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Customer to Brand: Surprise Me, Now!

J. Bode



Jens Bode is a passionate Innovator, inspired by experience for work applications.

Employed at Henkel AG until end of 2021 in a hybrid work model as employee and a free-lance innovator. At Henkel he worked at Packaging Design, Market Research & Consumer Insights, International Marketing, Trend-Scout & Innovation Game Changer. Part of diverse Think Tanks he coached the Innovation Philosophy worldwide in summary 24 years of Focus Inspiration, Applied Creativity and Transformation.

Starting as freelancer in 2008, he guided companies in the early stages of their Innovations Phase with his insights and ideas even with first prototypes. Jens loves it to discover the new, promote creative talent in companies and jointly interpret new trends into a concept. Since 2022 he is a 'corporate dropout' and independent innovator.

Jens is married to Nic, architect and expert for healing architecture, both have 2+2 children and they reside in Düsseldorf and Aachen in Germany.

<https://www.linkedin.com/in/der-innologe/>

Insight: My wife and I needed some items from the drugstore, and we go shopping to our favorite store in Düsseldorf. We stand in front of relatively full shelves, with a considerable selection, and yet, we simply feel a great boredom: interchangeable claims, similar storytelling, and practically all products are vegan. Okay, this may be a luxury problem, but it's really about much more: uniqueness, competitive advantage, and active customer loyalty.

Where are the ideas and concepts of brands that recognize the intrinsic value of truly experiential experiences and creatively, seductively, and innovatively implement them - with seductive haptics, emotionally touching scents, or a product staging never experienced before?

Yesterday › today ›› tomorrow: we live in constant change, new external influences, new technologies, new competitors, and also new customer needs. If needs and societal values change, then new business models and opportunities also emerge, but only for companies that truly understand the new needs.

The term **'Experience Economy'** was described about 25 years ago, and it is currently experiencing more than a revival. Offering experiences is no longer the domain of the travel industry. Thinking holistically about branding and the experience concept can be applied to almost all categories. If we look just at the last few years, we come from a wave of sustainable concepts. Then followed by Covid-19 as a catalyst for hygienic cleanliness during lockdown.

Today, people are craving to breathe in, unforgettable, and, above all, new experiences - even if it is the daily use of shower gels or detergents.

Transfer: Understanding customers means observing problems and rituals, anticipating wishes, and satisfying longings. The fact that products today are sustainable and simply do the job for which they were purchased is my minimal expectation. It's about the extra and the positive surprise in daily use. It's about the little **'adventure'** while washing dishes or the tangible time out while showering. We live in



the experience economy, and only the one who offers solutions for products and services that are unique and can be experienced with all senses, will create holistic growth. It's not just about turning existing customers into loyal customers, but also about inspiring new customers and target groups.

'Experience' can be translated as adventure & excitement, curiosity & playfulness, fun & pleasure, retro & nostalgia - the product use is in the sensory. As an impulse to design and emotionalize experiences, I would like to inspire your business model with eight chance fields:

- 1. Sharing:**
Shareable and community-based experiences
Trigger: Loneliness as the negative social trend
- 2. Gaming:**
Playful experiences
Trigger: Physical & virtual play
- 3. Multi-Dimensional:**
Hybrid experiences on different levels
Trigger: Technologies like color and scent changes in application
- 4. Diversity:**
Democratized experiences for all incomes
Trigger: Inflation and careful spending
- 5. Spiritual:**
Shareable and community-based experiences
Trigger: Transfer of experiences from other countries & regions
- 6. Wellbeing:**
Combination of health and joy & pleasure experiences
Trigger: Self-responsibility and health as currency

7. Partnering: Synergy of at least two brands and their individual strengths

Trigger: New consumer touchpoints & business models

8. Digital: Online and offline experiences

Trigger: Digitalizing sensorial experiences and making them tangible in social media & Co.

'Consumer Experience' makes the difference now and in the future, and please, it's less about extreme combinations like chocolate pizza or shampoo with jalapenos for an extra kick. Now is the time for no-fake claims, transparency, and ethically meaningful concepts that I, as a customer, can credibly experience.

For our next purchase, my wife and I are already looking forward to the intellectual transfer of brands into new, unfamiliar, and surprising product forms, applications, and of course, experiences.

And if they keep their promises under the label "new," we will be loyal and devoted customers, guaranteed

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Jens Bode

,der innologe®' & managing director of *instant*innovate UG (limited liability)

Meet the Anti-frizz Durable Shape Challenge

M. Hopkins Hatzopoulos, M. Bon, S. Neplaz, D. Mechineau, J. Cazette

abstract

The personal market is under continual development and raw material manufacturers need to develop new products to anticipate new consumer needs. Frizz is a key hair challenge for consumers looking for durable shape and hair discipline, whether they have wavy hair, curly hair, or straight hair. In this study we examine the effect and efficacy of Polycare® Frizz Therapy when compared under challenging conditions to a leading anti-frizz formulation as well selected ingredients commonly found in these types of products. Polycare® Frizz Therapy is shown to provide humidity resistant, durable shape and anti-frizz on a par or better to the high performing benchmarks.

Introduction

Each year, both men and women around the world dread the looming approach of summer humidity and the emergence of a frizzy head of hair. Along with dryness, frizz is one of the most difficult hair challenges. This goes for individuals looking for durable shape and hair discipline, whether they have wavy hair, curly hair, or straight hair.

Major hair care industry players dedicate a large portion of their product launches to anti-frizz initiatives, from blow-dry serums to anti-humidity hair sprays, relying on various ingredients and modes of action. Physical straightening can be seen as the deposition of an active by a formulation onto the hair fiber, before being blow-dried and flat ironed. This leads to the smoothing of the ingredient across the hair fiber, which results in the straightening of the fiber and an overall frizz reduction.

The diversity in brands, formats, INCI, highlights the strong demand for visible discipline, high humidity resistance and long-lasting efficacy. Unfortunately, very often, the efficacy offered by existing solutions is at the cost of softness and suppleness. No one likes greasy, flaky or sticky hair!

As this challenge is still unmet today, a new ingredient Polycare® Frizz Therapy was developed to answer it.

Materials & Methods

Materials

Polycare® Frizz Therapy

Polycare® Frizz Therapy is a synthetic low-viscosity cationic polymer (INCI: Polymethacrylamidopropyltrimonium Chloride).

For efficacy reasons, this polymer is ideally suited for leave-on treatments & styling products. It is supplied under a liquid concentrated form (active: 32-34%) and is readily soluble in water, alcohol, glycol and other common solvents. It delivers flexible hold properties without any negative, making it suitable for daily use.

Polycare® Frizz Therapy is REACH compliant and listed under the Inventory of Existing Cosmetic Ingredients in China.

Commercial Styling products

About ten commercial benchmarks have been identified as references tackling the Frizz challenge, with the idea of identifying the most relevant ones in terms of efficacy and diversity of technologies behind. Sprays and Creams are the most common formats. A previous study determined the top performer, a cream formulation, that is referred to as Leading Commercial Benchmark, composed of Polyquaternium, Modified Acrylates copolymer, Modified Hydrolysed protein and Amino acids and Oils among other ingredients.

Competitive active ingredients

Other key performance ingredients were used as comparative examples:

- Jaguar® C17 (Guar Hydroxypropyltrimonium Chloride), from Solvay, is a naturally-derived guar-based cationic polymer
- Amino acids, such as Glutamic acid and Arginine, from Sigma Aldrich.

Hair tresses were supplied by SPEquation, France (Brazilian Hair Curly III 2.5g or Mixed Race for Anti-frizz and Straightening tests, and Brown Caucasian Natural for DSC measurement).

Methods

Volume measurement

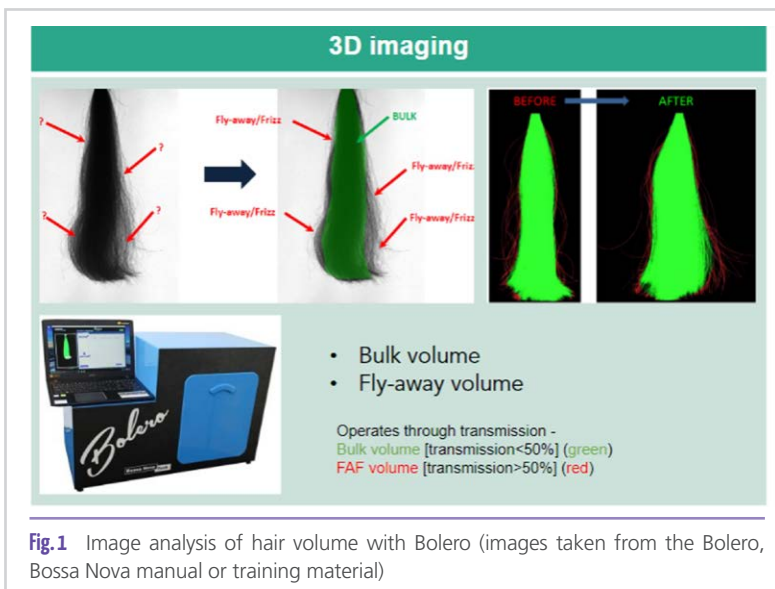
Typically, most customers assess straightening and anti-frizz efficacy through a visual inspection, which may go so far, however the use of quantitative approach is more helpful in comparing results especially when the outcomes appear close.

The instrument BOLERO (Bossa Nova Technologies) is a turnkey imaging system dedicated to hair swatch 3D volume reconstruction and fly-away/frizz analysis. It measures the amount of light going through a ponytail. The bulk volume represents the zone where less than 50% is transmitted (shown in green), and the FlyAway-Frizz volume, also called FAF volume, more than 50% (individual red fibers) (Figure 1).

A primary assumption is made that curly and frizzy hair occupies more volume in space compared to straight or less curly hair. Curls occupy greater volume when considering an excluded volume principle, a notion borrowed from polymer physics,

maybe applied here in the cases of straight hair, and curly hair whose fibers are not aligned to start with.

The hair tress volumes are monitored over time under constant temperature and humidity conditions A climatic chamber (HPP260, Memmert) was used to store the examined hair



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at a constant Relative Humidity (RH) of 50% or 80%, and at different temperatures (T) of 21 or 25°C respectively. These values are chosen based on the estimate of the conditions the consumer will find themselves in across Europe and the Americas.

However, tracking bulk and fly-away volumes without further processing yields quite disparate results even between hair treated with the same technology and evaluated under the same conditions leading to considerable statistical variance. This arises from hair's unique properties which are heavily influenced by origin and history. There comes a need then for rendering the results comparable across hair tresses and treatments. We do so by normalizing the obtained volumes by the initial volume of individual tresses before treatment, essentially leading to an efficacy term, the percent volume reduction, namely the % Bulk volume reduction and the % FAF volume reduction. In other words, the % volume reduction is the % difference between volume before any treatment and hair volume after treatment of the tress under examination. This allows for volume reduction efficacy to be plotted over time spent in the chosen humidity and temperature conditions. The results are always checked visually to avoid instances where the assumptions made previously do not hold.

The pretreated hair is measured for the bulk and fly away volumes and only then treated with the formulations and technologies. Typically, hair tresses were submerged in aqueous solutions of active ingredients, then blow dried and flat ironed at 230°C (5 passes, constant speed). The Leading Commercial Benchmark, which has a high viscosity was applied as a leave-in (500mg). Each treatment was conducted in triplicate.

Sensorial attributes

Sensorial assessments of the hair tresses were performed by trained experts, blind and using only hands and sense of touch, to better reproduce consumer's perception.

Heat Protection

High Pressure Differential Scanning Calorimetry (HP-DSC) is a thermal analysis technique measuring how physical prop-

erties of a sample change, along with temperature, against time. DSC can provide insight into how a treatment may affect deep structural changes in the hair keratin.

Mid-brown virgin Caucasian hair was used for this experiment, after being pre-washed by a 15% SLES solution. On damp hair, a preparation of 1% of Polycare® Frizz Therapy (PFT) in water was applied, as a leave-in. Hair tresses were blow-dried and flat-ironed (10 strokes at constant speed), with a temperature set on 230°C/450°F. These steps were repeated for 3 cycles before hair tresses were finally washed with SLES again and soaked into water overnight. This final step is key to remove all residues of polymer or other ingredients from the hair surface or the cortex, to make sure only natural hair keratin is left and analyzed.

Six replicates of hair fibers taken from the middle section of the pony tails were prepared for each of the treatments, and tested using high-pressure differential scanning calorimeter (DSC25, TA Instruments). Approximately 10 mg of finely chopped hair is placed in a high-pressure DSC pan together with 50 µl of DI water. The heating rate is 10°C/min. Denaturation temperature and denaturation enthalpy of each sample are measured. Prior to testing, the instrument is calibrated using an indium standard.

Results

Outstanding anti-frizz performance compared to the leading industry benchmark

Aqueous solutions of Polycare® Frizz Therapy at different concentrations were prepared and straightening/anti-frizz efficacy was assessed following the protocol described above. In **Figure 2** the evolution of the % Bulk and % FAF volume reduction at 50% RH and 21°C over the course of 3 days are shown.

There appear two distinct behaviors in the tresses examined. In the case %Bulk Volume Reduction and of the Natural Tress (hair which received no treatment beyond hair drying and flat

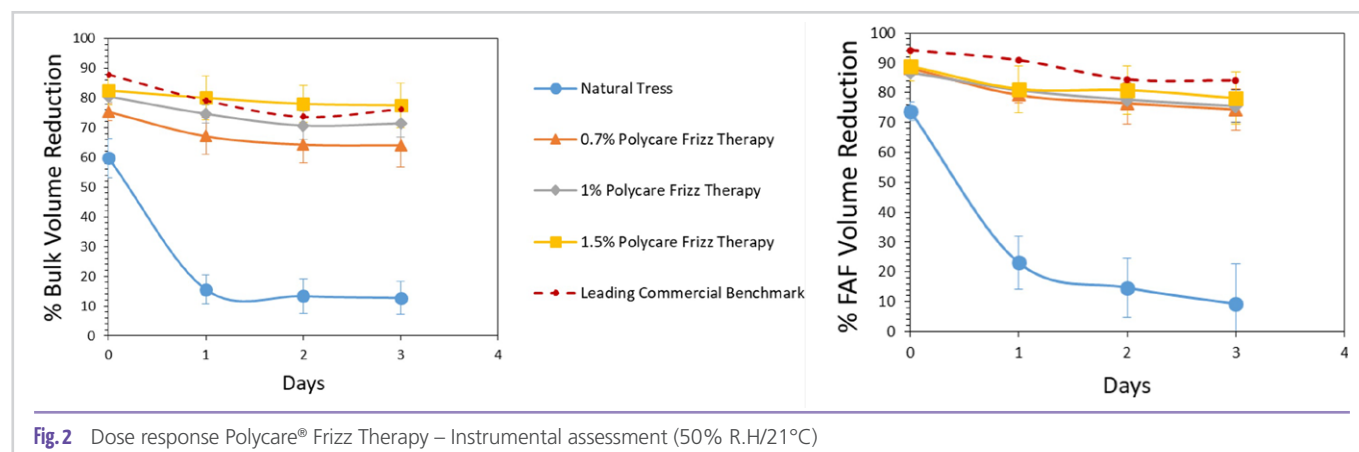


Fig. 2 Dose response Polycare® Frizz Therapy – Instrumental assessment (50% R.H/21°C)



Fig. 3 Dose response Polycare® Frizz Therapy – Visual assessment of Brazilian tress type 3 curls (50% R.H/21°C)

ironing) a 60% volume reduction is observed at day 0 (point directly after completed treatment), which drops drastically within one day to values between 10%-20% and stays as a plateau there for the rest of the duration of the experiment. That is to say that the hair tress has regained almost 90% of its original pretreated volume. In the case of the Leading Commercial Benchmark the volume reduction starts off at almost 90% and reaches a plateau at approximately 80% reduction within 1 day. In effect the hair maintains its treated configuration throughout the experiment and holds a lasting effect. For Polycare® Frizz Therapy the effect is observed for concentrations at or higher than 0.7wt% solutions with anything less than that exhibiting behavior akin to the Natural Tress above, and hence not shown here. For concentrations of 0.7 wt% and higher a small dose response is apparent. This indicates that most of the efficacy is already attained at the concentration of response and higher concentrations lead to diminishing levels of improvement. In all three concentrations of Polycare® Frizz Therapy examined here the behavior mirrors that of the Leading Commercial Benchmark with high levels of volume reduction holding as near-plateaus throughout the duration of the experiment. The Leading Commercial Benchmark falls in the error bar of the 1% of Polycare® Frizz Therapy. The results of %Bulk Volume Reduction mirror closely those of %FAF Volume reduction.

In the more challenging conditions of 80% RH and 25°C, Polycare® Frizz Therapy is still able to maintain its great efficacy, which as good as the Leading commercial benchmark.

A visual assessment of the hair tresses that were used to generate the graphs previously discussed shows good agreement

with the volume data. The Natural Tress triplicate (denoted as Untreated Flat Ironed in **Figure 3**) starts off with acceptable results but quickly regains frizziness and volume, in agreement with the decrease in % Bulk volume reduction shown in **Figure 2**.

The Polycare® Frizz Therapy, used at 0.7% maintains a good level of efficacy and a near constant volume up to Day 3 where some volume regain can be observed. This can be managed by increasing the level of Polycare® Frizz Therapy to 1% or 1.5%. The Sensorial Analysis of the tresses treated with Polycare® Frizz Therapy revealed great shine, good softness, disciplined fibers, no stickiness and no greasy feel, contrary to the Leading Commercial Benchmark. This highly formulated product is very dense and gives a greasy feel to the hair. The recommendation to maintain good Bulk volume and FAF volume reduction and good haptic performance is the use of Polycare® Frizz Therapy at 1 wt%.

Polycare® Frizz Therapy versus other cationic polymer

Cationic polymers based on guar polysaccharides are well known for their conditioning performance and film-forming properties and hence can be seen as potential candidates for straightening and anti-frizz efficacy and a challenger technology for Polycare® Frizz Therapy.

A highly caring conditioning polymer, the Jaguar® C17 was chosen to benchmark Polycare® Frizz Therapy against. As the 1% solution of C17 was quite viscous, 500mg of it were applied as a leave-on. It offers some straightening at t0, since the reduction of bulk volume is around 80%, but surprisingly this efficacy doesn't last. After four hours set at 80% RH, the

hair gains back in volume, more than at its original state. Hair treated with Polycare® Frizz Therapy shows 90% reduction of bulk volume that lasts at least 30 hrs. The Leading Commercial Benchmark starts around 85% Bulk volume reduction but decreases to 70% after 30h (Figure 4).

In Figure 5 are visual representations as guides on the effect of the technologies, albeit under different conditions here, but representative of typical behavior across the studies and conditions.

The column at the far right represents the Leading Commercial Benchmark. Tresses are very straight, throughout the timeline of the experiment. However, a keen eye will observe greasy deposition on the hair surface, a negative for the consumer, no matter the straightening efficacy.

As expected, the Jaguar® C17 starts off well, but very soon it gains back volume and grows until it is frizzing out. Once more a demonstration of the good correlation between the visual assessment and the quantitative graphs generated.

Polycare® Frizz Therapy versus Amino acids

Amino acids are a popular ingredient with multiple claims and they are also part of the proteins that make up hair. As key structural elements of hair the question arises as to whether they offer straightening and anti-frizz performance. A previous inhouse study evaluated the efficacy of amino acids that are commonly found in commercial styling products but also in the structure of the hair. The conclusion was that Glutamic acid and Arginine are highly performant under certain conditions. They maintain a high %bulk volume reduction up to at least 6 days. Comparing to Polycare® Frizz Therapy and the Leading Commercial Benchmark shows that Polycare® Frizz Therapy performs at least as well as the amino acids and remarkably close to the benchmark. Polycare® Frizz Therapy offers cost effective and durable high performance (Figure 6).

Heat protection

DSC can give insight into how a treatment may affect the deep structural changes in hair keratin. DSC measurements were conducted comparing a natural hair tress (Positive control), a heat-treated hair tress (Negative control), and a hair tress treated with Polycare® Frizz Therapy. The peak in each curve indicates the temperature of denaturation of hair keratin i.e. the temperature at which the protein loses its tertiary conformation. The area below the curve represents the enthalpy i.e. energy of denaturation. A drop in one of these two criteria indicates morphological changes and damage for the hair keratin.

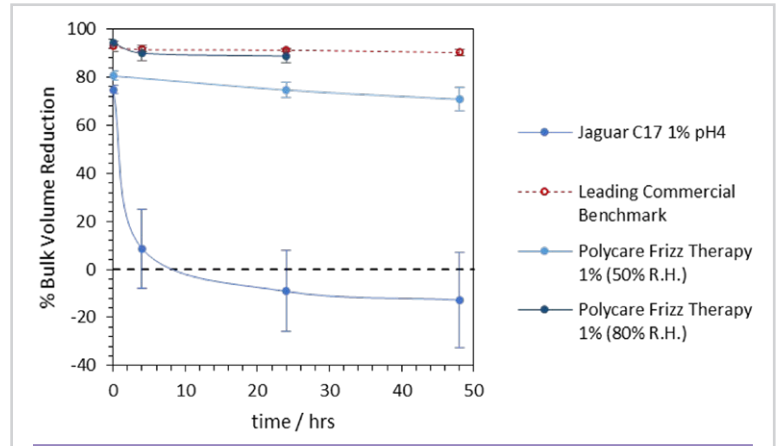


Fig. 4 Polycare® Frizz Therapy against other cationic polymer – Instrumental assessment (80% R.H/25°C)



Fig. 5 Polycare® Frizz Therapy against other Jaguar C17 cationic polymer – Visual assessment (Leading Commercial Benchmark included for reference)

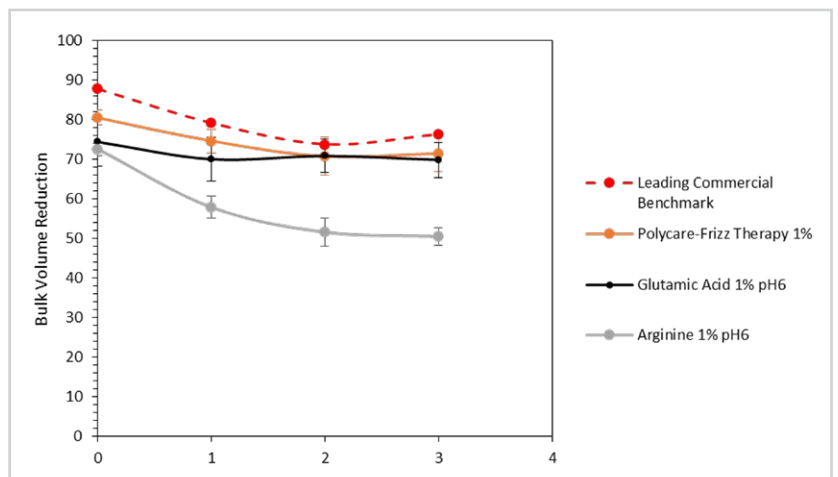


Fig. 6 Polycare® Frizz Therapy against amino acids – Instrumental assessment (50% R.H/21°C)

It is easy to observe that the negative control has lower denaturation temperature and enthalpy (142.8°C ; 10.3 J/g) than the positive control (153.1°C ; 15.0 J/g), which highlights the damaging effect of the heat from the flat iron (Figure 7).

When compared with untreated hair, the use of Polycare® Frizz Therapy appears to increase the matrix crosslink density of hair (denaturation temperature is statistically higher - 145.0°C) and to improve the structural integrity of ordered hair proteins (denaturation enthalpy is significantly higher – 11.3 J/g). By referring to the gap in denaturation temperatures, we can conclude that Polycare® Frizz Therapy offers significant protection against heat after only one application. The damage linked to the use of flat iron is lowered. Hair is more and more protected over repeated applications.

Example of formulation

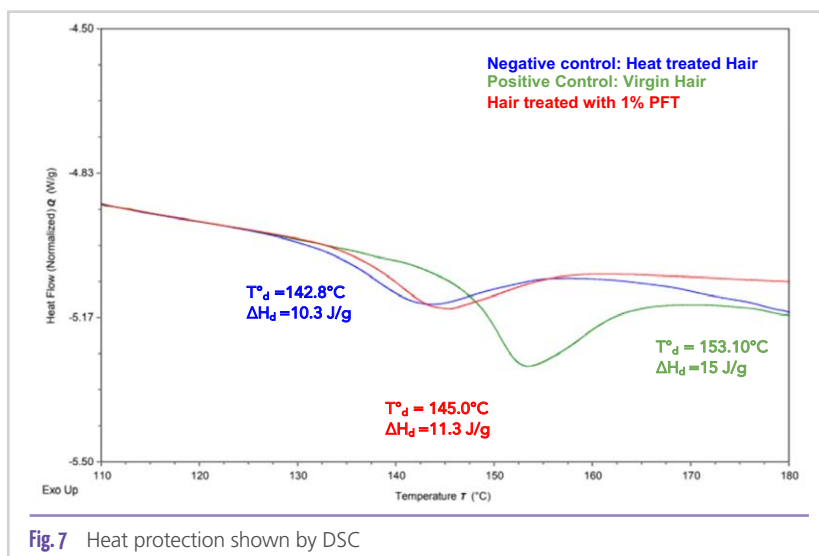
Styling is really a key part of the textured hair routine and aims to achieve for consumers the style of natural hair movement so desired. This styling foam has been built around Polycare® Frizz Therapy, to provide curl definition and strong anti-frizz effect, with no sensorial negative. This performance ingredient offers bouncy curls that last over time. But its versatility makes it suitable for all types of hair looking for a durable shape, straight or curly (Table 1).

Ingredient	% as supplied	% active
Polycare® Frizz Therapy Polymethacrylamidopropyltrimonium chloride	4,5%	1,5%
Mirataine® CB 35 ULS HP MB Coco-Betaine	2,85%	1%
Glycerin	0,5%	0,5%
Polycare® Rice C Cocodimonium hydroxypropyl hydrolyzed rice protein	0,5%	0,1%
Citric acid	Qs pH = 5	
Preservative	qs	
Water	QS 100	

Table 1: Composition Styling Foam - Free your curls

Conclusion

It is commonly known that humidity leads to fly-aways and frizzy hair. The presence of water inside the cortex tends to disrupt the internal structure of keratin, which leads to hair going back to its natural shape, with frizz and fly-away as additional consequences. Polycare® Frizz Therapy, as a small highly cationically charged polymer, deposits on the surface of hair and forms an homogeneous protective layer. This acts as a barrier



against moisture and lasts several days. Hair remains straight, smooth and disciplined.

As shown in this study, Polycare® Frizz Therapy maintains a reduction of bulk volume of at least 70% at 50% humidity for at least 3 days. As 1% alone, it performs as good as the best straightening cream commercially available, and better than other actives like cationic quars and arginine.

Therefore, Polycare® Frizz Therapy is ideal for the increasingly desirable minimalist beauty care regimen, as it provides an enjoyable combination of excellent heat protection and anti-frizz properties at the same time, which saves money, and time.

On one hand, it addresses anti-frizz challenges by providing high humidity resistance and maintaining durable shape and long-lasting discipline for straight or curly hair.

On the other hand, it helps to protect hair fiber against heat and related damage. Most of the consumers who want to straighten their hair, use heat appliances like flat or curl irons, which damages hair fibers, resulting in hair more sensitive to humidity, leading to increased volume and frizz. Which makes Polycare® Frizz the ideal answer to fight frizz, all with a natural feel, for curly or straight hair style.

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authors

Marios Hopkins Hatzopoulos
Margot Bon, Stephanie Neplaz, Delphine Mechineau, Jennifer Cazette
Solvay France
Corresponding Author: marios.hopkins-hatzopoulos@solvay.com

On the Map – Skin Actives for Scalp Care

E. Martin, R. Campiche, S. Gourion-Arsiquaud, M. Jomier, M. Waeckel, F. Guillemard

abstract

Scalp conditions such as itchiness and flaking are key concerns for consumers. This is stimulating interest in the role skin care ingredients could play in treating such symptoms if added to hair and scalp care products. Recent *in vivo* studies showed how our proven, 100% natural, moisturising skin active *Saccharide isomerate* (commercial name PENTAVITIN®) reduces two conditions associated with an oily and flaking scalp – increased transepidermal water loss and sebum secretion [2]. To support our findings further, we have conducted a new, proof-of-concept *in-vivo* study. In this study, in collaboration with our partners TRI Princeton and Newton Technologies, we trialled pioneering, scalp colour 3D mapping technology to visualise changes in scalp sebum levels and hydration following treatment with a shampoo containing *Saccharide isomerate*. Here, we present key data from our clinical study and full details of our 3D scalp mapping approach and proof-of-concept study. We also include visualisations of the improvements observed in scalp sebum and scalp hydration levels after seven days' frequent use of a shampoo formulation containing 0.5% *Saccharide isomerate*.

Would scalp skin benefit from similar treatments to facial skin?

As well as being quite common, scalp conditions such as itchiness, flaking, sebum secretion, oiliness, and compromised scalp barrier function can affect people of all ethnicities and age groups. Consumer studies suggest that people primarily associate stress, depression, and an unhealthy diet with their scalp concerns [1]. However, a not insignificant number also use scalp cleansing products to prevent these problems. With more consumers wondering whether they should care for their scalp in a similar way to their facial skin, there is a growing interest in using facial skin care actives in hair care products to treat scalp concerns directly: a trend which has become known as "skinification". An itchy scalp is the top concern consumers are seeking to address and there is particular interest in mild, cleansing, and moisturising solutions.

To respond to this interest, we began investigating the performance of some of our proven skin actives in the context of scalp care. In this article, we summarise the key findings from our 2021 study of *Saccharide isomerate* and the role it could play in improving scalp conditions associated with sebum secretion and transepidermal water loss [2]. We then describe a new, proof of concept study in which we used innovative 3D colour scalp mapping technology to present data on the performance of *Saccharide isomerate* in a visual and easy to understand format.

Investigating the scalp care benefits of *Saccharide isomerate*

Dandruff and an itchy scalp are top concerns for consumers around the world [1] and often experienced together. As increased sebum content and transepidermal water loss (TEWL) have been found in people suffering from these conditions previously [3], these were two of the parameters we investigated in earlier studies and are the ones we focus on here.

Saccharide isomerate is a 100% naturally derived, biodegradable moisturiser. It is made by transforming edible kernel corn sugars into a unique, skin-identical carbohydrate complex, similar to the natural moisturising factor found in the human *stratum corneum*. It supports *stratum corneum* hydration and water retention leading to improved moisturisation. Gene expression studies have also demonstrated that it effectively stimulates filaggrin, loricrin and SMPD1 which play a key role in skin hydration and skin barrier improvement. *Saccharide isomerate* has an established history as a facial skin moisturiser and its beneficial effects on the skin barrier [4,5] and skin hydration [6] have been proven. It was therefore an ideal candidate to investigate for its potential beneficial effects on scalp condition properties.

Our placebo-controlled, *in-vivo* clinical study involved healthy, Chinese subjects who were experiencing a flaky scalp. Participants applied shampoos comprised of either a placebo formu-

lation or a formulation containing 0.2% or 0.5% *Saccharide isomerate* once every other day for the whole study period. TEWL, sebum levels and scalp flaking scores were monitored over a period of 28 days [2]. For the statistical analysis, we used the ANOVA test for intra-group interpretation and the ANCOVA test for inter-group interpretation.

Saccharide isomerate shown to improve TEWL and sebum levels on the scalp

Our study and analysis demonstrated that *Saccharide isomerate* could indeed have a beneficial effect on scalp conditions when used in a shampoo. The graph in **Figure 1** shows

These findings provide convincing evidence that a rinse-off shampoo formulation containing *Saccharide isomerate* can improve TEWL and sebum levels on the scalp. Moreover, it is reasonable to believe that it is this ingredient which contributed to these improvements as it is already known to improve TEWL, skin barrier function and hydration on facial skin. As scalp conditions such as flaking are associated with increased TEWL and sebum content and reduced scalp barrier function, *Saccharide isomerate* could therefore be an invaluable ingredient in cosmetic formulations designed to improve these conditions. In this way, it could also have a beneficial effect on scalp properties that often accompany flaking, such as itchiness and irritation, and play an indirect role in overall improvements to scalp health.

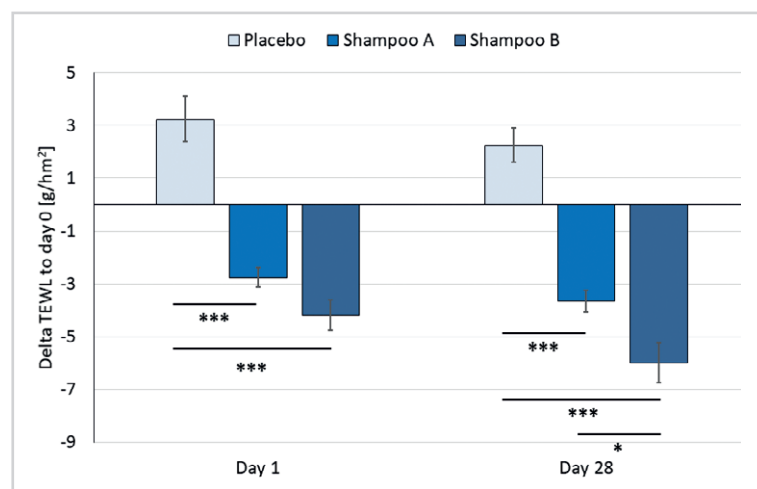


Fig.1 Change in TEWL over time in the three study groups. TEWL is displayed as water loss in grams per hour per square metre of skin. *p 0.05, ***p 0.001 by ANCOVA with Tukey adjusted p-value. Shampoo A = 0.2% *Saccharide isomerate* and Shampoo B = 0.5% *Saccharide isomerate*

changes in TEWL in the three study groups over the 28 days. Significantly, while a slight increase in TEWL was measured in the group that had used the placebo shampoo, a dose- and time-dependent decrease of TEWL was found in the groups that had used the shampoos containing *Saccharide isomerate*.

The graph in **Figure 2** shows changes in scalp sebum in all study groups over the 28 days. In a similar way to our findings about TEWL measurements, sebum levels in the placebo group were unchanged, whereas a steady decrease of sebum over time was observed for both of the *Saccharide isomerate* groups.

On day 0 and day 28, we also assessed scalp flaking by ASFS (total adherence scalp flaking score [7]) and noted a visible reduction in scalp flaking at 28 days for the two *Saccharide isomerate* groups, whereas the placebo group remained at the baseline level.

Making scientific data on the scalp care benefits of Saccharide isomerate tangible to non-experts

To extend on these promising findings, in conjunction with our partners, TRI Princeton and Newtone Technologies, we conducted a new, proof-of-concept study to visualise the extent to which *Saccharide isomerate* can improve scalp sebum levels and scalp hydration.

Many consumers and non-experts find it difficult to understand scientific data, so it is important to convert evidence into a more easily understood form. Visualisation technology can be particularly effective because information displayed as an image is captured more quickly and images generally speak for themselves. Aware of the need for understandable scientific data display, our company was the first to

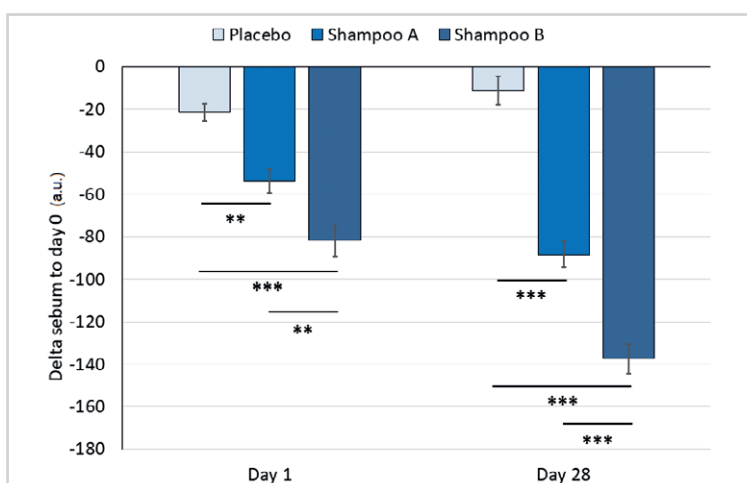


Fig.2 Change in scalp sebum over time in all study groups. The change in sebum content is displayed as delta sebum (a.u.) of scalp skin. **p 0.01, ***p 0.001. by ANCOVA with Tukey adjusted p-value. Shampoo A = 0.2% *Saccharide isomerate* and Shampoo B = 0.5% *Saccharide isomerate*

develop and introduce 3D facial colour mapping. Initially, we used this to represent skin hydration data and TEWL measurements [8]. We then extended our technology to display facial sebum content [9] and have also used it to show skin microbiome dynamics [10] and, most recently, facial texture [11]. As a next step, together with our partners, we have now transposed our facial visualisation approach to an innovative technique for generating 3D maps of the scalp.

How scalp colour 3D mapping works

Under this approach, *in-vivo* ATR-FTIR (Fourier-transform infrared) spectroscopic measurements are taken to evaluate scalp conditions and combined with specific algorithms to create 3D colour maps. These maps visualise hydration and sebum levels around the scalp and can be used to investigate variations in these levels in the presence of scalp bioactives.

FTIR Spectroscopy is a molecular technique which can be used to characterise and quantify molecular species (exogenous and endogenous) present inside biological samples relevant to the cosmetic industry (hair, skin, scalp and nails). It works on the principle that when infrared light passes through a sample, some of this radiation is absorbed selectively (at specific frequencies, wavelengths), depending on the bonds and functional groups in the molecules present in the samples investigated. The infrared light passing through the sample can then be recorded and analysed according to the spectral locations of their IR absorption. For *in-vivo* measurements of scalp properties, a specific ATR-FTIR probe and data analysis method were developed by TRI Princeton [12] in order to quantify hydration and sebum levels.

Figure 3, illustrates the different stages in the 3D scalp mapping approach. Twelve predefined sites on the hemi scalp are selected and ATR-FTIR spectra are collected at those same specific locations on the scalp, to evaluate sebum and water levels. The measurements taken are then used to generate specific scalp 3D maps with a colour scale based on the FTIR parameters selected to investigate scalp hydration or sebum levels. This specific 3D scalp mapping method has been developed by Newton Technologies [12] and maps biophysical attributes on the scalp using a 3D model of the skull. For the proof-of-concept study we describe here, scalp hydration is visualised with

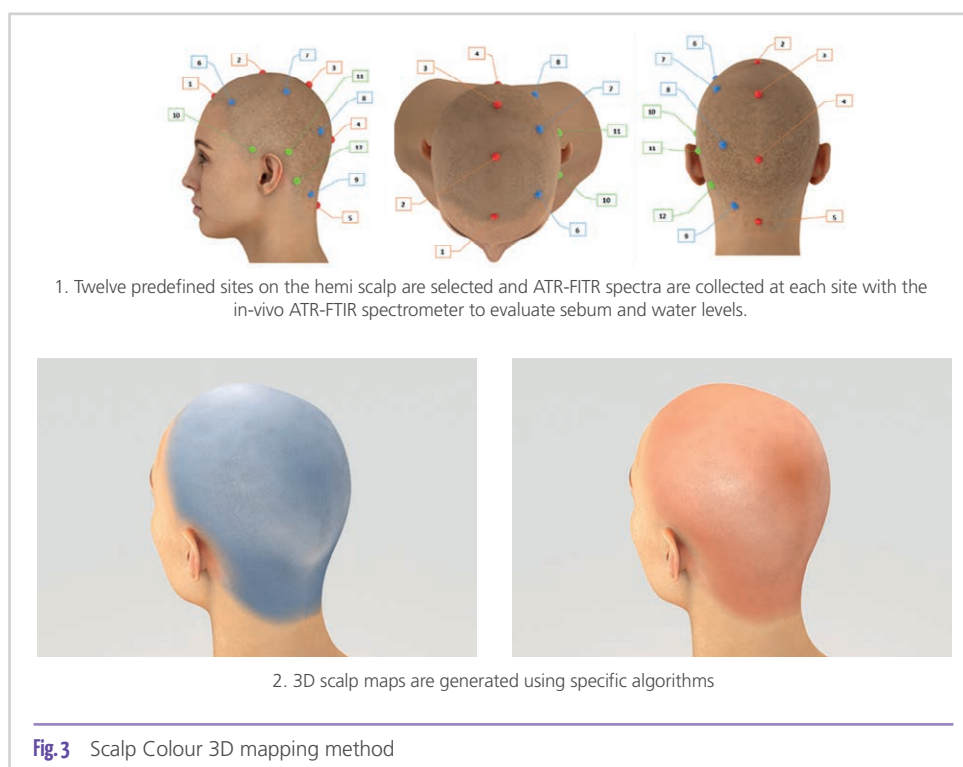
a colour scale from white (lowest scalp hydration level) to blue (highest hydration level), and scalp sebum with a colour scale from white (lowest sebum content) to brown (highest sebum content).

Scalp colour 3D mapping in practice – a proof-of-concept scalp hydration and sebum study to visualise the efficacy of Saccharide isomerate

Our proof-of-concept *in-vivo* study tested the performance of a placebo shampoo and a shampoo containing 0.5% *Saccharide isomerate* with two volunteers. For our scalp hydration study, our volunteer was a healthy, Caucasian female aged 27. For our scalp sebum study, our volunteer was a healthy, 24-year-old, Caucasian female who experienced scalp flaking and some oiliness. Both studies involved the following stages:

- Wash out with the placebo shampoo formulation every 2 days for one week (the Baseline).
- Daily use of the placebo shampoo for 7 days (Day 7).
- 10 days break (personal hair care routine).
- Wash out with the placebo shampoo formulation every 2 days for one week (the Baseline).
- Daily use of a shampoo formulation with *Saccharide isomerate* for 7 days (Day 7).

To evaluate scalp hydration and sebum levels, ATR-FTIR spectroscopy measurements were taken at the 12 predefined sites on the scalp, as described above, at the end of each wash out phase (the Baseline) and on Day 7 of applying the test formulations. These measurements were taken with an FTIR spectrometer with Remspec optical fibre. Water and sebum content were then calculated from the FTIR spectrum



and visualised with colour scales to show changes between the Baseline and Day 7 results.

Figure 4 shows a visualisation of scalp hydration levels at seven days, compared to the Baseline, following treatment with the placebo shampoo (**left**) and the shampoo with 0.5% *Saccharide isomerate* (**right**). On the chosen colour scale, white represents less hydration and blue more hydration. When placed side-by-side, a marked improvement in hydration after seven days' use of 0.5% *Saccharide isomerate* in a shampoo, compared to the placebo, can be seen.



Fig. 4 A comparative visualisation of scalp hydration levels at seven days vs the Baseline following treatment with a placebo shampoo (**left**) and a shampoo with 0.5% *Saccharide isomerate* (**right**). Hydration levels are represented on a colour scale from white (less hydrated) to dark blue (more hydrated).

Figure 5 shows a visualisation of scalp sebum levels at seven days compared to the Baseline following treatment with the placebo shampoo (**left**) and the shampoo with 0.5% *Saccharide isomerate* (**right**). On this colour scale, dark brown represents more sebum and white represents less sebum. And in a similar way to the scalp hydration maps, we can observe a marked reduction in sebum after seven days' use of 0.5% *Saccharide isomerate* in a shampoo, compared to the placebo.

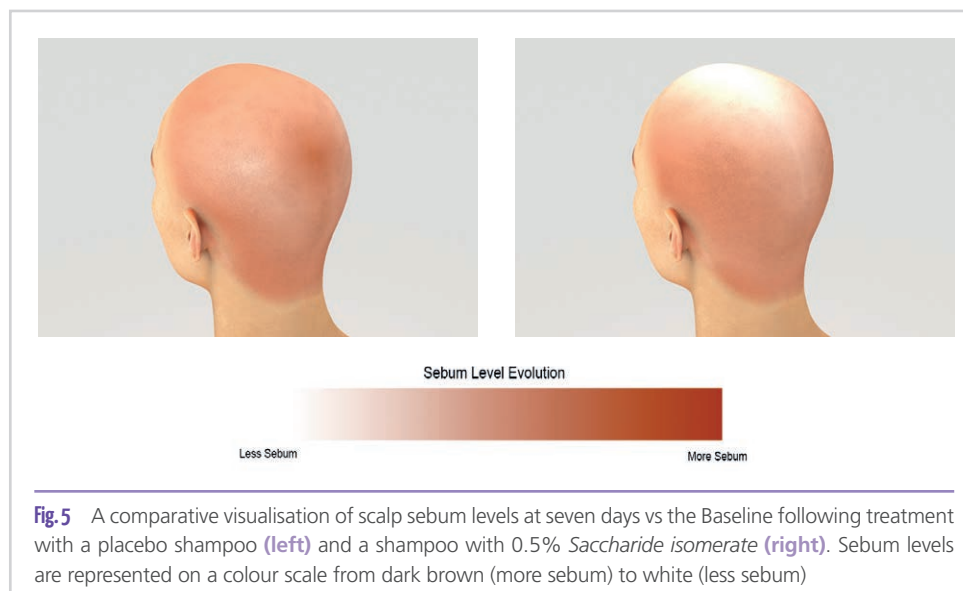


Fig. 5 A comparative visualisation of scalp sebum levels at seven days vs the Baseline following treatment with a placebo shampoo (**left**) and a shampoo with 0.5% *Saccharide isomerate* (**right**). Sebum levels are represented on a colour scale from dark brown (more sebum) to white (less sebum)

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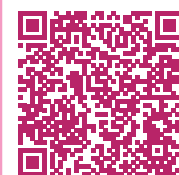
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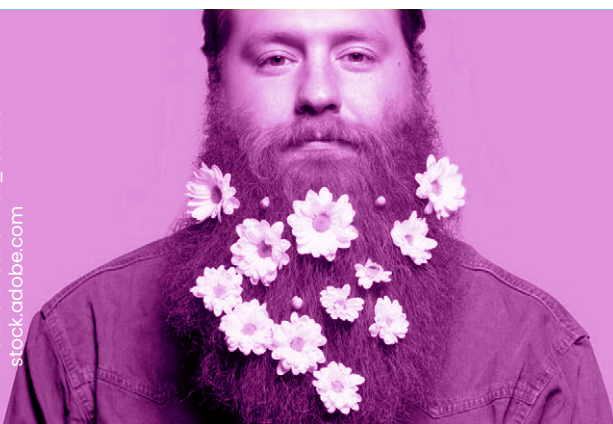
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The next steps

Our new, proof-of-concept study reflects our earlier, published findings about improvements in scalp sebum levels and TEWL following treatment with cosmetic formulations containing Saccharide isomerate. As symptoms associated with these properties, such as flaking and itchiness, are common and key concerns for consumers, this ingredient therefore offers an effective solution. Moreover, our studies point to the potential in skin-care actives to address scalp care concerns – which is an area we continue to explore with various proven ingredients in our portfolio.

The scalp colour 3D mapping approach we used to demonstrate the performance of *Saccharide isomerate* meets another consumer need, namely, for tangible and easily understood evidence of ingredient efficacy. In view of the encouraging results observed in this study, and to further substantiate the beneficial role skin actives like *Saccharide isomerate* can play in a scalp care context, we will now deploy the technology further in our future scalp care solutions.

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authors

Emmanuel Martin¹, Remo Campiche¹, Samuel Gourion Arsiquaud²,
Matthieu Jomier³, Mélanie Waeckel¹, Fabrice Guillemard¹

¹DSM Nutritional Products, Wurmisweg 576, 4303 Kaiseraugst, Switzerland,
²TRI Princeton, New Jersey, USA | ³Newtone Technologies, 69006 Lyon, France

Correspondence: emmanuel.martin@dsm.com



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Evaluation of the Type of Polymer and Co-surfactant in Coacervate Formation

W. Cabrejos Caracciolo

abstract

Coacervates are complexes formed from a polymer-polymer or polymer-surfactant interaction. Coacervates formed by a cationic polymer and an anionic surfactant enabled the development of the first conditioning shampoos (also called 2-in-1 shampoos). The objective of this work is to contribute with the identification of formulation parameters that increase the formation of coacervates. Polymer charge, micelles charges and the total content of surfactants are determining factors in the formation of coacervates. Factors such as polymer molecular weight and ionic strength also contribute, although in lesser order of importance, to the formation of coacervates. However, the role played by the degree of hydrophilicity/hydrophobicity of the polymer, as well as the effect of different co-surfactants, has not been determined with certainty. In the present study, three different types of polymers and six types of co-surfactants will be evaluated, keeping constant the amount of anionic surfactant, total content of surfactants and ionic strength. These results will serve to optimize the formulation of conditioning hair cleaning products.

Introduction

It was *Goddard and Hannan* who in a 1976 paper first described in a detailed manner the characteristic interactions that occur between anionic surfactants and cationic polymers, and which served as a reference for the later development of conditioning shampoos [*Goddard*, 1976]. In that study, it was found that upon addition of the anionic surfactant Sodium dodecyl sulfate (SDS) to a fixed solution of the cationic polymer Polyquaternium-10 (PQ-10), an initial increase in viscosity took place, followed by the appearance of turbidity and precipitation with concomitant loss of viscosity. Larger levels of additional surfactant were able to solubilize the precipitate. The stoichiometric neutralization of the opposing charges occurred at a constant ratio of 1:2.3 SDS to polymer. In a later paper, the occurrence of two adsorbed layers was described: the first one is a single layer of surfactant adsorbed on the polymer corresponding to the maximum precipitation, and a second layer of surfactant that enables resolubilization of the complex [*Goddard*, 1977a]. Polymer/surfactant interactions seems to be favored by: (a) a longer hydrocarbon chain of the surfactant, (b) a straighter chain, and (c) a terminal head group with respect to the chain. Viscosity variations are also associated with initial polymer/surfactant association (increase in viscosity), neutralization (viscosity drop), and resolubilization (new increase in viscosity) [*Goddard*, 1977b]. When it comes to the ionic interaction of species, surfactant's anion has a primordial role both to promote interaction and later adsorption to the polymer, and to participate in the desorption of previously deposited polymer on hair, reducing the risk of overdeposition or what's known in the cosmetic industry as "build up" [*Hannan*, 1978]. Many studies have emerged, describing

the interaction of different types of polymers and surfactants, and the mechanism behind those interactions. Similarly to *Goddard, Dubin et. al.* focused on the interaction of oppositely charged molecules [*Dubin*, 1983]. He found that rather than the amount of polymer of surfactant used, phase separation depends on ionic strength of the anionic surfactant and its mole fraction (basis total surfactant). This finding correlates well with the charge (coulombic) interaction between polyions and oppositely charged mixed micelles (anionic/nonionic, and anionic/zwitterionic), as a means of precipitation mechanism. Progressive saturation of polyions with mixed micelles above a critical surface charge density explains the shape of turbidimetric titration curves and their dependence on polymer concentration. The negligible contribution of the polymer to the solution viscosity is consistent with intrapolymer condensation of micelles, whose composition controls the surface charge density [*Dubin*, 1985]. Cationic polymers have a dependance on ionic strength of anionic surfactants, where below critical conditions stable aggregates are present, and at critical conditions (near phase separation) the dependance is linear. Turbidimetry studies of mixed anionic/nonionic micelles with a strong polyelectrolyte in dilute aqueous solutions of high ionic strength supported this idea, showing that the aggregation state depends primarily on the ionic strength and the mole fraction of anionic surfactant [*Dubin*, 1985]. It was also found that near the precipitation zone, a pseudo phase transition to soluble polyion-micelle aggregates takes place, while farther from this phase boundary, macroscopic phase transitions are observed, like the formation of a second liquid phase rich in polymer and surfactant. This coacervation takes place only when the ratio of polymer:surfactant concentrations lies within certain bounds, where a continued increase in the mole fraction on anionic

surfactant ultimately leads to irreversible precipitation of an amorphous solid, showing the presence of strong attractive intermacromolecular coulombic forces. Nevertheless, cationic polymers differ widely with respect to chemical composition or molecular weight, as well as for several anionic and nonionic (or zwitterionic) surfactants. Dye solubilization as well as fluorescence measurements indicate the existence of hydrophobic environments in the pre- and post-precipitation regions [Ananthapadmanabhan, 1985]. These environments in the immediate vicinity of the precipitation region in the case of a cellulosic polymer/SDS system are much more hydrophobic than those in an acrylamide copolymer/SDS system. It was found that in the pre-precipitation zone, a hemi-micelle/inverse cylindrical micelle-type aggregate is formed, and in the post-precipitation zone, a conventional micelle-type structure exist. Adsorption studies of SDS and of PQ-10 on alumina surfaces suggest that the structure and the properties of the SDS-PQ-10 complexes are important factors in determining the nature of the adsorption process [Arnold, 1985]. Whereas synergistic adsorption occurs under certain conditions (e.g., at pH 6 and relatively low ratios of SDS to PQ-10), under different conditions, either components can inhibit the adsorption of the other one, due to electrostatic interactions between the sorbate moieties and the surface. An investigation of the interaction of SDS with two cationic polyelectrolytes showed that small additions of SDS to PQ-10 of 1% concentration lead to intermolecular interactions between the polymer chains via the bound surfactant, whereas in the more flexible and globular vinyl polyelectrolyte, intramolecular interaction is favored [Leung, 1985]. Just into the resolubilization zone, where excess anionic surfactant is present, PQ-10 favors a polymer micellar association, whereas the more flexible vinyl polymer seems to stabilize a structure involving association of surfactant into smaller units, perhaps surfactant pairs. When the surfactant is in large excess (5%), micellar structures predominate in both systems, probably with the macromolecule woven into the micellar domains, resembling an entangled string of beads. The binding of Dodecyltrimethylammonium bromide (DTAB) to dextran sulfate has been shown to be a highly cooperative process [Santerre, 1985]. The standard entropy of binding decreases with increasing temperature, and the enthalpy of binding is endothermic at low temperature and exothermic at higher temperatures, which closely resembles the case of micellar aggregation of surfactants, specifically, the thermodynamic parameters for surfactant-polyion binding at low concentration. Measurements of relative viscosity and shear dependent viscosity were made on solutions of a cationic cellulose ether polymer with various ratios of added SDS [Goddard, 1985]. It was observed that with 0.1% polymer solutions, evidence is found for inter- rather than intramolecular interaction which is brought about by polymer bound surfactant ions. The intermolecular interaction manifests itself as high solution viscosity at low SDS to polymer ratios. At high concentrations of SDS, beyond the region where precipitates of polymer and surfactant form, the results are consistent with a polymer chain associated with many surfactant micelles in a globular structure. The viscosity,



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in this range, is much lower. The associative phase separation occurring for systems of oppositely charged polymer and surfactant leads to one dilute and one concentrated phase [Goddard, 1999]. The concentrated phase can be solid or liquid in nature depending on the system, typically having a liquid crystalline nature. Several structures were identified in these systems, being the most important lamellar, hexagonal, and cubic ones (Figure 1).

Four different electrolytes are present in the system: the surfactant, the polyelectrolyte, the complex polyon-surfactant and the two counterions. Triangular phase diagrams represent two-dimensional cuts in such three-dimensional pyramids (Figure 2).

Phase separation is indicated into dilute and concentrated phases induced on dilution with water. If we add more water, the concentrated phase will be even more concentrated. The figure explains that the underlying mechanism is a dilution of the simple salt (that comes from the counterions). The salt decreases the attraction between the surfactant aggregates and the polyions. On dilution the attraction becomes stronger, inducing phase separation by forming a complex known as "coacervate", formed between the polyelectrolyte and the surfactant [Thalberg, 1993]. A phase behavior study of anionic SDS surfactant in cationic PQ-10 polymer aqueous solutions identified a metastable phase (coacervate) (Figure 3) between the differing redissolution phase boundaries reported in the literature for the surfactant-rich regime, showing the relative importance of both hydrophobic and electrostatic interactions and providing the first approximation for the corresponding microstructures in the different phases [Li, 2012].

Objectives

Our research focuses on studying the relevance of hydrophobic interactions between polymer and surfactant of opposite charge, as well as the effect of adding different co-surfactants. Factors such as polymer charge, micelles charge and the total content of surfactants have been extensively studied, while other factors such as polymer molecular weight, the effect of co-surfactants, and the degree of hydrophilicity/hydrophobicity of the polymer, have received less attention. The results of our study will serve to optimize the formulation of conditioning hair cleansing products.

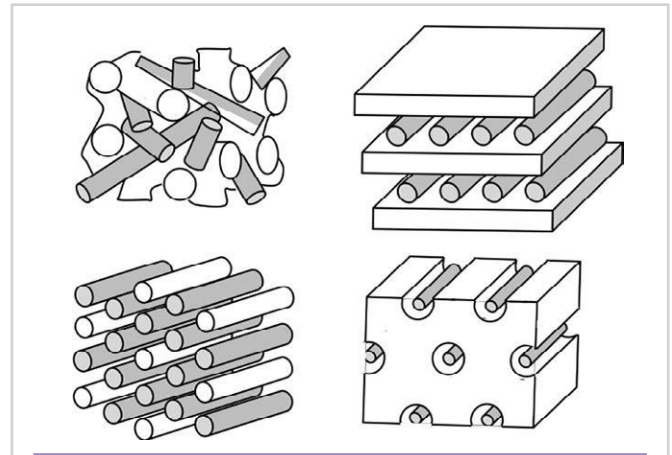


Fig.1 The most important liquid crystalline structures occurring in mixtures of a polyelectrolyte (gray) and an oppositely charged surfactant (white) [Bilalov, A., Olsson, U. and Lindman, B., Soft Matter, 2012].

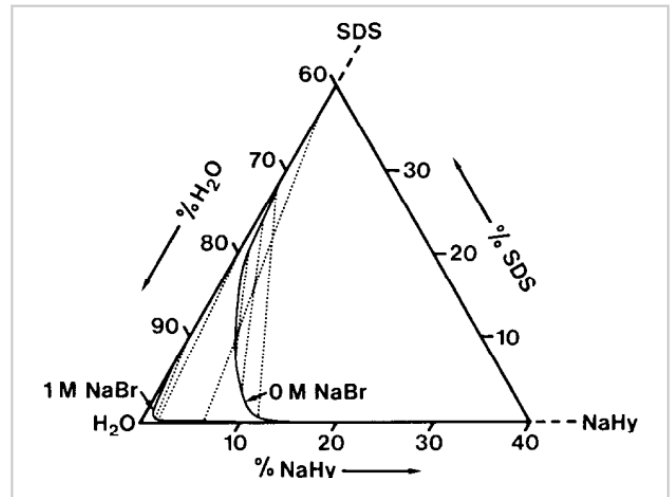


Fig.2 Phase separation in mixtures of a polyelectrolyte and a similarly charged surfactant is typically segregative and may be enhanced on salt addition if there is an electrolyte induced micellar growth. The example refers to mixtures of Sodium dodecyl sulfate (SDS) and the anionic polysaccharide sodium hyaluronate (NaHy). (Thalberg, K. and Lindman, B., Colloids & Surfaces, 1993).

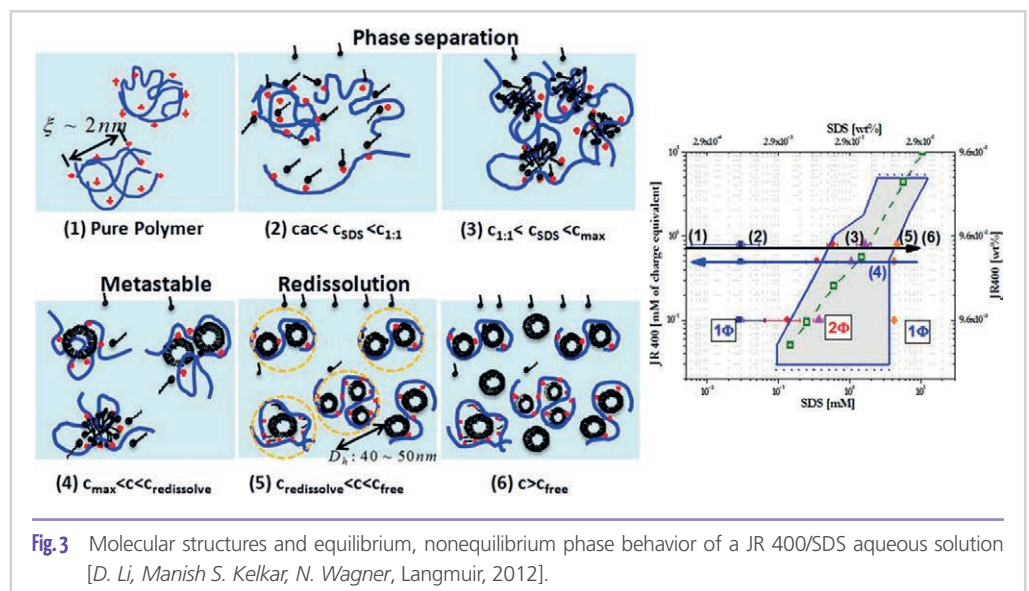


Fig.3 Molecular structures and equilibrium, nonequilibrium phase behavior of a JR 400/SDS aqueous solution [D. Li, Manish S. Kelkar, N. Wagner, Langmuir, 2012].

Materials & Methods

All surfactants were obtained from Prochem. They were used as supplied without further purification, and the concentrations described in the studies were based on each material's active content. Polymers were obtained from Ashland (Polyester-11 and Guar Hydroxypropyltrimonium Chloride, under the commercial names of Clarisilk and N-Hance CG13, respectively) and Lubrizol (Polyquaternium-7 under the commercial name of Merquat 550).

Precipitation studies: effect of the co-surfactant

A mixture of Sodium lauryl ether sulfate (SLES) and Guar hydroxypropyltrimonium chloride (GHPTC) was initially prepared. Aliquots of this solution were taken and mixed with different co-surfactants with the appropriate amount of water. The final ratio of ingredients for each solution was 12:1:0.5 of SLES/co-surfactant/GHPTC. Then, a 1:3 dilution (test mixture/water) was done to favor coacervate formation, indicated by a sediment at the bottom of the test tubes [Gamez-García, 2002]. Precipitation ratings were made after 3 days, to allow for equilibrium.

Precipitation studies: effect of the polymer

A mixture of Sodium lauryl ether sulfate (SLES) and a polymer was initially prepared. Then, Cocamidopropyl betaine (CAPB) was added to each test mixture with the appropriate amount of water. The final ratio of ingredients for each solution was 12:1:0.5 of SLES/CAPB/polymer. Like in the previous study, a 1:3 dilution (test mixture/

water) was done to favor coacervate formation, indicated by a sediment at the bottom of the test tubes. Precipitation ratings were made after 3 days, to allow for equilibrium.

Results and discussion

Precipitation studies: effect of the co-surfactant

SLES, upon addition to polymer solutions of GHPTC at a fixed concentration, first caused a pronounced increase in solution viscosity. As the surfactant concentration was increased, turbidity and then precipitation were observed together with a rapid loss of viscosity. Resolubilization occurred at still greater surfactant concentrations, which agrees with previous evidence found in the literature [Goddard, 1999]. After addition of each co-surfactant and later dilution (1:3 ratio of test mixture/water), precipitation occurred, first as fine particles suspended in the solution, which later deposited at the bottom of the test tube. **Table 1** summarizes the results of this test.

SLES (%)	GHPTC (%)	Co-surfactant (%)	Co-surfactant name	Co-surfactant type	Precipitation	Relative amount
12.0	0.5	1.0	Cocamidopropyl hydroxysultaine	Amphoteric	Yes	Low
12.0	0.5	1.0	Cocamidopropyl betaine	Amphoteric	Yes	High
12.0	0.5	1.0	Lauramine oxide	Zwitterionic	Yes	Medium
12.0	0.5	1.0	Cocamide DEA	Non ionic	Yes	Medium
12.0	0.5	1.0	Decyl Glucoside	Non ionic	Yes	Medium
12.0	0.5	1.0	Stearamidopropyl dimethylamine citrate	Cationic	Yes	Medium-high

Table 1: Precipitation test with different types of co-surfactants, at a dilution rate of 1:3 of test solution/water.

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The results show that the type of co-surfactant has a marked influence over the amount of coacervate formed. The influence of the co-surfactant CAPB has been previously noted by Lepilleur et. al., although, the exact mechanism was not discussed [Lepilleur, 2011]. A plausible explanation could be the strong affinity of SLES for CAPB molecules, whose solutions have low CMC. This phenomenon is supported by the marked increase in viscosity of this mixture and high foaming properties. The presence of CAPB might make SLES free unimers to pair with CAPB rather than interact with the polycation, reducing the amount of free SLES that can solubilize the coacervate. Thus, precipitation of the coacervate would occur at low dilution levels, producing a higher amount of the complex that precipitates out of the solution. The cationic surfactant Stearamidopropyl dimethylamine citrate also exhibits a strong interaction with SLES which yields a good amount of precipitate upon dilution. Other types of co-surfactants also contribute to coacervate formation although at a lesser extent.

Precipitation studies: effect of the polymer

In the previous study, it's been shown that CAPB had the strongest affinity with SLES amongst the co-surfactants evaluated, which promoted precipitation of higher amounts of coacervate upon low dilution levels. We then used a mixture of SLES/CAPB and tested it with different polymers, to evaluate the influence of their hydrophilic character on coacervate formation. **Table 2** summarizes the results of these tests.

While GHPTC produces a high amount of coacervate with SLES upon dilution, both Polyquaternium-7 and Polyester-11 failed to form any coacervate under the conditions of our experiment. The results found with Polyquaternium-7 seem to contradict previous studies [Wilgus, 2011]. Nevertheless, since Polyquaternium-7 is an amphoteric polymer, once the pH was lowered, a coacervate was formed but in a significantly lower amount than the one formed when GHPTC was used. When Polyester-11 was used, no precipitate was formed, which could be explained by its transient cationic character and consequent lower interaction with anionic groups.

Conclusions

Results from our studies showed that the type of co-surfactant plays an important role in promoting the formation of a coacervate upon dilution. It's also been shown that the type of polymer is crucial, which could help cosmetic formulators decide which type of polymers should be chosen for conditioning cleansers.

Acknowledgements

We thank Pontificia Universidad Católica del Perú for letting us use their laboratory and equipment to run few of the tests.

SLES (%)	CAPB (%)	Polymer (%)	Polymer name	Hydrophilic	Precipitation	Relative amount
12.0	1.0	0.5	Guar hydroxypropyltrimonium chloride	Fairly	Yes	High
12.0	1.0	0.5	Polyquaternium-7	Very	No	-
12.0	1.0	0.5	Polyester-11	Somewhat	No	-

Table 2: Precipitation test with different types of polymers, at a dilution rate of 1:3 of test solution/water.

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author

Wilson Cabrejos Caracciolo

Department of Chemistry, Pontificia Universidad Católica del Perú
Univeritaria Avenue N° 1801 - San Miguel 15088, Lima, Perú

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Green, Purple, or Red? Developing Stable and Effective Color Concepts for Aqueous Personal Care Products with Natural Extracts

I. Ekimova, D. Schicker, A. Springer

abstract

Creams, shower gels and bubble baths are often developed with a color concept to achieve a refreshing or relaxing effect or to emphasize certain ingredients. Natural extracts are particularly popular in natural cosmetics, but also come with challenges when used in aqueous products and their storage. With this study we propose a method to verify stability and to reconcile product efficacy and shelf life. We also highlight the advantages to not only work with coloring the product, but also pay attention to the design of the packages, especially with regards to colors and smart labelling, to support the appearance and message of the product.

Psychophysiological effect of colored products

Colors are transporting information and thus influence us. Therefore, they are explicitly used to induce emotions or attract attention, especially in the context of marketing [1] as they can affect brand personality and purchase intent [2]. Depending on the message they are intended to transport, colors can be selected by the two dimensions activation and evaluation [3]: **1)** Colors with extreme short or long wavelengths (red and blue) are associated with higher activation levels than colors with mediate wavelengths (e.g. green). **2)** Colors with shorter wavelengths (cool colors, e.g. blue) are more positively evaluated than colors with longer wavelength (warm colors, e.g. red). A relation between color and perceived sensory quality was also explicitly shown for colored body lotions [4]. However, the psychological effect of a color is not always the same. For example, red can on the one hand elicit avoidance-based motivation and thus is often used for warning signals [5]. On the other hand, in relational situations, red enhances men's attraction to women and thus has an appetitive implication [6]. The color green on the other hand is often associated with a relaxing effect and calmness [7] but also with eco-friendliness. Thus, in marketing green is used to advertise the sustainability of products. However, persuasion knowledge can reduce a subsequent positive effect and even induce the opposite effect [8].

In line with the psychological effects of colors, cosmetic products like shower gels or creams are often developed with a color concept to achieve a refreshing or relaxing effect or to emphasize certain ingredients. Additionally, coloring can modify sensory attributes. For example, color can impact the perceived texture (yellow enhances perceived thickness compared to green color) or smell (green enhances perceived freshness compared to yellow color) of a body lotion [9]. In industrial applications, synthetic dyes are widespread due to low costs and long-lasting properties, although they can be harmful [10].

In an effort to provide healthy products and to become more ecological as well as environmentally friendly, natural plant-based colorants are becoming increasingly popular. However, the instability of plant-derived colorants is challenging [11]. In the following, we propose a method to verify stability and to reconcile product efficacy and shelf life for the plant-based colorants chlorophyll, black carrot extract, and beet extract.

Use of plant-based colorants

The green leaf pigment chlorophyll is not a single compound, but contains several substances related to each other by a common structure, which differ in their aldehyde and vinyl groups (**Figure 1a**). In terms of quantity, chlorophyll a forms the largest part of the pigment, accounting for about 75%. Chlorophyll a absorbs predominantly violet (428 nm) and red light (650 nm), while the absorption maxima of chlorophyll b are in the blue light range (452 nm). This difference results in chlorophyll a being perceived by the human eye as blue-green and chlorophyll b as yellow-green. The central metal atom of the porphyrin ring is also important for the color properties of chlorophylls. This also influences the stability of the complex. If Mg^{2+} is removed, the color changes to grayish and olive brown. If it is replaced by Zn^{2+} or Cu^{2+} , a green stable complex is formed [12].

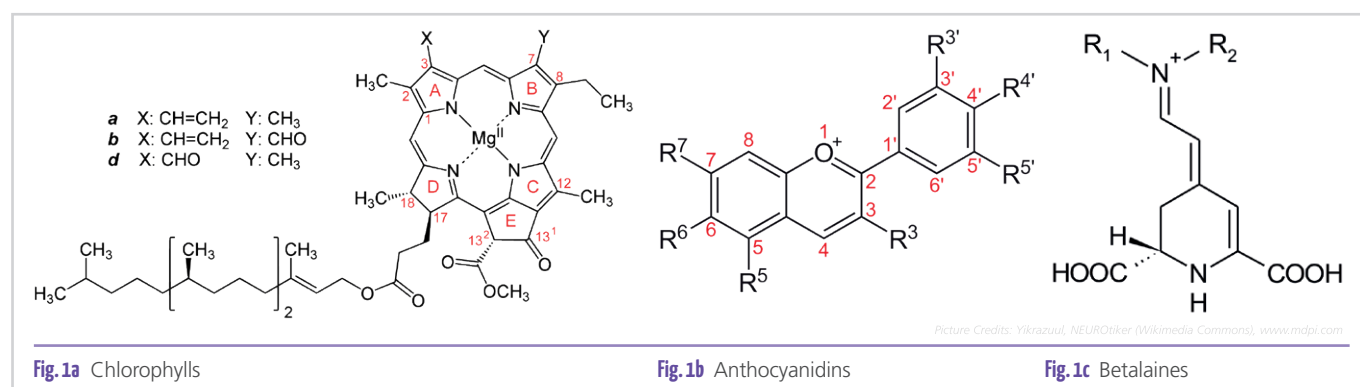
Black carrot extract has a dark purple color, which is explained by the presence of anthocyanins, where the actual coloring substances (chromophores) are anthocyanidins [13]. All anthocyanidins have the same structure (2-phenylbenzopyran) and differ in the position and number of hydroxyl groups, which are also often methylated (**Figure 1b**). With the change in pH, anthocyanins undergo protonations or deprotonations that al-

ter the absorption behavior [14]. When pH is increased, the non-acylated anthocyanins convert into colorless carbinole by hydrating the red flavylium cation. The absorption maximum thereby shifts from about 520 nm (pH = 1) to the UV range. Since the black carrot extract is low in non-acylated and rich in acylated anthocyanins, it is also more color-stable than extracts from purple corn or red grapes and more suitable for use in acidic products [15,16].

A group of compounds called betalains is responsible for the color of beet extract. They all have the same basic structure (Figure 1c) and are divided into two groups: red-violet betacyanins and yellow betaxanthins. The quantitatively most important

red pigment of beet betanin occupies 75-95% of the total content of betacyanins. Vulgaxanthin I is the most important yellow compound in the extract [17]. Betanin has an absorption maximum at 537 nm, which is due to absorption of green light and is perceived by humans as a violet color. Vulgaxanthin I, on the other hand, absorbs mainly in the blue-green range (absorption maximum at 476 nm), resulting in perception of a yellow-orange color by the human eye. A mixture of these two compounds thus gives the beet extract a red-violet color [18,19].

To conclude, several parameters can have an influence on the color effect of the natural colorants in aqueous matrix. This can also influence storage stability of the product. Since cosmetic



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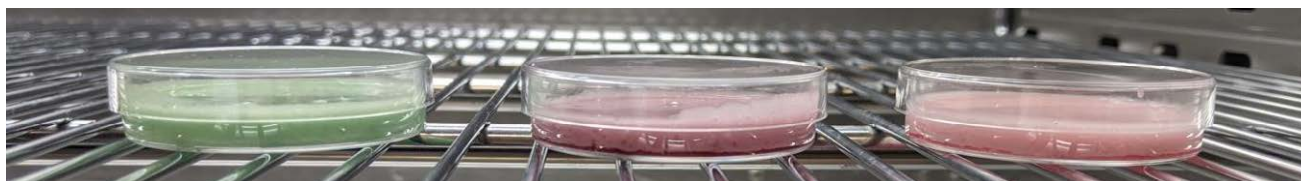


Fig. 2 Storage of O/W emulsions in light (side view; from left to right: chlorophyll, black carrot extract, beet extract).

products should not change visibly during their long shelf life, it is important to accompany product development with stability tests. A method for standardized testing of color retention was developed and tested at the Fraunhofer IVV.

Color stability of pigments in aqueous formulations

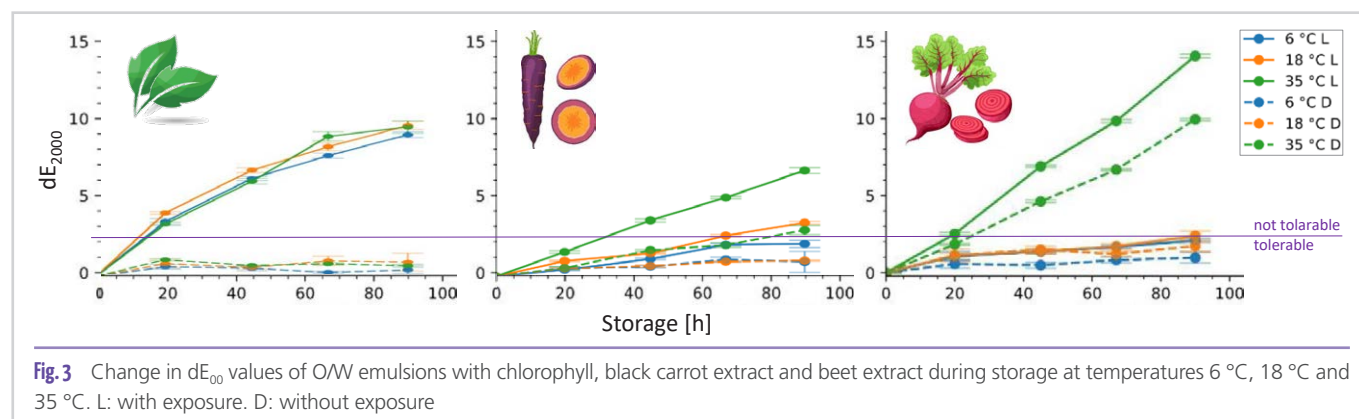
To develop a method to quantify color stability during storage, a base emulsion was prepared with 74.4% deionized water, 18% rapeseed oil and 7% glyceryl stearate, thickened with 0.2% xanthan gum and preserved with 0.2% potassium sorbate. The pH adjustment took place with about 0.2% citric acid. The manufacturing process consisted of the suspension of oil, emulsifier and xanthan gum and the addition of deionized water. Subsequently, homogenization was performed at medium speed (17,500 rpm) for one minute at 80°C. After cooling, potassium sorbate and citric acid were added and homogenized again at medium speed for one minute. The pH was adjusted to 4.3-4.5. To obtain the different sample variants, triplicate determinations were each spiked with 1% of the coloring extracts (Cu-chlorophyll complex, black carrot extract, red beet extract) and homogenized again for one minute. The O/W emulsions were transferred to Petri dishes and then stored in triplicate at 6°C, 20°C and 35°C, once without and once with light exposure (halogen 6000 K, 0.8 W/m²), respectively, for 100 hours. In **Figure 2** it is clearly visible that a strong and appealing coloration was achieved by using the natural colorants. Image acquisition and subsequent color evaluation were performed once a day in a standardized illuminated and calibrated photochamber. The image processing program ImageJ was used to quantify the storage-induced discoloration. The limit for tolerable color change was set at $dE_{00} = 2.2$ on the CIEDE₂₀₀₀ scale [20,21].

Figure 3 shows the changes over the storage time of the three colored formulations at the respective storage parameters. It can be seen that the emulsion with chlorophyll was highly light sensitive, but the color change occurred independently of temperature. This dye showed the fastest color change of all three. However, the curve flattened with storage time, indicating a saturation effect. The change at later times was weaker, as at the beginning. For the emulsion with black carrot extract, the rate of color change increased with temperature, being stronger when exposed to light. This showed the least color variation with a linear progression. Similarly, the emulsion with beet extract showed a greater rate of color change than the black carrot extract. Also, for the emulsion colored with beet extract, the course was linear and still seemed to change after 100 h of storage at a similar rate as at the beginning. However, the limit of tolerable color change was reached for all samples when exposed to light after only one day or in the first few days of storage, depending on the temperature.

This approach shows that although the use of plant-based colorants in water-containing formulations provided strong color, it did not last for all substances and storage parameters in this basic formulation without protective ingredients.

Product protection by packaging

To achieve the usual minimum shelf life of many months at room temperature, even for sensitive formulations, emulsions colored with natural coloring extracts should be protected from the effects of light. Unlike sun care products, where the light protection is primarily intended to prevent the degradation of UV filters and must therefore absorb in the UV range [22],



the pigments in colored water-based cosmetic products absorb in the visible light range. Thus, light protection should be used which also absorbs in the visible spectrum. Completely transparent packaging is therefore difficult to implement. Packaging made of opaque materials can also transmit certain amounts of light, which is why outer packaging is recommended. Light protection sleeves or light protection labels can also be used. Both the use of outer packaging and a sleeve or label have the advantage of providing additional space to display the product concept.

Product performance by packaging

Moreover, package coloring can significantly affect the product's appearance and as such, consumers' expectation and perceptions [23,24]. In the area of food, there is already some data that may be transferable to cosmetic products. For example, whereas food products in blue and green colored packages are perceived as healthier, red packaged products are perceived sweeter [25]. In addition to the color, highly visible claims on the packaging can also have a major impact on consumer acceptance. The impact of organic or healthiness labels for food products has received much attention in research in the last years, showing a clear trend that label do

effect consumer's food perception and behavior [e.g. 26,27, 28,29]. Food labels can elicit top-down language-level cognitive effects [30] and can activate reward areas like the ventral striatum [31]. However, the effects of labels cannot be generalized, as they are group-specific [32]. In investigations at the Fraunhofer IVV, we further investigate whether not only the claim itself but also the specific wording has an effect. Therefore, we are conducting an fMRI study to not only investigate behavioral ratings but also underlying neuronal mechanisms.

While food packaging and labeling are well studied, less studies have been conducted regarding cosmetic products so far. One study suggest that the perceived information utility of cosmeceutical product advertising is the most significant factor in engaging young female consumers' interests and desire to try cosmeceuticals [33]. Another study investigated the impact of the "not tested on animals" claim on consumers' attitude and behavioral intention towards a cosmetic product [34]. In further work it was found, that safety perceptions for common cosmetic substances can be significantly influenced by the claims about the naturalness and dose of cosmetics ingredients [35]. To the authors' knowledge, there are no specific results on the general claim wording on cosmetic packaging and its perception. Even if effects of food product labeling could be generalized to cosmetic products, we suggest to

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conduct specific studies as not only the products differ but also the main consumer groups and their expectations. With the help of measurement methods for recording consumer acceptance, measures can be derived at Fraunhofer IVV as to which product and packaging design optimally supports the product effect. In this way, companies are provided with a decision-making aid through which parameters in product and packaging design the greatest consumer acceptance can be achieved.

Conclusions

Even though natural colorants have numerous advantages for their effect on consumers, there are challenges in their use in water-containing products, which can be individual depending on the colorant and the basic formulation. Therefore, it is beneficial to use a method for comparable systematic and reproducible quantification of color change, such as that proposed in this study. One possibility is the use of external packaging to allow the use of natural colorants even in sensitive formulations. These offer the additional possibility of underlining the product concept through suitable claims and packaging presentation. With the help of consumer acceptance studies, packaging design can be further enhanced to achieve the targeted level of product acceptance. If this or an individually adapted solution is to be implemented in your company, it is advantageous to have a competent partner with an interdisciplinary scientific team at your side.

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Author Info:

B. Sc. Iana Ekimova studied Food Technology and Biotechnology at the Technical University of Munich and gained experience as a scientific assistant and internee at the Fraunhofer IVV in the laboratory in the department Quality Maintenance Food. She is now employed as a working student in the product development department of a cosmetics manufacturer.

M.Ed. Doris Schicker studied scientific education at the TU Munich. Now she is doing her PhD in neuroscience at the Fraunhofer IVV on influences on human odor perception. At the same time, she works as a Senior Scientist at the Fraunhofer IVV to further explore multisensory aspects of product perception using data science methods.

Dipl.-Leb.Chem. Arielle Springer studied food chemistry at the TU Dresden and gained professional experience as a product developer in the cosmetics industry. Together with experienced experts, she is currently working as a business development manager and scientist across departments to continuously develop the research field of Personal & Home Care at the Fraunhofer IVV.

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authors

Iana Ekimova, Doris Schicker, Arielle Springer

Fraunhofer Institute for Process Engineering and Packaging IVV
Giggenhauser Str. 35 | 85354 Freising | Germany

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Arielle Springer: arielle.springer@ivv.fraunhofer.de
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Advances in Enzyme Engineering: Delivering on the Need for Sustainable Laundry Detergents

A.J. Hoekstra, E. Carey, T.P. Graycar

abstract

There is a market need for more sustainable laundry detergents. Consumers are looking for cleaning products that are biobased and biodegradable, but do not compromise on stain removal performance. Enzymes play a key role in today's liquid laundry detergents. This article reports on recent advances in biotechnology to improve the stability and low temperature performance of enzymes for laundry. It also demonstrates how protein engineering can enable detergent formulators to remove chemical stabilizers.

Introduction

Enzymes have been used for many years in detergents, and their penetration globally is still growing. They are key contributors to sustainable cleaning. Enzymes are biodegradable, efficient, and enable low temperature cleaning. They are biocatalysts that can be produced by industrial fermentation under mild processing conditions. However, enzymes are also proteins, and their activity can be negatively affected by other ingredients in the detergent, especially in liquid detergents. The key to solving some of these formulation problems is protein engineering, or in other words: accelerating enzyme evolution in the lab to meet consumer needs.

Enzyme Stabilization in Liquid Detergents

A key enzyme functionality in detergents is protease. Protease hydrolyses protein and protein is part of many different stains that consumers can find on their clothes. Protease contributes to cleaning by breaking down protein in foodstuffs like meat, in bodily fluids like blood, and in outdoor stains such as grass. However, protease is also a protein. Hence, there is a risk that protease breaks down itself or other enzymes when stored in a liquid detergent for several weeks.

The conventional way of addressing this problem is to add enzyme stabilizers to the detergent. The function of these stabilizers is to slow down the reactivity of the enzyme in the liquid detergent by inhibiting the catalytic triad or active center [1]. Another approach is to reduce the water activity of the formulation.

The mechanism of enzyme activity loss can be broken down in two different steps. Unfolding of an enzyme is caused by surfactants. An enzyme can have hydrophilic and hydrophobic segments and typically has a surface charge depending on

the pH of its environment. The interaction with surfactants can result into loss of the three-dimensional structure of the enzyme, also known as unfolding. This makes the enzyme susceptible to proteolysis, or hydrolysis by protease. Unfolding and consecutive proteolysis results into activity loss of enzymes during storage.

Materials and Methods

Enzyme activity in a detergent is measured by means of a biochemical assay. This assay is used to measure the impact of different detergent compositions on the stability of enzymes. The enzyme is dosed at a known quantity into the detergent which is subsequently stored in an incubator. Typically, the detergent is stored for 8 to 12 weeks at an elevated temperature to accelerate the reaction. Aliquots are taken at fixed time intervals, and these aliquots are mixed with an artificial substrate under controlled conditions. Hydrolysis of the enzyme substrate results into a color reaction, and the color intensity is directly proportional to the residual enzyme present in the sample.

In this study, the protease and mannanase activity were measured by means of a colorimetric assay. For protease, the rate of degradation of N-succinyl-ala-ala-pro-phe-p-nitroanilide, a substrate commercially available from Sigma Aldrich, was monitored. The release of the substrate's p-nitroanilide is measured at 405 nm. The assay for mannanase activity is based on the hydrolysis of a locust bean gum substrate (Sigma Aldrich). The amount of reducing sugars generated during the reaction was measured at 560 nm using Pierce™ BCA Protein Assay reagent from Thermo Scientific. Colorimetric analysis was done on a Gallery auto-analyzer from Thermo Scientific and SpectraMax® ABS Plus from Molecular Devices.

The cleaning performance of the heavy-duty liquid (HDL) detergent was measured by using an enzyme responsive stain set that is commercially available from Center for Test-materials (CFT BV, The Netherlands). Experiments were carried out in Miele W1935 WPS Ecoline (Cotton, Short cycle) at 30°C and water hardness of 14°GH using a 3.0 kg cotton wash load and 4 strips SBL2004 soil ballast. The detergent dosage was 35 ml/wash. Stain removal measurements were carried out using a Mach5+ multi area spectral imaging device (CFT BV/Colour Consult), averaged using 2 internal and 4 external replicates, and expressed in a Stain Removal Index (SRI) % based on Delta E color differences.

Figure 1 shows the decay curve for a protease in different detergents during storage at 37°C. On the horizontal axis the incubation time is given; the vertical axis shows the residual protease activity as measured by a biochemical assay. Four different decay curves are shown which represent detergent compositions with varying levels of enzyme stabilizers. The figure demonstrates that by increasing the boric acid and propylene glycol level in the formulation, the protease stability can be improved significantly.

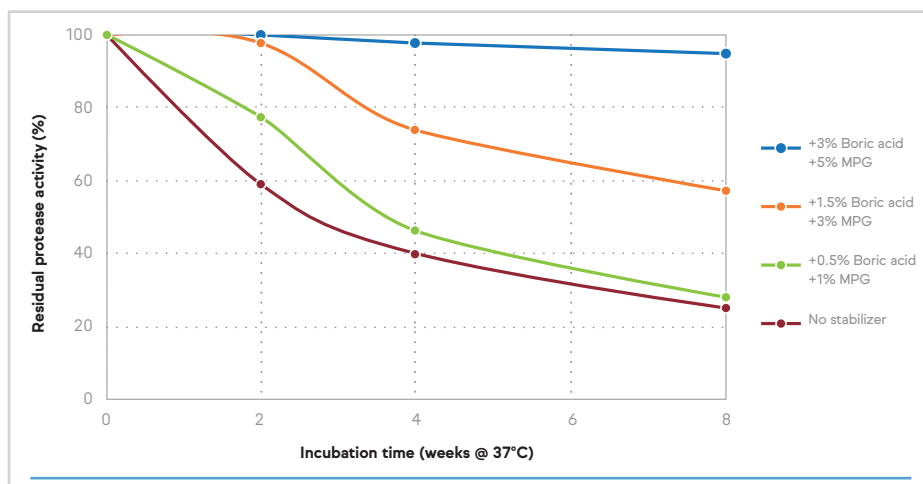


Fig.1 Decay curves of protease in a detergent with varying level of stabilizers.

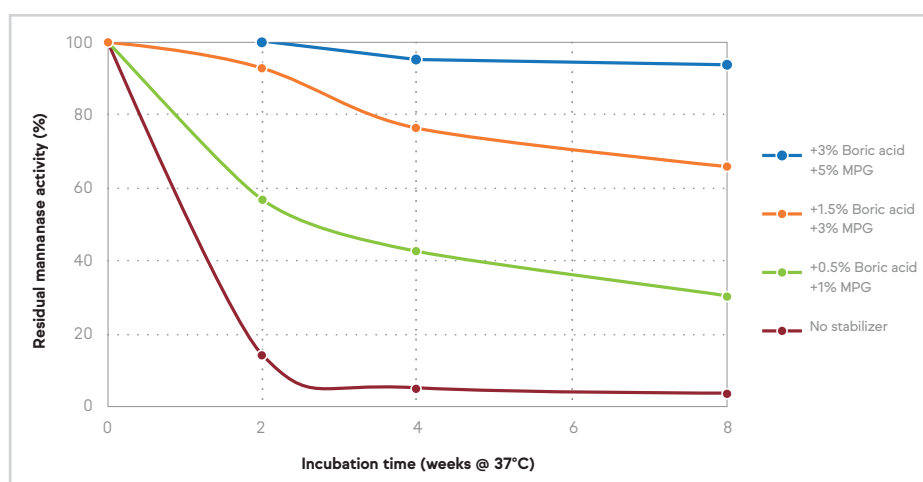


Fig.2 Decay curves of mannanase in a protease comprising detergent with varying level of stabilizers.

Stabilizers are also effective against proteolysis, or the breakdown of other enzymes by protease. This is demonstrated in **Figure 2**, where the decay curve for mannanase is presented in a detergent with varying level of chemical stabilizers. Without stabilizers the mannanase loses its activity rapidly because of unfolding and proteolysis. The addition of boric acid and propylene glycol to the detergent has a dramatic effect on the stability of mannanase as well. It demonstrates that the protease active center is effectively inhibited by boric acid and propylene glycol.

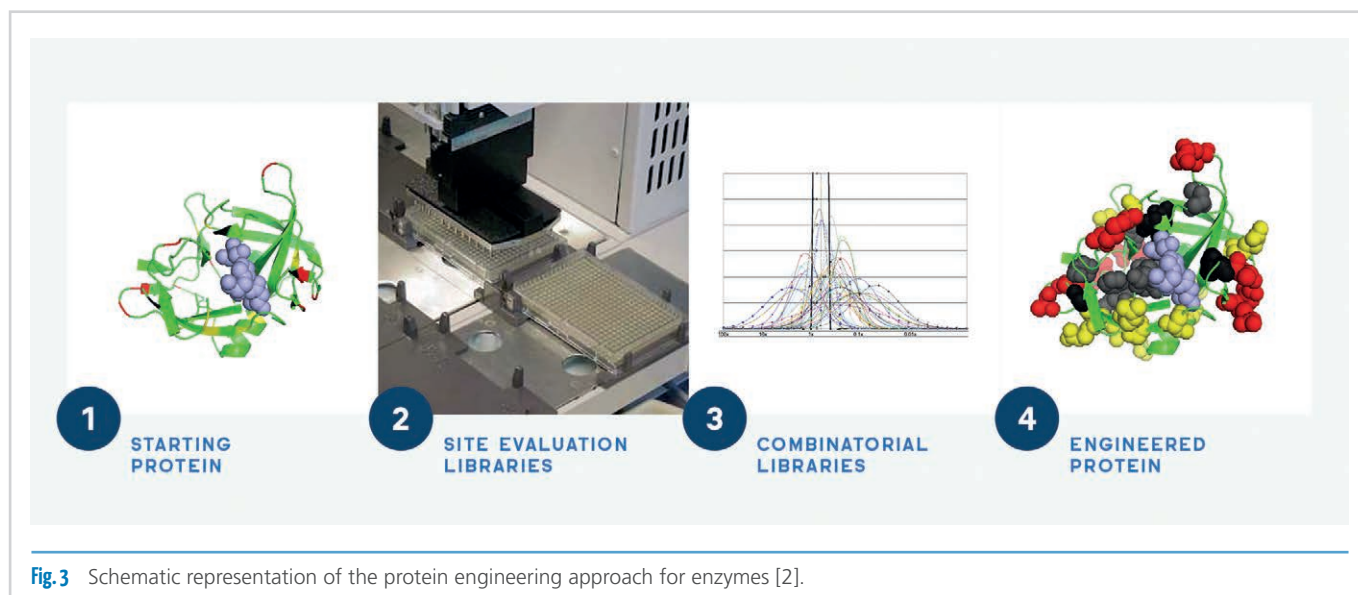
The Issue with Chemical Stabilizers

The addition of boric acid to a liquid detergent is effective in stabilizing enzymes, however, there are several reasons to reconsider this approach.

First, consumers are becoming increasingly conscious about their environmental footprint. Millions of consumers around

the globe do their laundry every day resulting in large quantities of water and chemicals used in the laundry process. Consumers are looking for products that address their concerns about sustainable cleaning. We see brands increasingly communicating their credentials to the consumer by making environmental, natural, and functional claims on the product pack.

Another important factor is legislation in Europe. According to the Classification, Labelling and Packaging Regulation, or CLP, boric acid and related boron compounds are classified as reprotoxic 1B. A recent CLP amendment will further restrict the use of boric acid by applying the generic concentration limit of 0.3% by weight in the formulation. This limits the efficacy of boric acid as a protease inhibitor, and the industry is looking for alternative ways to stabilize their enzymes in liquid detergents. There are options to improve enzyme stability by product concentration and reduction of water activity, for example in unit dose detergents, or to formulate with additional calcium or formate. However, calcium chloride and sodium formate are generally less effective as a stabilizer compared to boric acid.



Another complicating factor is the recent price increases for solvents such as propylene glycol and glycerol. These solvents are effective in reducing the water activity of the formulation. Rising energy prices and supply chain disruptions have forced detergent formulators to reduce the use of these solvents, which puts the stability of enzymes at risk. In summary, there is a need for another approach to enzyme stabilization in liquid detergents.

The Protein Engineering Approach

Protein engineering enables the improvement of specific enzyme properties by changing the amino acid sequence. Specific amino acid mutations can result in better cleaning performance on specific stains and/or lower temperature, and improved enzyme stability in a detergent.

A schematic representation of the protein engineering approach is shown in **Figure 3**. The first step in the process is to build site evaluation libraries in which each residue of the starting protein is mutated with all nineteen possible amino acid substitutions at that site. These libraries of single mutation variants are then tested for commercially relevant properties such as detergent stability and stain cleaning performance. Mutations found to improve at least one property and not impair any other property are then selected for use in creating libraries of modified enzymes having two or more mutations in combination. Product candidates are identified through successive rounds of combinatorial library construction, testing, and data analysis.

An example of the recent advances in protein engineering for liquid protease is shown in **Figure 4**. The protease is dosed into a liquid detergent that contains no enzyme stabilizer like boric acid. PREFERENZ® P 100 has not been engineered for stability and loses its activity rapidly without stabilizers. Protein engineering has improved the stability of PREFERENZ® P 300 significantly, although a low level of stabilizers is still required in this detergent [3]. Our next generation protease for liquid detergents, PREFERENZ® P 400, delivers a further step change improvement in stability. After 8 weeks of incubation at 37°C even 70% of protease activity remains in this detergent without using chemical stabilizers.

Protein engineering allows us to improve the stability of secondary enzymes as well. **Figure 5** shows the level of improvement that can be achieved by improving the inherent stability of a mannanase when combined with protease in a detergent without stabilizers. PREFERENZ® M 200 mannanase has been engineered for stability in liquid detergents containing protease. By combining PREFERENZ® P 400 protease and PREFERENZ® M 200 mannanase a nearly perfect stability of the

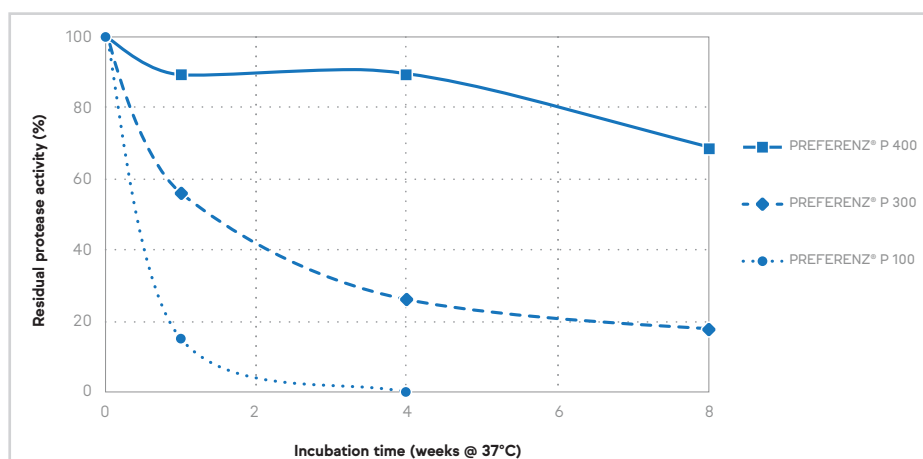


Fig. 4 The effect of protein engineering on protease stability in liquid laundry detergent.

mannanase in this detergent can be achieved during an accelerated storage test. It illustrates the potential of using the protein engineering approach for liquid protease as well as secondary enzymes like mannanase.

Enabling Low Temperature Cleaning

One of the key attributes of a detergent is its stain removal performance. In addition to improving enzyme stability, protein engineering allows for the development of enzymes that are more effective at ambient wash temperatures. Consumers are incentivized by the rising cost of energy to select a low temperature wash cycle on their washing machine, but not at the expense of a poorer cleaning result. **Figure 6** shows the level of stain removal improvement achieved for the next generation protease PREFERENZ® P 400 during a cold wash (20°C) in a European front-loading automatic washing machine. The boost in cleaning performance is clearly seen over the broad range of protease substrates found in everyday consumer stains such as blood, chocolate, egg, milk, and grass. This latest protein engineering development enables improved cleaning performance at low temperature and thus supports sustainable cleaning.

Conclusions and outlook

The latest advances in protein engineering demonstrate how we can address the consumers' need for sustainable laundry detergents. Protein engineering enables the removal of chemical stabilizers from the detergent formulation. By developing inherently stable enzymes there is no need to formulate using a pre-stabilized protease. Also, the next generation of IFF enzymes provides a robust cleaning performance, fresh and after storage, even at low wash temperatures.

At IFF we are passionate about the potential of protein engineering and industrial biotechnology, and we continue to develop new biomaterials that deliver performance, naturally better.

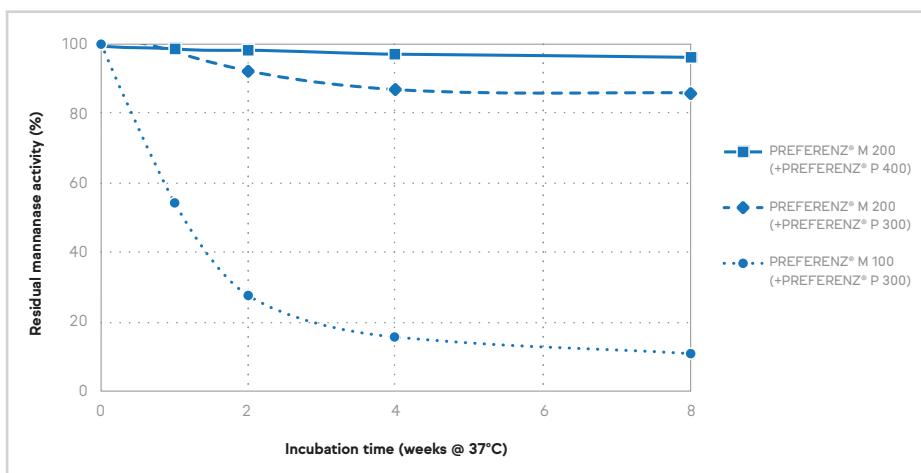


Fig. 5 Stability profile for different combinations of protease and mannanase in a liquid detergent.

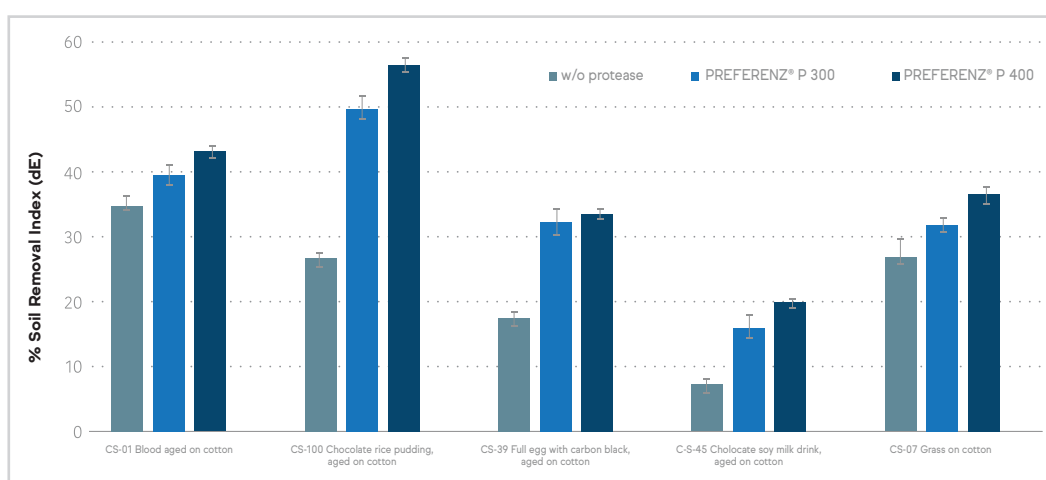


Fig. 6 Cold wash (20°C) cleaning performance of protease under typical European washing conditions.

Acknowledgments:

Dr. Sina Pricelius (IFF Health & Biosciences) is greatly acknowledged for a critical review of the article and correction of the German translation.

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authors

A.J. Hoekstra, E. Carey*, T.P. Graycar

IFF Health & Biosciences

Willem Einthovenstraat 4 | 2342 BH Oegstgeest | The Netherlands

*Corresponding Author: Enda.Carey@IFF.com

Unlocking the Potential of Circular Mass Balance for Home and Personal Care Ingredients

M. Chabert, M. Arzel

abstract

As consumer trends swiftly unfold, formulators and companies face a growing set of challenges as the market rapidly advances towards natural and circular raw materials to meet demanding sustainability objectives.

For detergent manufacturers, this means changing the sourcing of raw materials from fossil-based to natural or circular-based. However, one to one replacements can be technically challenging, and would not always be positive from an overall environmental standpoint. In addition, natural feedstocks are available in limited quantities and are currently unable to meet the demand of the whole industry.

A new way forward is thus needed to tap into the potential of the circular economy. Consequently, a Circular Mass Balance Approach, that uses circular raw material in existing chemical manufacturing streams, is key to accelerating towards global sustainability targets. It allows one to one replacement of incumbent fossil-based solutions, leading to a rapid implementation of more sustainable solutions for the mass market. Executed correctly in accordance with Life Cycle Analysis principles, it ensures that this replacement not only has a positive effect on the CO₂ footprint, but also does not negatively impact ecosystems.

In this article, we examine how using a mass balance approach to manufacture existing products with circular raw materials can be a quick first step towards fully fossil-free detergent ingredients. As an example, we show how Solvay has been using this approach to manufacture "Upcycled with Performance" circular mass balance ingredients with a positive sustainability impact beyond CO₂ footprint.

A new paradigm for key industry players

In the light of more discerning consumers who are increasingly selecting products that better align with their environmental concerns, significant sustainability commitments have been developed and announced by key industry players. Generally, these commitments can be divided into two broad areas; focusing firstly on climate change by targeting carbon neutrality (generally by 2040), and secondly on ecosystems by aiming to minimize overall impact on the environment.

Switching to natural / circular raw materials

As manufacturers of surfactants, the core of our CO₂ emissions, and therefore the major part of the carbon footprint of our products, lies in the sourcing of our raw materials. Therefore, in order to minimise our carbon footprint and support the industry in reaching its CO₂ neutrality targets, we need to improve the sourcing of our raw materials toward more natural and circular feedstocks.

Minimizing environmental impact

However, this on its own is not enough. It needs to be done without disrupting the other key pillar of sustainable development related to impact on ecosystems. If, by seeking to reduce our CO₂ footprint, we change the sourcing of our raw materials but do not consider the bigger picture, that includes

the impact of this change on the planet as a whole, we have not achieved our sustainability goal. For instance, replacing a fossil resource by a natural one only makes sense if it does not significantly compete with food, does not create water pollution, etc... So, any approach to changing the sourcing of raw materials from fossil-based to natural or circular, requires **a holistic approach with a two-fold objective** to ensure the achieved carbon footprint reduction does not come at the expense of a negative impact on the global ecosystems.

Availability of natural / circular raw materials

The volume of surfactant used in homecare detergents is around 15 million tons per year, with 50% coming from oleochemicals such as betaines, and 50% from petrochemicals such as linear alkyl benzene sulfonates (**Figure 1**). It is not possible to simply replace a given petrochemical ingredient by an oleochemical alternative without significant reformulation work; in addition such a switch would come with an added environmental burden related to the culture of oleochemicals producing plant (e.g. palm trees).

The need to unlock circular economy potential – Now!

In this context, a readily available technology to replace fossil feedstock using existing manufacturing assets is through replacing fossil-based naphtha, an essential chemical feedstock,

by circular naphtha. In order to bring environmental benefits beyond CO₂ footprint, this circular naphtha should ideally be derived from waste streams, e.g. from residues of the agricultural or food industry (e.g. used cooking oil, wood waste, etc...). While this is desirable from a sustainability perspective, circular naphtha is today not available at a scale allowing a full switch of the downstream petrochemical industry to this raw material. In addition, segregation of two types of feedstocks in large petrochemical assets would come at significant upfront investment cost and generate operational complexity in existing plants. Therefore, in order to start fully developing the circular economy potential of the home care industry now, a circular mass balance approach is needed.

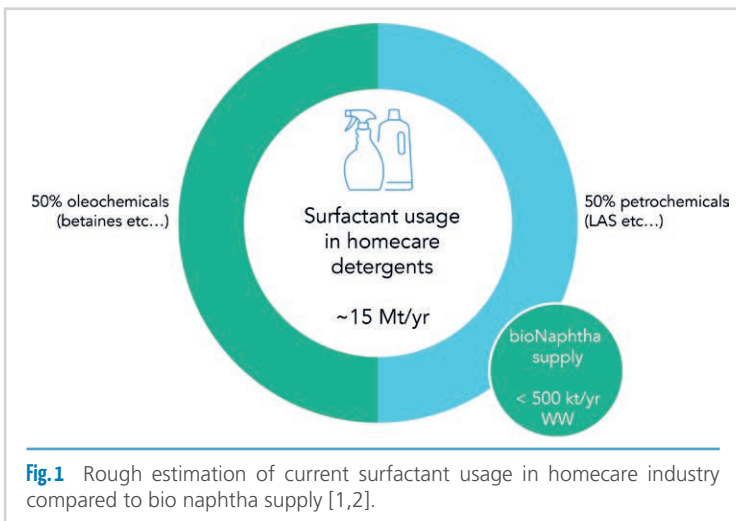


Fig.1 Rough estimation of current surfactant usage in homecare industry compared to bio naphtha supply [1,2].

Mass balance for an immediate and smooth transition

The circular mass balance approach has been designed as a custody method to trace the flow of materials through a complex value chain and represents an important milestone on

the pathway to a circular economy (Figure 2). Typically, mass balance offers the possibility of creating a mixed (i.e. non segregated) flow of circular feedstocks together with fossil feedstocks, that does not require new processing equipment,

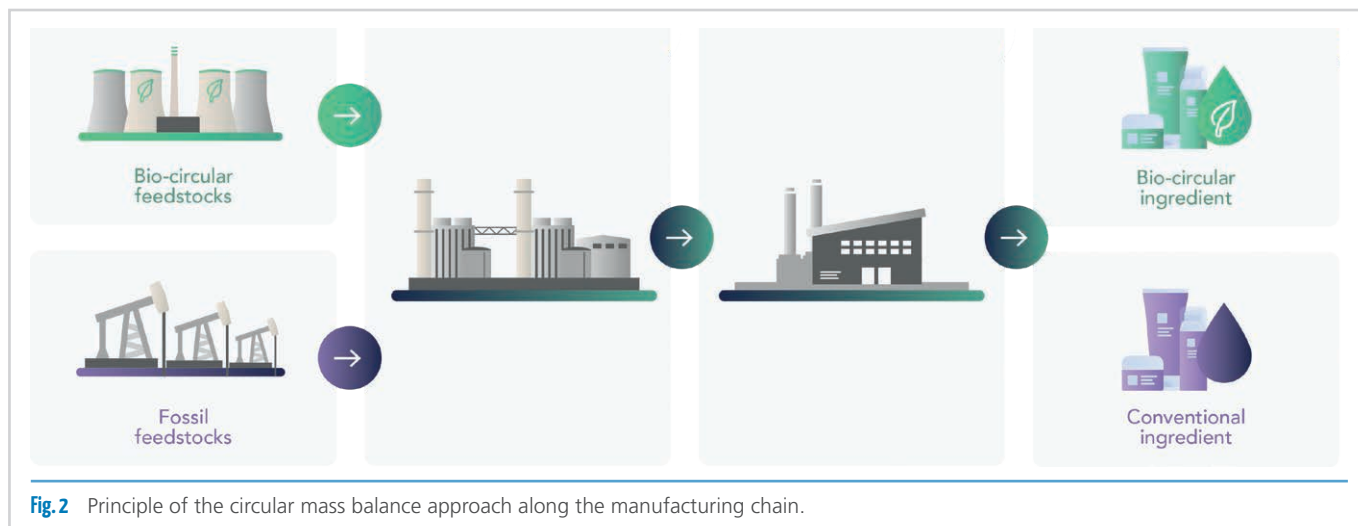


Fig.2 Principle of the circular mass balance approach along the manufacturing chain.



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and can be separated using a workable set of rules to ensure the traceability of renewable feedstock into new products.

The circular Mass Balance approach starts at the very beginning of the petrochemical manufacturing chain, at the refinery, where part of the fossil raw material is replaced by circular waste or biomass in adapted existing assets. Using certified auditing systems (such as ISCC+), it is possible to track the amount of circular or bio content in the chemical mix throughout the whole manufacturing chain, following all the intermediate stages, until the final surfactant is produced. The circular content and its benefits in terms of CO₂ footprint can then be attributed to part of the finished product. As a result, users of certified materials can claim a **reduced carbon footprint for their formulations**, and brand owners can document the **enhanced sustainability toward consumers**. And while the final product physically contains a mix of circular and fossil raw materials, the sustainability impact of purchasing circular mass balance based products is real, as it allows the introduction of more circular products to replace fossil feedstock in the manufacturing chain.

The utilization of circular raw materials in a Mass Balance approach "from refinery to detergent" is thus a capital efficient, flexible first step in reducing the share of fossil-based raw materials (and thus CO₂ footprint) in the homecare industry. It uses existing assets and petrochemical building blocks, and delivers a final product with unchanged specifications, allowing easy one to one replacement of fossil based ingredients in homecare formula.

One of the key points of Solvay's approach to circular mass balance detergent ingredients is that we perform precise life cycle analyses, from cradle to gate (**Figure 3**), for each of the ingredients we are considering to switch from fossil to natural or recycled raw material. We go beyond greenhouse gas (GHG) emission reduction to look at how the proposed change is going to impact land use, acidification, eutrophication, water consumption etc. This is important as the positives of switching related to GHG/CO₂ footprint can sometimes come with a negative impact regarding e.g. land use, meaning it may not always be advantageous to switch from a fossil to a natural raw material.

As described in **Figure 4**, we thus take a very detailed look at the bio-based raw materials proposed and their manufacturing flow to ensure their use will be positive under all

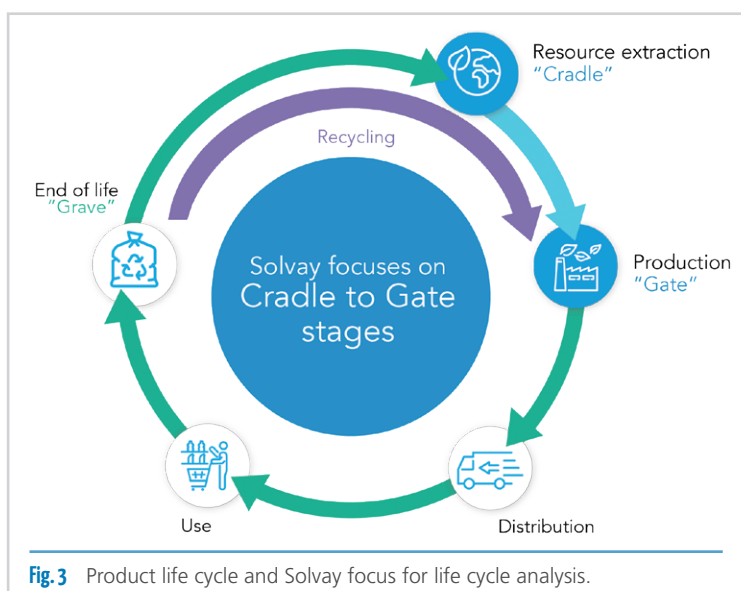


Fig.3 Product life cycle and Solvay focus for life cycle analysis.

sustainability aspects. In this process, the certification of our raw materials helps us to ensure that the origin, share and environmental footprint of circular feedstock is accurate even in a complex manufacturing chain, and in turn to guarantee a positive impact on the environment.

Examples of Solvay's circular mass balance approach application

The aim of Solvay's Circular Mass Balance approach is to maintain end product specifications and performances but change the sourcing of raw materials to improve the overall sustainability profile of our ingredients. Therefore, by upcycling waste products and performing a detailed Life Cycle Analysis, we ensure the development of circular raw materials with a reduced CO₂ footprint but also without negative impact on the ecosystem.

1. Circular DMAPA

DMAPA is a key intermediate in the production of amphoteric surfactants such as betaines and sultaines, that are widely

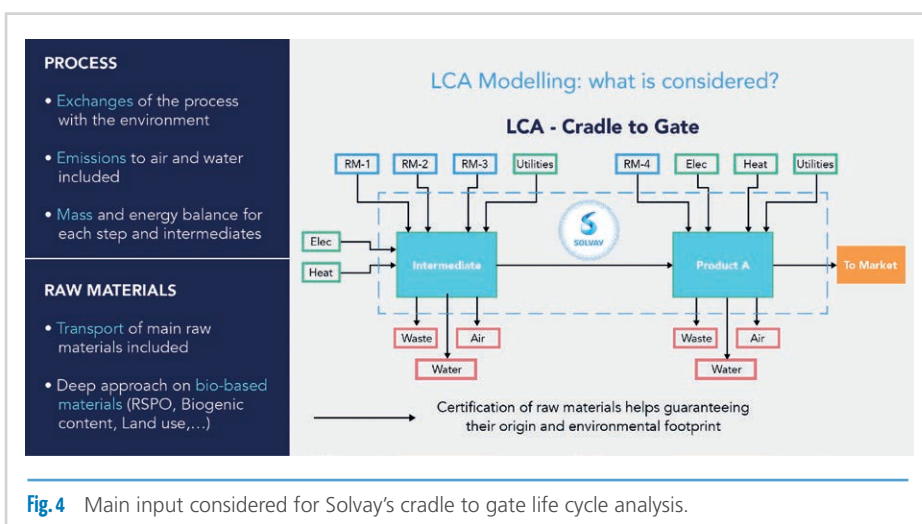


Fig.4 Main input considered for Solvay's cradle to gate life cycle analysis.

used both in homecare (e.g. in hand dishwash liquid) and personal care (e.g. in bodywash) applications. In order to reduce the environmental footprint of such surfactants, and consequently of our customers' formulas, we worked on changing the sourcing of our DMAPA raw materials. Our objective was not just to find a natural raw material but to apply a circular mass balance approach to identify an upcycled raw material from certified waste to manufacture our DMAPA.

As the graph shows, our circular sourcing of DMAPA raw materials compared to original DMAPA reduces the net CO₂ footprint of this key manufacturing block by 50% compared to standard fossil DMAPA, without creating a negative impact on other parameters such as land use (Figure 5). This is achieved by using wood waste-based feedstocks, resulting in our circular DMAPA being fully derived from upcycled carbon. Furthermore, as expected from our circular mass balance approach, the specifications of our mass balanced DMAPA are exactly the same as standard DMAPA and allow it to be used straight away for the manufacture of amphoteric surfactants.

2. 100% natural sultaine

To design a fully circular Cocamidopropyl hydroxysultaine such as our Mirataine® CBS UP we use circular DMAPA combined with green epichlorohydrin and RSPO fatty acids. This product comes with a 50% net CO₂ footprint reduction versus standard cocamidopropyl hydroxysultaine as pictured in Figure 6. It also uses less "virgin" carbon resources and comes as a 100% natural product according to the mass balance principle.

Balancing supply and cost of fully fossil-free detergent ingredients

Today, the market is rapidly moving towards natural/circular raw materials to meet ambitious sustainability targets both from the carbon footprint and overall ecosystem impact standpoint. Mass balancing of circular raw materials in classical chemical manufacturing streams is key to moving rapidly towards these targets. Together with a thorough Life Cycle Analysis going beyond the CO₂ footprint angle, this approach can rapidly yield existing ingredients with a much better environmental footprint. In Solvay, we are using this circular mass balance approach to improve the sustainability profile of our existing portfolio toward fossil-free ingredients with products such as Fentamine® DMAPA UP and its amphoteric derivative Mirataine® CBS UP.

Moving forward, we expect the circular mass balance approach to take more and more space in the manufacture of existing fossil-based detergent ingredients. The large-scale success of this approach will largely depend on the capacity of the chemical industry to access significant volumes of refined circular feedstocks in a market where several applications (e.g. biofuels) are competing for the same raw materials.

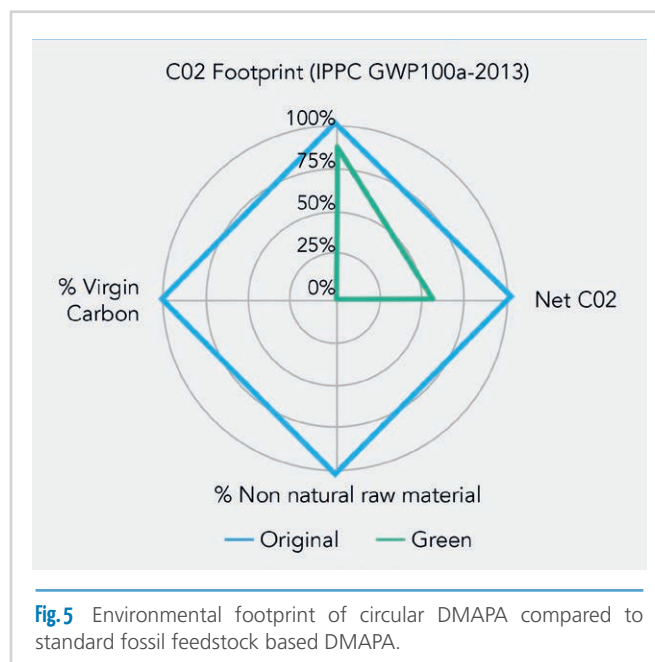


Fig.5 Environmental footprint of circular DMAPA compared to standard fossil feedstock based DMAPA.

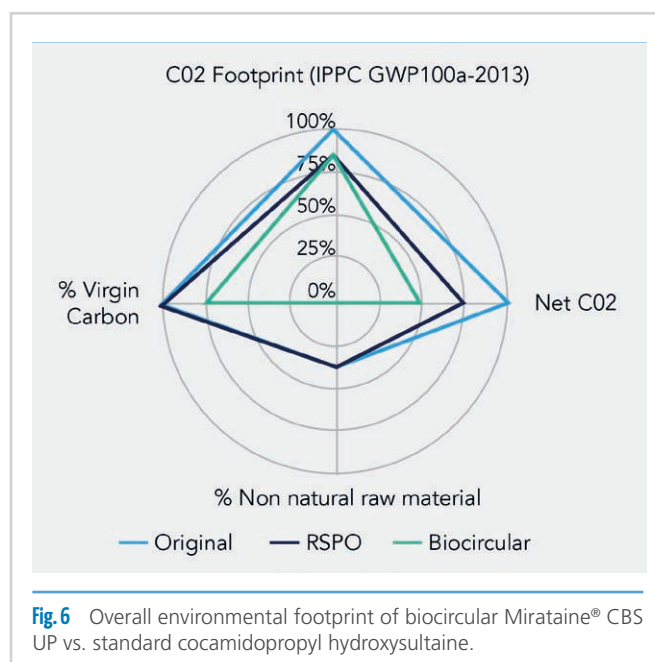


Fig.6 Overall environmental footprint of biocircular Mirataine® CBS UP vs. standard cocamidopropyl hydroxysultaine.

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authors

Max Chabert,
Marie Arzel

Global Marketing Home & Personal Care | Solvay Novicare

Sustainable Packaging for Cosmetics and Detergents

Group-Interview with rezemo, cosnova and Eurofins

Which packaging materials do you mainly use and how do they affect your product quality?

Stefan Zender, Managing Director & Co-Founder, rezemo:

With our forewood by rezemo GmbH approach we use only fully plant-based materials. The main component of our forewood materials are wood fibers from sustainable PEFC certified forestry in Southern Germany. In combination with fully plant-based biopolymers and our forewood knowhow in processing these materials we achieve great characteristics in regards of functionality, sustainability and product quality.

Daniela Soukup, Expert Corporate Responsibility, cosnova GmbH:

We mainly use plastics and glass for our packaging, depending on the product group and type of packaging, as they have the best properties for our assortment.

What measures are you already implementing in your company to make your packaging more sustainable?

Stefan Zender: We follow a 100% approach: only fully plant-based materials are processed for our packaging products. Together with our customers we optimize their packaging in regards to material use and functionality for a perfect match between product function and sustainability.

Daniela Soukup: We reduce material where we can, as this measure has the greatest effect in terms of resource savings. Furthermore, we try to make our packaging recyclable, which is not always so easy in our industry due to the application aids required. To assist our product development, we have screened our entire product assortment with an external expert and derived do's and don'ts for recyclability. In addition, we are increasingly using recycled materials. In order to implement all these measures, it is important to share the relevant knowledge. For this purpose, we have created internal documents and there is a weekly open consultation hour on the topic of sustainable packaging.

What scientific challenges are preventing you from making your packaging even more sustainable?

Stefan Zender: With our first products in the focus fields of cosmetics, food and agriculture packaging products we



have already shown how great plant-based materials can replace fossil plastics and aluminum. Further new and innovative packaging products made by forewood will be launched soon. Our R&D work focusses on opening our forewood approach to even more applications in these fields – doing so, we have to solve various challenges in terms of the chemical and physical requirements such applications include.

Daniela Soukup: They are more technical than scientific challenges: Our packaging often requires application aids, for example mascaras with the mascara brushes and the wiper, or lip glosses with applicators. Products that would not be applicable at all without these application aids. Where packaging and product form a perfectly coordinated symbiosis and you don't even know where the product begins and the packaging ends. According to the current state of the art, this entails a mix of materials that cannot be recycled.

Another challenge is that materials such as ABS or SAN are particularly well suited for some of our packaging. Materials for which there are unfortunately no established sorting streams via household collection and which are therefore not considered recyclable.

In your view, what is the safety risk of recycled packaging versus other packaging

Stefan Zender: Recycled packaging for primary packaging applications is a very tough field. Many applications in the food, cosmetics and pharma sector are high sensitive with respect to migration. Recycled packaging in many cases cannot guarantee those migration limits, as the quality of the recycled material especially from PCR collection is too heterogeneous. This is a clear advantage of bio-based material approaches like forewood materials.

Furthermore, we see the risk that there is not really a functioning recycling infrastructure to ever solve the global pack-



Picture Credits: @veconline, Andha Stock

aging problem in terms of available quantities. In our opinion, we all must focus on fully-plant based materials and building up recycling infrastructures for them generating the biggest benefits for our environment.

Daniela Soukup: We must be aware that the raw material for recycled packaging is not pure plastic but waste. Accordingly, the risk of contamination is higher, which must be minimized through legal requirements and stringent testing.

Andreas Grabitz, Global Packaging Compliance Manager, Eurofins:

We must distinguish between recycled PET and other materials. For recycled PET there is only very little risk in terms of contaminating the good which will be packed in. Currently the main risk is the availability of PCR PET in the market. Due to limited feedstock and high demand in the market prices for PCR PET are sometimes higher than virgin PET. That raises another risk. Manufacturers may offer virgin PET materials as PCR cause prices are higher for PCR materials. This is a sort of “packaging fraud”.

Recycled Polyolefines like PE or PP have a significantly higher risk to contain substances from earlier life cycles. There are currently no mechanical recycling technologies in the market which can remove these contaminations to a safe level in food contact applications. In other areas like cosmetics recycled HDPE is already broadly used but standardized risk assessment protocols are not yet established.

What do you think about the use of post-consumer recyclates?

Stefan Zender: Post-consumer recyclates are a first step, but they won't be able to solve our global packaging problem. PCR material is only applicable for a few product categories with low requirements and as long as their feedstock is petro-based, PCR fails to be a real sustainable option.

Daniela Soukup: We consider the use of PCR materials to be extremely useful and are already using it. For packaging components that do not come into contact with the texture, we use rPP from household collection (“Gelber Sack”), e.g. in the caps of essence extreme shine lip glosses or essence concealers. For packaging components that have contact with the texture, we use rPET, for example in the Catrice Glam & Doll Mascara range. This helps to save virgin plastics, energy and CO₂ emissions.

Andreas Grabitz: Increased recycling of plastic material is an obligatory way for a sustainable and circular economy. Hence recycling technologies must be improved as well as new applications for the use recycled plastics must be evolved. But overall plastic is a too valuable material to incinerate it.

How do you see the practical potential of natural materials such as paper, grass, cork, wood (...) and biodegradable barrier coatings made from algae, chitosan, casein (...)?

Stefan Zender: We at forewood see in natural materials the only way to solve our global packaging problem. Those materials meet two important aspects of sustainability. First, the sourcing (feedstock) is renewable and second, they do not contain a heavy disposal risk, such as traditional plastics do. That's why we focus from the beginning on creating high-value and sustainable packaging products being fully plant-based. With products like our rezemo wooden coffee capsules we prove that products made of natural materials have great characteristics, e.g. high barrier, good processability, etc. – the future of packaging is green.

Daniela Soukup: For some applications this may make sense. For our purposes in colour cosmetics, we do not consider it to be purposeful. We think the focus should be on keeping materials in the cycle. Biobased plastics that are similar to their petrochemical twin and recyclable are more future-proof, in our opinion, than natural materials that are provided with non-recyclable barriers.

Andreas Grabitz: Natural materials can be a part of a future tool box for packaging designer. Nevertheless they majority of packaging materials will stay “traditional” as such materials show outstanding properties which are hard to substitute. The issue of bamboo and wood flour as filler in packaging melamine plastic illustrated such problems. Furthermore natural ingredients like grass or wood can also contain substances from cultivation, harvesting or further processing like preservatives, plant protection products etc. which needs to be controlled.

Bio-based Surfactants

– a group interview with **Clariant, Dow, Sasol and Weylchem**

Can you explain the difference between bio surfactants and bio-based surfactants?

Christine Oberbillig, Marketing Manager Industrial & Home Care, Sustainability, **Clariant**:

There is no legal / regulated description or differentiation between bio-based and bio-surfactants, but a widespread classification is the following:

Bio-based surfactants are produced via a classical chemical process reaction and are either partially or fully made from bio-based origins in a segregated production process or a mass-balanced production processes where there is a physical mixing of fossil and plant-based (or even renewable which includes recycled materials) materials. Clariant's definition of bio-based is solely plant-based and excludes, for example, recycled material from plastic. Some other companies use the term renewable which also includes CO₂ or recycled material as origins.

Bio-surfactants are produced via microbial processes, e.g. fermentation, and build an own chemical category. They differ significantly from bio-based surfactants in their structure, especially for the hydrophilic head of the molecule, which is usually composed natural building blocks like proteins or polysaccharides based on microbial origin.

Several producers of bio-surfactants use the term bio-based surfactants as well so the terms are not always clear and easy to differentiate.

Saugata Nad, Global R&D Transformational Leader & Principal Research Scientist-Home Personal Care EMEA, **Dow Europe**:

All bio-based surfactants share certain commonalities in terms of their starting materials. According to US Code of Federal Regulations, bio-based surfactants are derived "in whole or a significant part from biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials." However, bio-based surfactants do not need to include 100% biobased and renewable raw materials to be categorized as bio-based.

The term biosurfactant refers specifically to those surfactants containing bio-based feedstocks and that are also produced by sustainable and non-chemical means like fermentation. Biosurfactants are biologically produced, meaning they are produced directly from microorganisms comprising of lipid, protein, and/or carbohydrate moieties that are frequently associated with cell walls or membranes. Biosurfactants include molecules with varying complex chemical structures, which

play different roles in the life cycle of each of these microorganisms. The production process uses fully renewable raw materials with no traditional chemical reactions.

Louis Snyders, Head of Home Care and I&I at Essential Care Chemicals, **Sasol Chemicals**:

Bio-based surfactants are drop-in chemicals with identical molecular structure to the currently available petrochemical surfactants. However, they are derived from biobased feedstocks instead of fossil feedstocks and typical sold as a mass-balanced final product. On the contrary, bio surfactants present unique molecular structures as being produced from biobased feedstocks/natural raw materials via fermentation using micro-organisms (yeasts, bacteria). Hence, bio surfactants are characterized by a fully natural production process while their unique molecular structures can give rise to additional and/or enhanced performance attributes.

Dr. Konstanze Mayer, Head of Business Development Consumer Care, **Weylchem**:

Bio surfactants are surface active molecules/compounds that are produced from natural feedstocks like vegetable oils, sugar, biomass, etc. by living organism/microorganisms through fermentation.

Bio-based surfactants are surface active molecules/compounds that are made from natural resources. They can be produced by biotechnology such as enzymatic or microbial synthesis or by chemical synthesis.

So the difference is that bio surfactants origin directly from nature while bio-based surfactants are made using natural feedstock.

What are the challenges for bio-based surfactants in the market?

Christine Oberbillig: There are several challenges for bio-based surfactants in the market:

The first one is price. They are still niche and generally used in eco or premium brands as they are not affordable for many traditional brands, especially in emerging markets.

Many surfactant chassis have been optimized over many years and an integration of bio-based surfactants in such chassis often requires full reformulation, both in IHC and PC, which often is expensive, time-consuming and resource intensive.

The capacity and global availability of established, traditional primary and secondary surfactants is high and very flexible



Picture Credits: © Arlene Domenech, Adobe Stock

and for large brands supply security is key. This makes it difficult for products with limited sources and lower capacity to crack the market.

Saugata Nad: One of the major factors hindering the growth and hampering the adoption of the bio-surfactant market is its high cost. Due to the shortage of homogenous and consistent feedstock, the production process at times is inefficient and the enzyme used is highly expensive. On top of it the performance profile of the bio-based surfactant may require reformulation and is not a simple “drop-in”, stability of bio-surfactants may be a challenge at extreme pH.

Louis Snyders: Key challenges for **bio surfactants** are three-fold, (i) the relatively high production cost, (ii) sourcing the right biobased feedstocks (*see comment below for bio-based surfactants) and (iii) the time & efforts needed to reformulate or develop new formulations exploiting the unique features of bio surfactants maximally. Holiferm and Sasol aim in a partnership at mass commercialization of biosurfactants enabled by Holiferm’s unique fermentation technology and Sasol’s reputation and capabilities as one of the main global suppliers of surfactants.

* *The key challenge for **bio-based surfactants** is production cost and finding the right bio-based feedstock with favorable Product Carbon Footprint characteristics and avoiding/minimizing (indirect) Land Use Changes which ultimately can result in deforestation and serious loss of biodiversity and sensitive eco-systems.*

Dr. Konstanze Mayer: Key challenges are performance and cost competitiveness. Currently there are no significant benefits in performance and costs of bio-based surfactants in comparison with traditional petro-based surfactants.

Which are the claims producers can make when formulating with bio-based surfactants?

Christine Oberbillig: Claims that can be made when formulating with bio-based surfactants include: mildness in most cases, Product Carbon Footprint savings, a high Renewable

Carbon Index, their plant-based nature and, depending on the technology, a segregated value chain.

Saugata Nad: Formulate your products with our bio-based surfactants and promote your commitment to sustainability and environmental responsibility. Our surfactants are readily biodegradable, CleanGredients® listed, meet US EPA Safer Choice criteria, and are suitable for ecolabelling. By choosing our bio-based surfactants, you can lower your carbon footprint while offering vegan and cruelty-free suitable products to your customers.

Louis Snyders: For **bio surfactants** 100% natural both from a materials and process technology perspective and providing potentially unique and additional performance attributes amongst which skin-friendliness (e.g. anti-acne, anti-aging). For **bio-based surfactants**, the main and arguably only claim relative to the petrochemical peers is the use of renewable biobased raw materials. When sourcing the right biobased feedstock, lower Product Carbon Footprints can be potentially also claimed, but not necessarily. For example, Palm (kernel) oil presents an example with actually **higher average** Product Carbon Footprints than the petrochemical peers due to GHG emissions associated with Deforestation/Land Use Change and continuous peat oxidation.

Dr. Konstanze Mayer: Low environmental impact, high biocompatibility and biodegradability, low toxicity, lower carbon foot-print, sometimes made of non-edible resources. Bio-based surfactants that show better biocompatibility and digestibility can also be applied in the food or pharmaceutical industries.

How do bio-based surfactants compare to surfactants from fossil source?

Christine Oberbillig: There is no single answer and it strongly depends on the technology. In principle it can be differentiated in two categories: 1:1 replacements (e.g. ethoxylates or amphoteric, mostly including MB solutions) and unique surfactant categories (e.g. APG). For example, for Clariant:

The Vita range of ethoxylates are one-to-one replacements with the same performance, the same properties and same regulatory profile, but with a better sustainability profile like PCF or increased RCI

GluoTain/GlucoPure is a separate, specific technology with a unique performance profile. Comparison strongly depends on benchmark, application and performance parameters, for example, in comparison to betaines, Glucamides perform similarly but have significantly reduced PCF and a higher RCI.

Saugata Nad: In terms of environmental benefits, bio-based surfactants are much better than surfactants from fossil source. It enables lowering of carbon foot print. Moreover, the bio-based surfactants have low to no 1,4-Dioxane levels, Vegan and Cruelty free suitable.

Louis Snyders: Bio surfactants will have by definition a different performance, which can be advantageous or disadvantageous whereas **bio-based surfactants** have in general very similar performance as petrochemical surfactants as long as molecular structures are largely similar. There are examples in the Bio-based surfactants category though (like Alkyl Poly Glucosides) which can also deliver different performance on basis of a (less) different molecular structure.

Dr. Konstanze Mayer: Bio-based surfactants usually show lower performance in application than traditional petro-based surfactants. Also bio-based surfactant have a higher price due to their high-cost production.

Do bio-based surfactants really reduce the carbon footprint significantly?

Christine Oberbillig: They definitely can, but it depends on the technology - on the origin and the complexity and the footprint of the production process, which can also be influenced by the scope 1 and 2 emissions of the production process. As an example, Glucamides, based on raw oils like GlucoPure Sense (based on sunflower oil), have a very low carbon footprint, because of the low PCF origin and very few production steps.

Saugata Nad: It depends upon the life cycle analysis (LCA), including feedstock but yes, it very often helps in lowering the carbon footprint.

Louis Snyders: Yes, both **bio-based surfactants** and **bio surfactants** can provide a reduction in carbon footprint provided that the right biobased feedstock is used and the process yields are decent. As explained above this is however

not necessarily the case and, hence, a holistic analysis of the entire value chain with in-depth Life Cycle Analyses is needed to claim convincingly a reduced Product Carbon Footprint.

Dr. Konstanze Mayer: This depends.

If huge reactors are needed to produce the bio-based surfactants (fermentation) the total energy consumption can be huge. Further there could be a lot of side-reactions which reduces the yield. So a detailed assessment will need to be done to really get a reduction of carbon footprint achieved.

Generally over a long term and for mass production, there should be a significant reduction of carbon footprint possible.

What are typical applications for bio-based surfactants?

Christine Oberbillig: Currently there is still low usage in traditional detergent formulations such as dish, laundry and HSC, and cosmetic cleaning products like shampoos and shower gels without natural/bio-based/sustainability claims, but significant growth and strong penetration of bio-based surfactants into classical cleaning products is expected in the coming years, mainly to meet PCF savings and the sustainability transformation targets of big brands. In the Personal Care industry, the emerging claims around 'sulfate-free' formulations also drive the use of bio-based surfactants. Success depends highly on their cost, capacity and global availability to compete with established fossil based solutions (LAS, AOS, CAPB, AO, fossil NIOs).

They are more widely already used in green / eco brands with in both home and personal care applications with a focus on cleaning products in IHC and PC, like shampoos, detergents and shower gels. There have been many launches, especially in hand dishwashing detergents and shampoos, which are products with more simple formulations suitable to play with and test the response of the market.

Saugata Nad: Typical applications for bio-based surfactants include liquid laundry detergents, hand dishwashing liquids and hard surface cleaners.

Louis Snyders: The main applications are in Fabric & Home Care, Personal Care & Cosmetics, but all other typical applications for surfactants like Industrial & Institutional Cleaning, Textile & Leather, Agro formulations, Paint & Coatings can be served with bio surfactants and bio-based surfactants.

Dr. Konstanze Mayer: This depends.

Personal Care and Home Care if they can afford it. Multifunctional properties can be an interesting point especially for Personal Care / Cosmetics.

Interview with Isabel Álvarez-Martos,

CEO & Co-Founder, Cellugy



Your ingredient EcoFLEXY is an alternative to petrochemicals used in the personal care industry. What makes EcoFLEXY so unique?

EcoFLEXY stands out over other sustainable alternatives in two ways – its production and the product itself.

The production process is fermentation versus extraction from natural sources such as plants. There is no need to cut down trees or harvest any other form of cellulose from plants that have a high energy demand and need harsh chemicals to get extracted. The process has been designed sustainably, without any harsh chemicals or fossil-derived ingredients, and in standard fermentation equipment, allowing for local production.

With EcoFLEXY personal care brands have the ability to differentiate their products with a high-performing, biobased and biodegradable multifunctional rheology modifier. EcoFLEXY perfectly integrates into the most challenging formulations, where many other rheology modifiers fail to perform, for example in the presence of salts or extreme pHs. At the same time, it provides a smooth and silky feel on the skin, making it superior to other rheology modifiers of natural origin which leave a sticky and unpleasant feel. It fulfills the dermatologists' recommendations for natural ingredients with better compatibility with skin and customers' expectations of organic, vegan, and biodegradable ingredients. Last but not least, it is functional at low dosage levels and for the first time in the market can be provided as a redispersible powder allowing for massive integration.

What are some typical applications for EcoFLEXY?

Its multifunctionality allows EcoFLEXY to be used in many different formulations. From serums, creams, hair applications, and sunscreen applications – it allows for a small dosage with high-quality results. Our current trial customers are testing the ingredient and have reported highly positive feedback on it. So far, the trial customers have been able to validate ingredient claims such as viscosity profile, shear-thinning behavior, particle stabilization properties, tolerance to salts and foaming agents, and different pHs. In parallel to this, they have undergone formulation development with the first results

showing the successful integration of EcoFLEXY into daily facial cream or cleanser formulas and the special remark to the good skin feeling, softness, and no peel-off effect.

What are your plans for the upscaling of production and commercialization of EcoFLEXY?

The company has come a long way since being founded in 2018. The main target of this year is to further scale up the process to produce the first kilos of EcoFLEXY, reaching manufacturing readiness level (MRL) 6 at the start of 2024. Cellugy is currently running pilots with several trial customers, including ingredient manufacturers, distributors, and brands who are testing EcoFLEXY in different personal care and cosmetic products. The goal is to reach commercial agreements with our trial partners starting this year.



Isabel Álvarez-Martos

How does Cellugy contribute to creating a more sustainable future in the personal care industry?

Cellugy harnesses biology to develop more sustainable, higher-performing ingredients for everyday products by using renewable resources rather than fossil fuels. We have developed a platform technology that mimics the way cellulose is produced and assembled in nature. We do so through energy-efficient and green

processes that bridge humanity's advancement with sustainability.

The technology we have developed can deliver the exact same product, as found in nature, but with better quality, competitive economics, and substantial savings in carbon footprint/greenhouse emissions. The power of this technology is its simplicity, in other words, there is just one reaction – the conversion of sugar into cellulose - but it happens within a microscopic factory, inside a microorganism. It is basically a fermentation process that uses probiotic wildtype organisms, so a similar process and facility requirements to those used to make beer, wine, or yogurt.

With EcoFLEXY our mission is to exchange all these harmful ingredients, so industrial stakeholders can also meet their sustainable goals. Our platform technology also allows us to create products with other properties based on biofabricated cellulose, so we aim to be a platform for companies and

brand owners to reach their sustainability goals while delivering superb performance. We are looking for co-development projects for specific product development where EcoFLEXY can be used. For example, we are currently looking into SPF Boosters and UV Filters in connection with a Eurostars project. This project enables us to further explore the capabilities of a ground-breaking hydrogel to be the very first low-cost, fully biobased, and biodegradable ingredient with UV-blocking properties. Last, we are looking for co-development projects to create film-forming applications.

What role do you see EcoFLEXY playing in the development of the personal care industry?

The future of the personal care industry goes towards biobased, biodegradable, and biofabricated ingredients. We believe that there is a growing demand from society to change more industries and aspects of one's life to be more

environmentally friendly – we can see this trend also growing in the personal care industry.

We are working on a pipeline of ingredients for the personal care industry, with the objective of eliminating those ingredients of fossil-based origin that have hazardous effects on humans and the environment. With EcoFLEXY, our ingredient, we would like to make a change in the personal care industry and eliminate microplastics that might be in cosmetic and personal care. Carbomers are one of the top ingredients found in cosmetics and help with thickening, gelling and as an emulsifier, it prevents an oil and water separation. However, according to ECHE, Carbomers are not only suspected to be irritative to our skin but also harm the environment. At Cellugy we saw the opportunity to provide something better for people, formulators, and the planet.

www.cellugy.com

Givaudan
Human by nature

Redefining the Gold Standard for Skin Hydration

Interview with **Mathias Fleury**, Head of Category – Actives at **Givaudan Active Beauty**

Hyaluronic acid is considered the hydration champion for skincare. Why did you decide to try to improve it?

Dehydrated skin represents one of the major skincare concerns for global consumers, with market demand for products with moisturising and hydration benefits continuing to increase. According to Mintel, more than 70% of product launches in the face care market in recent years claim moisturising benefits. Meanwhile, our research reveals that “hydrate and nourish” is the benefit most desired by women when looking for beauty products. Consumers of all ages and genders also want access to products that harness the potential of “hero ingredients”. Hyaluronic acid (HA), especially, is such a beauty blockbuster in the minds of consumers that 87% seek out products that include it.

But, while consumers recognise and have confidence in the ability of HA-based products to hydrate and moisturise the skin, they want these benefits to last longer. Likewise, existing HA formulations can only deliver hydration benefits when used in leave-in products. We wanted to find a way to supercharge and enhance the power of HA in leave-in beauty products and deliver its amazing properties in rinse-off formulas, too.

How did you approach this challenge, and what did you discover?

Our White Biotechnology Centre of Excellence in Pomacle, France has been involved in HA research and development since the early 1990s. Drawing on their long-standing experience and know-how, our Active Beauty experts investigated ways to improve the known benefits of third-generation HA by adapting its chemical structure.

The skin's surface holds a negative charge, so it attracts and retains positively charged molecules. We knew that if we could switch HA's negative charge to a positive one (through cationisation), we could improve its skin adhesion capabilities. To optimise efficacy, we began to play with the balance between HA's molecular weight and the degree of cationisation. One surprising discovery in our research was that a shorter polymer chain (or lower molecular weight) was able to deliver greater hydration benefits and more optimal skin coverage, as compared to higher molecular weight (HMW) forms of HA. HMW HA is less accessible for cationisation, whereas rather low molecular weight can reach a higher cationisation degree, offering the best structure and performance for skin adhesion. This discovery enabled us to craft a unique ingredi-

ent, PrimalHyal™ Hydra[+], with a low molecular weight and a high cationisation degree.

How does PrimalHyal™ Hydra[+] work, and what makes it so exciting?

Thanks to its new chemistry, PrimalHyal™ Hydra[+] strongly binds to the skin, delivering measurable biological benefits in terms of optimal skin coverage, barrier function improvement and intense moisturisation. At a dosage of only 0.1%, our analysis shows that the product provides instant hydration in a single application, reinforces skin barrier function by increasing lipid and protein production, and delivers long-term hydration with prolonged use.

When used in leave-on products, PrimalHyal™ Hydra[+] outperforms standard HA hydration benefits by at least a factor of two. Equally impressively, these benefits are maintained for up to four days after stopping the treatment. And that's not all: our studies also show that PrimalHyal™ Hydra[+] is similarly efficacious when used in rinse-off products.

How have you established these claims?

To test efficacy, we undertook several evaluations (ex vivo) of PrimalHyal™ Hydra[+] applied at 0.1% in different formats mimicking rinse-off or leave-on conditions. The studies measured skin adhesion properties, barrier function and skin hydration, demonstrating improvements in each case. These included a significant boost of skin water content in rinse-off (up to +67% compared to other HA grades) and leave-on conditions (up to +95% versus HMW HA).

In addition, we undertook several double-blind versus placebo clinical evaluations to test hydration improvements. Among other positive findings, these studies showed +11% instant gratification after a single use (shower gel), x2.6 flash hydration improving over time (lotion), and +100% moisturisation boost and improvement of skin barrier function after a single application (face mask). Additional results revealed significant increases in the content of lipids and proteins in the skin (up to +21%), the thickness of the *stratum corneum* (up to +30%) and total water content (up to +41%), each lasting for up to four days after the last application.

Finally, we undertook a home usage test with 120 volunteers (male and female). It established that PrimalHyal™ Hydra[+] not only triggers perceptible benefits to consumers at the clin-

ical dosage, but also when used three times lower (0.03%). Volunteers were able to perceive the hydration improvements to the extent that they also reported a willingness to pay twice the price for products with such benefits compared to the products of their usual routine!

How did you measure the accuracy of this perceived benefit?

We evaluated satisfaction using a new implicit finger-tracking movement technology to ensure accuracy and overcome bias. The technology captured users' gut feelings by measuring finger movement and reaction time, producing a more granular, discriminating and accurate analysis by eliminating the risk of false positive/negative reporting.

Without knowing that the formula contained HA, 79% of users reported the shower gel had increased hydration (82% at the clinical dosage, 76% at the lower dosage): "After using the shower gel, I felt my skin [as] hydrated as if I had used body lotion", remarked one volunteer.

What's next for PrimalHyal™ Hydra[+]?

Givaudan has created two inspiring marketing concepts to bring PrimalHyal™ Hydra[+] to market. For rinse-off application, S3D® HydraSplash Shower, an in-shower cream, combines 0.1% PrimalHyal™ Hydra[+] with BisabolLife® and aloe vera LG Veragel, replacing the need for body cream after showering. For leave-on application, S3D® HydraSpash Mask is a sheet mask made with 100% degradable fabric (containing 0.1% PrimalHyal™ Hydra[+], Masknyl™ and

Chamomile LG) that hydrates, brightens, soothes and repairs the skin after a single application.

These two concepts are designed to help our customers support global consumer demand for skincare products with increased moisturising and hydration. By offering a new HA gold standard for face and body care, PrimalHyal™ Hydra[+] will enable them to deliver never-before-seen benefits to the skin and expand the limits of skincare hydration in rinse-off products, too.



Mathias Fleury

To find out more,
visit our website



SYMPARE

Hair Shampoo



Phase	Ingredient	% wt./wt.	Function
A	Aqua	qs	Diluent
	SYMPARE MES (as 100%)	8.0	Surfactant
	Xanthan Gum	0.5	Viscosity Builder
	TENSAGEX SLES 70%*	13.0	Surfactant
	Cocamidopropyl Betaine 30%	10.0	Co-Surfactant
B	PALMOCOL CMMEA 85%*	2.0	Viscosity Modifier
	PALMERA Glycerine*	0.5	Humectant
	Polyquaternium 7	1.0	Conditioning Agent
C	Fragrance	As Needed	Fragrance
	Preservative	As Needed	Preservative
	Sodium Chloride	As Needed	Viscosity Adjuster

*Ingredients offered by KLK OLEO

PROCEDURE:

1. Heat aqua to 70°C, dissolve SYMPARE MES, add the remaining **Part A** ingredients, then cool to 40°C.
2. Add **Part B** and blend under gentle stirring, cool to room temperature.
3. Add **Part C**, stir. Adjust viscosity with Sodium Chloride.

TYPICAL PROPERTIES:

Appearance: Opaque Liquid
pH: 6.5 - 7.5

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FORMULATIONS

Natural Pearl Shampoo

HB-DE-22-KS-2714800-004



Phase	Ingredients	INCI	% by weight	Function
A	Water, demin.	Aqua	61.50	
	Dehyquart® Guar N	Guar Hydroxypropyltrimonium Chloride	0.20	Conditioning agent
	Citric Acid (50% solution)	Citric Acid	0.15	Neutralizing agent
B	Plantacare® 818 UP	Coco-Glucoside	14.00	Surfactant
	Plantapon® ACG 50	Sodium Cocoyl Glutamate	12.00	Surfactant
	Euperlan® NL Pearl	Hydrogenated Vegetable Oil, Cocamidopropyl Betaine, Glyceryl Oleate	3.00	Pearlizer
	Lamesoft® PO 65	Coco-Glucoside, Glyceryl Oleate	1.00	Conditioning agent
	Verdessence™ Xanthan	Xanthan Gum	1.20	Rheology modifier
	Plantasil® Micro	Dicaprylyl Ether, Decyl Glucoside, Glyceryl Oleate	3.00	Conditioning agent
	Sodium Benzoate	Sodium Benzoate	0.50	Preservative
	Perfume Green Vanille Nat (Düllberg Konzentra)	Parfum	0.30	Fragrance
C	Citric Acid (50% solution)	Citric Acid	3.15	pH Adjustment

SPECIFICATIONS:

pH value (23°C): 4,9

Viscosity (Brookfield; RVT; spindle 4; 10 rpm; 23°C): 11000 mPa s

PERFORMANCE:

Additional performance has not been evaluated

MANUFACTURING PROCESS:

1. Mix ingredients of **Phase A** while stirring in given order and allow to swell for 10 min.
2. Add ingredients of **Phase. B** (mix Plantacare 818 and Verdessence Xanthan separately) in given order to **Phase A** and stir after each addition until completely homogeneous.
3. Adjust pH value with **Phase C**.

MICROBIOLOGIE:

No microbiological testing was carried out

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FORMULATIONS

Soft and Smooth Textured Hair Gel

Hair Gel with Medium Hold (HB-DE-21-PG-2281984-209)



Phase	Ingredients	INCI	% by weight	Function
A	Water, demin.	Aqua	93.92	
	Glycerin	Glycerin	3.00	Humectant
	Calcium Chloride (10% solution)	Calcium Chloride	0.44	Complexing agent
	Sodium Benzoate	Sodium Benzoate	0.50	Preservative
B	Verdessence™ Glucomannan	Glucomannan	0.66	Rheology modifier and fixative
	Verdessence™ Alginate	Algin	0.66	Rheology modifier and fixative
	Verdessence™ Tara	Caesalpinia Spinosa Gum	0.66	Rheology modifier and fixative
C	Citric Acid (50% solution)	Citric Acid	0.16	pH Adjustment

SPECIFICATIONS:

pH value (23°C): 4,8

Viscosity (Brookfield; RVF; spindle 7; 10 rpm; 23°C): 112000 mPa s

PERFORMANCE:

Curl retention (gel; 5h; 25°C; 90% r.h.; ST-0120-02): 98+-2%

Curl retention (gel; 24h; 25°C; 90% r.h.; ST-0120-02): 98+-2%

Stiffness (Gel; 21°C; 65%; ST-0100-08): 453+-66 cN

MANUFACTURING PROCESS:

1. Stirr **phase A** until completely dissolved.
2. Add biopolymers from **phase B** using homogenizer to avoid lumps.
3. Stirr two hours using normal lab mixer. If still lumps are present continue stirring until formulation looks homogeneous
4. Add **phase C** and stirr another 15 minutes.

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FORMULATIONS

I SEE YOU

C.CO.23.03HPC



Phase	Ingredient	INCI	%
A	Celus-Bi® Feel 10	Zea Mays Starch, Polyvinyl Alcohol, Glycerin	3.00
		Mica, CI 77491 (Titanium Dioxide), CI 774499 (Black Iron Oxide)	81.80
B		Tocopheryl Acetate	0.10
	OxControl ROT	Brassica Campestris (Rapeseed) Seed Oil, Tocopherol, Rosmarinus Officinalis (Rosemary) Leaf Extract	0.10
	EMotion® Silky	Neopenthyl Glycol Dipelargonate	15.00
TOTAL:			100.00

CHEMICAL PSYCHICAL PARAMETERS:

1. Appearance: PERLESCENT POWDER
2. Colour: MAGENTA PEARLESCENT
3. Smell: LIGHT CHARACTERISTIC
4. pH: n.a
5. Density (g/ml): n.a.
6. Viscosity (BrookField Mod. RVDV-E 230): n.a.
7. Centrifuge (2 cycle*3000rpm*15'): n.a.
8. Stability (6 months at 4, 25, 40°C): YES
9. Dropping point (°C): n.a.
10. Surfactant actives content: n.a.

DESCRIPTION:

Precious eyeshadow with a velvet touch and intense red fruit colors shades.Highly pigmented pearl powder for a vibrant and metallic eye look on-the-go with high-impact shine. Designed to get noticed.

Celus-Bi® Feel 10, biodegradable texturizer alternative to microplastics
EMotion® Silky, soft and dry, silky touch

CLAIM AND KEY POINTS:

- Silky touch
- Lightweight texture
- Vibrant color
- Highly pigmented

MANUFACTURING METHOD:

1. Weight the components of **Phase A**;
2. Mix **Phase A** and add pre-mixed **Phase B** little by little while stirring until the product is homogenous.

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Editor in Chief

Robert Fischer | robert.fischer@sofw.com

Editorial Content

editorial@sofw.com

Advertising

advertising@sofw.com

Subscriptions

subscription@sofw.com

Publisher

Verlag für chemische Industrie H. Ziolkowsky GmbH

Print



Holzmann Druck GmbH & Co. KG
Gewerbestraße 2 | 86825 Bad Wörishofen
Germany

Issues

10 issues per year + scheduled special issues

Address

Verlag für chemische Industrie H. Ziolkowsky GmbH
Dorfstr. 40 | 86470 Thannhausen
Germany

Phone

+49 8281 79940-0

Fax

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