

A new effective, sustainable conditioning system (NCS)

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The new market trends have led Kao Chemicals Europe to develop a New Conditioning System (NCS) - with 100% active ingredients as ready-to-use white pearls - that shows an optimum cost-effectiveness ratio, as well as excellent ecotoxicological properties which allow that it is not classified according to the CLP system and not to be subject to storage restrictions.

Introduction

Hair is one of the most important elements in personal image. Style trends lead to subjecting it to strong alkaline chemical treatments, such as dyeing, rinsing or perms which usually damage it. In addition, the excessive combing and washing processes daily undergone by hair, as well as UV radiation, ultimately result in a dry, frizzy, hydrophilic hair.

A hydrophobic environment is required to keep the integrity of the cuticle, the outermost layer of the hair fibre. Hair conditioners have been proven to be the most effective treatment to prevent and counteract the damage caused to hair. Hair conditioners allow to keep hair hydrated and softer for a longer time, which means an improvement in hair manageability. They also provide it with a greater shine and achieve a greater control of

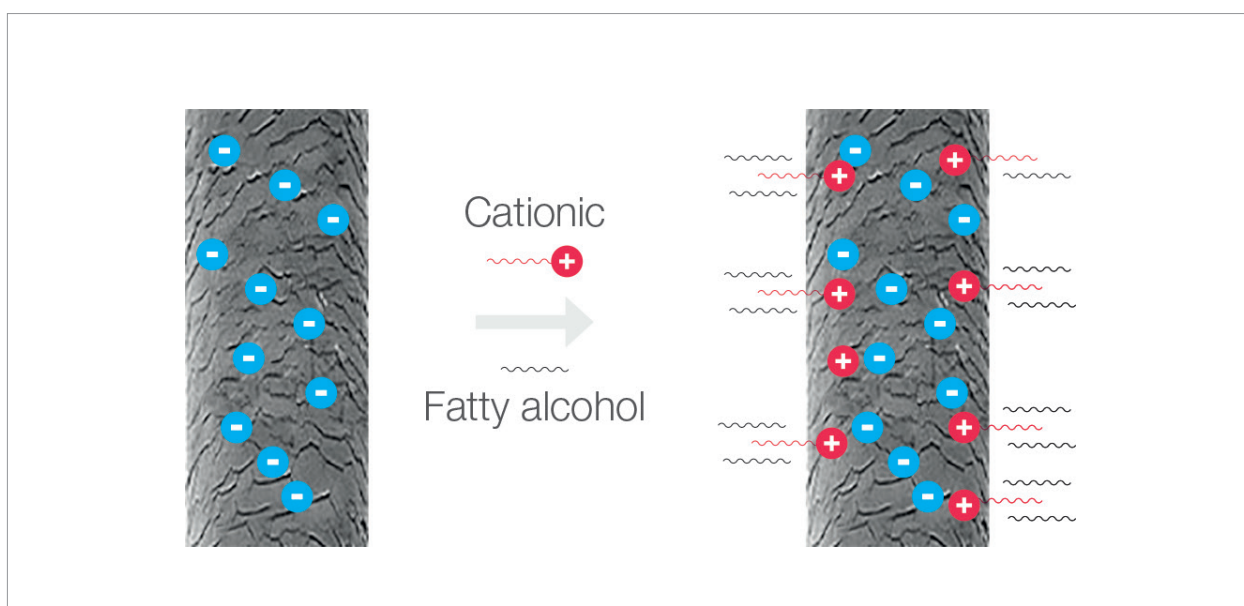


Figure 1. Drawing of how a hair conditioner acts on the hair surface.

frizz by preventing hair breakage thanks to the arrangement of cationic charges on the surface^{1,2,3}.

Broadly speaking, a hair conditioner contains cationic surfactants, fatty alcohols, additives and water. And the first is the main component.

Cationic surfactants (positively charged) are deposited on the hair surface, anionic by nature (negatively charged), and condition it thanks to the hydrophobic nature of the alkyl chain and the cationic charge of the polar group. (Figure 1)

Quaternary ammonium salts have traditionally been the main ingredients in hair conditioning formulations, using most commonly Cetrimonium Chloride (CTAC) and Behentrimonium Chloride (BTAC).

However, despite their good performance, they show a rather low ecotoxicological profile, as shown in Figure 2.

Consumers are increasingly looking for safe, effective products that are also sustainable and environmentally-friendly. This is forcing companies to innovate and reinvent themselves in order to meet the demanding market needs^{4,5}.

New Conditioning System (NCS)

The new consumption trends have led KAO Chemicals Europe (KCE) to the development of a new ready-to-use conditioning system (NCS) with an optimum cost-efficacy ratio, as well as excellent ecotoxicological

properties, which allow it not to be classified according to the CLP system and not to have storage restrictions.

Chemical description

The New Conditioning System (NCS) is based on a synergistic combination of cationic surfactants (33%) - of Esterquat and Alkylamidoamine type - with several fatty alcohols (67%), which allows formulation in a single step.

Esterquats are quaternary compounds, derived from triethanolamine, with an ester group in the long hydrophobic chains. These products meet the current market trends, as they are soft and compatible and not irritant or sensitising for the skin. These ingredients are environmentally-safe, and their sources can be of natural origin.

Alkylamidoamines, duly neutralised with an acid, are a good alternative to quaternary salts in typical conditioning formulations, as they have a good ecotoxicological profile, show a good compatibility with anionic surfactants and can be easily formulated. In addition, these molecules, in their cationic form, show a higher affinity for the hair surface, providing a greater antistatic effect⁶.

Specifically, the New Conditioning System (NCS) is made of Behenamidopropyl dimethylamine, Dipalmitoylethyl Hydroxyethylmonium, Methosulfate, Cetyl Alcohol, Stearyl Alcohol and Lactic Acid.

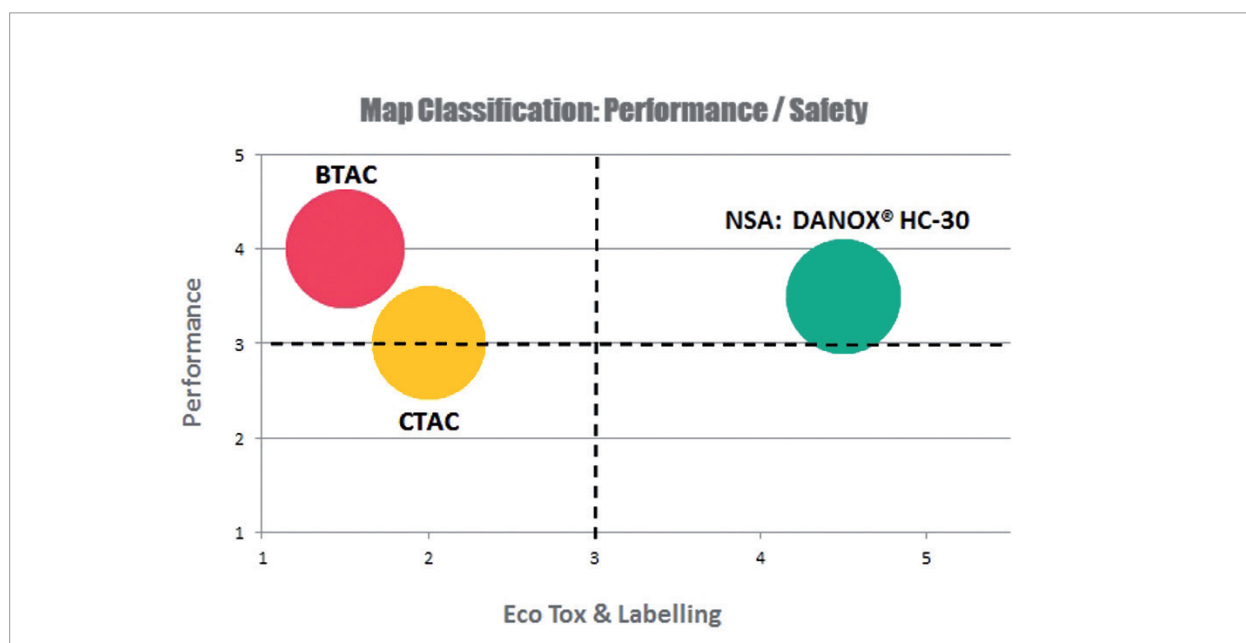


Figure 2. Classification map of the typical ingredients used in hair conditioning formulations. Where 1: very poor and 5: very good.

Physico-Chemical properties

The NCS product is available as white pearls (Figure 3), contains 100% active ingredients and does not contain solvents or preservatives.



Figure 3. Image of the appearance of the New Conditioning System (NCS) of Kao Chemicals Europe (KCE).

Ecotoxicological properties

The ecotoxicological profile of a surfactant is one of the most important characteristics to be considered, in

particular in Europe, where regulations are increasingly restrictive. Obtaining an “Eco” label for hair conditioning formulations requires that all ingredients in the formula are biodegradable and not toxic for aquatic organisms.

The New Conditioning System (NCS) has been designed to be a sustainable, safe ingredient (Figure 2). Its biodegradability and aquatic toxicity properties, as well as the absence of solvents in its composition, allow it not to be classified according to CLP, unlike other cationic surfactants traditionally used. (Table 1).

Application properties

The New Conditioning System (NCS) allows to prepare different types of hair conditioners according to their concentration range in the formula: from 2.5% for leave-on (no rinse out) conditioners to 12% for hair treatment masks. The recommended concentrations of use for typical hair conditioners range from 4% to 8%, depending on the intended final efficacy or viscosity. Finally, using the New Conditioning System (NCS) at high concentrations (60-80%) conditioners in solid format may be obtained, which is the last trend in the hair market. (Table 2)

The pH recommendation to obtain optimum conditioning and stability conditions ranges from 3 to 4.5.






	DANOX® HC-30	Cetrimonium Chloride	Behentrimonium Chloride
Appearance			
Product	33% Blend of cationics 67% Fatty alcohol	30% Cationic 70% Water	85% Cationic 15% Isopropanol
Labelling	NL		

Table 1. Comparison of the CLP classification of NCS of KCE versus the ingredients typically used in hair conditioning formulations (CTAC & BTAC).

PORCENTAJE USO EN FORMULACIÓN (%)	APLICACIÓN
2.5 – 3.5	Sérum
4.0 – 6.0	Acondicionadores capilares estándar
6.0 – 8.0	Acondicionadores capilares reparadores
10.0 – 12.0	Mascarillas capilares
60.0 – 80.0	Acondicionadores sólidos

Table 2. Recommended percentages of use in formulation for the New Conditioning System (NCS) according to the type of product desired.

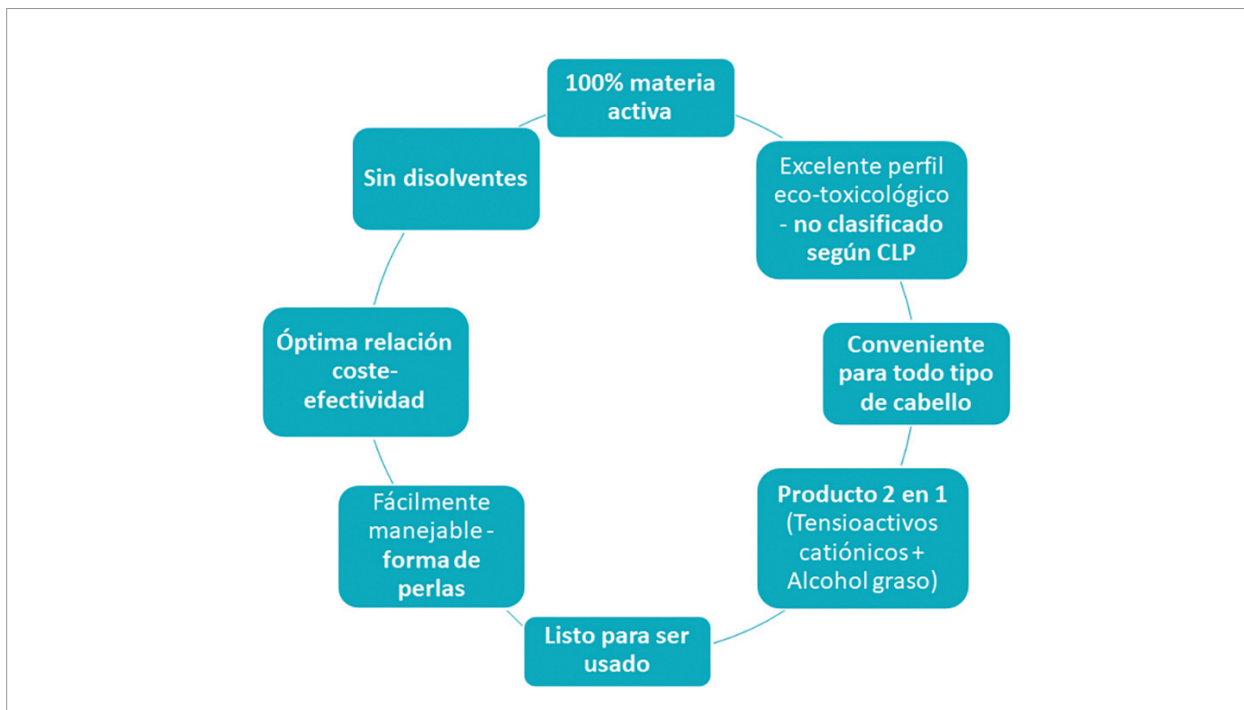


Figure 4. Scheme of the main characteristics of the New Conditioning System (NCS).

Formulability of the New Conditioning System (NCS)

The preparation of a hair conditioner always involves a long process, with a remarkable power consumption, as it requires temperatures close to 80°C which allow to include and emulsify the different components of the formula. The final appearance of the emulsion and its viscosity are essential parameters in the hair conditioner obtained. In some cases, obtaining high viscosities can be challenging for formulators. Therefore, there is a growing market demand for ingredients which can be easily formulated and adapted to a formula.

The New Conditioning System (NCS) allows a single-step formulation, as it includes all fatty ingredients already incorporated and pre-emulsified. This means a remarkable advantage over the standard method, as it saves time and energy.

Viscosity

The New Conditioning System (NCS) allows to obtain higher viscosities as compared to other cationic surfactants typically used. As shown in Figure 5, for a basic formula of conditioner, the viscosities obtained with NCS are higher than those obtained with BTAC or CTAC, and the viscosity is much more stable over time with NCS.

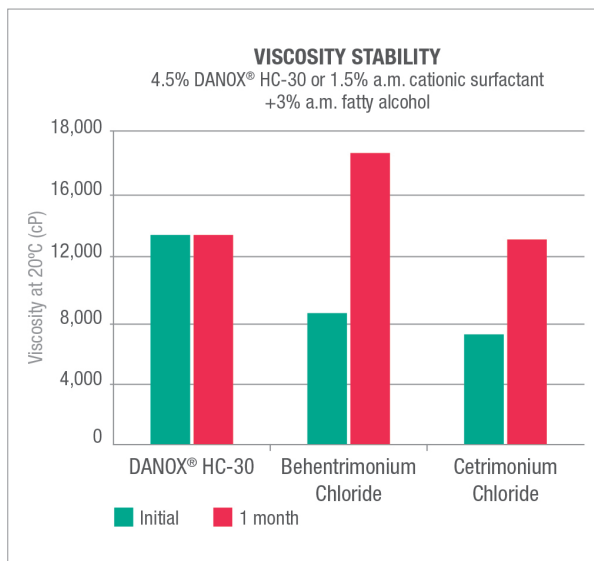


Figure 5. Stability of viscosity at 30 days in three typical hair conditioning formulations based on NCS, BTAC and CTAC.

In addition, higher viscosity values can be obtained modifying the process or increasing NCS concentration, which is directly proportional to the viscosity obtained.

Efficacy of the New Conditioning System (NCS)

Combability can be defined as the subjective perception of how easy or difficult is to comb hair. It is an important attribute to be evaluated, as the consumer associates directly a good combability with a better hair conditioning.

For developing good cosmetic products, it is essential to characterise the physical structure and mechanical properties of hair.

To verify the efficacy of the New Conditioning System (NCS) comparative tests were performed on combing force, detangling and antistatic effect^{6,7} versus the main ingredients used in hair conditioners: Behentrimonium Chloride (BTAC) and Cetrimonium Chloride (CTAC). A total of three regular hair conditioning formulations were tested: A) 4.5% NCS, B) 1.5% a.m BTAC + 3% fatty alcohol, and C) 1.5% a.m CTAC + 3% fatty alcohol.

Combing force

The New Conditioning System (NCS) reduces substantially combing force in all types of hair tested (Caucasian, Asian and mulatto). The results obtained (Figure 6) show that combability is better with NCS than with the conditioner formulated with CTAC, in particular in Caucasian hair, and close to the combability obtained with BTAC. In Asian hair virtually no differences are seen among the three formulas.

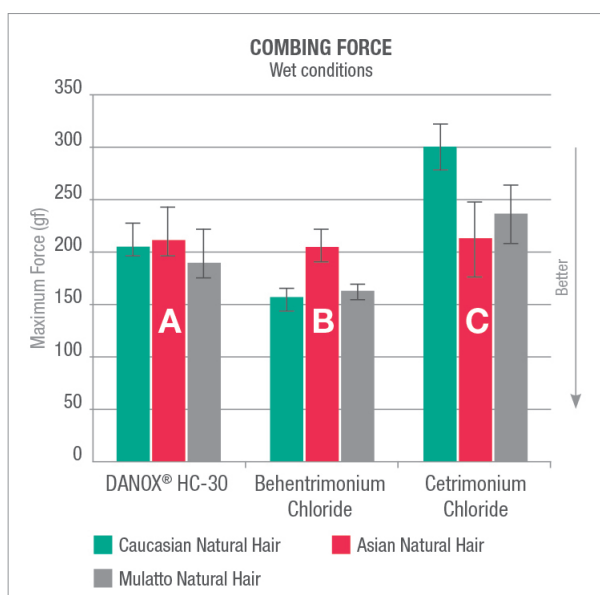


Figure 6. The combing force measured as the maximum force applied of the 3 formulas tested. A) 4.5% NCS, B) 1.5% a.m BTAC + 3% fatty alcohol, and C) 1.5% a.m CTAC + 3% fatty alcohol.

Detangling

As shown in Figure 7, the detangling results obtained with the New Conditioning System (NCS) are comparable to those obtained with Behentrimonium Chloride (BTAC) and are better than those obtained with cationic surfactants of short alkyl chain, such as Cetrimonium Chloride (CTAC).

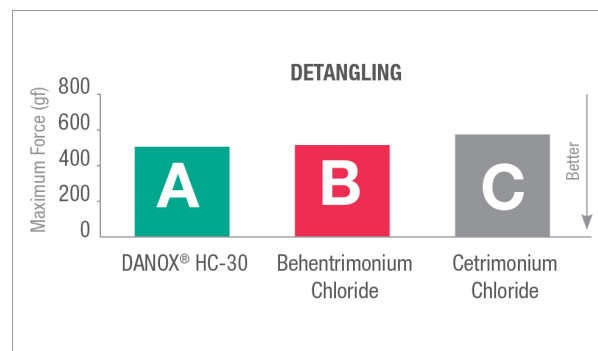


Figure 7. Detangling of each tested formula measured as the Maximum Force (gf). Where A) 4.5% NCS, B) 1.5% a.m BTAC + 3% fatty alcohol and C) 1.5% a.m CTAC + 3% fatty alcohol.

Antistatic effect

The electrostatic charge of the hair can be controlled easily with NCS as compared to formulations based on BTAC or CTAC where remarkably higher results are obtained. (Figure 8)

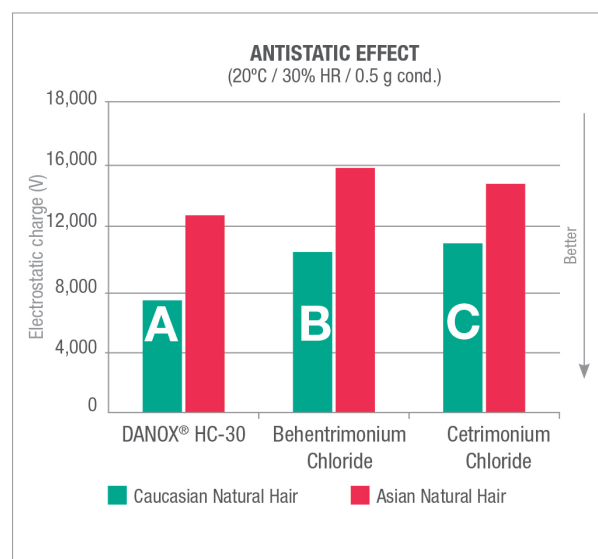


Figure 8. Antistatic effect measured as electrostatic charge (V). Where A) 4.5% NCS, B) 1.5% a.m BTAC + 3% fatty alcohol and C) 1.5% a.m CTAC + 3% fatty alcohol.

Good compatibility with oils and silicones

Silicones and oils are the usual ingredients in hair formulations. They are generally used as additives to obtain greater hair shine, softness and manageability. They are lubricating agents that cause a film-forming effect around the cuticles. They can re-establish temporarily the hydrophobicity of the damaged hair shaft, allowing the necessary sliding for easily detangling hair, reducing its porosity, which decreases the probability of moisture absorption. The disadvantage is that, when they are added to the formula, they usually destabilise it and reduce viscosity.

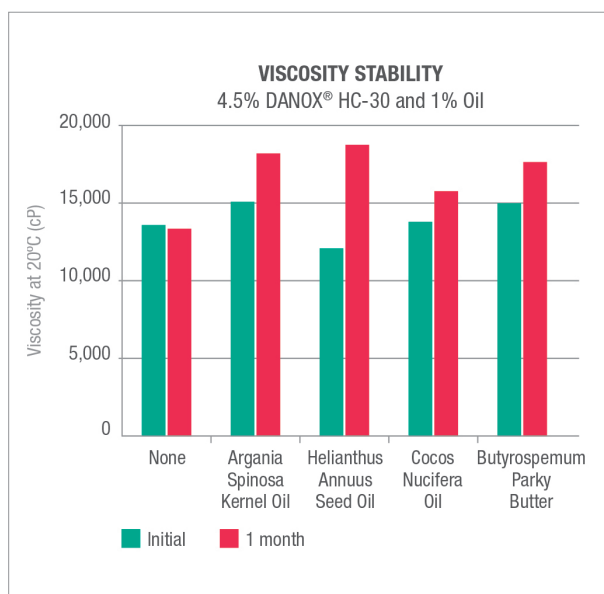


Figure 9. Effect of oils in formulations based on NCS.

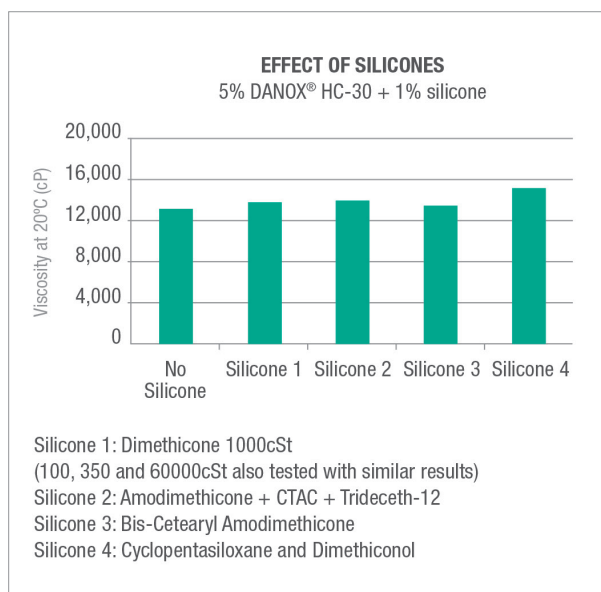


Figure 10. Effect of silicones in formulations based on NCS.

The New Conditioning System (NCS) allows to include silicones and oils easily without needing to add emulsifiers. Homogeneous, consistent, stable, viscous formulas are obtained, as shown in Figure 9 and 10.

Examples of formulations

“A SINGLE INGREDIENT, MULTIPLE APPLICATIONS”

Liquid format

Formula C-273 is a Cleansing Conditioner which allows to preserve the natural oils of hair that protect it from external damage. This formula is free of anionic surfactants and the washing is provided by Cocamidopropyl Betaine and the conditioning is achieved thanks to the combination of the New Conditioning System (NCS) and PPG-3 Caprylyl Ether (Table 3).

The mixture of silicones and oils with NCS allows to obtain a wide range of hair conditioning formulations, depending on the concentrations used and the intended final product. Tables 4 and 5 give an example of formulation for a Hair Conditioner for Damaged Hair with 5% NCS (formula C-256) and a Deep Moisturising Mask with 10% NCS (formula C-275), respectively.

Reference C-274 is a formulation example of a spray conditioner of leave-on type. The combination of NCS with PPG-3 Caprylyl Ether gives the conditioning effect to the hair. It provides hair with softness, improves combability and increases shine. Lauryl Lactate provides the necessary rheology to the formula for it to be evenly sprayed over hair (Table 6).

Ref. C-273	
CLEANSING CONDITIONER	%
BETADET® HR Cocamidopropyl betaine	18.4
DANOX® HC-30	12.0
Hydroxypropyl Starch Phosphate Ester	3.0
Glycerin	2.0
KAO SOFCARE® GP-1 PPG-3 Caprylyl Ether	1.0
Additives*	q.s.
Deionized Water	Up to 100

*Additives: pH adjustment, preservatives, fragrance, dyes, etc.

Table 3.

Ref. C-256

HAIR CONDITIONER FOR DAMAGED HAIR

	%
DANOX® HC-30	5.0
KAO SOFCARE® GP-1 PPG-3 Caprylyl Ether	0.5
Dimethicone (60000 cSt)	1.0
Additives*	q.s.
Deionised Water	Up to 100

*Additives: pH adjustment, preservatives, fragrance, dyes, etc.

Table 4.

Ref. C-275

DEEP MOISTURIZING MASK

	%
DANOX® HC-30	10.0
Dimethicone (60000 cSt)	2.0
Argan Oil	1.5
Shea Butter	1.5
Additives*	q.s.
Deionized Water	Up to 100

*Additives: pH adjustment, preservatives, fragrance, dyes, etc.

Table 5.

Ref. C-274

LEAVE-ON HAIR SPRAY CONDITIONER

	%
DANOX® HC-30	5.0
KAO SOFCARE® GP-1 PPG-3 Caprylyl Ether	1.0
EXCEPARL® LM-LC Lauryl Lactate	0.5
Propylenglycol	0.5
Quaternium-80	0.5
Fluid Cyclopentasiloxane	0.5
D-Panthenol	0.5
Additives*	q.s.
Deionized Water	Up to 100

*Additives: pH adjustment, preservatives, fragrance, dyes, etc.

Table 6.

Solid format

The growing concern for the environment has moved to the consumption habits of the population in European countries.

The market is progressing actively to meet consumer's demands. In the field of cosmetics, a growing number of companies is seen to target solid formulations, for the purpose of reducing water and package consumption, or packages made of reused material.

Ref.: C-315

SMOOTH SOLID CONDITIONER

	%
DANOX® HC-30	60.5
KALCOL® 6850 Cetearyl Alcohol	15.0
LEVENOL® H&B Glycereth-2 Cocoate	8.0
KAO SOFCARE® GP-1 PPG-3 Caprylyl Ether	5.0
Shea Butter	10.0
Additives*	q.s.

*Additives: Fragrance, preservatives, dyes, etc.

Table 7.

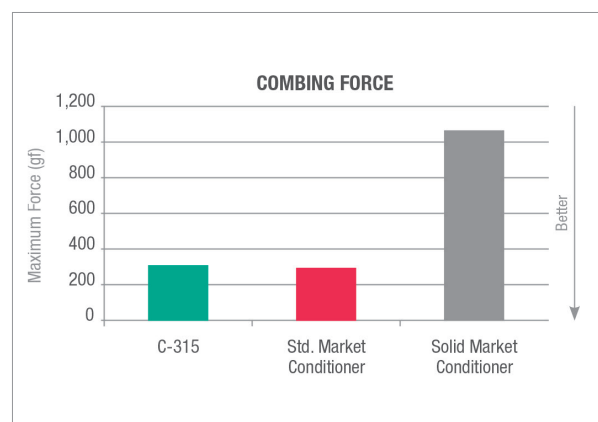


Figure 11. Combing force according to the maximum applied force of the formula proposed by KCE C-315, a standard market liquid conditioner and a market solid conditioner.

Reference C-315 corresponds to an example of a formula proposed for a Smooth Solid Conditioner (Table 7). NCS allows solid formulation, with percentages of 60-80% and a high efficacy. As shown in Figure 11, the formula proposed by Kao Chemicals Europe leaves a soft hair, comparable to commercial conditioners in liquid format and shows a remarkable improvement over the solid conditioners available in the market.

Ref.: C-317

SOLID SHAMPOO	%
EMAL® 30G-S Sodium Lauryl Sulfate	77.9
DANOX® HC-30	10.0
AKYPO® FOAM LM25 Potassium Laureth-4 Carboxylate	7.0
BETADET® SHR Cocamidopropyl Hydroxysultaine	1.0
KAO SOFCARE® GP-1 PPG-3 Caprylyl Ether	1.0
AMIDET® N PEG-4 Rapeseedamide	1.0
Propylene Glycol	1.0
Additives*	q.s.

*Additives: Fragrance, preservatives, dyes, etc.

Table 8.

The versatility of the New Conditioning System (NCS) allows the formulation of products not only corresponding to hair conditioners. An example is reference C-317, a Solid Shampoo (Table 8). In this case, Sodium Lauryl Sulfate is the main anionic surfactant which gives the

cleansing power to the formula. In order to make the formula softer, SLS is combined with another anionic surfactant with a very low irritation profile, Potassium Laureth-4 Carboxylate. This anionic surfactant also provides additional benefits to the formula, such as a creamier foam and a smaller bubble size (Figure 12). NCS together with PPG-3 Caprylyl Ether provides conditioning and a greater shine without needing to add silicones. To prevent the unwanted cracking effect on the bar of soap over time, PEG-4 Rapeseedamide is added.

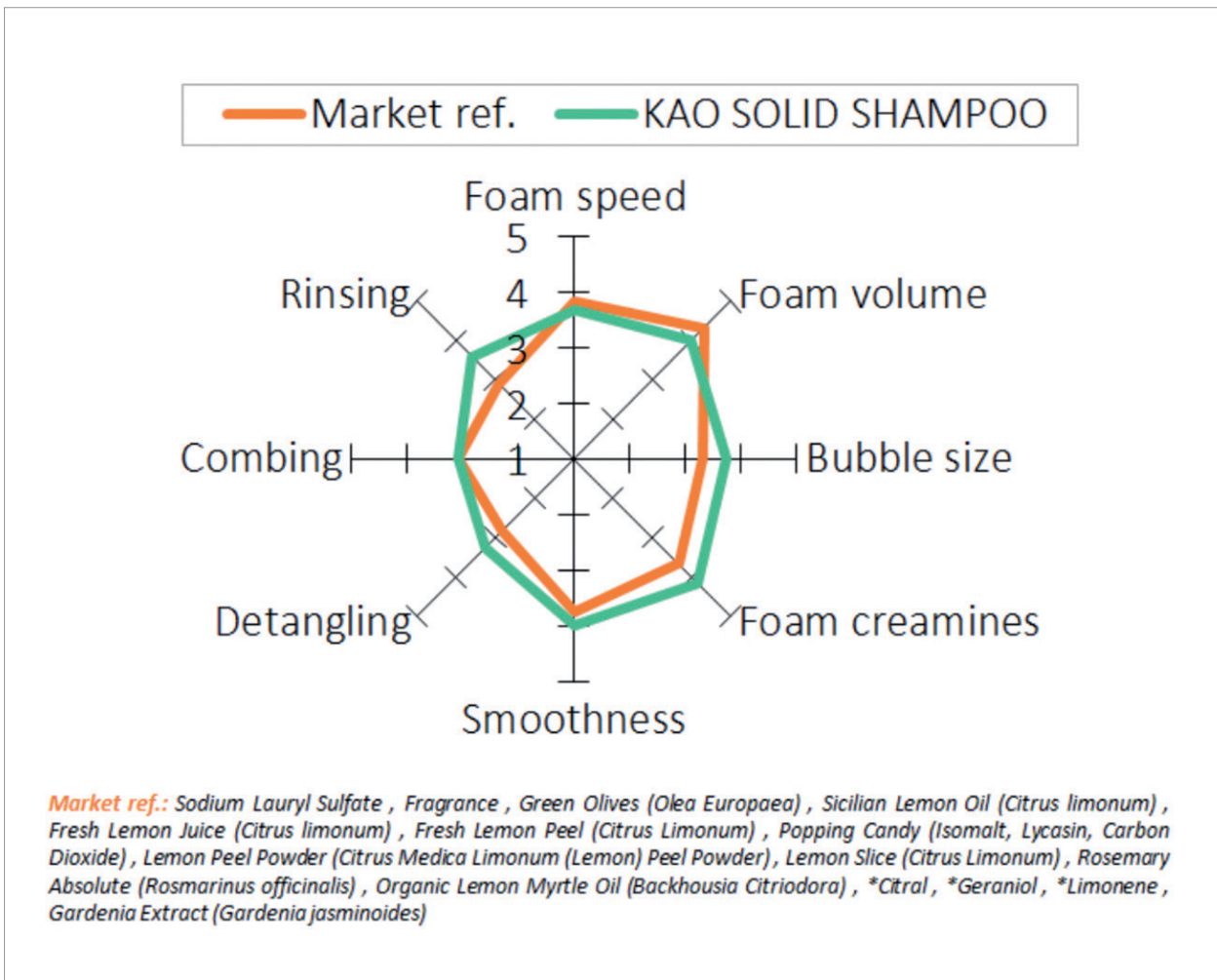


Figure 12. Sensory test on formula C-317 (Table 8) versus a market reference of a solid shampoo.

Conclusions

The current market trend is clearly marked by the need for creating safe, effective, environmentally-friendly products. The major cosmetic brands are continuously innovating and reinventing themselves to meet the demanding expectations of the consumer.

In recent years there has been a major change of mentality in the way of consuming. It is increasingly common to see on supermarket shelves products with packages made of recycled material or even free of plastic for the purpose of achieving a sustainable consumption without compromising efficacy.

The new consumption trends have led KAO Chemicals Europe (KCE) to the development of DANOX® HC-30, a New ready-to-use Conditioning System (NCS), unique in the market, which shows an optimum cost-efficacy ratio, as well as excellent ecotoxicological properties, which allow it not to be classified according to the CLP system and with no storage restrictions.

DANOX® HC-30 is supplied as white pearls, contains 100% active ingredients and no solvents or preservatives. In terms of application, it is a highly versatile product which allows to formulate a high variety of cosmetic products. From a hair serum to a solid conditioner.

In addition, thanks to its emulsifying properties and its good skin compatibility, DANOX® HC-30 is a product highly recommended for the preparation of skin care emulsions.

References

1. Dias, M. F. R. G., Pirmez, R., & Dutra, H. (2020). How to Select a Good Shampoo and Conditioner. In *Hair and Scalp Treatments* (pp. 253-264). Springer, Cham.
2. Kobayashi, E. (2012). Hair Conditioning Ingredients Developed with Focusing on Hair Surface Structure. *SÖFW-Journal*, 138(1-2).
3. Velasco, M. V. R., Dias, T. C. D. S., Freitas, A. Z. D., Júnior, N. D. V., Pinto, C. A. S. D. O., Kaneko, T. M., & Baby, A. R. (2009). Hair fiber characteristics and methods to evaluate hair physical and mechanical properties. *Brazilian Journal of pharmaceutical sciences*, 45(1), 153-162.
4. Eugene Zeffren, K.G (1989). The story of a conditioner. *Cosmetic & Toiletries*, 31-34.
5. Sancho, FB (1992). Bases cosméticas de los tensioactivos acondicionadores capilares. *Dermatología cosmética*, 80-92.
6. Minguet, M., Subirats, N., Castán, P., & EUROPE, K. C. (2008). Can Cationic Surfactants Really Protect Hair Against Damage?. In *Proceedings of the 25th IFSCC Congress, poster PS-233*.
7. Minguet, M., Subirats, N., Castán, P., & Sakai, T. (2010). Behenamidopropyl dimethylamine: Unique behaviour in solution and in hair care formulations. *International journal of cosmetic science*, 32(4), 246-257. ●

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