Anti-Breakage efficacy evaluation of hair care products using the hair breakage regression model.

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Abstract

Hair Breakage is a complex phenomenon which depends upon multiple factors and parameters. A battery of tests has been proposed by hair researchers to evaluate the hair breakage at lab scale; each of the tests used standardized instruments and techniques to measure relevant hair breakage parameters. A model to connect the hair breakage found in consumer testing with the various strand level and bulk level hair parameters was proposed earlier. We have extended the model and used it to discriminate the anti-breakage potential of various hair care product formats and regimens. The approach exemplifies the use of regression model to extend the in-vitro lab testing data to help predict the in-vivo consumer experience. To compare different hair care products on their anti-breakage potential, an index Hair Breakage Number (HBN) is formulated using the predicted consumer hair breakage counts. Proposed HBN presents a tool to aid formulators and cosmetic scientists in their quest to make anti-breakage hair care products with consumer relevant benefit.

Keywords: Hair breakage, Consumer relevant benefit, Regression model, Hair breakage number, Consumer product development

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Introduction

Hair Breakage is an important consumer-relevant parameter which has been the target of various hair care product development efforts [1]. Hair breakage is a complex multifactorial phenomenon involving tangle formation with hairs looped over other hairs, stretching of the tangles, localized stress formation and eventual fracture [2]. The parameters responsible for hair breakage can be categorized into hair morphology, single fibre parameters and fibre array (bulk hair) properties [3]; and there are many parameters available for testing. To make matter worse, no clear knowledge exists in terms of how these parameters are correlated with each other and with hair breakage. Current anti-hair breakage product design is based on improvement of one or may be two parameters; say tensile strength increase and surface lubrication improvement.

The evaluation of hair care products with anti-breakage claims is done using different hair breakage estimation methods defined elsewhere [4]. Most common method in research labs to optimize the anti-breakage hair care formulations involve product treatment on hair swatches and subjecting them to defined combing cycles (manual or automated) and count the broken hairs. An empirical attempt was made by Kaushik et al. [3]. To identify key in-vitro test parameters and their correlation to predict the consumer perceived hair breakage. A multi-factorial regression model was proposed to connect the counts of hair broken from Running Finger Coming Test (RFCT) in terms of key in-vitro test parameters identified-work Done on Tensile Extension, Smoothness Force, Detangling force, 1St cycle Peak Force and Hair Density. The model was proposed to be used for screening of anti-breakage hair care products by evaluating various test parameters at lab scale on hair swatches and using them to predict the consumer relevant hair breakage counts from RFCT.

Literature Review

Hair breakage model appropriation

We used the model to differentiate the anti-breakage benefit of different hair care products and treatment regimes. We screened different classes of commonly used hair care products mentioned below using standard hair swatch washing and product treatment protocols mentioned elsewhere [3]. Hair Swatches were prepared by sourcing hair from local supplier from subjects who have not undergone any chemical treatment on their hair.

- **Non-conditioning shampoo treatments**: Multiple wash cycles using 15% SLES Solution
- **Conditioning hair shampoo**: Marketed Shampoo formulation with conditioning polymers-swatch washing
- **Rinse-Off Conditioner (RoC):** Marketed conditioner formulation used post wash-swatch wash cycle using 15% SLES and RoC application
- **Hair oils:** Type 1 (100% Veg Oil), Type 2 (100% Mineral Oil) and Type 3 (Mix of Veg Oil and Mineral Oil) – Oils applied on hair swatches and kept overnight at Relative Humidity of 60% and Temperature of 250C The swatches are then washed with 15% SLES Solution.
- **Hair serum:** Marketed formulation applied on towel dried hair post washing with 15% SLES solution

The treated hair swatches were tested for in-vitro lab parameters using 1) Diastron Combing Force Set-Up for Smoothness Force, Detangling force and 1st Cycle Peak Force and 2) Diaston MTT 175 Hair Tensile tester for Work Done on Tensile Extension. We carried out testing for 8 hair swatch replicates for Combing Test while the tensile test is done using 40 hair strands chosen randomly from the swatches. We assumed no change in the hair density from the treatments done and hence, safely assumed the hair density to stay constant at 250 hairs/cm2. Thus, we would be predicting the hair breakage counts for normal healthy subjects and in future this parameter can be altered to include people suffering from hair fall issues by appropriating suitable hair density number.

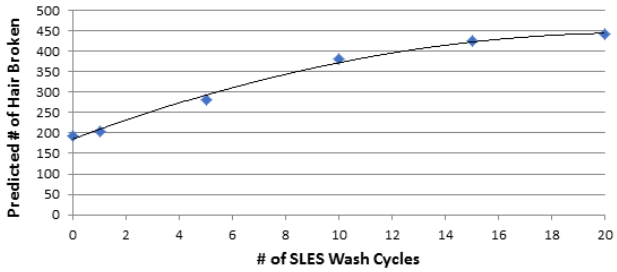

Figure 1. *Hair breakage prediction from the model with repeated wash cycles of non-conditioning shampoo–15% SLES Solution.*

Results and Discussion

Hair breakage Model prediction

The results obtained for non-conditioning shampoo are summarized in Figure 1 with wash cycle 0 for the untreated virgin hair swatch. As the number of SLES wash cycles increases the predicted hair breakage count increases but eventually gets flattened out around 15 cycles. Approximately 2 x increase in hair breakage count was predicted with 10 SLES wash cycles. The data is inline with the damaging effect of SLES on hair structure due to its tendency to leach out proteins and lipids from the hair matrix as well as the skin layers [5,6]. The initial steep rise can be attributed to the historical faults and cracks in the hair structure, while the structural damage is completely organic for the progressive wash cycles.

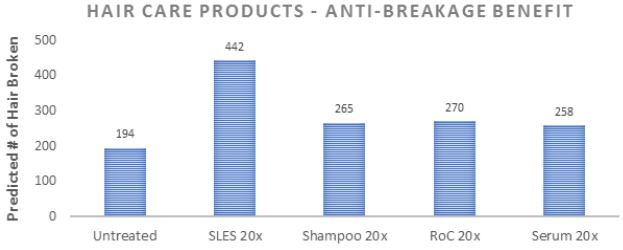

Figure 2. *Hair breakage prediction with repeated wash cycles of common marketed hair care products.*

For the range of commonly used hair care products the results obtained from the model are summarized in Figure 2. As opposed to a more than 125% increase in breakage with 20 wash cycles of a non-conditioning shampoo, a conditioning shampoo leads to ~3.5 x less broken fibres. This is attributed to the milder surfactant and conditioning polymers used in the shampoo formulation which lowers the harsh impact of surfactant damage and subsequent combing breakage. In case of RoC and Serum, though SLES is used for washing but the residual protective layer formation by the products the breakage is similar to that of the conditioning shampoo at the end of 20 cycles. Thus, the commonly used hair care treatment products provide similar level of protection from breakage with repetitive wash cycles.

The hair oils evaluated for the breakage prediction are divided into three categories:

- **Type 1 Hair Oil**: Expelled coconut oil was used.
- **Type 2 Hair Oil**: Light Liquid Paraffin (LLP) cosmetic grade was used.
- **Type 3 Hair Oil**: Combination of mineral oil and vegetable oil were used. One of the samples include mineral oil and mustard oil in 75:25 ratio; while other sample comprises of mineral oil and coconut oil in 80:20 ratio respectively.

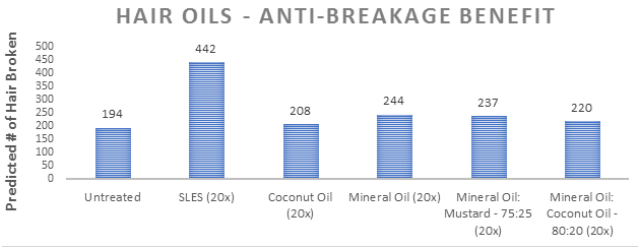

Figure 3. *Hair breakage prediction with 20 x cycles of oil treatment and SLES wash for different hair oil combination.*

The results of the study and resultant predicted value for broken hair fibres is shown in Figure 3. As it can be seen, the effect of oils on breakage is better as compared to other hair care formats. The same can be attributed to the external occlusive layer formation on the hair surface to prevent the water and surfactant to enter into hair cortex and hence, avoid the progressive removal of hair building blocks [7]. Amongst the oils, coconut oil shows the better benefit with less than 10% increase in breakage post 20 cycles of SLES wash – this is in-line with the various studies reported on the two-way action of coconut oil on hair. Coconut oil not only provides occlusive layer [8,9] but it also penetrates inside the hair cortex to strengthen the lipid layers as well as fill the porous cavities [10,11]. For LLP which does not penetrate the hair cortex [11,12] the benefit comes from the external lubricating layer (even post wash) which reduces hair-comb friction and hence the breakage. In case of Type 3 hair oils, the one with coconut as vegetable oil shows better benefit than the one with mustard (which does not penetrate hair core) [10].

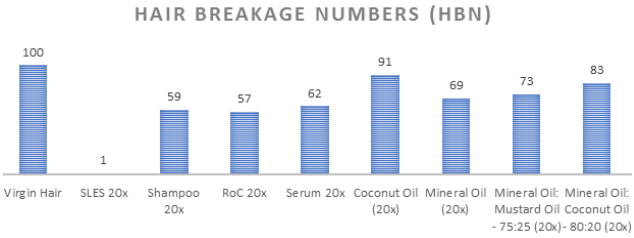

Figure 4. *Hair breakage numbers for different hair care products used in this work.*

Index for anti-breakage potential for hair care products

Using the model, we were able to screen products based on their potential for anti-breakage benefit. We observed the progressive damage to hair and hence increased hair damage with repetitive SLES wash cycles. Hair Care product formats like Conditioning Shampoo, RoC and Serum helps manage the hair breakage due to protective residual coatings. The protective coating anti-breakage benefit is seen even better for hair oil treatments which work principally by increasing hydrophobicity of hair. Specific hair oils like coconut oil which penetrate hair strands take the hydrophobicity increase to the hair core and the same gets reflected in their impact on hair breakage reduction [13]. To quantify the potential anti-breakage benefit of a certain hair care product, we can define an index "Hair Breakage Number" (HBN). HBN is calibrated such that virgin hair has an HBN of 100 and 20 SLES wash cycles will bring down the HBN to 1. All the other hair care products can be indexed based on the above calibration; higher the HBN of a product, better the propensity to prevent hair breakage. HBNs for different hair products used in this work are mentioned in Figure 4.

Conclusions

In this article, we have shown how to use the regression model proposed for consumer hair breakage in hair care laboratory settings to discriminate the anti-breakage potential for hair care products. The presented approach can be used as a tool for product development scientists to check for the anti-breakage efficacy of their formulations even before going for the consumer testing of their products. We have also proposed an index–Hair Breakage Number (HBN)–to quantify the anti-breakage benefit of a given product.

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