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CHANGING HAIR STRAIGHTENING CHEMISTRY TO PROVIDE A NEW PROGRESSIVE TECHNOLOGY THAT ALLOWS HAIRDRESSER TO MANAGE SHAPING EFFECT AND FIBER INTEGRITY.

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1 INTRODUCTION

Hair straightening is an important cosmetic segment that allows consumers to express new needs for curly hair shaping management. Standard straightening technologies normally consist into alkaline actives, combining thiols and bases, that are able to reduce the disulfide bonds that lock the intermediated filaments of proteins inside the hair fibers, enabling the hair mechanical shaping. Usually, during this process, the straightening molecules present high reactivity at its pH, resulting in severe modifications of hair constituents, a fact that can be perceived by users as high level of damage. Since the beginning of the 21st century, the usage of acid-straightening technologies containing formaldehyde started in Brazil and gained its place in the world market. Even though this kind of technology is well known to provide lower levels of damage, as compared to alkaline straighteners, it is considered as mutagenic and carcinogenic. Formaldehyde is, therefore, highly regulated and restricted as preservative only (dosages < 0.3 %). In addition, there is a request from hairdressers for new progressive solutions that would allow them to better manage the resulting effect according to the consumer's expectation and basic hair fiber quality.

In this context, new chemical approaches were explored in order to propose a safe and innovative alternative that combine the benefits of both types of existing technologies. 350 raw materials were analyzed, in acidic pH, in terms of straightening power, safety and impact on hair integrity, highlighting the usage of thiolactic acid (TLA), at pH 3.5, as a potential hair straightening active. Following many assays, we proposed a new hair straightening procedure based on TLA and heat combination (Heat Bond) [1].

This work analyses the action of Heat Bond in the fiber, comparing it to other two mainly used technologies in the Brazilian market: formaldehyde and ammonium thioglycolate. Moreover, the effect of Heat Bond on hair's shine, combing energy and frizz and volume reduction were investigated.

2 MATERIALS AND METHODS

HAIR SAMPLES AND CHEMICAL TREATMENTS

Human natural hair fibers of dark brown coloration were used. The hair has been randomized in swatches according to the assay as described in Table 1.

Table 1. Hair swatches specificities according to the assay

Assay	Origin	Curliness [2]	Length	Weight
Amino acid analysis	Brazilian	3	27 cm	2.7 g
Tensile strength	Brazilian	3	27 cm	2.7 g
Combability	Caucasian	1	25 cm	2.7 g
Shine	Caucasian	1	27 cm	2.7 g
Frizz and volume assessment	Caucasian	3	25 cm	5.0 g

All hair swatches underwent a standard cleaning process with neutral shampoo and were dried in a standardized environment at 22 ± 2 °C and 55 ± 5 % relative humidity, during 24 hours before and after the chemical treatments listed below.

THIOLACTIC ACID (TLA)

A reducing product containing 8 % of thiolactic acid at ph 3.5 ± 0.5 was applied to the hair swatches with 30 min pause. After rinsing, the hair was dried with a blow dry and in sequence, the swatches were thermo-mechanically straightened by flat iron strokes at 230 °C. After the heating step, the neutralizer containing 2.4% of hydrogen peroxide at pH 2.5 ± 0.3 was applied to the hair and rinsed after 10 min pause.

AMMONIUM THIOGLYCOLATE (TGA)

A reducing product containing 15 % of ammonium thioglycolate at pH 9.0 ± 0.2 was applied to the hair swatches with 30 min pause. After rinsing, the hair was thermo-mechanically straightened while submitted to successive brushing strokes (associated to a hair dryer), followed by flat iron strokes at 230 °C. After the heating step, the neutralizer containing 2.4 % of hydrogen peroxide at ph 2.5 ± 0.3 was applied to the hair and rinsed after 10 min pause.

FORMALDEHYDE

A leave-on product containing 19 % of formaldehyde at ph 2.0 ± 0.5 was applied to the hair swatches with 30 min pause. The excess of product has been removed by compressing the hair with sliding fingers and then, the tresses were thermo-mechanically straightened by flat iron strokes at 230 °C.

METHODOLOGIES OF EVALUATION

AMINO ACID ANALYSIS

Hair material was analyzed after hydrolysis with concentrated methane sulfonic acid aqueous solution at 110 °C overnight. After dilution and neutralization with lithium hydroxide, the resulting solutions were filtered and analyzed by high pressure liquid chromatography on an ion exchange column by a Hitachi L8900 apparatus. The amino acids were revealed by post column reaction with ninhydrine.

TENSILE STRENGTH

Fifty fibers per treatment were randomly selected from 2 hair swatches and crimped for tensile analysis. The cross-sectional area of each fiber was determined using Dia-Stron, Laser Scanning Micrometer. Tensile properties of hair were measured using a Dia-Stron Miniature Tensile Tester with a 10 mm/min extension rate and a pre-strength of 20 mN.

COMBABILITY

The needed energy to comb the hair swatches before and after TLA application was obtained using the EMIC DL-500 test equipment, together with a fixed holder with a standard comb that moved along the tresses at the constant speed of 300 mm/min.

SHINE

The study was performed using the Samba Hair system form Bossa Nova Vision, US. The Bossa Nova Technologies (BNT) luster coefficient bh[4] was measured on the hair swatches before and after TLA application.

FRIZZ AND VOLUME

Digital photographs of the hair swatches were taken in a tabletop with standardized light and position. The original images were converted to a grey scale and an algorithm was used to quantify the frizz and the volume of each swatch.

3 RESULTS & DISCUSSION

The amount of cystine that is transformed during the application of TLA in Heat Bond is half lower before the heating step than what is obtained with TGA in standard thiol based straightening systems, indicating that less disulfide bonds are modified during the application of the product. After the heating step, the quantity of modified cystines is equal to the level obtained with TGA without heat, as shown in Table 2.

This means that during the manipulation step, which is the critical one that may lead to some hair breakage if not well controlled, the cystine bonds are progressively reduced at a level that is lower than what happens with alkaline technologies.

Table 2. Cystine content of the hair after the reducing treatment with TLA and TGA.

Cell	Cystine (%)
No treatment	100
1 X TLA, rinsed, no heat	89
1 X TLA, rinsed, heat, not neutralized	75
1 X Thioglycolate, no heat, not neutralized	74

Further, the hair is maintained in acidic conditions which limits the possibilities of swelling usually observed in alkaline systems, hence bringing some additional robustness to the fiber during the manipulation and the thermo-activation.

The applied chemical treatments are responsible to change the microstructure of the hair fibers, altering its mechanical behavior. This fact can be perceived by the significant modification of all four parameters evaluated in the tensile strength assay (Figure 1) when comparing the chemically treated cells to the non-treated one.

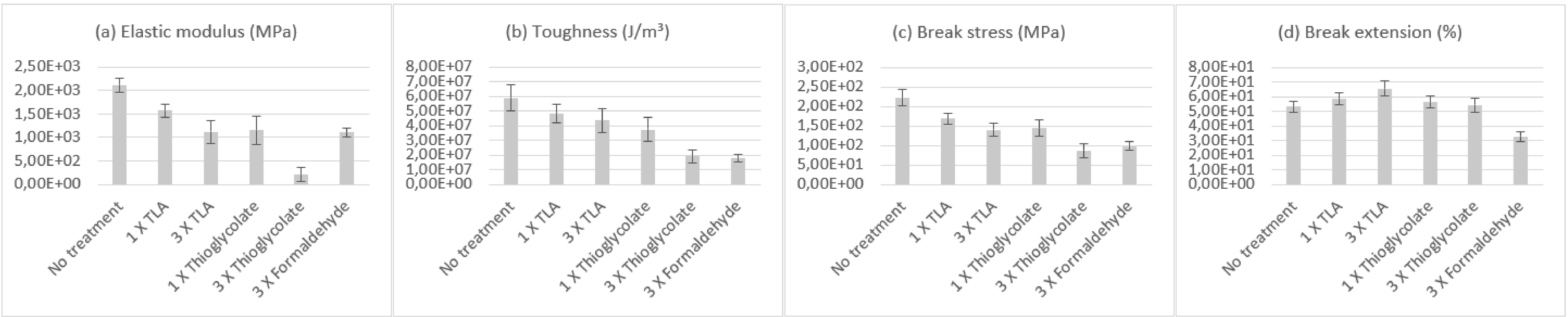

Figure 1. Representative graphs of the values obtained for each tensile strength parameter: (a) Elastic Modulus, (b) Toughness, (c) Break Stress and (d) Break Extension.

The elastic modulus results show that TLA leads to a significant higher resistance to the reversible deformation in the hookean region when compared to thioglycolate. On the other hand, the multi-application of TLA leads to a similar elastic behavior when compared to the multi-application of formaldehyde. In the moment of failure, the hair fibers treated with TLA achieve significant higher stress values than those treated with thioglycolate, with a consequently higher deformation too. In contrast, the hair fibers treated with multi-application of formaldehyde becomes more rigid due to the proteins chains reticulation and, as consequence, the fibers break at significant lower stress and deformation compared to TLA. Finally, when analyzing the toughness values, it is possible to note that hair fibers treated with TLA requires significant higher energy to break than those treated with thioglycolate or formaldehyde.

Furthermore, the application of TLA on natural hair swatches, leads the hair significantly smoother and shinier. In addition, it was observed that TLA induces a significant reduction in hair frizz and volume, which can last up to 12 washes with a bundle of standard shampoo and conditioner.

4 CONCLUSIONS

The assays reveal that the thiolactic acid penetrates into the fiber during the pausing time, but due to its low reactivity at pH 3.5, the cystine reduction is progressive and lower compared to other standard alkaline technologies. Likewise, at this step, it is possible to deliver a more controlled chemical reaction, avoiding higher plasticity or breakage of the fiber, thus providing more confidence for hairdressers during its application. Then, the reaction is catalyzed by heat during a flat ironing step, modifying the structure of the fiber and leading to progressive straightening. This step provides the same straightening power of alkaline straighteners, but shows a higher mechanical resistance.

Heat Bond reinvent hair-straightening chemistry, based on a new progressive and controlled hair shaping procedure. The innovation merges good hair quality from acid technologies with safety from the conventional alkaline ones. In addition, Heat Bond also provides good shine, reduction of the surface friction force and frizz and volume reduction for improved consumer's satisfaction.

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