Continuing Medical Education

Hair care: a medical overview (part 2)

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ABSTRACT

The authors complement the first article on the approach of dermatological aesthetic hair treatments. This article addresses the ultimate hair straightening with major straightening legalized - sodium, lithium and guanidine hydroxides and ammonium thioglycolate - their differences, mechanisms of action, indications and safety to human health. Besides these straighteners, we discuss the illegal and indiscriminate use by hairdressers salons in Brazil in the group of aldehydes (formaldehyde and glutaraldehyde) for smoothing hair. This study focuses its legal implications and public health, carcinogenic potencial and the identification of such filings with ANVISA. Also studied the shampoos and conditioning agents indicated for treatment of the hair shaft. Finally, we discuss the implications of hair care in general health of the hair shaft and the scalp.

Permanet hair and straightening

Straightening

Hair straightening is a temporary or permanent breaking of chemical bonds that keep the tri-dimensional structure of keratin molecule in its original rigid form. These are divided in strong (disulfide bridges) and weak bonds (hydrogen bridges, ionic bonds and van der Waals forces). Weak forces are broken in the simple act of wetting the hair. The weaker chemical bonds result from attraction between positive and negative charges. There are temporary hair straightenings, which use **physicochemical** techniques as the hair drier and piastra ("flat iron") and also the technique of hot comb. They are temporary because they last until the next hair washing. Hair need to be previously wet, in order to break hydrogen bridges in the process of keratin hydrolysis, allowing the temporary opening of these bridges helicoidal structure. With this process hair becomes straight. The rapid dehydration of hair dryer maintains the hair straight shape. Application of flat iron shapes cuticle cells (scales) as if flattening them parallel to the hair stem. The hair gets straight and shiny as it reflects more incident light.[1]

Permanent hair straightening aim to break the disulfide bridges of keratin. They may be based on sodium hydroxide, lithium and potassium hydroxide, guanidine (calcium hydroxide + guanidine carbonate), ammonium bisulfite and thioglycollate, or ethanolamine, which use chemical reactions of reduction.[2,3]

Hydroxides

Sodium hydroxide, lithium hydroxide, and guanidine hydroxide (composed of guanidine carbonate and calcium hydroxide) are the most powerful and are intended, in general, to Afro-ethnic hair. The first is used in concentrations ranging from 5% to 10%, at pH 10% to 14%, promoting the most dramatic results and is the one causing more hair damage. Guanidine hydroxide is less potent than sodium hydroxide, but still has high potential to damage the hair fiber. They act by promoting the breaking of keratin disulfide bridges in a process called lanthionization, which is the replacement of 1/3 of amino acid cysteine by lanthionine. Hair is composed of approximately 15% of cystine.[4] Alkaline pH (between 9 and 14) is used, which causes the swelling of fiber, allowing the opening of the outer layer, the cuticle, so that relaxer penetrates this and the next layer, the cortex. After

that, a substance that acidifies pH is applied interrupting the process and closing again the disulfide bridges in the desired hair new format. Generally, acid shampoos are used for this purpose (pH between 4.5 and 6.0).

Thiols

Ammonium or ethanolamine thioglycollate belongs to the "thiols" family and is the most used in Brazil. It is far less potent than sodium hydroxide and, in general, milder than guanidine. It has the highest cost among all relaxers. Its concentration depends on the pH of ammonia solution. If a thioglycollate solution 6% at pH 9.8 is used, the same action power of a 10% solution at pH 9.35 is achieved, but the first solution is potentially more abrading, and due to the higher concentration of ammonia, it has a much more unpleasant odor. In most cases, a solution between 7.5% and 11% at pH between 9 and 9,3 is used. It can be applied to dry (preferably) or wet hair. The product concentration should be chosen according to hair type (Table 1).[4]

Thioglycollate is currently the most used compound for Caucasian hair straightening. It breaks the disulfide bridges of cysteine amino acids, causing the formation of two cysteines for each cystine. Through this process, keratin suffers edema and becomes malleable enough to be curled (perm) or straightened. In perm process, waving rollers or rods are used, and in hair straightening a hairdryer is used first and then a flat iron is applied to stretch the hair. A better straightening is achieved by applying the flat iron in very thin locks of hair. Afterwards, the hair is washed with tap water and thioglycollate is neutralized with the application of an oxidative agent, usually containing hydrogen peroxide. The chemical process is then stopped, with hair strands being kept permanently in the new format. The entire process can last up to 7 hours, if flat iron was applied in very thin locks of hair. The so-called "relaxation" is the application of thioglycollate without the use of flat iron. It is a faster process, but the smooth effect is less dramatic. In chemically treated hair, an application of the thioglycollate should be done in a strand test before starting the process to determine the hair resistance to product. Application of permanent coloring or toning can be done about 15 days after straightening. It should be noted that relaxed hair become more susceptible to chemicals, especially to bleaching. Thioglycollate is not compatible with hydroxides, and simultaneous application of both products on the same area will result in the hair tonsure.[5,6]

Table I - Thioglycollate concentration according to hair type (Bouillon C, Wilkinson J - 2005)[4]

Hair type	Thioglycollate concentration
Natural hair difficult to straight	8 ou 9%
Natural hair easy to straight	7%
Slightly bleached hair	5%
Very bleached hair	1%

Light Emitting Diode (LED)

LED is a semiconductor diode (P-N junction) that emits visible light when energized. The light is monochromatic and produced by electron energetic interactions. The light emission process through the application of an electric source of energy is called electroluminescence. In any P-N junction directly polarized within the structure, near the junction, there is gaps recombination of electrons. This recombination requires the energy possessed by the electron, which until then was free, to be liberated, which occurs as heat or light photons. There are techniques using thioglycollate associated with LED application in hair already submitted the straightening. The proposal would be that the light would help the penetration of thioglycollate and also, by itself, generate breaks in disulfide bonds of keratin, which would allow the use of lower concentrations of straightening with less damage to the hair and more power of straightening. In medical literature there are no studies to support this result, wich would scientifically justify the use of LED in association with thioglycollate.

Formaldehyde

Use of formalin for hair straightening has become frequent because, besides being cheaper, it is a quick process and leaves hair with an intense glare. Indeed, formalin is a formaldehyde solution at 37% and its sale in pharmacies is prohibited. The solution is empirically mixed with liquid keratin, which consists of positively charged amino acids, and cream conditioner. The final product is applied on hair strands and spread with the help of a comb. Then a hairdryer and flat iron are used. Formaldehyde binds to cuticle proteins and amino acids hydrolyzed keratin solution forming a hardener film along he hair, waterproofing and keeping it hard and straight (Figure 1). The effect is the same as in caramel apple: beautiful and bright outside, but dehydrated and brittle inside (Figure 2). The hair is susceptible to fracture as a result of daily normal trauma, such as combing, brushing, and tight the hair. The biggest problem is that formaldehyde is volatile and, after heating, a larger amount is inhaled by both those who apply and those undergoing treatment. Formaldehyde is allowed in cosmetics in concentrations up to 0.2% as a preservative and 5% as a nail hardener (ANVISA - Legislation in force: Formaldehyde preservative, RDC Resolution No. 162 of 11 September 2001 and formaldehyde as nail hardener: RDC Resolution No. 215 of 25 July 2005), but its use as a hair straightening is not allowed due to volatilization. Recently, a

Figure 1 – Aspect of shiny hair with formaldehyde straightening.

Figure 2 – Tensile testing of the same patient with previous formaldehyde straightening, showing the hair fragility with a simple "pull". "Caramel apple" effect.

new resolution was issued prohibiting its use for this purpose (ANVISA - RDC Resolution No. 36, June 17, 2009). To achieve the smoothing effect, formaldehyde should be used in concentrations of 20% to 30%, which is totally banned.

Glutaraldehyde is a colorless liquid slightly acidic in its natural state, which is being commonly used as a hair straightener since the ban of formaldehyde. It is a clear liquid found in aqueous solution at 50%. After activation with baking soda to make the solution alkaline, the liquid becomes green. In Brazil, after dilution, it is marketed as sterilant and disinfectant for hospital use at concentrations of 2%. Glutaraldehyde (glutaral) is a relatively common preservative in cosmetics, and can be used in concentrations up to 0.2%. Its activity is due to the alkylation of sulfhydryl, hydroxyl, carboxyl, and amino groups, altering DNA, RNA, and protein synthesis. Mutagenicity of glutaraldehyde is very similar to that of formaldehyde. The inhalation exposure to glutaraldehyde and formaldehyde results in damage to upper respiratory tract epithelium. Glutaraldehyde is 6 to 8 times stronger than formaldehyde to produce protein cross-links in DNA and about 10 times stronger than formaldehyde to produce tissue damage inside the nose after inhalation. The International Agency for Research on Cancer (IARC) classifies the substance in group 2A; that is, as a probable human carcinogen. Yet, the New Zealand Nurses Organization believes that glutaraldehyde is a neurotoxic, leading to memory loss and concentration difficulty, in addition to tiredness and fatigue.[6]

Formaldehyde Risks

The risk of formalin in its inappropriate application is proportional to its concentration and frequency of use (the higher the concentration the bigger the risk). Inhalation of gases and contact with skin is dangerous for both professionals and users (Table 2).

Inhalation of this compound may cause irritation to eyes, nose, mucous membranes and upper respiratory tract. In high concentrations may cause bronchitis, pneumonia, or laryngitis. The most frequent symptoms in case of inhalation are severe headaches, coughing, shortness of breath, dizziness, difficulty breathing, and pulmonary edema. Contact with vapor or solution can leave the skin whitish, rough, and cause strong sense of anesthesia and superficial skin necrosis.

Long periods of exposure can cause dermatitis and hypersensitivity, skin rashes (dryness) and ulcerations, mainly between the fingers. It can also cause conjunctivitis. The formaldehyde vapor irritates all parts of the upper respiratory system and also affects the eyes. Most people can detect formaldehyde at concentrations as low as 0.5 ppm, and, as the concentration is increased until the current Maximum Exposure Limit, the irritation is more pronounced (Table 3).[7]

Formaldehyde concentration measurements in the air of pathology laboratories have shown levels between 0.07 and 2.94 ppm (parts per million). Environments in which the substance is used can not have more than 0.019 mg/m3 in the air and, certainly, the levels exceed this limit after heating.

Table II - Formalin risks

Reactions of formalin use
Skin contact - toxic. Causes skin irritation, redness, pain, and burns.
Eye contact - causes irritation, redness, pain, tearing, and blurred vision. High concentrations cause irreversible damage.
Inhalation - can cause respiratory tract cancer. Can cause sore throat, nose irritation, cough, decreased respiratory rate, irritation, and respiratory tract sensitization. Can also cause serious injury to airways, leading to pulmonary edema and pneumonia. Fatal in high concentrations.
Chronic exposure - a frequent or prolonged exposure may cause hypersensitivity, leading to dermatitis. The prolonged contact may cause allergic reaction, weak vision and enlarged liver.
In the case of hair straightening, depending on formaldehyde concentration, it can also cause hair loss.

Table III - Relationship between concentration of formaldehyde in parts per million (PPM) and symptoms

Concentration of volatilized formaldehyde	Symptoms
0,1 to 0,3 ppm	Lower level of reported irritation
0,8 ppm	Odor threshold (starts to smell)
1 to 2 ppm	Mild irritation threshold
2 to 3 ppm	Eyes, nose, and throat irritation
4 to 5 ppm	Significant increase in mucous membrane and tearing irritation
10 to 20 ppm	Intense lacrimation, severe burning sensation, cough, and can be tolerated for only a few minutes (15 to 16 ppm can kill mice and rabbits after 10 hours of exposure)
50 to 100 ppm	Cause serious damage in 5 to 10 minutes (exposure of mice to 700 ppm can be fatal in 2 hours).

Carcinogenicity, the assessment of carcinogenic potential, of formaldehyde was assessed by 4 international research institutions and was classified in 1995 by the International Agency for Research on Cancer (IARC) as carcinogenic to humans (Group 1, July 2004), tumorigenic, and teratogenic because it produces reproductive effects in humans. The USA Environmental Protection Agency (EPA) and the Occupational Safety and Health Association (OSHA) believe that the agent is suspected of causing cancer in humans. The USA National Toxicology Program (Fourth Annual Report on Carcinogens) reported in 1984 that formaldehyde is a carcinogenic agent to rats in the following doses: oral, 1170 mg/kg; dermal, 350 mg/kg; and inhalation, 15 ppm/6 hours.[8]

Hair straightening products are registered as cosmetic with degree of risk 2 by the Brazilian drug administration organ (ANVISA), i.e. they require registration for marketing. However, a practice now considered illegal and prohibited is the addition of formaldehyde or glutaraldehyde in these products to increase straightening capacity. To determine whether a product is registered as a degree 2 cosmetic, simply visit the site of ANVISA, using the following path: http://www7.anvisa.gov.br/datavisa/Consulta_Produto/consulta_cosmetico.asp. Through the trade name or registration number appearing on the label, it is possible to know if the product is illegal or not. This number starts with the numeral 2, and has 9 or 13 digits (Figure 3).[9]

Final Consideration on Hair Straighteners

Once hair is straightened by the application of guanidine or sodium hydroxide it can not be straightened again because there is the risk of breakage. Now when thioglycollate is used, it is recommended to straighten only the newly grown hair, however, when using a low concentration, a new application

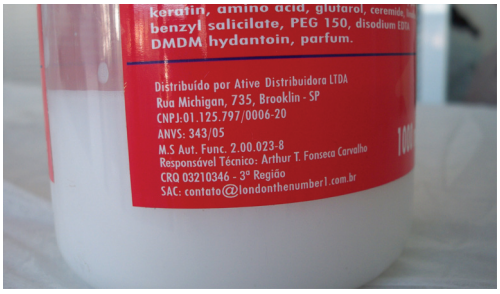

Figure 3 – Note the ANVISA registration number without the specifications of a product designed for hair straightening.

is required and a careful strand test should be done before the whole process. Straightened hair can only be subjected to another straightening process with the same substance used initially. Hair straightening should be done at least 2 to 4 weeks prior to hair coloring.

The hair straightening process know in Brazil as "progressive brush" (without formalin) is the application of thioglycollate every 4 months or so, to a progressive straightening effect. While "Japanese brush" is the application of thioglycollate in high concentration for a fast straightening in only one session. Hair straighteners should not be applied directly to the scalp, and for the most potent as sodium hydroxide, the skin should be protected with prior application of oil or petroleum jelly.

Hair Shaft Care

Shampoos

Currently, the goal of shampoo is not only to remove sebum, sweat, debris, ions, hair products fatty acids, oxidized metal particles, and impurities from the scalp, but also to help hair aesthetics. In our days a shampoo can have more than 30 ingredients in its formula, since, there are the conditioning agents to minimize hair aggression, besides the surfactants, which are cleaner agents. These agents can be lipids, carboxylic acids, cationic agents and silicones (dimethicone, amodimethicone).[1]

The main element of a shampoo is a surfactant or detergent, which is a molecule with a non-polar or hydrophobic portion, which binds to lipids of sebum and other impurities, and a polar or hydrophilic portion, which connects to the water allowing the removal and rinse of desired material. There are four basic categories of surfactants: anionic, cationic, nonionic, and amphoteric (Table 4). Each of these groups has different qualities of cleaning the scalp and conditioning the hair. Typically, many surfactants are combined into a single formula to achieve the desired result.[10]

Anionic surfactants such as sodium lauryl sulfate and ammonium laureate, ammonium sulfate and alpha-olefin

Table IV - Shampoo surfactants1		
Shampoo surfactants		
Type	**Examples**	**Characteristics**
Anionic	Lauryl sulfate, lauryl ether sulfate, sarcosine, sulfosuccinate	Deep cleaning. Let the hair dry, hard, opaque.
Cationic	Quaternary ammonium salts	Poor cleaning, producing little foam. Leave hair soft and malleable.
Nonionic	Polyoxyethylene alcohol, polyoxyethylene sorbitan ester, alkanolamides	Mild cleasing. Leave hair soft.
Amphoteric	Betaine, sulfatein	Moderate cleaning, non-irritating to the eyes. Leave hair soft.

sulfonate are the most widely used commercially. They are excellent for removing sebum from the scalp. However, they are not well accepted by consumers because of its unsightly result to hair, living it opaque, slightly malleable, and difficult to comb. To keep the power of a cleanser shampoo, the withdrawal of hair natural sebum is minimized, and many formulas add other secondary surfactants as the nonionics.

Cationic surfactants are used in shampoos for dry or chemically treated hair due to their limited power to remove sebum, and for keeping the hair soft and malleable. The most common cationic surfactant is cetyl trimethyl ammonium chloride. It forms positively charged ions when in aqueous solution and has cleansing properties and weaker foaming power than anionic. For this reason, a coconut type chain can be added to cationic surfactant to allow greater amount of foam.

Non-ionic detergents are used in combination with anionic as secondary cleaners, as they present a small capacity to clean the scalp. Their goal is to soften the anionic surfactant. Some examples are PEG-80 sorbitan laurate and cocoanphocarboxyglycerinate.

The last surfactant category consists of amphoteric detergents, which are substances that present both negative and positive poles. This causes them to behave as cationic detergent at low pH and as anionic at high pH values. Examples are: **cocodietanolamin**, betaines, cocoamidopropylbetaine and cocoamphoacetate. This type of surfactant is used in shampoos for babies, since it does not irritate the eyes and is also suitable for thin hair.[11]

Currently, there is a strong negative advertisement about the presence of salts in shampoo formulas. Salts such as sodium chloride or similar is needed to control viscosity. If salts are not present in quantities above the ideal, they do not offer risk to hair health. In very high quantities they are substances that, by having a positive charge, compete with the polymer for the same binding site, thereby reducing the power of conditioning products. However, even in high amounts they offer the benefit of removing polymer residues deposited between scales.

Shampoos and chemical treatments increase the hair electrostatic charge (negative charge), which is compensated by applying a cationic conditioner (positive charge). This leads to accumulation of waste in cuticle, particularly endocuticle, in junction areas between the cell layers, called cell membrane complex. Such waste increases hair static electricity, raising the scales, leaving the hair frizzy, difficult to comb, and unsightly. In addition, the fatty acids in conditioning shampoos and conditioners bind to calcium and magnesium present in shower water and are deposited on hair fiber. Therefore, the weekly application of anti-residue shampoo is needed; whose high power astringent surfactant is ammonium lauryl sulfate.

Conditioners

They are substances designed to detangle hair, facilitate hairstyle, and reduce aggression of physical and chemical effects to which hairs are subjected daily, such as the simple act of combing, keeping the aesthetic aspect of hair, the softness, and reducing the appearance of rebellious hair (frizz effect). Conditioners consist of mineral and vegetable oils, waxes, long chain alcohol, cationic substances (positively charged), triglycerides, esters, silicones and fatty acids.[12]

The intention is to bind these substances in damaged areas of cuticle and cortex. Binding and interactions of cosmetic components with keratin are influenced by the electrical charge of each ingredient, molecular size, isoelectric point of hair fiber, and ingredients previously adhered to cuticle. The common ingredients to conditioners are stearalkonium chloride, sodium chloride cetrimonium, dicetyldimonium chloride, Polymer JR (polyquaternium-10), quaternary polymers, cationic guar gum, acrylamide, methacrylate, neutral polymers (copolymers, polyvinyl), and fatty acids (lauric, myristic, palmitic).

The ingredients can act both on the hair surface and deeply in the cortex. Substances that act in the cuticle have a high potential for adsorption, which means a form of adherence or coating, also called a film effect. Substances of high molecular weight act more in the cuticle, while the low molecular weight substances penetrate the hair inner layer.

There is also influence of pH, since acidic substances act more quickly, with detangling effect by decreasing the electrostatic charge. Alkali substances penetrate deeper in the cortex and act more slowly. The former are conditioners and the others are fast action products (1 to 3 minutes), and the others are the masks that require at least 15 minutes of application. Ideal conditioner should have pH between 4.1 and 4.9. Unfortunately, it is not required to specify the product pH in packaging.

One widespread category among conditioning agents are polymers, which are substances found in shampoos, conditioners, creams with and without rinsing, mousses and fluids. Their function is to reduce the hair electrostatic charge and increase the hair strand substantivity forming a protective film.

Polymers bind to hair in three ways (ionic and covalent, hydrogen bonds, and attractive forces of Van der Waals) and are classified as:

a) *cationic*: polyquaternium ammonium, dimethyl ammonium, stearalkonium chloride, o**r** cetrimonium chloride;

b) *mono and polypeptides*: hydrolyzed proteins (amino acids), polypeptides derived from collagen.

The molecular weight and size of polymer influence the absorption and dispersion through the hair fiber and its binding to keratin. Polymers of low molecular weight diffuse themselves inside the fiber (MW 10,000 to 250,000), and polymers of high molecular weight diffuse themselves on the fiber surface (over 250,000).

Moreover, the hair electric charge allows a greater or lesser binding of polymers. Most hair cosmetics have pH more alkaline than the hair strand pH, charging them negatively and facilitating the binding of cationic polymers. Cationic polymers are difficult to remove by ordinary shampoos (residues). The polypeptides bind to the fiber because they have many ionic points and sites of polar bonds. They are large molecules and have binding areas for Van Der Waals forces; while monomers of proteins (methionine, tyrosine, tryptophan) when in aqueous solutions have low molecular weight and penetrate inside the fiber.

Currently, the most widely used agent and conditioner is silicon. Silicones as cyclopentasiloxane, dimethiconol, dimethicone, and amodimethicone have a film effect and protect the hair from high temperatures of hairdryer and flat iron, as the heat spread along the fiber. They also reflect light, which increases the shiny. Silicones help to flatten the cuticle anucleate keratinocytes, causing the scales not detached from each other, helping to keep the hair untangled.

Recently, hair care treatments included the use of sunscreens. They were first used for preserving hair products from the action of sunlight, but today it is known that these filters act on the hair strand while minimizing degradation of tryptophan and the breaking of disulfide bridges by UVB rays through absorption. Examples are incroquat UV 283, merquat, and escalol HP 610. Sunscreens such as quaternized chloride cinamidepropyl trimethyl ammonium and dimethyl-PABA-amidopropyl-laurdimonium tosylate have a positive charge that binds to hair strand which is negatively charged, forming a protective film coverage. All these products should be reapplied when the hair is wet.

It is noteworthy that topical application of nutrients, vitamins, pro-vitamins, panthenol, among others substances announced in shampoos and conditioners, do not alter the hair strand structure, and there is no scientific evidence of benefit in their use.

Implications of Cosmetic Treatments on Hair Shaft

The medical literature reports some possible effects after hair straightening: shaft fracture (usually at the point of junction of pre-treated hair with the new hair being chemically treated, or even in distal part of the hair) (Figure 4), scarring alopecia, follicular degeneration syndrome (hot comb alopecia, whose name tends to be replaced), induction of telogen effluvium, and possible damage to hair follicles.[13,14]

Moreover, there are frequent scalp burns occurring when the product is applied directly to skin. The permanent dyes using paradiamine oxidation are the main causes of contact eczema. The most involved in allergy are: p-phenylenediamine, p-chloro, and toluenediamine phenylenediamine. Formaldehyde can also cause contact eczema. Eczema condition starts in scalp periphery and behind the ears, followed by scalp itching. Lesions may extend to face, particularly in eyelids and periocular region.

P-phenylenediamine can induce asthma in hairdressers. There is a concern about the systematic use of hair coloring products. Studies to investigate the carcinogenic potential of various types of dyes did not consider the substances currently available in the market as being risky. The substance 2,4-diamino anisole was withdrawn from the market due to its relationship to carcinogenicity. New studies on the toxicological potential of hair dyes are still in development, covering larger populations and more prolonged use of dyes.

Chemicals used for hair straightening, permanent, or coloring leave hair rough, porous, and brittle, with lower tensile strength due to the generation of negatively charged ions along the keratin molecule. Shampoo also removes excess sebum and natural fat present along the hair strand.

Figure 4 – Dermoscopy of hairs ends of a patient with very serious physical and chemical damage. Trichoptilosis (splitting of hairs at the ends) is a common finding.

Small everyday traumas, to which hair is subject such as the act of combing and brushing, also generate the production of negative ions in cuticle and cortex, particularly in chemically treated hair.[15-18]

To minimize these effects, conditioning agents are used after washing to keep hair soft, easy to comb, shiny and silky. Conditioners reduce static electricity and friction between the hair strands detangling them because they deposit ions positively charged inside the hair, which bind to negatively charged ions and neutralize them. Friction is then reduced, causing an increase in adherence of cuticle scales and, therefore, the hair is more reflective of incident light and silky in touch. There are several types of conditioners: instant, deep (to rinse), and "leave-in" (without rinsing); the components of the first two should be resistant to subsequent rinse.[19]

During pregnancy and lactation, it is not recommended the use of any type of chemical for hair coloring, perming, or straightening, even with henna. There is no consensus about the fetus safety during the use of such techniques and substances, but it is known that the risk is higher for professionals who apply chemicals without wearing gloves and masks that give adequate protection. There are reports on cases of neuroblastoma and congenital cardiovascular diseases caused by mothers exposed to dyes, permanent and toning. Some authors consider henna to be mutagenic and capable of living residues on scalp.[20]

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Questions for Continuing Medical Education – CME

1 - How straightening chemicals such as thioglycollate, sodium hydroxide, and guanidine react?
a) They break the disulfide bridges of keratin molecule permanently.
b) They break the hydrogen bridges of keratin molecule on a temporary basis.
c) They break the hydrogen bridges of keratin molecule permanently.
d) They break the ionic bridges between sulfur amino acids permanently.
Ans.: a

2 - The process of lanthionization consists of:
a) Is characteristic of thioglycollate the breaking of a cystine molecule in two cysteine residues.
b) It is exclusive of sodium hydroxide the replacement of 1/3 of the amino acid cystine in lanthionine.
c) It is exclusive of guanidine the replacement of 1/3 of the amino acid cystine in lanthionine.
d) It is the mechanism of hydroxides action (sodium, lithium, and guanidine) and consists of the replacement of 1/3 of the amino acid cystine in lanthionine.
Ans.: d

3 - The mechanism of action of ammonium thioglycollate or ethanolamine is:
a) Lanthionization.
b) Hydrolysis.
c) Breaking disulfide bridges of cysteine molecules.
d) Breaking disulfide bridges of lanthionine molecules.
Ans.: c

4- Permanent hair straightening chemicals are incompatible with hair previously treated with:
a) Permanent dyes.
b) Bleachings.
c) Toners.
d) Ammonia.
Ans.: b

5 – From the substances mentioned below, which can act as both perming and straightening (wave hair when applied in rolls or rods):
a) Thioglycollate.
b) Sodium hydroxide.
c) Lithium hydroxide
d) Guanidine Hydroxide
Ans.: a

6- What substance is being used in a clandestine manner to replace formaldehyde in hair straightening?
a) Formalin.
b) Hydroxyapatite.
c) Ammonia.
d) Glutaraldehyde.
Ans.: d

7 - Aldehydes are mutagenic substances and, therefore, capable of producing harmful side effects to health. What are the main effects of short or long-term use of aldehydes as hair straightener?
a) Chemical pneumonia.
b) Cancer (leukemia, brain, airway).
c) Changes in the CNS and decreased visual acuity.
d) All of the above.
Ans.: d

8 – What is the concentration allowed by ANVISA for the use of aldehydes as hair straightener (formaldehyde and glutaraldehyde)?
a) 2%.
b) Up to 5%.
c) 0.2%.
d) They are not allowed as hair straighteners at any concentration.
Ans.: d

9 - Sodium lauryl sulfate and sodium laureth sulfate are examples of surfactants:
a) Anionic.
b) Non-ionic.
c) Cationic.
d) Amphoteric.
Ans.: a

10 – The cationic surfactant most commonly used in shampoo for chemically treated hair is:
a) Cocobetain.
b) Sodium laureth sulfate.
c) Cetyl-trimethyl-ammonium.
d) Cocoanphocarboxyglycerinate
Ans.: c