COMPANY X

HAIR SHINE MEASUREMENT (SAMBA HAIR) : 
EVALUATION OF A HAIR COLOR TREATMENT 
FOLLOWED SHAMPOOS MULTI-APPLICATION

Report N° 320000RAE001-A

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<th>Modifications Description</th>
<th>Operator</th>
<th>Writer</th>
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<td>21/07/17</td>
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<td>K. NOWBUTH</td>
<td>K. NOWBUTH</td>
<td>P. STERLE</td>
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</table>

CONFIDENTIAL
SUMMARY

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1. **OBJECTIVE**

- This document is the report concerning the evaluation tests of a coloring dye treatment, and followed by shampoos multi-application on BNT hair Luster measurement.

2. **NOTES AND REFERENCE DOCUMENTS**

- Quotation SP EQUATION 320000DEV001-B,

3. **STUDY DESCRIPTION**

3.1. **OBJECTIVE**

The purpose of this study is to measure the BNT LUSTER value of natural hair swatches:

- Before coloration
- After coloration treatment with a dark shade
- After 6 shampoos
- And after 12 shampoos

3.2. **TESTED PRODUCTS**

The study was carried out on 2g brown hair tresses, 20 cm length.

The coloring product tested is the coloring cream, which is mixed extemporaneously with the Oxidizer in a 1 + 2 ratio. This product is used with a terminal care.

Six and twelve shampoos are then applied after the treatment.

3.3. **DATE OF THE STUDY**

**Beginning of the study:** May 24th 2017

**End of the study:** May 30th 2017
3.4. Protocol

3.4.1. Products Application

The applications were carried out according to the following indications:

**Coloration Application**
- After mixing the coloring cream with the oxidant the cream is applied on each hair swatch at a rate of 10g per swatch with a pause time of 35 minutes, the hair swatches are rinsed with warm water. The application is carried out on an electric hot plate at 27 °C.
- The hair swatches are detangled and then dried on a hairdresser helmet (40°C).

**Shampoo application**
- The shampoo is applied with 0.4g /1g, 6 massages (from root to tip) with the fingers and then rinsing with 45 times under water.
- The hair swatches are dried into a hairdresser helmet (40°C).

3.4.2. Method Principle

The evaluation of hair shine is carried out with a SAMBA Hair developed by BOSSA NOVA Technologies using the properties of light polarization with a polarimetric camera.

The device has 3 main parts:
- A polarized light,
- A polarized camera,
- A cylinder / hair support.

The measurement consists in making two pictures of hair tress on the cylindrical support:
- One in crossed polarized light (orthogonal to the direction of polarization of incident light),
- The other in the parallel direction

These two pictures being taken very quickly thanks to a system of polarizer tilting

![Figure 1: Device configuration](image)
The option of a polarized light for both source and detection makes it possible to separate the diffuse light (depolarized) from the specular light (polarized). The cylinder hair support enables to measure the angular distribution between -45 ° and + 45 ° without moving any part of the device.

Figure 2 : Hair-Light Interaction

The "specular image" and "diffused image" can be displayed. Signal profiles are extracted from these images as a function of the angle.

Figure 3 : Angular Distribution Profile

The Specular light is related to the first reflection (called Shine) and the second reflection (called Chroma because it contains "color" information owing to the fact it has penetrated the hair fiber)

The Shine and Chroma are obtained by mathematical analysis of the specular. This is based on the fact that the Shine (first reflection) is the same color than the illuminant.
From those data, it is possible to determine a parameter called Luster which characterize the visual appearance of an object and particularly "the shine" by light reflection.

3.4.3. Measurement Parameters

Different “Luster parameters” have been calculated to describe the perception of shine, but the calculation of this shine parameter is not easy to study. Indeed, the shine depends on three parameters which are:

- The intensity of the reflected light (a). The greater the reflected light is, the higher the shine perception is.
- The width of the gloss band (b). The more concentrated the reflected light (i.e. the smaller the width of the gloss band) is, the greater the gloss perception is.
- The sharpness of the object (c). The darker the object is, the higher the gloss perception is.
Different Luster formulas have been proposed by scientists using goniometers and other devices to understand the shine perception. Those parameters take in account:
- The amount of specular light, S,
- The amount of diffuse light, D
- And the width of the specular distribution light $\theta_{1/2}$

Those parameters are Reich-Robbins, TRI, Stamm and Guiolet, the most quote in publication literature is Reich-Robbins:

$$L_{Reich-Robbins} = \frac{S}{D \times \theta_{1/2}}$$

$$L_{TRI} = \frac{S}{S + D \theta_{1/2}}$$

$$L_{Stamm} = \frac{S - D}{S}$$

$$L_{Guiolet} = \frac{S}{D}$$

The TRI formula is similar to Reich-Robbins, the only difference is in the diffuse light which is replaced by the sum of diffuse light and specular light. Also the Luster is normalized to a reference angle.

The main disadvantage of those parameters is that, for dark hair, the evolution of the parameters according to the treatments applied, does not reflect what is seen visually.

A new parameter has been developed to take in account this phenomenon, the BNT Luster (BNT for Bossa Nova Technologies) which mathematically separates the amount of specular light into two entities: $S_{in}$ and $S_{out}$

$$L_{BNT} = \frac{S_{in}}{(D + S_{out}) \times W_{visual}}$$

- where $S_{in}$ Corresponds to the specular in the central light distribution
- where $S_{out}$ Corresponds to the specular light for extreme angle.


The other specificity of this parameter (BNT Luster) is that, it takes into account the width of the shine band: $W_{visual}$ parameter.
3.5. **CALCULATED PARAMETER**
Considering its particularities and the good correlation with the visual perception of this index, the BNT Luster was chosen in this method as a parameter to study the shine of hair tresses.

For the same hair swatch 5 measurements have been carried out (for the variability of the trials) and for each condition 6 swatches are used (for the variability of the trials).

3.6. **STATISTICS PROTOCOL**
Statistical analysis is performed with SPSS version 20.0 according to the following criteria:
- Normality and Homogeneity are verified for a risk of 1%.
- Tests are computed with a risk of 5%.
- The statistical tests (Student Test – ANOVA) are carried out with an alpha risk of 5%
- The details of the statistical result are in appendices §6.
4. RESULTS

4.1. PREAMBLE
The colorimetric measurement have been carried out before and after coloring treatment, the color distant (DE*76) is lower than 3, the BNT measurement can be done because there is no significant color difference.

4.2. BEFORE TREATMENT

<table>
<thead>
<tr>
<th>Luster BNT</th>
<th>Mesure 1</th>
<th>Mesure 2</th>
<th>Mesure 3</th>
<th>Mesure 4</th>
<th>Mesure 5</th>
<th>Mean</th>
<th>STD</th>
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<tbody>
<tr>
<td>Tress 7</td>
<td>11.60</td>
<td>13.70</td>
<td>12.99</td>
<td>11.81</td>
<td>11.92</td>
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<td>0.90</td>
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<td>Tress 8</td>
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<td>11.70</td>
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<td>14.75</td>
<td>13.58</td>
<td>12.97</td>
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<tr>
<td>Tress 9</td>
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<td>10.45</td>
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<td>10.38</td>
<td>10.22</td>
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<tr>
<td>Tress 11</td>
<td>14.49</td>
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<td>13.47</td>
<td>15.22</td>
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<tr>
<td>Tress 12</td>
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<td>10.04</td>
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<td>11.28</td>
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</table>

Table 1: Measurement Before Treatment

4.1. AFTER TREATMENT

<table>
<thead>
<tr>
<th>Luster BNT</th>
<th>Mesure 1</th>
<th>Mesure 2</th>
<th>Mesure 3</th>
<th>Mesure 4</th>
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<td>30.31</td>
<td>31.97</td>
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Table 2: Measurement After Treatment

After Coloration + 6 Shampoos

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<th>Mesure 3</th>
<th>Mesure 4</th>
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Table 3: Measurement After 6 Shampoos
After Coloration + 12 Shampoos

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<thead>
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<th>Mesure 2</th>
<th>Mesure 3</th>
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<td>3.39</td>
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<tr>
<td>Tress 9</td>
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<td>31.77</td>
<td>30.72</td>
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<td>31.93</td>
<td>31.70</td>
<td>0.82</td>
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<tr>
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<td>34.67</td>
<td>33.52</td>
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**Table 4 : Measurement After 12 Shampoos**

4.2. RESULTS PLOTS

Luster BNT after Coloration:

![Luster BNT After Coloration](image)

**Figure 8 : Luster BNT after coloration**
Luster BNT after Coloration + 6 and 12 shampoos:

![Luster BNT After Coloration Graph](image)

*Figure 9: Luster BNT after coloration and shampoos superposition*

Average Plotting:

![Average Luster BNT Plot](image)

*Figure 10: Evolution of BNT Luster (average on 6 tresses)*
4.3. **Statistics**

Statistical analysis is performed with SPSS version 20.0 according to the following criteria:

- Normality and Homogeneity are verified for a risk $\alpha$ of 1%.
- Tests are carried out with a risk $\alpha$ of 5%.

The details of the statistical result are presented in appendices §6.

### 4.3.1. Statistical Test

The tables below show the results of the P-Value for the comparison before/after and comparison between products.

- The Luster measurements before coloration is significantly lower than the other conditions.
- The Luster measurements after coloration and after 6 shampoos are not significantly different. Nevertheless after 6 shampoos, the Luster has a tendency to be higher (P value = 0.080).
- The Luster measurements after 6 and 12 shampoos are not significantly different.
- The Luster measurement after 12 shampoo is significantly higher than after coloration.

![Graph showing Luster measurements](image)

**Table 1: Statistical Results**
5. CONCLUSIONS

The color application followed by the care treatment on brown hair tresses shows a significant increasing of the shine (the Luster index goes from 12.3 to 30.2).

The shine after 12 shampoos is significantly higher than after coloration: the 12 successive shampoos application increase significantly the shine of the colored hair tresses.
6. APPENDICES

Tests of Normality

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<th>Kolmogorov-Smirnov*</th>
<th>Shaprio-Vilk</th>
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* This is a lower bound of the true significance.

Lilliefors Significance Correction

Test of Homogeneity of Variance

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<td>Based on Median and with adjusted df</td>
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<td>Based on trimmed mean</td>
<td>3.907</td>
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Multiple Comparisons

Dependent Variable: Measure

Tukey HSD

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<tr>
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<td>shampooing s6</td>
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<td>shampooing s6</td>
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November 23° 2017
HAIR SHINE MEASUREMENT (SAMBA HAIR): EVALUATION OF A HAIR COLOR TREATMENT FOLLOWED SHAMPOOS MULTI-APPLICATION

Before coloration

After coloration