Review Article

Immunocosmeceuticals: An emerging trend in repairing human hair damage

Abstract

Hair is one of the most important portions for beauty care and in recent years grooming and cosmetic treatment of hair has drastically risen. Substantially, it may deteriorate and weaken the hair by modification of keratin protein. This makes the hair dry, brittle and split vend occurs due to loss of hair strength and the damage further increases with cosmetic treatments. The various poor ingredients are being used for repairing which have extremely poor compatibility with hair. Now the hair care products can be introduced with an active ingredient comprising a yolk derived anti-hair antibody immunoglobin obtained from egg of chickens immunized with damaged hair as antigen. This immuno-cosmeceuticals can repair the hair damage and imparts flexibility and smoothness to the hair. These effects are not lost by the ordinary shampooing. This article focuses on the characteristic of human hair, its damaging processes and the effects of immuno-cosmeceuticals for repairing the hair damage.

Key words:
Anti-hair antibody, hair care, immuno-cosmeceuticals, keratin

Introduction

Hair is one of the most important portions for beauty care and various beauty treatments are applied, in which a variety of chemical processes and treatments are used.[1] Hair care products such as shampoos and conditioners aid the maintenance and grooming process. Mechanical processes such as combating, cutting, and blow-drying serve to style the hair. Chemical treatments and processes such as chemical dyes, colorants, bleaches, permanent wave and straightening enhance the appearance and hue of the hair.[2,3]

Generally, the mechanical and chemical treatments will damage the texture and nature of the hair shaft. Especially, the chemical treatments will deteriorate the hair and results in deformity.[4] The chemical products deposit on the hair cuticle and make them vulnerable to damages such as split ends and broken hair.[5] The hair, once damaged is unable to restore itself to its original state.[6] So as a measure of prevention of such hair damages, it has been attempted to incorporate several other proteins into hair care composition to form a protective film on the surface of hair fibers. Although, the protein components can exhibit some benefits they do not sufficiently repair damage to hair.[7]

Today a hot topic in the cosmetic industry is immuno-cosmeceuticals, which is the fastest growing segment of the natural personal care industry.[7] Immuno-cosmeceuticals are topical cosmetic-immunological and pharmaceutical hybrids intended to enhance the beauty through ingredients that provide additional health-related benefits. These active ingredients are developed with the knowledge of skin biology, hair science, immunology and pharmacology.[8,9]

Now-a-days the hair care products are blended with an antibody having immunological activity to repair the hair damage.[10] These antibodies are obtained from an immunological activity to repair hair damage. These antibodies are obtained from an egg yolk of hen immunized with damaged human hair extract as an antigen. These anti-hair antibodies immunoglobin Y (IgY) bind to hair

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specifically and also prevent the occurrence of hair damages. The effects of this immuno-cosmeceuticals are not lost by repeated ordinary shampooing.[10] It is necessary to understand the components and nature of hair, damaging processes and effect of immuno-cosmeceuticals (anti-hair IgY) for repairing the damaged hair.

Morphological Components of Hair Shaft

In cosmetic research, it is important to understand the morphological components of human hair,[11] which aid in developing new hair care products and minimizing the hair deterioration. The hair shaft is composed of three different types of epithelial cells: Cuticle, cortical and medullary cells.[12,13]

The cuticle

Cuticle is the outermost layer, which wraps and protects the hair fiber by (scale-like structures) flat overlapping cells.[14] Human hair typically has 5-10 thin colorless layers, which form a very efficient defense against injury from the environment and it is responsible for much of the mechanical strength of the hair fiber.[15,16] The cuticle cells are smooth and glossy hence, it reflects light, this together with the melanin within the cortex, gives hair its characteristics appearance.[1,17]

The cuticle is internally multi-laminated, consisting of various sub-lamellar layers, which include the epicuticle, the A-layer, the exocuticle, the endocuticle, inner layer and the cell membrane complex (CMC). The cuticle scales containing covalently bonded 18-methyleicosanoic acid (18-MEA), this saturated fatty acid contributes the lubricity to the hair fiber.[18,19] This existence of a thin chemically resistant layer called epicuticle has been known since 1916.[20] The recent investigation identified the epicuticle as being a sharply defined and continuous layer approximately 13 nm thick, covering and protecting the entire outwardly facing intracellular surface of every cuticle layer.[21,19] The A-layer resistant layer and exocuticle contains proteins which are densely cross-linked by the di-sulfide bonds of cysteine, hence they are mechanically tough and chemically resilient.[22] The endocuticle contain a high content of acidic and basic proteins.[23]

The CMC consists of cell membrane which binds the cuticle and corticle cells together.[17] It contains low sulphur containing amino acids, lipids and fatty acids. Together with the endocuticle the CMC from the non-keratinous regions which are becoming more and more important to cosmetic science because, they are believed to be the primary pathway for entry of diffusion of cosmetics into hair.[1,24]

The cortex

The cortex containing the major part of human hair and mainly consists of low sulphur keratin.[1] Several dozen microfibrils make up a cortical cell. Macrofibrils are fibre-shaped structural units made up of protein which, in turn are composed of hundreds of microfibrils which adhere to each other by mean of mechanical forces. A microfibril or intermediate filament has a diameter of 7 nm (1 nm = 1 billionth of a meter). Microfibrils are made up of protofibrils which consist of keratin protein with a spiral shaped α-helix structure. The combination of macrofibrils and matrix protein form a highly cross-linked structure called 'disulphide-bridges', which is extremely strong and resists stretching and twisting.[25,26,17] Two different types of cortical cells can be distinguished in human hair according to the packing arrangement of the macrofibrils within the cell: Paracortical cells, in which the macrofibrils are so closely packed and orthocortical cells, in which the macrofibrils are seen as discrete near-circular entities separated by small amounts of inter-macrofibrillar material.[17] The cortex contains hair pigment "melanin" which, has been shown to protect the biomolecules of hair, such as lipids and nucleic acids from ultraviolet damage. They absorb the ultraviolet light[27] and scavenge the free radicals.[28]

The medulla

The hair of larger diameter often has a third type of cell in the center of the fiber. Such hair reveals the presence of a sponge such as a matter with pores and incomplete keratin fibrils. They seem to be devoid of cystine, but contain relatively large amount of glutamic acid.[15] The original function of medulla was to improve the thermal insulation properties of hair. Generally, only a small percentage of medulla makes up the mass of whole hair and is believed to contribute negligibly to the mechanical properties of hair fibers and it is serves sometimes as the reservoir for pigments.[25]

Chemical compositions of human hair

Human hair is predominantly proteinaceous in nature; consist of 65-95% protein, the remaining constituents are water, lipid, sugar, pigments, nucleic acids, and trace elements.[1] The hair protein can be classified as disulphide cross linked proteins, the intermediate filament proteins, keratin associated proteins and disulphide and isodipeptide cross linked mercaptolyse resistant protein, found in the cuticle layers, CMC and in nuclear remnants. Analysis of the elements contained in hair reveals the presence of 45.2% carbon, 6.6% hydrogen, 27.9% oxygen, 15.1% nitrogen, and 5.2% sulphur. The sulphur plays an important part in the hair behaves, especially when it is given cosmetic treatments.[29] In addition, trace elements are detected that may play a role in the composition of pigments.[30]

The total hydrolysis of human hair protein reveals different amino acids [Table 1].[17,30,31] Among cystine is one of the important amino acids. The total cystine content of virgin human hair ranges from 13% to 18%, they provide stability to the hair as long as it is exposed to reducing, oxidizing and hydrolytic agents or to weathering.[30] Cystine has the capacity to crosslink the protein by its stabilizing the hair fiber, leading in particular to its relatively high wet strength, moderate swelling and insolubility.[20,32]

In addition to disulphide bonds, hair is also rich in peptide bonds and non-covalent bonds. The non-covalent bonds consist of three main groups: Hydrogen bonds, ionic bonds (or salt bridges), and hydrophobic effect. The hydrogen bonds can be realized between –CO and –NH groups in the peptide chains and the amino and carboxyl groups in the side chains, or between suitable donor and acceptor groups in the amino acid side chains, especially in the helical rod domains of the keratin intermediate filaments.[12] The so-called bridges are due to electrostatic interaction between cationic and anionic side chain groups, being responsible for the amphoteric nature of fiber and its ability to combine with a large amount of acids and bases. The hydrophobic effect results from the approach of two non-polar side groups, with the resultant exclusion of associated water molecules and contributes to the mechanical strength of keratin, particularly at high water content.[30]

Damaging process of human hair

Generally, hair damages occurs mostly by mechanical (physical) and chemical means, sometimes by a combination of both (chemo-mechanical).[2] When hair becomes rough or dull it is observed that the outer layer is damaged. The cuticle damage is caused by mechanical processes from the daily grooming actions like combing, scratching, cutting, washing, brushing, blow-drying, and sun rays.[6,24] The hair near scalp had complete cuticles while no cuticles were found near the tip. This may be because of the hair near the scalp.[33] Thus, cuticle erosion near the tip is the main reason for appearance of split hair. Split ends are simply the separation of individual hair cell layers. They result from consistent abuse to the hair. The processes

Table 1: Amount amino acids present in normal human hair in order of their quantity[17,28,30]

Amino acid	Amount in %
Cysteine	17.5
Serine	11.7
Glutamic acid	11.1
Threonine	6.9
Glycine	6.5
Leucine	6.9
Valine	5.9
Arginine	5.6
Aspartic acid	5.0
Alanine	4.8
Proline	3.6
Isoleucine	2.7
Tyrosine	1.9
Phenylalanine	1.4
Histidine	0.8

such as brushing and combing may wear away the cuticles, especially high temperature treatments like blow-drying can degrade the hair cuticles.[17]

Some hair care products create a desirable style and look but they also bring about significant damage to the fibers. When the hair is exposed to chemical treatments such as permanent waving, straightening, coloring, dyeing, and bleaching formulations chemical deterioration occurs.[34] The uplifting and chipping of cuticle edges is accelerated by frequent unprofessional hair treatments such as perms and bleaches. Most of the perms and bleaches are performed in alkaline pH, which causes the hair to swells, if proper neutralizers are not used; hair swells too much and can be damaged irreversibly.[35] The chemicals are believed to diffuse through the CMC and break down the disulphide bonds of the fibers,[1] or may oxidize the keratin matrix and result in deformity [Table 2].[35,36] Over the last 30 years research indicated that the chemical treatments results in losing the mechanical properties of hair[36] while some chemical treatments rupture the cuticle, thus, the hair proteins gradually get eluted and make them appear thinner,[37,38] such damages are considered to have occurred because the structure of hair was weakened due to deterioration of hair protein "keratin." Consequently, the hair dries and become brittle, split ends are formed or the hair breaks and loses its strength.[10]

Immunocosmeceuticals-containing the repairing effect

Recently, grooming and cosmetic treatment of hair has brought variations to hairdos. On the other hand, mechanical processes and cosmetic treatments steadily deteriorate and destroy the surface structure of the hair. Substantially the hair damages such as split ends and broken hair are increased.[7] It is impossible to repair the damaged hair biologically because the hair fibers are composed of dead cells.[6] Hence, the use of proteinaceous material as an additive in hair damage treatment is known art. Various proteins such as collagen, keratin protein and egg albumins have been used, but they do not provide satisfactory effects.[10]

Usually, conditioners are used to control and prevent damage. Conditioners contain cationic polymer emulsion (cationic surfactants, fatty alcohol and silicones), which gives positive electrical charge. Thus, the negative charge of the hair is easily attracted to the cationic polymers and gets deposited on the hair. Therefore, larger amount of polymers can be adsorbed onto hair fibers especially, when they are damaged.[6] The damaging process results in hair fibers being even more negatively charged. The attraction of hair toward conditioners results in reduction of static electricity hence, "fly away" behavior is also reduce consequently.[34] The polymer emulsion has some drawback, like no selectivity when adsorbed. Healthy hair also adsorbs them and the inherent smooth tactile feel and natural

Table 2: Chemical treatment and damaging processes of human hair

Treatment	pH	Chemicals used	Damages occur	Reference
Bleaching	9-11	Hydrogen peroxide	Oxidation of keratin matrix Severe amino acid degradation	Wolfram *et al.* (1970)[23]
Dyeing	Acidic	Nitoanilines, nitrophenylenediamines, nitroaminophenols, para dyes and hydrogen peroxide	Deposits on hair surface and penetrate the cortex, resistance to shampooing	Tsujino *et al.* (1991)[43]
Permanent wave	9-9.5	Mercaptans, sulphites and thioglycolic acid	Rupture of ionic linkage or H-bonds leads to hair deformations and cleave cysteine links	Zviak (1986)[36]
Straightening	8-9.5	Alkaline agent	Breakage of disulphide bond	Gray (2001)[34]

texture of the hair are lost. These cosmetic compositions have insufficient damage prevention or restorative effect and do not necessarily provide satisfactory effects.[7]

To overcome the above described problems an antibody (immuno-cosmeceuticals) has been obtained from an egg of a domestic fowl immunized using damaged hair as an antigen.[10] These anti-hair antibodies have immunological activity toward damaged hair, i.e., these anti-hair IgY are selectively adsorbed by a specific portion of hair fibers, due to the specificity of the antibody to suppress and repair the damaged hair.[7] The human hair repaired by chemical treatment such as permanent waving, dyeing, bleaching, straightening or the like are used as an antigen in order to provide specificity.[10] The hair is swollen with a protein modifier such as lithium bromide, urea, guanidine hydrochloride or SDS and pulverized using a mortar or a sand mill at the temperature of liquid nitrogen. Thus, the hair constituents are reduced to a size of 100 μm or less. Immunization of chicken may be performed by subcutaneously, intraperitoneally or intramuscularly injecting the ground hair constituents.[7]

Previously, it is known that the antibody production in mammals such as rabbits, mice, guinea pigs, and cows are associated with the multiple injections or antigens and repeated blood sampling process.[39] Recently, laying chickens are utilized as an alternative source of antibody production. Considering the welfare of the laboratory animals the use of chickens for antibody production represents a refinement in painful collection of blood samples and final scarification are replaced by collecting eggs.[40] Moreover, large amounts of antibodies can be harvested from the egg yolk than laboratory rodents, thus making blood sampling obsolete.[10] These egg yolk antibodies IgY are phylogenetical progenitor or immunoglobin G antibodies, which can be approximately harvested to concentration of 100 mg IgY/egg.[41] IgY does not bind to protein-A and G, does not activate the mammalian complement system and does not appear to cross-react with mammalian immunoglobulin. Hence, IgY antibodies were successfully applied in a different area of research.[42]

Other than prevention and restoration of split hair, this immuno-cosmeceuticals also impart excellent properties including conditioning effect such as moisturizing, flexibility, smoothness and luster to hair even in the dry state.[10] Moreover, protein elution and thinning of hair can also be prevented. These effects are not lost by repeated ordinary shampooing.[10] Further, hair care products can be blended with the anti-hair antibodies in the form of a solution or preferably the concentration can be conducted by conventional distillation under reduced pressure and the drying can be performed by lyophilization. The yolk derived anti-hair antibodies are added to any hair care products including for example, pre-shampoos, shampoos, hair rinses, hair conditioners, hair treatment agents, setting lotions, jelly styling agents, hair tonics, hair creams, hair oils etc.[3] Though hair is a dead structure, it is a protein to which the antibody binds and immunologically antigen antibody reaction takes place. When the anti-hair IgY along with conditioners is applied to hair surprisingly they get selectively adsorbed by the damaged portion of hair.[7]

Conclusion

Considering all of the above mentioned advantages of IgY technology in hair care and some drawbacks of chemical treatments, it should be pointed out that the anti-hair antibodies from chicken egg yolk has long lasting properties in preventing hair damage and specifically act on damaged parts of hair and effectively restore the hair to its inherent potential. These anti-hair antibodies can also be immobilized with hair dye, thus, it provides a strong coloring capability specific to hair, and the hair dye will never stain the skin because of their specific affinity to hair. They do not cause irritation or allergic effects especially to the eyes and mucus and improve the tactile properties of hair.

References

1. Robbins CR. Chemical and Physical Behavior of Human Hair. 3rd ed. New York: Springer-Verlag; 1994. p. 10-391.
2. Koji T, Akira N, Naoka M, Akira I, Keita S, Hisao S. Influence of oxidative stress and/or reductive treatment on human hair 9I: Analysis of hair-damage after oxidative and/or reductive. Treat J Oleo Sci2003;52:541-8.
3. Uchiwa H, Hirano M, Murakami U, Sugimoto K, Minamino H, Horikoshi T, *et al*. Hair treatment composition and hair care product both containing anti-keratin antibody and production of anti-keratin antibody. (US patent) 5425937. 1995.

4. Kon R, Nakumara A, Hirabayashi N, Takeuchi K. Analysis of damaged components of permed hair using biochemical technique. J Cosmet Sci 1998;49:13-22.
5. Tate ML, Kamath YK, Reutsch SB, Weigmann HD. Quantification and prevention of hair damage. J Soc Cosmet Chem 1993;44;347-71.
6. LaTorre C, Bhushan B. Nanotribological characterization of human hair and skin using atomic force microscopy. Ultramicroscopy 2005;105:155-75.
7. Koyama T, Watanabe K, Nojiri H, Naito S, Sawada M, Imokawa G, *et al*. Hair cosmetic composition. (US Patent) 6123934. 2000.
8. Dureja R, Kaushik D, Gupta M, Kumar V, Lather V. Cosmeceuticals: an emerging concept. Indian J Pharmacol 2005;37:155-9.
9. FDA/CFSAN. Is it a cosmetic, a drug or both (or is it soap?). U.S Food and Drug Administration, Centre for food safety and applied nutrition, Office of cosmetics and color fact sheet. Available from: http://www.fda.gov/Cosmetics/GuidanceComplianceRegulatoryInformation/ucm074201.htm. [Cited 2002 Jul 8].
10. Nojiri H, Naito S, Takahasi H, Fujiki M, Kim M. Yolk antibody-containing hair care products. (US Patent) 5976519. 1999:1-8.
11. Monteiro VF, Natal AM. Morphological analysis of polymers on hair fibers by SEM and AFM. Mat Res2003;6:501-6.
12. Robbins CR. Chemical and Physical Behavior of Human Hair. 4th ed. New York: Springer-Verlag; 2001. p. 9-24.
13. Van Steensel MA, Happle R, Steijlen PM. Molecular genetics of the hair follicle: The state of the art. Proc Soc Exp Biol Med 2000;223:1-7.
14. Marshall RC, Orwin DF, Gillespie JM. Structure and biochemistry of mammalian hard keratin. Electron Microsc Rev 1991;4:47-83.
15. Swift JA. The electron histochemistry of cysteine containing protein in the guinea pig hair follicle. Histochemistry 1968;19:88-98.
16. Swift JA. Human hair cuticle: Biologically conspired to the owner's advantage. J CosmetSci 1999;50:23-47.
17. Swift JA. Morphology and histochemistry of human hair. In: Jolle P, Zahn H, Hocker H, editors. Formation and Structure of Human Hair. Basel: Birkhauser verlag; 1997. p. 149-75.
18. Cao J, Wijaya R, Leroy F. Unzipping the cuticle of the human hair shaft to obtain micron/nano keratin filaments. Biopolymers 2006;83:614-8.
19. Swift JA, Smith JR. Microscopical investigations on the epicuticle of mammalian keratin fibres. J Microsc 2001;204:203-11.
20. Zahn H, Messinger H, Hocker H. Covalently linked fatty acids at the surface of wool: Part of the cuticle cell envelope. Text Res J 1994;64:554-5.
21. Smith JR, Swift JA. Lamellar subcomponents of the cuticular cell membrane complex of mammalian keratin fibres show friction and hardness contrast by AFM. J Microsc 2002;206:182-93.
22. Verma V, Verma P, Ray P, Ray AR. Preparation of scaffolds from human hair proteins for tissue-engineering applications. Biomed Mater 2008;3:025007.
23. Wolfram LJ. Human hair: A unique physicochemical composite. J Am Acad Dermatol 2003;48:S106-14.
24. Swift JA. Mechanism of split-end foramation of human hair. J Soc Cosmet Chem 1997b; 48:123-6.
25. Gray J. The World of Hair. Available from: http://www.pgbeautygroomingscience.com/the-world-of-hair1.html.
26. Horio M, Kondo T. Crimping of wool fibers. Text Res J 1953;23:373-86.
27. Krol ES, Liebler DC. Photoprotective actions of natural and synthetic melanins. Chem Res Toxicol 1998;11:1434-40.
28. Rózanowska M, Sarna T, Land EJ, Truscott TG. Free radical scavenging properties of melanin interaction of eu- and pheo-melanin models with reducing and oxidising radicals. Free Radic Biol Med 1999;26:518-25.
29. Jones LN, Steinert PM. Hair keratinization in health and disease. Dermatol Clin 1996;14:633-50.
30. Zahn H, Wortman FJ, Hocker H, Chemie, Aufbau der Wolle. Chemie in Unserer Zeit. 1997;31:280-90.
31. Baden HP. Biochemistry of hair protein. Clin Dermatol 1988;6:22-5.
32. Robbins Cr, Kelly CH. Amino acid composition of human hair. Text Res J 1970;40;891-6.
33. Lodge RA, Bhusan B. Wetting properties of human hair by means of dynamic contact angle measurement. J Appl Polym Sci 2006;102:5255-65.
34. Gray J. Hair care and hair care products. Clin Dermatol 2001;19:227-36.
35. Wolfram LJ, Hall K, Hui I. The mechanism of hair bleaching. J Soc Cosmet Chem 1970;21:875-900.
36. Zviak C. Dermatology. In: The Science of Hair Care. Vol. 7. New York, Basel: Verlag Marcel Dekker Inc.; 1986. p. 248-50.
37. Chao J, Newson AE, Wainwright IM, Mathews RA. Comparison of the effects of some reactive chemicals on the protein of whole hair, cuticle and cortex. J Scoc Cosmet Chem 1979;30:401-13.
38. Robbins CR, Kelly CH. Amino acid analysis of cosmetically altered hair. J Soc Cosmet Chem 1969;20:555-64.
39. Hau J, Hendriksen CF. Refinement of polyclonal antibody production by combining oral immunization of chickens with harvest of antibodies from the egg yolk. ILAR J 2005;46:294-9.
40. Narat M. Production of antibodies in chickens. Food Technol Biotechnol 2003;41:259-67.
41. Bollen LS, Hau J. chicken eggs in polyclonal antibody production. Scand J Lab Anim Sci 1996;23:85-91.
42. Hodek P, Stiborova M. Crimping of wool fibers. Text Res J 1953;23:373-86.
43. Tsujino Y, Yokov Y, Sakoto K. Hair coloring and waving using oxidases. J Soc Cosmet Chem 1991;42:273-82.

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