylene diamine
		resorcinol	resorcinol
	Type	cream	cream
Neutralizer	component	35% H_2O_2	35% H_2O_2
	Type	cream	cream

3.3 Measurement tools and devices

To measure the tensile strength of hair treated with 6N and 7N oxidative dyeing agents neutralized in the coloring hair used in the experiment, a hair tension test was performed using a physical property analyzer. The equipment used in the experiment is Yeonjin Estek's Texture Analyzer as in Fig. 1.

Fig. 1. Experimental apparatus for tensile strength of hair

3.4 Measuring methods

A piece of hair treated respectively with Neutral 6N and 7N oxidative dyeing agents, were calibrated to 110g weight of F1 hair at room temperature and ambient humidity, in a state in which pre-processing is not performed. It was fixed with the tensile grip of the Texture Analyzer of Yeon-jin Stech while identifying the standard weights. For the measurement of tensile strength of hair, the data was collected at 300 pieces per second, and the A/D filtering ring was run at a speed of 0.33 mm/sec (20 mm/min). The hair samples were repeatedly measured three times in total to measure mean values of Max. modulus and Tangential modulus according to Max. load, Max. stress, Max. elongation, Break load, Break stress, Break elongation, and strain section.

4. Experiment Results

4.1 Result of 6N

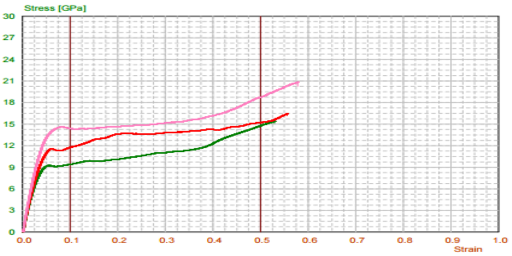

Fig. 2. Modulus change according to 6N sample strain
(Green graph : 6N-1, Red graph : 6N-2, Rouge graph : 6N-3)

Table 2-4 shows the results of measuring the tensile strength of the 6N sample over three times. As Max. load, Max. stress, Max. elongation, Break load, Break stress, and Break elongation of hair showed mean values such as 140.64 (gf), 17.56 (GPa), 55.41 (%), 139.59 (gf), 17.43 (GPa), and 55.42 (%), respectively, all showed lower values comparing to those of the coloring hair in the 6N-7N control groups.

Table 2. 6N Sample Length, Max. Load, Max. Stress, Max. Elongation

	Length (mm)	Max. Load (gf)	Max. Stress (GPa)	Max. Elongation (%)
control	44.65	155.80	19.45	62.60
6N-1	55.14	123.31	15.40	52.89
6N-2	39.82	131.68	16.44	55.53
6N-3	48.52	166.93	20.84	57.81
Average	47.83	140.64	17.56	55.41
Standard deviation	7.69	23.15	2.89	2.46
Standard deviation(%)	16.1	16.5	16.5	4.4

Table 3. 6N Sample Break Load, Break Stress, Break Elongation

	Break Load (gf)	Break Stress (GPa)	Break Elongation (%)
control	150.67	18.81	62.66
6N-1	122.67	15.32	52.90
6N-2	131.08	16.37	55.53
6N-3	165.02	20.60	57.83
Average	139.59	17.43	55.42
Standard deviation	22.42	2.80	2.46
Standard deviation(%)	16.1	16.1	4.4

Table 4. According to strain interval of 6N sample. modulus and tangential modulus

	0~0.05 Max. Modulus (GPa)	0~0.05 Tangential Modulus (GPa)	0.10~0.50 Max. Modulus (GPa)	0.10~0.50 Tangential Modulus (GPa)
control	474.99	211.24	149.15	7.91
6N-1	350.75	183.41	94.12	13.47
6N-2	1139.68	220.86	117.74	8.63
6N-3	1126.39	263.94	143.82	11.12
Average	872.28	222.73	118.56	11.07
Standard deviation	451.70	40.30	24.86	2.42
Standard deviation(%)	51.8	18.1	21.0	21.8

In the strain section of the sample 6N, Max. while modulus was 872.28 (GPa) higher than the 6N-7N control at 0 to 0.05 section, it showed 118.56 (GPa) at 0.10 to 0.50 section which is lower than that of 6N-7N control. The tangential Modulus (GPa) at both 0~0.05 strain section and 0.10~0.50 strain section showed mean values of 222.73 (GPa) and 11.07 (GPa), respectively, which were higher than those of 6N-7N control.

4.2 Result of 7N

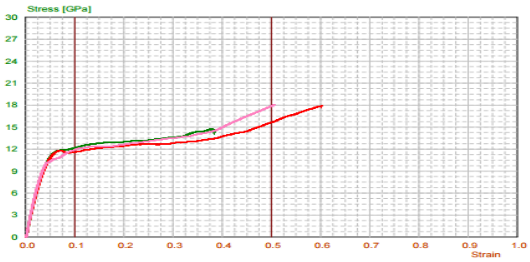

Fig. 3. Modulus change according to 7N sample strain
(Green graph : 7N-1, Red graph : 7N-2, Rouge graph : 7N-3)

Table 5. 7N Sample Length, Max. Load, Max. Stress, Max. Elongation

	Length (mm)	Max. Load (gf)	Max. Stress (GPa)	Max. Elongation (%)
control	44.65	155.80	19.45	62.60
7N-1	45.13	118.11	14.75	37.71
7N-2	40.95	143.40	17.90	60.11
7N-3	50.24	144.61	18.06	50.39
Average	45.44	135.37	16.90	49.41

Standard deviation	4.65	14.96	1.87	11.23
Standard deviation(%)	10.2	11.1	11.1	22.7

Table 6. 7N Sample Break Load, Break Stress, Break Elongation

	Break Load (gf)	Break Stress (GPa)	Break Elongation (%)
control	150.67	18.81	62.66
7N-1	112.31	14.02	38.37
7N-2	142.69	17.82	60.12
7N-3	143.89	17.97	50.40
Average	132.96	16.60	49.63
Standard deviation	17.89	2.23	10.90
Standard deviation(%)	13.5	13.5	22.0

Table 7. According to strain interval of 7N sample. modulus and tangential modulus

	0~0.05 Max. Modulus (GPa)	0~0.05 Tangential Modulus (GPa)	0.10~0.50 Max. Modulus (GPa)	0.10 ~0.50 Tangential Modulus (GPa)
control	474.99	211.24	149.15	7.91
7N-1	313.41	220.52	121.88	9.00
7N-2	312.80	217.88	116.08	10.15
7N-3	830.81	207.73	119.35	15.02
Average	485.67	215.38	119.10	11.39
Standard deviation	298.90	6.75	2.91	3.20
Standard deviation(%)	61.5	3.1	2.4	28.1

Table 5-7 shows the results of measuring the tensile strength of the 7N sample over three times. As Max. load, Max. stress, Max. elongation, Break load, Break stress, and Break elongation of hair showed mean values such as 135.37 (gf), 16.90 (GPa), 49.41 (%), 132.96 (gf), 16.60 (GPa), and 49.63 (%), demonstrating lower values as compared with those of coloring hair in 6N-7N control.

In the strain section of 7N sample, while Max. Modulus at 0 to 0.05 section showed 485.67 (GPa), higher than that of 6N-7N control, the values 0.10~0.50 section were 119.10 (GPa) which is lower than those of 6N-7N control. The tangential modulus (GPa) at both 0 to 0.05 strain section and 0.10 to 0.50 strain section, showed mean values of 215.38 (GPa) and 11.39 (GPa), respectively, which were higher than those of 6N-7N control.

5. Conclusion

For hair dyeing, one of the hair beauty manuals for modern human beings' appearance, the use of chemical oxidative dyeing agents is inevitable in reality. However, because hair damage due to this should also be taken care of, through experiment, analysis and research about the morphological changes of hair after oxidative dyeing agent treatment, this study tries to grasp the selection of the more appropriate oxidative dyeing agents, the amount of use, and the control of the time to leave. Especially, due to the increase of the elderly population, we have focused on the neutral oxidative dyeing agent which is widely used for hair dyeing, and the experiment results are as follows.

First, between the control and the 6N-7N experimental groups, it was found that there was a significant difference in Max. modulus and Tangential modulus according to Max. load, Max. stress, Max. elongation, Break load, Break stress, Break elongation, and strain section.

Second, all of Max. load, Max. stress, Max. elongation, Break load, Break stress and Break elongation showed the highest values in the control group, and there was no significant decrease in the experiment group according to the treatment.

Third, Max. modulus and Tangential modulus according to the strain section showed no apparent tendency to increase or decrease constantly despite differences between the control and experimental groups. It is thought that this is because the modulus is affected by hair thickness and length, and that there is no clear tendency due to irregular thickness and length within the hair.

It is thought that this study may serve as a practical guide to hair dyeing that can maximize beauty while minimizing hair damage, and will be useful as a basic data of hair beauty education.

REFERENCES

[1] Beauty Textbook Research Group. (1993). *Beauty theory.* Seoul : Yu-shin Culture History. DDC 646.7218

[2] H. G. Kim. (2015). A Study on the Convergence Marketing of Pursuing Value and Beauty Service in Accordance with Men's Acceptance of Information about Beauty Care. *Journal of Digital Convergence, 13(10),* 569-578. DOI : 10.14400 / JDC. 2015.13.10.569 / UCI : G704-002010.2015.13.10.006

[3] H. W. Kim. (2012). *A study on the competition of Korea beauty industry.* Master of Thesis. Hanyang University.

[4] G. S. Jo. (2013). A Study of Use of Beauty Salon by Social Strata in Elderly Women. *Journal of Investigative Cosmetology, 9(4),* 100-109. DOI : 10.15810/jic. 2013.9.4.012 / UCI : G704-SER 000001787.2013.9.4.002

[5] H. J. Kim. (2006). *A study on the silver generation's using behavior of beauty salon and satisfaction.* Master of Thesis. Yongin University. KDC 593.234

[6] G. S. Oh. (2011). The Activation Plan of Beauty Managers-Centered Beauty Tourism. *Journal of Korea Society of Design Culture, 17(1),* 319-335. UCI : G704-001533.2011.17.1.009

[7] K. S. Kim, E. J. R, S. T. Jo, Y. H. Choi & H. S. Heon. (1995). *Permanent Wave and Hair Coloring.* Seoul : cheonggu munhwasa. KDC 593.2356.

[8] M. O. Lee. (2004). *A study on the Effect of Hair Breeching on Hair Dying and Degradation.* Master of Thesis. Silla University. KDC 593.2324.

[9] J. S. Kim. (2004). *Comparison of hair damage caused by natural or synthetic hair dyes.* Master of Thesis. Konkuk University. 16-18. DDC 646.72422.

[10] S. G. Hong. (2006). *A Study on the Importance of Treatment and Hair Damaged by Chemical Treatment. 32.* Master of Thesis. Sookmyoung women's University.

[11] S. Y. Kang & K. A. Lee. (2017). A study of convergence management types based on self-perception of scalp and hair among college students majoring in cosmetology. *Journal of Korean Convergence Society, 8(2),* 235-241. DOI : 10.15207/JKCS. 2017.8.2.235 / UCI : G704-SER000004000.2017.8.2.010

[12] H. K. Ann. (2007). A Study on the Seasonal Changes of Hair Color. *Journal of fashion business, 11(1),* 1-14.

[13] Richard W. Hertzberg. (1990). *Deformation and Fracture Mechanics of Engineering Meaterials.* 261-288, Seoul : huijungdang. DDC 620.1123

[14] E. J. Lee. (2008). *Trichology.* 190-200, Seoul : Kwangmunsa.

[15] P. Y. Song. (2006). *Measurement of Hair Damage Rate and Mechanical Properties after Chemical Treatment.* Master of thesis, Kon-kuk University. DDC 646.72422.

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