Title of the article (Maximum of 25 words)

Fundamental Understanding of Highly Textured Hair through Technical Investigation and Social Listening for High Performance Solutions aimed at Natural and Straightened Textures.

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Abstract (Maximum of 250 words)

Dow leveraged its deep scientific hair care expertise, world class testing capabilites and hair care market knowledge, in close collaboration with the internal employee network, Global African Affinity Network (GAAN) to address the needs of the underserved textured hair care market and meet the needs of texture hair consumers. The female consumers that contributed to this work were based in North America and South Africa.These women helped build our knowledge of the highly textured hair consumer routine, identified the needs, contributed to testing and shaped the overall technical program. The collaborative team was able to understand the barriers faced by consumers in the textured hair care market, connect the market gap with the broader societal issues faced and highlight the beauty of the natural hair textures with proven technical Solutions.

The fundamental knowledge gained provided the design team a foundation to develop appropriate test methods that addressed the need for moisturization, reduced combing force, and less damaging products targeted at the needs of the textured hair care consumer.Test methods included but are not limited to heat protection,curl definition and retention,Fourier Transform Infrared Spectroscopy,hydrophobicity, and visual and sensory evaluation.These methods helped to screen a series of potential formulation candidates to take forward into consumer testing.

The outcome was a set of unique formulations developed tailored specifically for consumers with textured hair. Dow Personal Care scientist and GAAN Partnered to show how chemistry and employee networks can work together to deliver high performance Solutions.

Keywords: hair; highly-textured; African; kinky/coily; testing.

Introduction:

Dow believes everyone deserves good hair days. To show that, employees with textured hair and technical experts partnered to show how chemistry and employee network groups such as Dow's Global African Affinity Network (GAAN) can work together to deliver high performance solutions. These solutions not only provide visible benefits but ease common daily routine and lifestyle frustrations of consumers with texture hair.

The highly textured hair market segment has been underserved for many years. 82% of Black American women identify their natural hair texture to be type 3A to 4C and 60% of the world's population have textured hair[1]. Black consumers even spend nine times more on hair care products than non-black consumers. But only a small part of the products on the shelf space today addresses the needs of this consumer group, highlighting a large gap in the personal care market and shedding light on larger societal issues.

Many portions of this market remain underserved and untapped, creating a significant growth potential for hair care brands. Consumers and brands are eager to serve this underserved market which is evident with the increasing number of product launches for coily hair that has been seen over the last 5 years.

During Dow's social listening study, people are hoping to embrace their natural hair, but face challenges due to the gaps in product selection and performance and the impact on lifestyle due to wash days taking 2 hours or more and the need for 5 or more products.

The purpose of this collaboration between Dow's technical experts and GAAN ERG was designed and carried out to bring solutions to the global textured hair market. The prototypes were designed to reflect the most common product types used in a general daily routine based on insights and surveys from salon owners and from GAAN members. The prototype formulation kit includes staples such as shampoo, conditioners, styling products, but also a scalp treatment and oil/serums that cater to the unique needs of textured hair consumers.

Methods:

Firstlyfundamental understanding of highly textured hair physiochemistry was first investigated [2]. Test methods were designed and modified for type 3 and 4 hair types(Andre Walker Scale)[1] .Tests procedures used included Coefficient of Friction,combing,Scanning Electron Micorscopy(SEM),heat protection,curl definition and retention,Fourier transform Infrared Spectrocopy(FTIR),hydrophobicity,visual evaluation and sensory evaluation.

In addition, Bossa Nova Technology's RUMBA instrument was utilized to measure hair orientation for dark and highly textured hair, enabling evaluation of curl definition across

different hair types by looking at the mean angle of the hair at a specific vertical location and the standard deviation of that mean angle. Finally Corneometer for moisturization testing.

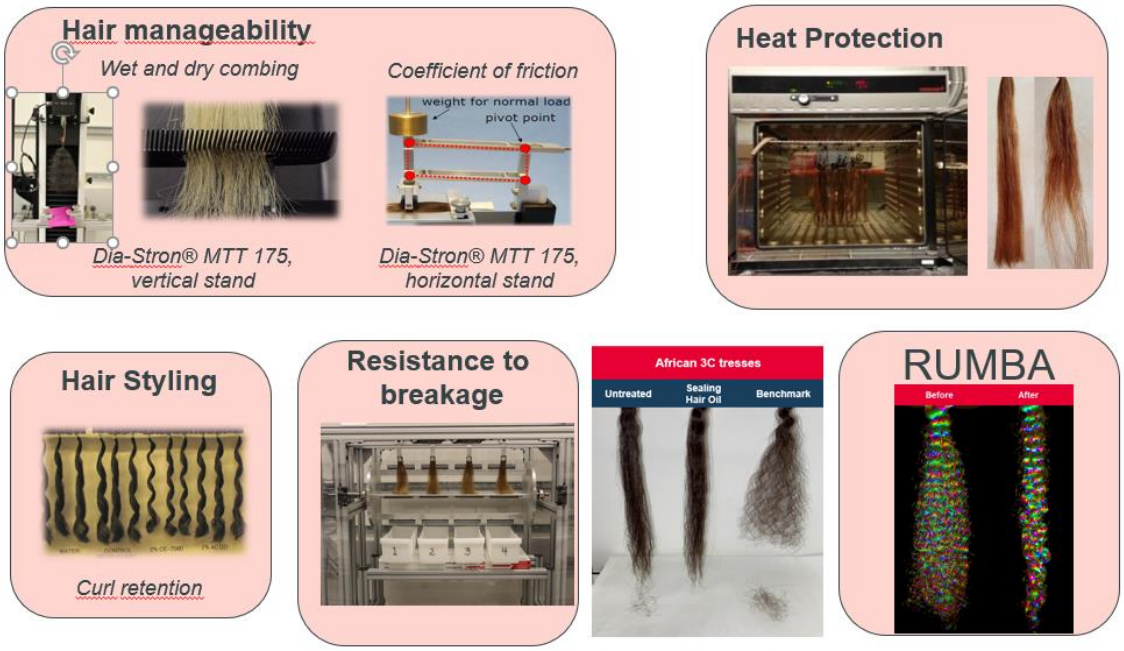


Fig 1:Summary of Various Test methods Used in this Study

These methods were used to screen technologies and identify the best candidates to take forward for consumer testing.

Results:

Studying the physiochemistry of highly textured hair, the results showed lipid layer compositional differences, higher cuticle packing, higher ellipticity, lower hair population density and increased porosity leading to a lack of moisturization perception, harsher feel and increased combing force, as well as very low hair manageability and style retention compared to Caucasian hair as summarized in Table 1:

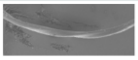
	Caucasian	African descent/highly textures
Ellipticity (aspect ratio)	1.4 	1.9  
Average diameter (um)	70	90 (with considerable variability along shaft)
Cuticles (number of layers and distribution vary)	The cuticle is 8-11 layers thick	Variable thickness with 6-10 layers at the end of the major axis, reducing to 1-2 layers at the ends of the minor axis
Ortho and paracortex contents	Straight is 100% para-cortex fibers and curly has a thin one-cell-layer Ortho-cortex fibers at the periphery	Approximately equal amounts of the two types of fibers
Fiber area (m^2)*	~1.20E-09	~8.00E-09
Fibers/mm^2 on the scalp	High	~40% of the Caucasian population density
Sebaceous glands on scalp	Many and active	Fewer and less active
Bound water in hair		5% lower than Caucasian
Lipid layer composition	Fatty acids>>wax/chol esters>cholesterol	Less fatty acids and more esters than Caucasian. ~30% more "total" lipid than Caucasian (virgin African hair)
Trace elements (separate from essential functional composition; e.g. amino acids, keratin, melanin)**	Bleached hair shows trace levels of sodium, copper and nickel and had the lowest levels of calcium.	Below average levels of sulfur, higher levels of calcium and iron.

Table 1: Unique physiochemical and structural properties of highly textured hair

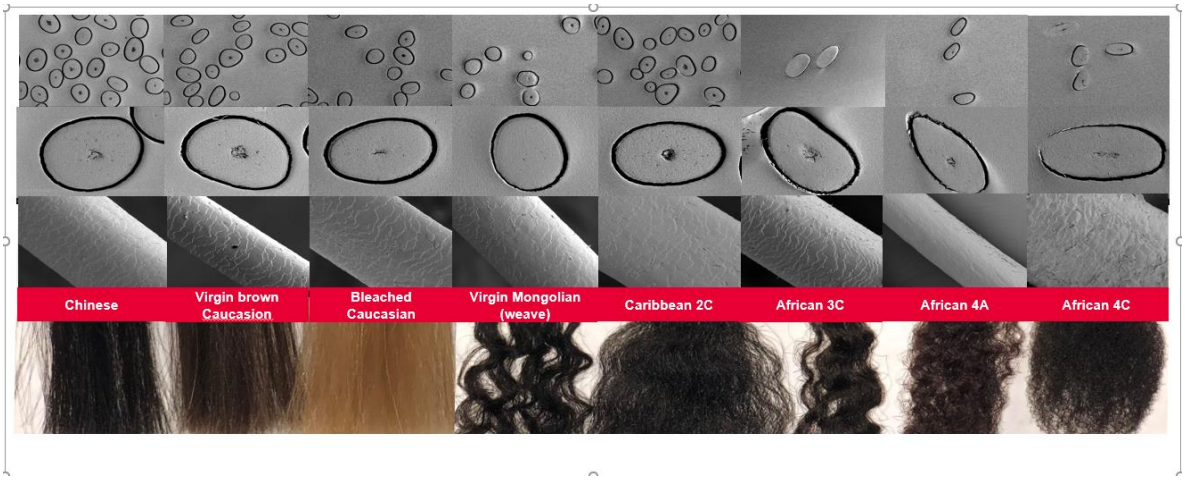


Fig 2: SEM Evaluation of Ellipticity, diameter and cuticle packing of different Hair types

Scanning Electron Microscopy (SEM), Figure 1 shows the ellipticity and diameter of different hair types. It also shows the differences in the damage levels and cuticle packing.This emphasizes the differences in the surface which leads to higher treatment levels for the African tresses over the Chinese and Caucasian tresses. Note the Mongolian weave for example, if this was selected to focus on the curl pattern or texture and ignoring the ethnicity differences in the physiochemical properties of the hair, testing and product development would be flawed. The Mongolian hair is of a curl pattern or texture 3C, but it looks completely different compared to African 3C hair.

It is important to consider curl pattern, texture, and ethnicity which are all equally critical to formulating and selecting the best technologies to deliver benefits and meet the unmet needs.

The instrumental technical in vitro testing identified and measured the potential benefits which were then tested by consumers at home and in lab half head testing to validate results and benefits.

Key technologies identified that provided superior benefits to Highly Textured Hair:

A quaternized silicone elastomer microemulsion with unique crosslinked elastomer structure and amino functionality groups was found to provide intense conditioning via ease of combing and styling properties such as curl retention and definition.

A combination of High molecular weight silicones and an innovative hydroxyamino functionalized silicone was tested and restoring hair's hydrophobic state, providing reduced breakage, softness and ease of styling benefits

Combination of Acrylate polymers was found to provide long lasting curl retention and definition when formulated into a clear gel format.

Alkylmethyl siloxanes provided curl elongation and improved sensory from butter O/W formulation.

These most promising technologies were successfully formulated into 6 different concepts covering full hair treatment regime,these formulations ranged from shampoos, conditioner to styling and leave on treatments that met the needs of consumers with highly textured hair with varying ethnicity and curl pattern

s.

Fig 3: Formulation concepts developed for Highly Textured Hair

Conclusion:

Through its commitment to diversity and inclusion, Dow worked to enable real and impactful change for consumers. The combined synergy of Dow's people, the deep scientific know-how and one of the broadest portfolios in the industry is helping to bring solutions to the underserved textured hair care market. In close collaboration with the Global African Affinity Network (GAAN) at Dow, the team was able to understand the barriers faced by consumers in the textured hair care industry and connect this market gap with the broader societal issues faced. GAAN highlighted the need to develop improved products to address key performance factors such as moisture, frizz control and shine. The outcome was a set of 6 unique formulations specifically developed to provide superior benefits to highly textured hair via in vivo and in vitro technical testing. This is one of the first times that Dow that was able to demonstrate the impact of inclusion and diversity relationships within their own employee demographic. Learning from each other through this collaboration and embracing the true meaning of inclusion and diversity helped to deliver an impactful solution for our consumers and the business. Dow Personal Care sceintists and GAAN partnered to show how chemistry and employee networks can work together to deliver high performance solutions. These solutions not only provide visible benefits, but ease common daily routine and lifestyle frustrations of consumers with texture hair.

Acknowledgments.

ReNisha Newton, Elisa Malone, Toni McKinney, Taylor Byndon, Alexis Blakely

Conflict of Interest Statement. NONE

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