Formulating

Improving the Sensory Properties of Lye Hair Relaxers

Feb 20, 2015 | View online to Contact Author | By: Hans-Martin Haake, Halid Kader and Karine Kross-Maita, BASF Personal Care and Nutrition GmbH, Düsseldorf, Germany

Keywords: hair | lye relaxer | ethnic care | sensorial properties | straightening | penetration | salon test

Lye hair relaxers are highly alkaline emulsions used to permanently straighten curly hair. While they are highly efficient, they also must be used with caution to prevent eye injury or scalp irritation. In addition, their straightening effect tends to damage hair by reducing mechanical stability and deteriorating tactile and visual properties. During this straightening treatment, a significant number of disulfide bonds in the hair are converted into lanthionine by eliminating one sulfur atom, thus the mechanism by which relaxers straighten hair is referred to as lanthionization. However, it has been shown that this reaction is only part of the whole mechanism, if not even just a side reaction. The conversion of curly hair to a straight configuration means a significant morphological transformation.

In the late 1970s, the no-lye relaxer was introduced to the market, claiming to be less irritating to the scalp. This product is based on a two-component system that is mixed immediately before use. One of the components contains guanidine carbonate; the other is the activator—typically a hydroxide other than sodium hydroxide (or lye). Most also contain calcium hydroxide. Upon mixing the two, guanidine hydroxide is formed. This substance is unstable, which is why mixing must occur immediately before use. Due to claims for reduced irritation potential, no-lye technologies are often used in retail products, whereas lye relaxers are dominantly used by professional hairdressers. One draw-back to no-lye relaxers, however, is that the calcium ions present can form insoluble salts that deposit on the hair, leaving a dull appearance and brittle feel. Individuals who relax their hair at home also have a higher risk of over-processing it, resulting in additional damage.

Outside of relaxing technologies, there is a straightening technology that implements reductive and oxidative treatments on hair while it is forced in a straight configuration. This is basically the same chemistry used for perms. In brief, most of these products first use thioglycolic acid (TGA) salts for opening disulfide bonds, followed by hydrogen peroxide for the oxidative reformation of bonds into the new, straighter configuration. The permanency of this straightening effect is significantly less compared to lye- and no-lye relaxers, especially under conditions of high humidity.

With all straightening treatments, the amount of hair damage caused correlates with the resulting straightening effect. This means that less damaging treatments could be developed by reducing the concentration of active ingredients, e.g., hydroxides or thioglycolates. However, this reduces the straightening efficacy of the treatment and durability of the effect. Another way to reduce the damage caused by hair relaxers is to add ingredients such as conditioning polymers or protein hydrolysates, although these have limited effects on the sensory properties of relaxed hair.

Previous work found soluble silicates in lye relaxers to impart positive effects. Therefore, a compound based on potassium silicate, alkyl polyglycoside and glycerin was developed to improve the effects of lye relaxers on the mechanical and sensory properties of hair. This article explores various properties of this compound using two lye relaxer test formulations and variations of them.

Materials and Methods

Sensory assessment: Virgin Caribbean hair strands (n = 22; 1 g/12 cm) were treated with two versions of a strong relaxer formulation, one with and the other without the test compound (see Formula 1). A 4-g sample of relaxer formulation was applied to the tresses for 20 min. The strands were rinsed with warm water and shampooed using a simple acidic shampoo (pH 5) containing sodium laureth sulfate, cocamidopropyl betaine, polyquaternium-10 and phenol red as the indicator. The shampoo treatment was repeated until the yellow-orange color of the shampoo remained unchanged. Strands were dried for 1 hr using hot air (65°C), then compared by a trained sensory assessment panel (n = 11) under double-blind conditions. The panelists rated the hair samples for 22 parameters using a five-level ranking scale: +1 and -1 indicated strong differences, +0.5 and -0.5 meant small differences, and 0 indicated no difference. Statistical evaluations were confirmed via the Wilcoxon signed-rank test.
Silicium content: Changes in sensory attributes were believed to be caused by the active principle of silicates in the test compound penetrating the hair during relaxer treatment. Energy-dispersive X-ray (EDX) spectroscopy (data not shown) as well as tensile strength results confirmed this penetration. Therefore, the amount of silicat in hair before and after treatment was quantified by ashing hair strands treated with a mild relaxer (Formula 2), including 0-5% of the test compound; mixing the ash with borates and nitrates; then fusing the blend at 1,100°C to glass disks. These disks were analyzed using X-ray fluorescence spectroscopy.

Tensile strength: Tensile strength is a well-established parameter to assess damage in hair. Due to the biological origin of hair, however, results show great variability. Thus, a high number of single fibers must be tested. One method to reduce such variability is by testing each fiber before treatment in the Hookean region. For each test formulation, 50 single test hair strands of Brazilian origin were therefore measured for their strength in this region before and after treatment with the mild relaxer (Formula 2) and again including 0-5% of the test compound.

Salon test: Finally, the strong relaxer (Formula 1), with and without the test compound, was evaluated in a half-head study of 21 panelists under double-blind conditions. Hair relaxers were applied by professional hairdressers, and both the hairdressers and panelists rated each treatment directly after treatment and one week post-treatment. Ratings for ten different parameters were given, ranging from 1-5; with 1 = poor and 5 = excellent.

Results: Sensory Assessment

Results of the sensory assessment are shown in Figure 1. This diagram shows the median and absolute average deviation for each parameter; the symbols show levels of statistical significance (100% minus p value). Hair strands treated with the test compound rated significantly better (p < 0.01), with less dryness, more softness, more smoothness and a healthier look and feel. They also were found to have less volume, easier glide and more suppleness (p < 0.05).

As mentioned previously, sensory properties in relaxed hair could be improved by sacrificing straightening performance. However, as shown in Figure 1, the straightening effect actually improved with the test compound (p < 0.01). In addition, as shown in Figure 2, hair strands treated with lye relaxer benchmarks from the U.S. market were less effective in straightening hair than test Formula 2 with 2% test compound. This effect was more obvious after storing the relaxed hair at high humidity conditions for 24 hr.

Results: Silicium Content

Sensory assessments showed that adding the test compound to relaxer formulations improved various properties, which as noted, could be attributed to the active principle of silicates in the test compound. Therefore, the silicium content in hair samples treated with a range of test compound concentrations (Formula 2) was measured. For the relaxer with no test compound, silicium content below a 100-ppm detection limit was found (see Figure 3), which corresponds to the natural silicium content in hair of about 20-30 ppm reported in literature. The silicium content detected in hair relaxed with varying levels of the test compound show a clear dosage-dependency. Similar results have been found for several other formulas (data not shown).

Furthermore, 1% of the test compound was directly added to a commercial relaxer from the U.S. market, and the silicium content of treated hair was analyzed by the same method. This result also is shown in Figure 3 (orange square). The results indicate that even by simply adding the compound to a finished relaxer emulsion, silicium is deposited in hair. However, due to the high viscosity of relaxers, adding the compound during emulsiﬁcation is instead recommended.

Results: Tensile Strength

Hair damage can be expressed as a decrease in Young’s modulus, which is the nearly linear slope at the beginning of a stress-strain curve (up to 3% extension). Figure 4 shows the changes in Young’s modulus for relaxers with increasing silicate compound content. A significant decrease in the loss of Young’s modulus was observed for relaxers containing the test compound. This indicates that adding the silicate compound to the test relaxer improved the tensile strength of treated hair due to the increased amount of silicium content penetrating and interacting with hair.

Silicate (SiO$_4^{4-}$) ions will have strong interactions with positively charged portions of hair proteins. This explains the strong effects of the test compound as well as the change in trend for concentrations of it above 2% in the relaxer; i.e., too much silicate penetrating the hair could have a negative effect on the elastic modulus.

Results: Salon Test

In the half-head test of relaxers on 21 panelists, as noted, ratings were given for different parameters by both the hairdressers (see Figure 5 and Figure 7) and panelists (see Figure 6 and Figure 8), immediately after treatment and one week post-treatment. Overall, both formulations received high ratings, with slightly better results for hair treated with the relaxer containing the test compound. Due to this small panel size, however, only the initial ratings by panelists for “hair shine” were statistically significant (p < 0.1). Also, in the follow-up rating by panelists, only the parameters for “hair straightening” and “hair condition/not dry feel” were significant (p < 0.1). It is important to consider that in contrast to the sensory assessment test using hair strands, in these consumer tests, only the newly grown part of hair (approximately 2 in) was in an untreated state. These factors could have reduced the impact of potentially perceived benefits by consumers—which were measurable in lab tests.

Conclusion

http://www.cosmeticsandtoiletries.com/formulating/category/haircare/Improving-the-... 19.10.2015
A compound based on potassium silicate was developed for addition to lye relaxer formulations to improve their sensory characteristics. Sensory testing was performed, and hair strands relaxed with formulations containing the compound showed perceptively improved properties while maintaining relaxing efficacy. In addition, the amount of silicium in relaxed hair strands correlated with the concentration of the compound in the relaxer, showing its penetration into hair.

Furthermore, tensile strength measurements of single hair fibers showed that the well-known negative impact of relaxer treatments on the Young’s modulus of relaxed fibers was significantly less when the silicate compound was included in the relaxer formulation. Finally, a salon study demonstrated that the addition of the compound to a hair relaxer improved panelists’ hair.

References
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Media

Figures

Figure 1. Sensory assessment of Caribbean hair strands

Sensory assessment of strands treated with a relaxer with and without the test compound

Figure 2. Straightening efficacy test on Caribbean hair

Hair strands treated with lye relaxer benchmarks from the U.S. market were less effective in straightening hair than test Formula 2 with 2% test compound.
Figure 3. Silicium content vs. compound concentration in relaxer

The silicium content detected in hair relaxed with varying levels of the test compound show a clear dosage-dependency. Similar results have been found for several other formulas.

Figure 4. Tensile strength measurements of single hair fibers treated with relaxers

A significant decrease in the loss of Young's modulus was observed for relaxers containing the test compound. This indicates that adding the silicate compound to the test relaxer improved the tensile strength of treated hair.

Figure 5. Initial stylist ratings

Ratings for 21 panelists for different parameters by hair dressers immediately after treatment

Figure 6. Initial panelist ratings; $p < 0.05$ was considered significant
Ratings were given by the 21 panelists immediately after treatment.

**Figure 7. Follow-up stylist ratings**

Ratings were given for different parameters in the 21 panelists by hairdressers one week post-treatment.

**Figure 8. Follow-up panelist ratings; \( p < 0.10 \) was considered significant**

Ratings were given for different parameters by the 21 panelists one week post-treatment.

**Footnotes**

*Footnotes [Haake 130(2)]*

Plantasill Relaxcare (INCI: Potassium Silicates (and) Caprylyl/Capryl Glucoside (and) Glycerin), BASF Personal Care, [http://personal-care.basf.com](http://personal-care.basf.com)

**Formulas**
**Formula 1. Strong Test Relaxer Formula**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% w/w</th>
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<tbody>
<tr>
<td>Paraffinum Liquidum (Mineral Oil)</td>
<td>18.0%</td>
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<tr>
<td>Petrolatum</td>
<td>25.2</td>
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<tr>
<td>Stearyl Alcohol</td>
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<tr>
<td>Ceteareth-30</td>
<td>3.0</td>
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<tr>
<td>Hydrogenated Vegetable Glycerides</td>
<td>2.0</td>
</tr>
<tr>
<td>Sodium Hydroxide</td>
<td>2.3*</td>
</tr>
<tr>
<td>Potassium Silicates (and) Caprylyl/Capry Glucoside (and) Glycerin</td>
<td>0.0 or 2.0</td>
</tr>
<tr>
<td>Propylene glycol</td>
<td>2.0</td>
</tr>
<tr>
<td>Water (aque)</td>
<td>qs to 100.0</td>
</tr>
</tbody>
</table>

*Note: Approx. 0.1% NaOH is consumed by the saponification of ingredients*

This strong relaxer, with and without the test compound, was evaluated in a half-head study of 21 panelists under double-blind conditions.

**Formula 2. Mild Test Relaxer Formula**

<table>
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<th>Ingredient</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Paraffinum Liquidum (Mineral Oil)</td>
<td>15.0%</td>
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<tr>
<td>Cetearyl Alcohol</td>
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</tr>
<tr>
<td>Ceteareth-20</td>
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</tr>
<tr>
<td>Ceteareth-30</td>
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</tr>
<tr>
<td>Sodium Hydroxide</td>
<td>1.8</td>
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<tr>
<td>Potassium Silicates (and) Caprylyl/Capry Glucoside (and) Glycerin</td>
<td>0.0-5.0</td>
</tr>
<tr>
<td>Water (aque)</td>
<td>qs to 100.0</td>
</tr>
</tbody>
</table>

This mild relaxer includes 0-5% of the test compound.