

A Study on the Wave Formation and Hair Damage Levels Relating to the Uses of Treatments for Heat Permanent Waves

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Abstract

Public interest in healthy hairs gets growing as damaged hairs are seen more frequently with the generalization of heat permanent waves. For this study, experiments have been conducted to understand the influences on the changes in physical and morphological features of wave forms and damaged hairs, by collecting virgin hairs from the women in their mid-20's, who had not experienced chemical applications, and by dividing the applications of heat perm hair treatments, PPT(for pre-treatment) and LPP(for post-treatment), into the pre-treatment, the post-treatment, the pre & post-treatment, and the non-treatment. For the wave formations, curl waves were investigated by the bare eyes using the pictures taken by a digital camera. For the comparison of physical features, the experiments of tensile strength and elongation were done and their mean values were found. For the observations of morphological features, the pictures were taken by SEM for comparison. As for the findings, regarding the curl wave shapes of hairs, the most even and elastic S curl was formed in the case of non-treatment. In the physical features, both of the tensile strength and elongation showed a decreasing tendency in line with the hair damage levels, and the case of the pre & post-treatment indicated the tendency most similar to the control group. In the morphological features of the cuticle, observed with an SEM, the pre-treatment showed the higher possibility of reducing the cuticle damages than the post-treatment did. LPP was found to play the role of protective membrane for the post-treatment, and the pre & post-treatment turned out to reduce most effectively the cuticle damages.

Key Words : heat permanent wave, hair treatment, damaged hair, permanent wave form, damage level

I . Introduction

Modern industrial society has seen the rapid development in human needs for aesthetics, along with the continuous improvement in culture

and science. Accordingly, the hair care industry has also grown rapidly, resulting in the introduction of many kinds of tools and application skills. Particularly, the rapidly-changing lifestyle of contemporary human beings has helped the spread

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of the new hair style of heat permanent wave(to be referred to below as "heat perm").

Public interest in healthy hair is getting higher with the increasing hair damages while people experience the various heat perm suitable to their tastes. The hair business sector has also become conscious of the importance and necessity of hair treatment. Thus, the hair business sector introduced the products fit for various hair conditions in the market, and the trend has shown a gradual specialization into hair clinics. Hairs are not restored to the original state once they are damaged, lacking in their ability of self-healing. It is very important to prevent or cure the damaged hairs with treatments prior to the operations, particularly because the uses of tools for perm, dyeing or drying are very popular at present among people, young and old. Hair treatments serve to firmly protect the cuticle layer of hairs, to complement or maintain the appropriate moisture or oil in the hairs, and to prevent hair damages through the management needed for the porous or damaged hairs, which are associated with the operations of heat permanent waves.

The preceding studies on the hair damage level are as follows: the comparison of hair shapes by the permanent wave method by Kim, Sung Nam¹⁾; the study on the morphological damages of hairs by the processing temperature for heat perm by Kim, Tae-Gune²⁾; the study on the hair changes by a magic straight permanent by Lee, Jung Eun³⁾; the study on the heat treatment effects of Ample in the process of perm for heavily damaged hairs from dyeing by Park, Jin-hee⁴⁾; the study on the hair changes by the operations of permanent, dyeing, bleaching, and coating by Jung, Yeon⁵⁾; and the study on the effects of the wave formations and hair damages by the uses of treatments in digital

setting perm by Kim, Yang Ja⁶⁾. The preceding studies reported much about the types of permanent treatment products, operation frequency, and operation methods, but few reported about the heat perm and its treatment methods. Thus, this paper aims to look into the physical and morphological changes, by the standard of healthy hairs, from the different applications of PPT and LPP for heat perm, to present the more effective methods for the minimization of hair damages, and to provide the basic data applicable to the on-the-job practices.

II. Materials and Methods for the Study

1. Sample Hairs

The experiments for the study were conducted in April through August of 2007. The sample hairs were collected from the women in their mid-20's who responded not to have experienced any chemical processes of drug-taking, smoking, excessive dieting, and hair permanent, dyeing or bleaching. The virgin hairs of Level 4 or so were selected and used as the formal samples for the study. The hairs on the occipital region were cut from the part 5 centimeters off the scalp, and those of 20~25 centimeters long were selected. The sample hairs were measured by two grams on an electronic scale, and they were fixed with silicon at the one centimeter point from the hair roots. For the prevention of the damages of prepared hairs, they were washed with lukewarm water into which neutral shampoo was dissolved, and they were used in the experiments after being washed out three times with distilled water and dried at the normal temperature.

2. Treatment Chemicals

The chemicals used in the experiments were selected among those generally used at present beauty parlors. Out of the products with a relatively high ranking in terms of sales at the hair-care materials markets in Seoul, the product by Manufacturer G was selected as the wave chemical for heat perm. PPT(Polypeptide Protein Treatment) by Manufacturer G was selected for the pre-treatment, and LPP(Low Polypeptide Protein) by Manufacturer A was used for the post-treatment. Their components are listed in <Table 1>.

3. Operation Methods for Heat Permanent by the Treatment

The first chemical for heat perm wave, a deoxidizer, was applied to the sample materials of the experiment groups, and the latter were washed out clean with distilled water and dried with towels after 10 minutes for softening, and then left alone for another 15 minutes. Later, they were wound by 12 mm rods of digital permanent instrument, went through the heat treatment at 100°C for 10 minutes, and after the confirmation of dryness, left alone for another 10 minutes. The second chemical for heat perm wave, an oxidizer, was applied to the sample

materials, after its being cooled down, and the latter were washed out clean with distilled water after being left alone for 10 minutes. They were naturally dried, and the results of sample materials were compared and measured. By the application method, the experiments were divided into and carried out by the pre & post-treatment, pre-treatment, post-treatment, and non-treatment. For the pre & post-treatment, PPT was applied to the sample hairs prior to the heat perm operations, and after the application of the oxidizing agent they were treated with LPP at the final process of washing. For the pre-treatment, PPT was applied to the sample hairs prior to the heat perm operations, and for the post-treatment LPP was applied to the sample hairs after the application of the oxidizing agent at the final process of washing. In the case of non-treatment, the experiments were conducted for the heat perm operations without any application of PPT or LPP. The composition of operation methods are depicted in <Figure 1>.

4. Measuring Methods for Wave Forms

After the completion of all the operations, the hair samples were arranged by the group for the observations of wave forms, using the pictures taken with a slim digital camera, Samsung KENOX

<Table 1> The Components of Permanent Wave Chemicals and Treatments

types	Heat permanent wave chemicals		Polypeptide Protein Treatment(PPT)	Low Polypeptide Protein(LPP)
components	1st chemical	thioglycolic acid ammonium L-Cysteine Monohydrochloride	Parahydroxybenzoate, benzeneophenone 9, hydrolyzed collagen	methylchloroisothiazolinone, methylisothiazolinone, Parahydroxybenzoate, butyleneglycol, hydrolyzed, ATAC, chitosan 2000ppm,
	2nd chemical	sodium bromate		

#1, and the comparison and analyses were carried out.

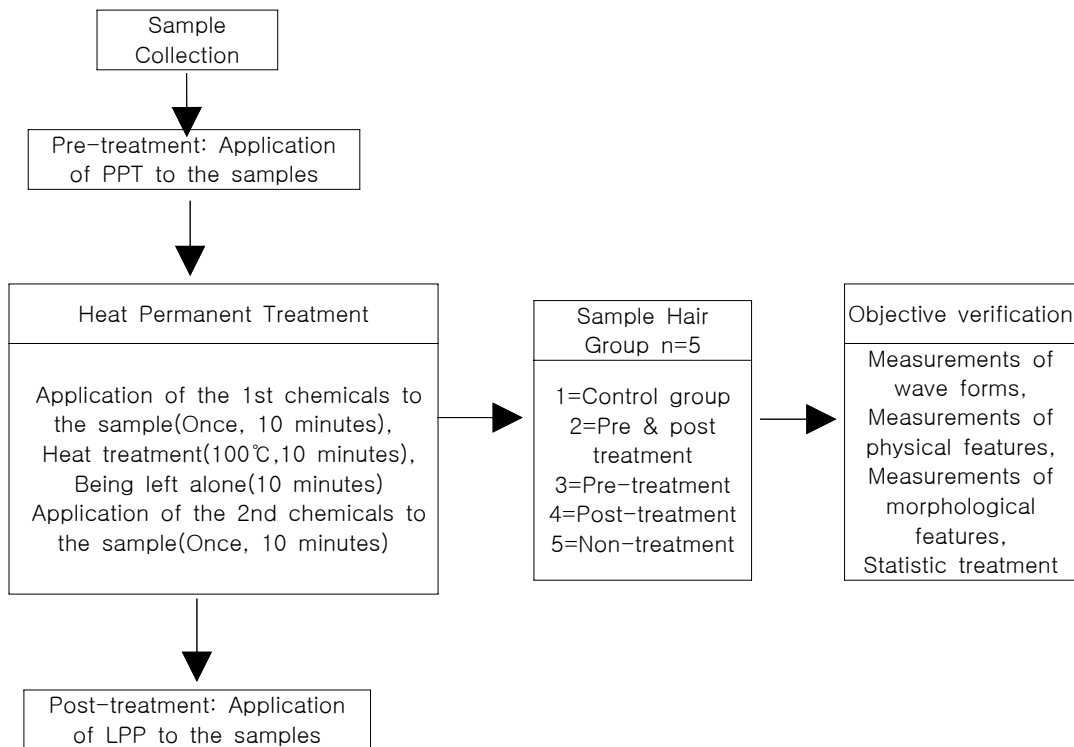
5. Observations of the Physical Features of Hairs

The physical features of the hairs were investigated with the tensile testing machine (Instron 4302, C.R.E type), and tensile strength and elongation were measured according to Korean industrial standards(KS K 0323) after the selection of 10 even hairs of 110 μ m from each of sample materials. The samples were preconditioned under the standard state for 30 minutes, and they were measured by the tensile speed of 20 mm/min, repeatedly 10 times for

each of sample materials. Through the statistical operations, the mean values were obtained for the comparison and analyses.

6. Observations of the Morphological Features of Hairs

The morphological features of the hairs were measured with the fixing of the middle part, as the observation part, in the control group and each of experimental groups. They were cut for about 3 mm, and fixed to the sample stand (silver fasten) and vacuum-coated for 5 minutes with an ion sputting device(JFC-1100 E JEOL, Japan). They were enlarged by 500 times and 1,500 times with a scanning electro microscope (JSM-5410LV JEOL, Japan) for the observation.



<Figure 1> Operation Methods for Heat Permanent by the Treatment

7. Statistical Treatment

The mean and standard deviation values were found for the data analyses with SPSS 12.0, the significance differences were verified through ANOVA, and the post-verification was done through Duncan-test.

III. Results and Interpretations

1. Measurements of Wave Forms

The results of wave form measurements are shown in <Figure 2>. The hairs with the operations of the non-treatment or the post-treatment formed the S curl which generally appeared to be most even and elastic in the wave cycles, and the shapes of round springs were observed in the waves at their edges. The waves with the operations of the pre & post-treatment and those of the pre-treatment also formed the elastic and strong curl, but their shapes were a little loose toward the hair roots in comparison with the hairs with the non-treatment

or the post-treatment. These differences are presumed to have resulted from the delayed permeation of the first chemicals of the permanent for softening. The softening of the heat perm means the expansibility and flexibility of hair cuticles and cortex by the first chemicals of the perm, and the softening facilitates the permeation of the solution into the hair interior and thereby affects the performances of perm waves.⁷⁾ Thus, the prolongation of softening period is considered to enhance the curl formation in the case of the pre-treatment for the heat perm of healthy hairs.

2. Physical Features of Hairs

If a hair is pulled, it stretches and gets thinner at a same time and eventually breaks. The elongation rate of the hair is called elongation coefficient(%) and the weight at the time of breaking is called tensile strength(g). As the tensile strength depends on the thickness of the hair, the value of the weight divided by the unit area at the time of breaking is defined as the 'strength of hair'.⁸⁾



<Figure 2> Wave Forms by the Method of Treatment

In the changes of tensile strength, the control group's hairs was 205.4g. Those of the pre & post-treatment was 200.3g, less by 5.1g at a change rate of 2.5%, while those of the pre-treatment was 175.4g, less by 30.0g at a change rate of 14.6% and those of the post-treatment was 173.3g, less by 32.1g at a change rate of 15.6%. In the case of the non-treatment hairs, the tensile strength was 170.7g, less by 34.7g at a big change of 16.9%. A significant difference was found at the level of $p < 0.001$. As a result, the pre & post-treatment was confirmed to have affected the physical features at the time of heat perm operations, with the treatment-by-treatment reductions of tensile strength indicating that each treatment method affects the hair damages by a different degree. In particular, based on the fact that the tensile strength of the pre & post-treatment hairs showed a trend similar to that of the control group and that of the non-treatment hairs represented the smallest value, it is presumed that the hairs with the pre & post-treatment suffered little from hair damages and those without any treatment suffered most. As the hair damages rise, the tensile strength falls.⁹⁾ Thus, the application of hair treatments at the time of heat perm was considered to assist for the hairs to keep the conditions held before the perm operations, and this resulted in the findings in the agreement with the study of Kim, Yang Ja that the use of treatments has little influence on the hairs at the time of perm operations and helps the maintenance of healthy hairs.¹⁰⁾

In the changes of elongation, the hairs of the control group showed 78.9%. Those of the pre & post-treatment was 69.3%, less by 9.6% at a change rate of 12.2%, those of the pre-treatment was 67.4%, less by 11.5% at a change rate of 14.6%, and those of the post-treatment

was 67.3%, less by 11.6% at a change rate of 14.7%. The hairs of the non-treatment was 68.6%, less by 10.3% at a change rate of 13.1%. A significant difference was found at the level of $p < 0.001$. As a result, the pre & post-treatment for heat perm showed the most similar trend to the control group, and it was also confirmed to have affected the physical features of heat perm from the standpoint of elongation. Generally, the elongation of hairs rises with the fall of tensile strength through the chemical actions. If the hairs suffer from serious damages, however, the level of rises in elongation is considered to be less due to the dryness of hairs out of the lack of moisture and the hardening of keratin protein out of thermal denaturalization.¹¹⁾ Accordingly, summing up the results of tensile strength and elongation after the uses of treatments for heat perm, the pre & post-treatment was confirmed to be the operation method appropriate for healthy hairs. <Table 2>

3. Morphological Features of Hairs

Generally speaking, the cuticle of healthy hairs accounts for about 10–15% of the hair, and with its higher percentage the hair gets solid and shiny at the high resistance against moisture and friction. This is because the scale of hair cuticle is a thin and transparent corona cell with hydrophobicity, regularly layered over the surface of hair as the scale of fish, thus performs not only the functions of providing the luster to hairs and protecting the hair interior against outside stimuli, but it also prevents the dryness of hairs by blocking the evaporation of moisture in hairs, about 15% of them existing inside.¹²⁾ In this study, the conditions of the hairs in the control group prior to the operations of heat perm showed the forms of cuticles without any damage,

<Table 2> Physical Features by the Use of Treatment

	Control Group N=10 M.(S.D.)	Experimental Groups				Total N=50 M.(S.D.)	F	Significance level
		Pre & post-treatment N=10 M.(S.D.)	Pre-treatment N=10 M.(S.D.)	Post-treatment N=10 M.(S.D.)	Non-treatment N=10 M.(S.D.)			
Tensile strength (g/1hair)	205.4(8.3) B	200.3(14.1) B	175.4(10.2) A	173.3(7.7) A	170.7(12.0) A	185.0(18.0)	18.833	0.000***
elongation (%)	78.9(5.1) B	69.3(3.0) A	67.4(3.0) A	67.3(3.9) A	68.6(2.7) A	70.3(5.6)	14.622	0.000***

***p<0.001 A<B M: mean value S.D: Standard deviation

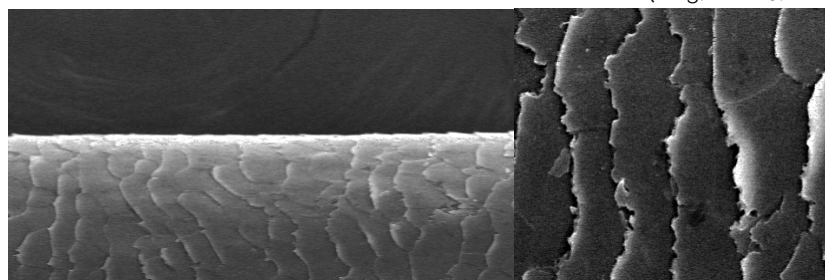
indicating the outer shapes of smooth and straight scales as a whole, as shown in <Figure 3>. The morphological changes in hair cuticles with the application of treatments were observed through a scanning electro microscope, and the findings are as follows. In the case of the pre & post-treatment as shown in <Figure 4>, the hairs showed the appearances of cuticles, which were in the relatively even and solid shape, with some of the scales parted away, though. In the case of the pre-treatment as shown in <Figure 5>, some part of cuticles was moved away, thus the edges seen dim, and the scales were observed to be in an unstable condition compared with those of the pre & post-treatment, though with relatively even forms. In the case of the post-treatment as shown in <Figure 6>, the alignments of scales became very disorderly, with the boundaries grown indistinct among them, and the rupture and parting of the cuticle layer were seen obvious. In addition, the gap was larger in the cuticle layers. In case of the non-treatment as shown in <Figure 7>, the phenomena of the rupture and parting of the cuticles spread a little larger than those of the operations of the post-treatment, and the coagulation occurred due to

the rough and loose cuticles, letting the surface become indistinct with boundaries among the scales. As a whole, the hairs with the pre & post-treatment were observed to have the shape most similar to those of the control group, and the hairs in the non-treatment indicated unstable state of the cuticles. Thus, the pre & post-treatment is presumed to have resulted in the lowest level of cuticle damages, and the non-treatment produced the highest level of cuticle damages. The elements found in the physical features were also seen in the observations of morphological features, which in turn substantiates the agreement in the changes between the physical features and the morphological ones. In addition, in view of the fact that the hairs with the pre & post-treatment and the pre-treatment kept much more even scales of the cuticle layer with a lower damage level than the hairs of the post-treatment and the non-treatment, the application of PPT in the pre-treatment prior to the heat perm indicated the more reduction of the cuticle damages than the application of LPP in the post-treatment. Moreover, the post-treatment rather than the non-treatment, and the pre & post-treatment rather than the pre-treatment revealed the less

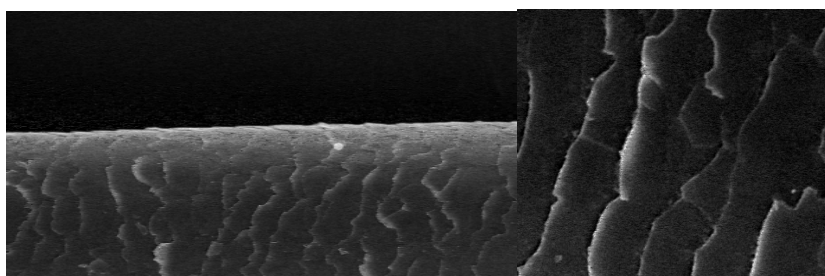
damages to the cuticle layers of hair surface, which explains the LPP's role of protective membrane for the hairs in the post-treatment. In

view of the above findings, the pre and post-treatment method for heat perm is considered to reduce most the damages of the cuticle layer of hairs.

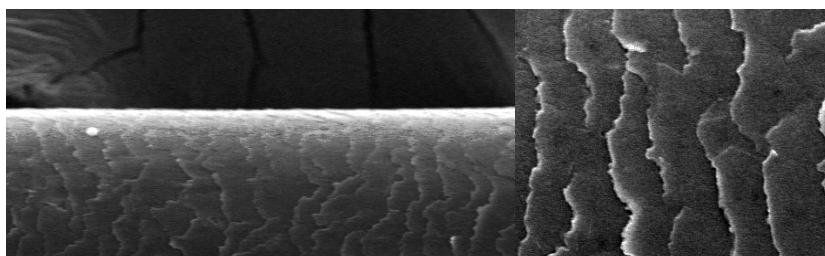
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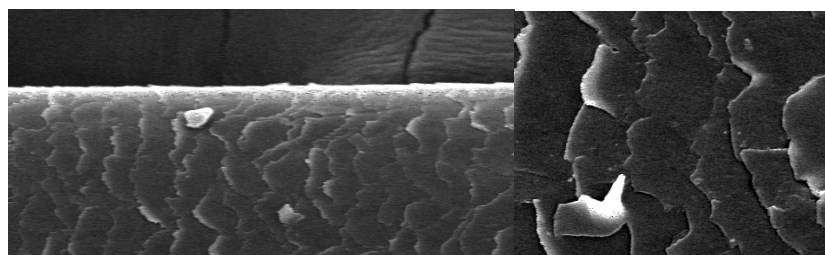
<Figure 3> Control Group



<Figure 4> Pre & post-treatment

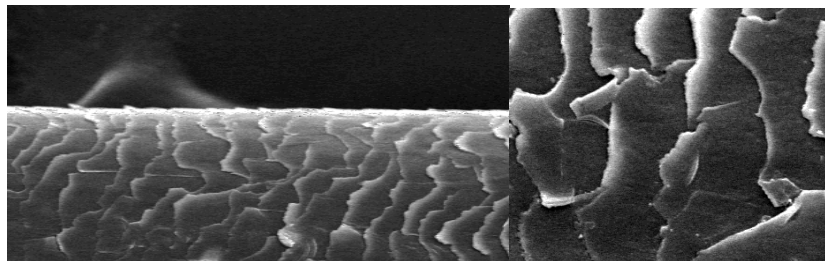


<Figure 5> Pre-treatment



<Figure 6> Post-treatment

(magnification : ×500 ×1500)



<Figure 7> Non-treatment

IV. Conclusions

In this study, we would like to present the operational methods for the minimization of damaged hairs and to provide the basic data to the on-the-job practices. Experiments were carried out to understand the influences on the changes in the wave forms, and the physical and morphological features of damaged hairs at the time of heat perm using the hairs collected from the women in their mid-20's. The wave forms of sample hairs were observed using the pictures taken with a digital camera, the changes in physical features were compared by means of tensile strength and elongation, and the changes in morphological features were observed with a scanning electro microscope. The findings are as follows.

1. In the wave forms, the case of non-application of treatment produced the most even and elastic S curl.

2. In the physical features, both of tensile strength and elongation showed a decreasing trend with the hair damages, and the case of the pre & post-treatment indicated the trend most similar to that of the control group.

3. In the morphological features of hair cuticle layers, observed with a scanning electro microscope, the pre & post-treatment proved to reduce most the damages of cuticle layers. In addition, the pre-treatment showed more reduction

of the damages of cuticle layers than the post-treatment, and LPP was observed to function as the protective membrane for heat perm.

In the case of the pre & post-treatment for heat perm, the hair damage level was not high, but the wave forms did not show a relatively regular cycle. On the other hand, the hairs done without any treatment were damaged much, with the production of the most even and elastic curl in wave shapes. Since hairs are not restored to the original state, once damaged, lacking in the ability to heal by themselves, it is very important to prevent their damage or to let it be cured. Thus, special care should be taken at the time of hair-doing. In this regard, the pre & post-treatment was confirmed to serve as the best method for minimizing hair damages at the time of heat perm and for obtaining the satisfactory results in the morphological aspect.

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